TOWARD THE DESIGN OF A COMPUTER-BASED INTERACTIVE FANTASY SYSTEM

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of the Ohio State University

By

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DEDICATION

for Hilary and her friends
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**Fields of Study**

Major Field: Dramatic Theory and Criticism  
Minor Fields: Acting, Directing, and Design
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PREFACE

By the time this study is published, much of the technical information contained in it will be out-dated. The sensational discoveries of the moment will be old news, ongoing research will have been completed, and a whole new set of capabilities will have been realized. What is the value of a feasibility study in such a rapidly changing context?

Idle fantasies are ultimately frivolous, but something that is demonstrated to be possible may evoke serious thought. One may hear glib remarks about interactive movies at science-fiction conventions and high-tech cocktail parties—Ray Bradbury imagined one and George Lucas thinks they are great—and everyone seems to assume that somehow or another they will inevitably come to be. But the truth is that building such a thing is neither easy nor inevitable—it requires an enormous amount of effort and an unfashionable level of discipline, and it fulfills a purpose that is not universally recognized as necessary or even important. The body of this study is intended to persuade the reader that an interactive fantasy system is possible and desirable—in short, that it should be built; this Preface is intended to demonstrate its importance as an idea.

Reality has always been too small for human imagination. The impulse to create an "interactive fantasy machine" is only the most recent manifestation of the age-old desire to make our fantasies palpable—our insatiable need to exercise our imagination, judgment, and spirit in worlds,
situations, and personae that are different from those of our everyday lives. Perhaps the most important feature of human intelligence is the ability to internalize the process of trial and error. When a man considers how to climb a tree, imagination serves as a laboratory for "virtual" experiments in physics, biomechanics, and physiology. In matters of justice, art, or philosophy, imagination is the laboratory of the spirit.

This study is the Chronicle of two particular adventures. The first is my own adventure with computer technology. It began with a moment of awe in the computer-imaging laboratory at Battelle Memorial Institute in 1976. The first time I laid eyes on a computer, I saw a machine that could reconstruct images sent back from space. It could also draw pictures of fantastic worlds that existed nowhere but in some programmer's mind. I had what I believe may be called a "conversion experience." What I saw was a new presence in the world. Man had invented a playmate for himself in the lonely world of his imagination.

Ten years earlier, Alan Kay had coined a phrase to describe this new presence: the fantasy amplifier. Alan's adventure was similar to mine in that it began with the same impulse, the same joyous recognition. Alan had been working in the "real world" of computers for over a decade when I met him. At Xerox Palo Alto Research Center (PARC), one of the most celebrated "think tanks" of its time, Alan was father and midwife of a programming language called SMALLTALK. SMALLTALK was intended to enable people—especially kids—to use computers as tools for thought. It catalyzed a revolution in the notion of what computers are for, and its influence is still apparent in the LOGO language, in the window-style
interface that is used by a variety of personal computers, and in the work of a remarkable group of individuals that Alan assembled at the Atari Systems Research Laboratory in 1982.

Unlike researchers in the most prestigious labs (Stanford Research Institute and PARC, for example), Alan's recruits were, for the most part, young, green, and inexperienced. Many were new graduates of the Architecture Machine Group at the Massachusetts Institute of Technology, an innovative laboratory conceived by Nicholas Negroponte to investigate a domain that was just coming to light: the human-computer interface. Other researchers (like myself) were refugees from the world of consumer computer products, distinguished (and sometimes alienated) from their fellows by their evangelical zeal and their inability to fit in a corporate culture that consistently underestimated the intelligence of both people and machines. It is remarkable, in retrospect, that Alan was able to cajole support for such a dangerous crew.

Alan's strategy was simple: create the richest possible environment and plop creative people into it, and something wonderful is bound to be the result. Atari in 1981-82 was the perfect place for such a grand experiment—with revenues in excess of a billion dollars, the company was in a position to build a "dream lab" for creating the future of high-tech consumer products. For perhaps the first time in the history of computer research, an entire lab was funded without a single dollar from the Department of Defense, and the research was explicitly directed at creating technology for regular people.
With a multi-million-dollar budget and a few dozen people who felt as though they had stepped into a dream, work began at the Atari lab. VAX computers, terminals, and a dozen LISP machines appeared. A video-editing suite and an animation lab were built. Music and speech synthesizers, speech recognizers, body-tracking equipment, frame buffers, monitors, robots, mechanical tribbles, white boards, earphones, and miles of cable occluded the white walls and gray office carpets. Researchers settled into loose collectives to work on their pet ideas. Groups sprang up to investigate topics like interactive animation, multi-modal interfaces, computer music, and the "encyclopedia of the future." By the end of the first year, research agendas had been created. By the end of the second, real work was being done—prototypes were being built, seminars were being conducted, and some "technology transfer" inside the company was beginning to occur. By the end of the third, the lab was gone.

In December of 1983, as most people know, Atari began to fall apart. The crash of the video game business had been foreseen, it would seem, by everyone but upper management. Desperate reorganizations and layoffs followed in most of the major personal-computer companies. Because it had developed very few products other than video games, Atari fared worse than most of its competitors. In March of 1984, the long-term research group was dissolved. A few months later, the company was sold.

There are two "morals" to the story of the Atari lab. The first is that the evolution of the computer into a tool for the mind that is accessible to ordinary people—a great leap forward in man's potential to learn and create—is not assured. High technology could well remain cloistered in
universities, think tanks, and government agencies. The overwhelming majority of "high-tech" consumer products—including talking toasters, Cadillac dashboards, and most video games—have been used, not to empower, but to enslave. A goal of consumer marketing is to establish dependency on a product in order to maximize sales. This approach is inimical to the notion of personal power. It is not the devices themselves but the way they are conceived and marketed that is destructive. The consumer-marketing mentality is what killed Atari. Video games were conceived as hot commodities—fad products. People were addicted to them. But when people tired of them, there was nothing else to do with the computer. Nobody really used one to balance a checkbook or organize recipes. The video-game phenomenon seemed to prove that the whole personal computer business was indeed a passing fancy—a fad that promised everything but delivered cheap thrills. As I write, public disillusionment is still creating havoc in the "consumer side" of the computer industry.

Fortunately, however, most of the consumer-fad people disappeared with the video-game crash. There are no new cheap thrills. Slowly and with only modest commercial success, personal-computer software is evolving beyond video games and computerized spread sheets. But the companies that are still producing personal-consumer products seem to be peopled by veterans and survivors. For them, the video game crash meant something different than it meant to the consumer marketeers. It proved that people are intelligent and curious after all, and that you can't fool them for long. It proved that a good strategy for inventing computer-related products is to imagine something that would fulfill one's own fantasies. The key to
innovation is to delight oneself. When a nine-year-old turns away from a video game, he proves two things: that his imagination has been engaged, and that he is too curious and too intelligent to settle for a half-realized dream. Ultimately, healthy humans are addicts, not of cheap thrills, but of the exercise of imagination. The only things that can ever satisfy them are learning, growth, and change. The second "moral" of the Atari story is that the researchers there had the right idea.

And thus we return to Alan Kay and interactive fantasies. He was one of the first to articulate the belief that computers could enhance the imagination and creativity of man. He believes that, in order to do good research, one needs a "grand idea"—a vision of something that might exist, far in the future and beyond our abilities to imagine it fully. That something must be so powerful that it creates a kind of magnetic field, a force that guides our thoughts and aligns our creative efforts. The "grand idea" gives our work motivation and coherence. It gives us hope.

The grand idea that motivated the people at the Atari lab is a vision of technology—software and hardware—that empowers the mind of the individual. The "fantasy amplifier" is one aspect of that power—a collaborator for the imagination. An interactive fantasy system is one version of that collaborator.

Redwood City, California

October 1985
CHAPTER I
INTRODUCTION

The Idea of Interactive Drama

A young woman sits before a personal computer console using the joystick to maneuver her starship into firing position as she fends off a simulated attack by a swarm of Zylon vessels. When the attackers are destroyed, she taps the keyboard to display a map of her quadrant of the galaxy on the screen to determine where other concentrations of Zylons are awaiting her. For now, she is assuming the role of captain of a starship, with the goal of defending the galaxy from the alien onslaught.¹

In Niven and Barnes' science fiction novel *Dreampark*, adventure game aficionados pay hundreds of dollars apiece to participate for two days in a simulated adventure. They assume characters with various magical powers and instruments, drawn from the lore of adventure gaming. They

¹*Star Raiders*, personal computer game (Atari, 1979). The term "video game" is used in the text of this study to refer to computer games that run on either personal computers or video-game machines; however, in order to assist the reader in identifying a particular game, computer games will be described in footnote references in terms of the type of machines on which they run—arcade games (coin-operated machines), video games (video-game machines), and personal computer games (personal computers).
encounter holographic monsters, explosions, and hoards of murderous ghouls as they seek treasures in the world of the Cargo Cults of the 1930’s.²

There exists in our culture a number of deeply felt, shared fantasies of the kinds of experiences we might have with high technology. The idea of first-person, interactive excursions through imaginary worlds is one such powerful fantasy, which has been expressed in literature, film, and popular culture for decades. It is at the root of the desire which is evoked but only partially fulfilled by the video game fad. The wished-for experience might be compared to volitional dreaming, or to the idea of becoming a character in a play, affecting the action and outcome by making choices and performing actions in the imaginary world of the drama. What would it be like to be Hamlet or Captain James T. Kirk? How would it feel? How might one do things differently than the characters who have already been created? What could one learn by doing it?

Such an experience would afford the user pleasures which are both similar to and distinct from those offered by viewing or writing a play or by playing a video game. Like an audience member, the user could experience the “willing suspension of disbelief,” allowing himself to participate emotionally in an experience without having to cope with any real-world consequences. Like a writer, he could control the thoughts and actions of a character and create or influence various events in the environment, and could have the pleasure of creating a new work of art. Like the player of a video game or role-playing game, he could imagine himself to be actually involved in the experience as an agent by assuming a

fictitious role. A playwright may in fact have similar experiences "in his head" as he works on a script: he may "enact" his characters in his mind, taking vicarious pleasure in choices, actions, and their consequences in an imaginary world. No form of experience currently exists, however, in which one could hope to partake of all these pleasures at once in any world more palpable than that of the imagination.

Critical Qualities of Interactive Drama

Using the theory of the drama and the tools afforded by computer technology, it is possible to imagine a system which would fulfill the fantasy of first-person, dramatic interaction in an imaginary world. What are the critical qualities of such a system?

First, the experience enabled by the system must be interactive. Interaction may be defined as "mutual or reciprocal action or influence." A fully interactive experience is the product of ongoing collaboration between the principal participants. The principal participants in the proposed interactive experience are the human user and a system animated by artificial intelligence. The interactive requirement means that the user and the system must have mutual or reciprocal influence on the action that occurs.

Second, the experience must be dramatic; that is, it must be productive of the pleasure associated with drama. That pleasure arises from the selection and arrangement of incidents and from the organic beauty of a whole. Drama does not provide an imitation of life in all its redundancy and

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confusion, but rather presents an imitation of action which, through artistic formulation, excludes unnecessary detail and complication and makes visible the causal connections among events. The dramatic form functions to maximize the pleasurable experience of emotion on the part of the audience (or "user"). The system, then, must be capable of structuring the experience in dramatic form.

Finally, the user must be able to interact with the system within the context of the experience itself, assuming (or creating) a role within the fantasy world. This quality can be described as "first-person experience," and it requires that the user's suspension of disbelief never be interrupted by attending to the system which is "behind" the fantasy world. Informational questions, error messages, and explicit prompts are examples of such interruptions, and can be characterized as "second-person" transactions.

The first-person requirement is best met by casting the user in the role of an agent, or character, within the fantasy world. This solution is also ideal in meeting the dramatic requirement of the experience: the user-character may be treated by the system, with some additional levels of inference and predictive modeling, as just another agent in the action being imitated. Thus the user's actions may be more easily integrated into the dramatic form.

An Interactive Fantasy System (IF)

An "interactive drama," then, is a first-person experience within a fantasy world, in which the user may create, enact, and observe a character

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whose choices and actions affect the course of events just as they might in a play. The structure of the system proposed in the study utilizes a playwriting expert system that enables first-person participation of the user in the development of the story or plot, and orchestrates system-controlled events and characters so as to move the action forward in a dramatically interesting way.

The name "Interactive Fantasy System" was chosen because it better suggests the critical qualities of the experience than the term "interactive drama." To the uninitiated, "interactive drama" could imply an interactive play-authoring system, and would not necessarily suggest the first-person quality of the interaction. Fantasies are typically first-person affairs, with emotionally satisfying structures and outcomes that are reminiscent of the drama. (Incidentally, the acronym "IF" is also more appropriate to the system than the alternative, "ID.")

Antecedents of an IF System

Several forms which combine notions of interactivity and dramatic experience have contributed to the conception of an IF system. The three principal antecedents of the system are "traditional" drama, certain artificial intelligence programs, and certain interactive computer programs.

A play may be defined as an imitation of an action which is represented in a dramatic manner; that is, it is enacted by performers in real time, "as though they were actually doing the things described."\(^5\) During the performance of a play, the relationship between the audience and the

\(^5\)Aristotle, 1448a/20-23.
performance is severely constrained. The audience views the performance and may experience and investigate emotional, kinesthetic, and rational responses to the ongoing action. An audience member may communicate the gross nature of some of those experiences to the performers in the form of audible responses (through laughter or applause, for instance). Such audible responses may affect the performance of the actors on stage, but will not, except in experimental works which are intended to be participatory, affect the course of the dramatic action or change a single line of dialogue. Beyond the secondary effects of audience responses upon the actors in the performance, then, no interaction between the audience and the play occurs.

The absence of interaction between the audience and the play is necessary in order to preserve the dramatic form. A play is an imitation of a whole action, accomplished through the representation of a number of causally related incidents, each of which stands in organic relation to the whole. The selection and arrangement of those incidents is essential to the drama:

The truth is that, just as in the other imitative arts one imitation is always of one thing, so in poetry the story, as an imitation of an action, must represent one action, a complete whole, with its several incidents so closely connected that the transposral or withdrawal of any one of them will disjoin and dislocate the whole.6

Interaction between the audience and the play must therefore be prevented in order to preserve the integrity of the play itself.

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6Ibid., 1451a/30-35.
While interaction between the audience and the play at the time of performance is traditionally proscribed, there are occasions in which interactive play-writing can be successful. Actors in improvisational forms like the Commedia dell'arte are required to have sufficient knowledge of dramatic form and structure so as to create viable plays in real time, thus the actors' relationship to the play may be described as interactive. One might imagine an audience member or critic making suggestions for changes in a play to the playwright during the revision process. The critic is thus interacting indirectly with the play through the playwright. In some non-traditional theatrical genres like street theatre and improvisational performance pieces, actors are trained to invite audience participation and to incorporate audience responses into an evolving plot. The thing that such examples have in common is the participation of a playwright, or the introjection of playwriting expertise, into the interactive process.

Children at play exhibit a facility similar to playwriting expertise when they collectively create and maintain an internally consistent fantasy world for a whole afternoon (or series of afternoons). As Aristotle observed, much of children's play is imitation. The expertise which both maintains the integrity of the fantasy world and enables each participant to create, seemingly effortlessly, characters that are "good, appropriate, like, and consistent," is in fact humanity's native skill in imitation.7 Although lacking the formal structure of drama and thus its distinct emotional and aesthetic qualities, the imitative play of children will serve as a powerful predictor of the behavior of human users of an IF system.

7Ibid., 1448b/4-10.
A highly structured form of imitative play, known as fantasy role-playing, is structurally quite similar to an IF system. "Dungeons and Dragons," the first role-playing game to enjoy wide popular appeal, seems from its inception to have been especially popular with computer professionals and enthusiasts, and computer-based versions began to appear almost immediately (the genre of computer-based "adventure" games was the result).

Traditional (non-computer-based) fantasy role-playing is a collaborative affair:

A fantasy role-playing (FRP) game is one wherein the players construct characters who live out their lives in a specially made game-world. The characters need not be anything like the people who play them. . . . The game world is operated by a referee (sometimes called a game master, adventure master, dungeon master, etc.) who sets up the situations which the players confront and who also plays 'the world.' An FRP game, then, is an interaction between players, who operate (run) characters, and a referee, who runs the world in which the adventures occur.8

The "rules" by which an FRP game is played arise from three sources: the lore and conventions of FRP game-playing (documented in the many FRP kits and books on the market today), rules that are arrived at consensually by a group of players, and the intrinsic constraints suggested by the nature of the particular fantasy world.

FRP games differ from an IF system in terms of enactment, personness, and dramatic structure:

Most of the play is verbal exchange. The players tell the referee what they wish or intend to do. The referee then tells them if they can or may do it and, if not, what happens instead.9

The experience does not involve the elements of spectacle and music as a dramatic enactment would, nor does it occur in the first person, but rather through the medium of second-person transactions with the "referee." The beginning and end of the game for each player are unique, defined by the creation and death of the player’s character, and not by the shape of any whole action.

FRP games have influenced the development of a class of "interactive" books. Such books cast the reader as a central character and typically are written in the first person. Each page (or group of pages) narrates an incident. At the end of the page, the reader-as-character typically is asked to choose between two alternative courses of action. Depending upon his choice, he is then directed to turn to another page in the book and continue reading. The incidents in the book are chosen so as to form different stories in different combinations; thus, the book contains a different "story" for every pathway of choices.10 Although "interactive books" are still being produced, similar works of "interactive fiction"—based on alternative pathways through a finite set of incidents—are presented more effectively by computers. Computer-based "interactive fiction" can contain more incidents and more choice pathways (and thus more stories) than its

9Ibid.

paper counterpart, and may also include computer-graphic illustrations that change according to the user's choices.¹¹ "Interactive fiction" has also been produced on videodiscs, in which live-action sequences replace narration of incidents.¹² The limitations of "interactive fiction" are inherent in the design strategy: a finite number of incidents and choice pathways are represented, and each must have been foreseen and implemented by the author or programmer.

Plays have occasionally been performed in the theatre which involve the audience in some level of choice-making which influences the action. *Night of January 16th* by Ayn Rand, for instance, enjoyed decade-long success on the London stage and also played in New York, various American companies, and throughout Europe during the 1930's and 40's.¹³ The play is a courtroom drama, and early in the first scene the "Clerk" reads the names of twelve audience members who are asked to sit in the jury box on stage for the duration of the play and to render a verdict at its conclusion. The jury's decision is the final action in the drama, followed by a few brief lines of dialogue (one set of line for a "guilty" verdict and another for "not guilty"). By casting the audience members as jurors, the script constrains the

¹¹See, for example, *Mindshadow*, personal computer game (Activision, 1984) and *Alcazar: The Forgotten Fortress* personal computer game (Activision, 1985).

¹²See, for example, *Mystery Disc: Murder, Anyone?*, a Laservision videodisc (Vidmax, 1982.)

plot until the final incident, but manages to amplify their first-person involvement even in the absence of ongoing interaction.

More recently, an interactive musical play entitled *The Mystery of Edwin Drood*, written by Rupert Holmes, has enjoyed considerable success on Broadway. The play is a "music hall" treatment of a rather gothic mystery plot conceived by Charles Dickens. Dickens' work was unfinished, and the musical solicits the participation of the audience at several points in answering some of the story's open questions. Actors descend into the aisles to query audience members, who respond as themselves and not as any character in the drama. The script provides alternate incidents at each branch point, with several possible endings.\(^{14}\)

Another kind of antecedent for an IF system—"automatic" story generation by computer—has been developed in the realm of artificial intelligence. Story-generation programs may be described as interactive authoring environments for narrative forms. An example of such a story-generation program is TALE-SPIN, created by James Meehan at Yale University. Meehan describes TALE-SPIN as a program which "makes up stories by simulating a world, giving characters some goals, and telling us what happens." TALE-SPIN employs techniques of artificial intelligence to generate stories, and allows a human user to interact with the authoring process by supplying "much of the information about the initial state of the world, such as the choice of characters and relationships between one

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character and another." In one of its modes of operation, the program simply reports everything that happened in the "story" which was generated on the basis of the given characters and their goals. In another mode, the program employs narrative expertise to eliminate obvious and redundant information and descriptions of events which had no interesting consequences. In its most interactive mode, the program can produce "Aesop-like fables" to illustrate a "moral" (e.g., "Never trust flatterers") which has been selected by the user.\(^{15}\)

One might imagine a similar computer program which could construct plays rather than stories, thus providing an interactive playwriting environment. Just as TALE-SPIN produces stories which may be read later as any other story might be read, a play-writing program might be made to produce simple plays which might later be read or enacted. The play would be the result of an interactive authoring process, but the play as experienced by an audience would be no more interactive than any other "traditional" play.

The most immediate and provocative antecedents of an IF system are some contemporary computer programs and video games. The similarities between certain types of interactive computer programs and drama are striking, and they provide examples of dramatic elements in interactive contexts. There exists a class of interactive works that are mimetic; that is, they imitate actions, things, and events that do or might occur. Examples of

such works are computer simulations of processes or events, such as the workings of a nuclear power plant or the development of a tropical storm.

A sub-class might be described as poetic, and it is differentiated from the class of mimetic interactive works in terms of its end cause. Poetry as an art has as its end cause the pleasurable expression of emotion. Even such emotions as fear and grief, the experience of which would, in life, be unpleasant, may be introduced and developed by poetic works in such a way as to provide pleasurable experiences for the audiences of such works. The emotional experiences afforded to an audience by poetry derive from the empathic connection of the audience to the piece; that is, emotions are experienced vicariously by the audience. The absence of real-world consequences allows the audience to indulge in emotional experiences without risk, and poetic forms provide various kinds of resolution or catharsis which return the audience to a balanced emotional state.

Poetic interactive works have as their end cause to entertain, engage, or please the humans who play with them, inviting the user to partake of the vicarious experience of emotion and to delight in the imitation. The subclass thus excludes mimetic works which are intended primarily to assist the human user by performing such tasks as computations, analyses, or instruction. Examples of poetic interactive works include video games such as Space Invaders\textsuperscript{16} or Asteroids\textsuperscript{17}, text-based adventure games such as

\textsuperscript{16}Space Invaders, arcade game (Taito, 1979), video game and personal computer game (Atari, 1980-81).

\textsuperscript{17}Asteroids, arcade game, video game, and personal computer game (Atari, 1980-82).
Zork,\textsuperscript{18} maze games like Pac Man,\textsuperscript{19} and recreational simulations like Pole Position.\textsuperscript{20} Some programs with the ostensible goal of educating the user also fall into the poetic class, as their primary value to the user is the pleasure of interacting with them. As Aristotle observed, man's delight in imitation derives in large part from the pleasure of learning,\textsuperscript{21} a principle which often eludes those who design both video games and instructional computer programs.

Those poetic interactive works which imitate agents and their actions (as do most adventure games) and those which cast the user as an agent in the action (as do most video games and recreational simulations) are composed of elements which correspond to Aristotle's six elements of the drama. Chapter II includes an analysis of such works in terms of Aristotelian dramatic theory and proposes extensions of that theory in areas where poetic interactive works and drama diverge. That analysis yields a set of formal and structural criteria which are then used to design a functional model of an IF system.

\textsuperscript{18}Zork I: The Great Underground Empire, Zork II: The Wizard of Frobozz, and Zork III: The Dungeon Master, personal computer games (Infocom, 1982).

\textsuperscript{19}Pac Man, arcade game (Williams, 1980), video game and personal computer game (Atari, 1981).

\textsuperscript{20}Pole Position, arcade game (Atari, 1982), personal computer game (Atari, 1983).

\textsuperscript{21}Aristotle, 1448b/12-20.
Toward the Development of an Interactive Fantasy System

What remains to be done in the realization of an interactive, dramatic form can be described as three major steps. First, the functional requirements of a system which could produce experiences in that form need to be identified. Second, a functional model must be designed which meets those requirements. Finally, hardware and software systems must be built in order to implement a system based on that model.

Contributions of persons with diverse theoretical and technical skills will be required to bring an IF system into existence. The system will necessarily be built by pieces, as essential techniques and tools are developed in many fields. This section presents a discussion of the functional requirements of an IF system.

Functional Requirements of an IF System

An IF system is intended to allow a human user to enter into an imaginary world and to move through it as an active character, participating in an experience that is dramatic in nature. The functional requirements of a system can be expressed as three broad imperatives: create a world, make that world interactive, and make the user's experience of that world dramatic.

An IF system must provide a means for the fantasy world itself, the context of the interactive experience, to come into being. The physical characteristics, inhabitants, distinct environments, and laws of that world
must be conceived and then represented in some manner to the user of the system. The world also includes some relevant history, which must be available to the system itself in order to orchestrate new events and dole out expository material to the characters (including the user).

The conception of a fantasy world is and will almost certainly remain a task for humans and not for machines. Playwrights and novelists perform similar acts of creation when they define the worlds in which the actions they represent take place. The author of an interactive fantasy world, however, must cope with the additional requirements posed by interaction. In a play or story, the author need only create those portions of the world which will be used by his characters. The author of an interactive environment must create a world that will support choices and actions on the part of the user which the author may not have foreseen. If the user is to have the widest degree of freedom in the interaction, the author must ultimately specify laws by which new environments and characters can be created, as conceiving of (and storing) representations of all possible phenomena in an imaginary world is an impossibility.

The discipline of knowledge representation in computer science, as well as the techniques of inference and truth maintenance which are being developed in the domain of artificial intelligence, promise eventually to prove sufficient to create a fantasy world of great magnitude. In the near future, however, the technology will accommodate the internal representation of relatively simplistic worlds, and will require that the freedom of the user to wander where he will be closely constrained.
The representation of the fantasy world to the user may take several forms. In many computer-based adventure games, the world is represented in textual form on a screen. In other computer games, graphics, animation, and sound are used to represent the characters and the environment. The first-person requirement of the proposed system suggests that the ultimate representation should have first-person sensory characteristics; that is, that it should occur in three-dimensional space and should invoke all the senses of the user.

Whatever modes of representation exist in the interface environment, a further functional requirement of the system will be to provide the means for translating the author's description of the world into a representation of that world for the user. Currently, it is the work of humans to interpret that description and then to prepare materials in a variety of media to represent it, much like the creation of sets and costumes for a film or a play.22

The second functional "mandate" is to make the fantasy world interactive. The interactive requirement means that the system and the user must be able to mutually and reciprocally influence the action. The "action" is composed of the events in the story that is unfolding during the interactive experience. The implication, then, is that the interaction must be manifest on the level of plot. The first-person requirement further implies that that interaction must occur in "real time"; that is, there may not be a perceptible delay for the processing of interaction (such a delay would constitute a destructive interruption of first-person experience).

Dramatic form employs enactment as its manner of imitation; therefore, the system should ultimately require no symbolic (i.e., non-enacted) inputs from the user. In concession to the limitations of current and near-future technology, however, a principle can be expressed that will maximize the ability of the interactive design to meet the dramatic requirement: because interaction must occur in the context of the fantasy itself, it follows that all communications between the system and the user occur in the modes in which the fantasy is represented. (This principle applies to traditional works as well: a novel, for instance, exists in a textual "mode," and its user interacts with it by reading.) If the fantasy world is represented in graphical displays and animation, for instance, the system should not require the user to interact in a textual mode. The medium of communication is the fantasy itself. If the world of the fantasy includes speech from the user, then the system must employ speech recognition and natural-language-understanding techniques.

The plot—the selection (or creation) and arrangement (or order) of incidents in the experience—is successively formulated as action flows through the system. The interactive function of the system necessitates the design of structures for communication between the user and the system that can elicit and interpret the kind of information which is required for the synthesis of the plot. Because the system's informational needs are determined by its playwriting activities, the interactive and dramatic functions of the system are closely related.

The third functional "mandate" is to make the user's experience dramatic. The interactive, real-time synthesis of plot constitutes the central
dramatic function of the system. To accomplish that function, the system requires access to all the elements of the fantasy world as created by the author. That information describes the dramatic potential and delimits the range of possible events and actions within the plot.

The system must also have the ability to sense and interpret the actions of the user. Because the choices and actions of the user-character provide materials from which the plot is created, they can be seen as contributions to material causality in the system. A functional requirement of the system, then, is to be able to receive and formulate (give dramatic form to) those contributions. Material contributions on the levels of spectacle, music, and diction must be sensed directly (with the use of such techniques as body tracking and speech recognition). User contributions that are of the nature of thought and character must be inferred by some intelligence within the system itself.

The system must have a way to know what is going on with the user, the other characters, and the environment. It must create an internal representation of what has happened, what is happening, and what is likely to happen. In the latter case, the system must have a way to predict possible courses that future events will take, and to assign a probability to each predicted course. It must be able to construct a logical hierarchy of actions and to trace the causal relations among them. In order to construct a dramatic plot, it must be able to formulate and dynamically revise a description of the central action of the plot; that is, the whole action of which the events in the experience are parts. By predicting the probable shape of
the whole action, the system provides for itself an *ad hoc* version of the finished piece which can contribute to formal causality.

The system must be able to determine what should happen next. Incidents generated by the system must conform to a variety of dramatic criteria: they must be appropriate in terms of the action being represented (material criteria), in terms of the evolving dramatic structure (formal criteria), and in terms of their probable effects on the course of the action (causal criteria).

The system must know the nature of and be able to produce beginnings and endings. That task requires the afore-mentioned ability to identify the central action of the piece. Another dimension of the task is the ability to stimulate the user's cooperation in creating a beginning or an end for the experience.

Except in those fantasy worlds where there is only one character (portrayed by the user), the system is responsible for creating and animating other dramatic characters. Some characters may be explicitly required by the fantasy world itself; the world of *Star Trek*, for example, always includes a "Mr. Spock." The possibility for creating other characters may also be allowed by the fantasy world, and in those cases, the system must be able to create them according to the laws of the world and the exigencies of the particular action unfolding in the interactive fantasy experience.

Characters are imitations of agents, and are differentiated from one another by their unique traits and predispositions. The system must represent the traits and predispositions of each character in actionable ways. Characters are also defined in terms of their goals and states. The
system must be able to assess and influence the goals of each character and to monitor the changes in the various states of each character as the action proceeds. For each character, the system must also maintain information about his relationships with the other characters (including the user) and the state of his knowledge about the world.

Characters in the system may have varying degrees of intelligence, or self-motivation. They may be animated by the system either as puppets, or as self-directed agents whose actions are relatively autonomous. Given traits, goals, and predispositions by the author, for instance, characters may be most effectively animated by giving them the intelligence to produce speech and make choices in certain types of situations.

The system must maintain formal control over the contributions of the user-character. The user must be prevented from introducing new potential into the fantasy world; materials that are not represented in the fantasy world or admissible according to its laws cannot be handled by the system; e.g., Hamlet may not draw a laser weapon because a system operating on the knowledge of Hamlet's world would not know what a laser weapon is.

To prevent the breakdown of the system or the necessity for second-person communications, the system must employ the plot to influence probability as it is perceived by the user. The system must be able to create, through the plot, lines of probability that will draw the user away from "fatal" mistakes. While it cannot be asked to prevent acts of perversity or vandalism on the part of the user, and even though some willingness on the part of the user to cooperate with the system can be assumed, the system is solely responsible for guiding the action in a dramatically interesting direction.
FIGURE 1: OVERVIEW OF AN INTERACTIVE FANTASY SYSTEM
In other words, the system must assume ultimate responsibility for playwriting. As the master of the plot, the system has control of the form the experience may take. This formal control is necessary in order to guarantee that the structure of the piece is dramatic; it is also necessary in order to maximize the pleasure of the user. Theatrical improvisations of the classroom variety are seldom satisfying because the actor must perform two different functions at once, thus giving his full concentration to neither. He cannot lose himself in the experience of creating a character because he must keep an eye on the development of the plot; he cannot enjoy the act of playwriting because he is constantly distracted by the requirements of acting. By assuming formal control of the experience, the system frees the user to immerse himself fully in the experience of creating and enacting his character.

**Overview of an IF System**

Figure 1 presents an overview of an interactive fantasy system. The user-character is physically located in a multi-modal interface environment known as a "media room." His words and actions are sensed by various devices in the media room and transmitted to the system as data. In addition to that user-sensing data, the system utilizes two other kinds of information in the synthesis of plot: information about the potential of the world as described by a human author, and information about the history of the world so far, including the choices and actions of the user and the other characters. The system employs various kinds of knowledge and expertise in creating the plot of the interactive fantasy. The system enacts its plot
decisions for the user by sending commands to the various output devices in
the media room, where the action is represented by such means as
animation and speech synthesis. The two arrows in Figure 1 are used to
represent action. The plot is formulated as action flows through the system.

Objectives, Methodology, and Resources

The primary objective of this study is to demonstrate the feasibility of
creating an interactive fantasy system with the above-mentioned functional
characteristics. This objective can be resolved into four ancillary goals
which are addressed in various sections of the study.

The first goal is to establish a theoretical base from which system
design and development can proceed. Many of the theoretical issues that
must be explored have broad implications for the whole field of interactive
technology, especially in regards to the nature of computer-generated
representations and the design of human-computer interfaces. Chapter II
focuses on the application of dramatic theory to the structure of computer-
based interactive works. Chapter III explores the notion of the user as a
character in an interactive fantasy world and presents techniques for
creating first-person experiences.

The second goal is to demonstrate the technical feasibility of building
such a system by reviewing the technologies involved. In Chapter IV, the
technical means for representing the fantasy world, sensing and
understanding the user, and creating “intelligent” characters are explored.
Chapter V introduces the notion of an expert system to perform the playwriting functions of the system. The first section of Chapter VI reviews the technical means for producing the enactment of an interactive fantasy in a media-room environment.

The third goal is to specify the dramatic expertise that must be possessed by the system and to suggest ways that such expertise can be embodied in a computer program. Chapter V focuses on the portion of the system in which dramatic expertise resides: the playwriting expert system, or PLAYWRIGHT. An expert system is an "intelligent" computer program that emulates a human expert or group of experts in the performance of some task. It provides the means for incorporating the kinds of intuitions and hunches that characterize expert behavior as well as the more formal, well-known rules of a domain. Chapter V identifies what the PLAYWRIGHT needs to know, what it must be able to do, and how it might function.

The fourth goal of this study is to argue for the desirability of building an interactive fantasy system. Such a project can provide a motivating force for the exploration of a variety of theoretical and technical issues. The theories presented in Chapters II and III represent an understanding of human-computer interaction that may be valuable in the design of a variety of computer-based products and activities. The notion of an interactive fantasy system may suggest research topics and approaches in a variety of technical areas as well, e.g., story generation, "intelligent" animation, and speech synthesis. Such a system would also enable theatre scholars to employ dramatic theory prescriptively and predictively in the evolution of a
new form. Chapter VI discusses the uses of an interactive fantasy system in entertainment, education, and research.

The study employs dramatic theory in the design of an interactive, computer-based system. While the process reflects the methodology of computer software design and is informed by the techniques and limitations of the technology, the design hinges on the application of the principles of Aristotelian dramatic theory to interactive structure. While Meehan and others have applied some principles of narrative literature to the generation of stories by computer, the application of dramatic theory to the design of poetic interactive works is largely unexplored territory.

This study draws on a wide variety of resources. The idea of a computer-based interactive fantasy system arises from the intersection of two broad domains: dramatic theory and computer science. Because that particular intersection has not been treated in any academic or scientific studies known to the author, many of the resources used from both domains may be thought of as primary.

Although every effort has been made to review the most recent developments in technical areas, the phenomenal rate of change in computer-related technologies suggests that some of the technical information in this study may be outdated by the time it is published; however, predictions from reliable sources about the likely directions of technical change have been included. Waiting for "the technology" to exist before designing such an application as an IF system would accomplish nothing. Contrariwise, if the application can be demonstrated to be feasible and desirable, it may function to motivate and focus research and
development in key areas. One of the most impressive examples of such a dynamic is the American space program: the feasibility and desirability of launching machines (and people) into space has stimulated concentrated and accelerated research and development in rocketry, microcomputers, robotics, and a host of other technologies.

In the domain of drama, the *Poetics* of Aristotle provides the theoretical foundation for this study. Aristotle's dramatic theory is preferred over others because it is pervasive and generally well-understood, and also because it incorporates notions of causality that can be employed in the design of the system itself as well as in the specific process by which the system formulates dramatic plots. As discussed in Chapter VI, other dramatic theories may be employed to create different versions of an interactive fantasy system; indeed, one of the uses of such a system is to provide the means for exploring a variety of dramaturgical techniques by applying them prescriptively.

Beyond those cited in the body of the study, several resources exist of which the reader should be aware. The area of fiction is a tremendously rich source of concepts and images of interactive systems. The science-fiction novels of Robert Heinlein and James P. Hogan provide visions of full-blown electronic personalities, their capabilities, and their possible uses. Vernor Vinge, Larry Niven, Ray Bradbury, and others have created models of fully interactive, first-person experiences with technologically-created fantasy environments. The "non-linear" novels of Julio Cortasar, Jorge Luis Borges, and other South American authors provide notions of interaction in narrative
forms. Complete citations for works of fictions that have contributed to the notion of an interactive fantasy system are included in the bibliography.

This chapter has introduced the notion of an interactive fantasy system and has characterized such a system in terms of the pleasures it may produce, the nature of the user's experience, and the functional requirements that it must meet. The objective of the study is to demonstrate that building such a system is feasible. In the following chapters, the study will address four goals that arise from that objective: developing a theoretical base for interactive drama, reviewing the state-of-the-art and research directions in each of the component technologies, describing the dramatic expertise that is required in formulating a plot, and arguing for the desirability of building an IF system.
CHAPTER II
DRAMATIC THEORY AND INTERACTIVE STRUCTURE

Elements of Qualitative Structure

Poetic interactive works, like poetic literary works, may be seen to be more or less dramatic. While specific formal and structural criteria for interactive drama may be established, works which do not conform to those criteria in every way may still be profitably analyzed in terms of their dramatic qualities. To perform such an analysis, and to support the hypothesis that substantial similarities between traditional and interactive forms exist, an understanding of common formal and structural attributes is required.

In the Poetics, Aristotle identifies six qualitative elements of the drama and describes the causal relations among them.\(^1\) These six elements, with expanded definitions in some cases, can be used to describe the form of interactive drama and may also be useful in the analysis of other kinds of interactive works. In this section, the six elements will be defined so as to comprehend interactive form. Table 1 summarizes the major features of those definitions.

\(^{1}\)Aristotle, 1449b/31-1451b/40.
<table>
<thead>
<tr>
<th>ELEMENT</th>
<th>IN DRAMA</th>
<th>IN POETIC INTERACTIVE WORKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLOT</td>
<td>The whole action being imitated. The outcome of the action will be the same in each performance.</td>
<td>The whole action, which is interactively shaped by both system and user. The outcome may vary with each interactive session.</td>
</tr>
<tr>
<td>CHARACTER</td>
<td>Bundles of predispositions and traits, inferred from agents' patterns of choice.</td>
<td>The same as in drama, but including the user as well as fictitious agents.</td>
</tr>
<tr>
<td>THOUGHT</td>
<td>Inferred internal processes leading to choice: cognition, emotion, and reason.</td>
<td>The same as in drama, but including the user.</td>
</tr>
<tr>
<td>DICTION</td>
<td>The selection and arrangement of words; the use of language.</td>
<td>The selection and arrangement of discursive signs, including visual, auditory, and other non-verbal signs, when used linguistically.</td>
</tr>
<tr>
<td>MUSIC</td>
<td>Everything that is heard.</td>
<td>(same)</td>
</tr>
<tr>
<td>SPECTACLE</td>
<td>Everything that is seen.</td>
<td>(same)</td>
</tr>
</tbody>
</table>
Plot

A play is an imitation of an action which is complete in itself; that is, it
has a beginning, a middle, and an end. Plot may be defined as the
combination of incidents which make up that whole action. This definition of
plot is distinct from colloquial usage in which "plot" is synonymous with
"synopsis" or "summary." (When discussing a play, for instance, someone
might ask, "What was the plot?" The Aristotelian answer to that question is
"the entire action of the play.")

Using this definition, an interactive work like a video game can be
seen to have a plot: an action with beginning, middle, and end is being
imitated (or represented) in the course of the game. The beginning may be
defined as the start of the game (almost always initiated by some user input),
and the middle as the action which follows. The end is usually defined
within the game program as the presence of one of two conditions: either the
user has completed all of the game activities, or the user has been
"defeated" by an opponent (typically, the game itself). The termination of
game-play in midstream by the user does not constitute an "end" any more
than the departure of the audience during a performance constitutes the end
of a play.²

²Interactive adventure games in which the user's "character" and progress
may be saved from session to session tend to be episodic in nature.
Because it is often the user's goal to leave his character in a position of
strength, the user's termination of the session may represent the end of an
episode in the plot, although it may also be arbitrary and unrelated to plot.
One measure of the dramatic quality of an interactive work is the appropriateness of its end. According to Aristotle, an end is "that which is naturally after something itself, either as its necessary or usual consequent, and with nothing else after it." Interactive works that terminate because a certain amount of time has elapsed (the token-operated video games found in some arcades and amusement parks, for instance) lack an end which bears any relation to what has gone before.

The most obvious way in which plot in poetic interactive works differs from plot in traditional drama is that a human user may be involved in the action as an agent, rather than simply as a member of the audience. What happens in a play from one moment to the next is determined in large part by the choices and actions of the agents (characters) that are represented. In traditional drama, those choices and actions are fixed; the plot remains the same in any performance based upon the same script. In an interactive drama, however, the choices and actions of a human user (or user-character) are part of the whole action and influence its course. "Functional interaction" may be defined as interaction which affects the plot; interaction

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3 Aristotle, 1450b/30-31.

4 The use of the terms "functional" and "incidental" is derived from Hubert Heffner's use of those concepts to categorize character traits—functional traits are manifest on the level of plot, while incidental traits are not. See Hubert Heffner, Samuel Seldon, and Hunton D. Sellman, *Modern Theatre Practice: A Handbook of Play Production*, 4th ed. (New York: Appleton Century Crofts, 1959), pp. 86-88.
that has no effect on the plot may be described as "incidental."\textsuperscript{5} Insofar as choices and actions may vary for a given user over several interactive sessions, and for different users, the plot itself may vary. In fact, the range of variability in the plot of an interactive piece can be seen as a measure of the system's ability to admit of functional interaction.\textsuperscript{6}

The definition of plot as "the combination of incidents that make up the whole action being represented" is applicable without revision or extension to both traditional and interactive drama. A distinguishing characteristic of the element of plot in the two forms is variability; in traditional drama, plot is fixed, while in interactive drama, it is to some degree variable, based upon the choices and actions of a human user.

Character

Aristotle maintains that the object of (i.e., what is being imitated by) a drama is action and not persons: "We maintain that Tragedy is primarily an imitation of action, and that it is mainly for the sake of the action that it

\textsuperscript{5}Functional interaction may be achieved by audience members in some non-traditional theatrical genres; for example, improvisational performances often incorporate audience suggestions in their plots. In pieces that invite audience members to act as characters (for example, interactive theatre pieces produced by the Antenna Theatre in San Francisco), participants are typically constrained to incidental rather than functional interaction for two reasons: incidental interaction does not disrupt the plot, and highly constrained interaction is less difficult for the participant.

\textsuperscript{6}Other sources of plot variability in computer-based poetic works include self-motivation or local intelligence in system-generated characters and the ability of the program to introduce chance or random events. These topics are treated in Chapter V.
imitates the personal agents."7 *Character* may be defined as bundles of traits, predispositions, and choices which, taken together, form coherent entities. Those entities are the agents of the action represented in the plot.

Characters in both traditional and interactive drama need not be represented as discrete individuals, or even as humans. In most Greek tragedies, for instance, the Chorus functions as a single character. The alien attacker in the *Space Invaders* video game is represented as a horde of what may be ships or creatures, but it operates as a single character in the context of the action: the individual "invaders" are indistinguishable from one another. Whether the horde is interpreted as a collective life-form, a swarm of robots, or extensions of a single maniacal intelligence is of no importance to the plot; however, recognition of its traits, predispositions, and patterns of choice is imperative if the user is to survive, however temporarily, in the imaginary world of the game.

*Character* may be seen to exist in poetic interactive works as well as in traditional drama. While the same basic definition of character applies in both forms, some distinguishing characteristics should be noted. An obvious distinction is the ability of interactive characters to respond to the choices and actions of human users. In a traditional play, the actions of dramatic characters are not affected by the audience (although the actors who portray them may be). In poetic interactive works, the user may influence characters as if he were a playwright or as another character in the action.

When the user functions as a "playwright," interaction between human users and system characters may take several forms. He may be given the

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7Aristotle, 1450b/1-5.
opportunity to make choices at specified nodes for one of the characters (and thus indirectly influence other characters in the work). In the videodisc arcade game *Dragon’s Lair*, for instance, the user may determine at specified nodes which of four directions the character Dirk may go, and whether or not he should use his sword. The results of those choices are enacted by the character. In the arcade game *Pac Man*, user control of the Pac Man character is more continuous: the user specifies via the game controller the direction and speed of the Pac Man character and expresses character choices by continuously moving the character around, rather like a puppeteer. In both examples, other characters are influenced indirectly by the user through the interactive character. It is important to notice that the players of these and other such games do not feel themselves to “be” the interactive character, but rather to give advice or directions to that character.

Another aspect of the “playwright” mode is the ability of the user to select or configure characters that will participate in the action. In the CyberVision version of *Rumplestiltskin*, for instance, the user is allowed to choose which of several characters will function as the Queen’s messenger. The *Face-It* program developed for the Sesame Place amusement park allows the user to select and combine physical traits to form graphical representations that could be used as characters.

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8 *Dragon’s Lair*, videodisc arcade game (Starcom, 1982).


10 *Face-It*, personal computer game (Children’s Television Workshop, 1979).
In many adventure games, the user is allowed to select the traits of the interactive character that he will later control in the course of the game. Typically, a finite set of traits are available (e.g., strength, courage, intelligence, charisma) from which the user may choose, or the relative values of which he may set, prior to the beginning of the game. In these games, the user may or may not feel that he "is" the interactive character; that is, the interaction may be experienced as either first-person or second-person in nature, depending upon the qualities of the interface.

The second primary type of human-character interaction casts the user as a character in the action. The "user-character" mode is distinct from the "playwright" mode (in which the user directs the actions of a character) in that it is consistently and intentionally a first-person experience. The entire input of the user on all levels is structurally interpreted as dramatic agency.

In many instances, the user-character mode of interaction has developed as an artifact of the treatment of spectacle in interactive works; that is, the idea of first-person visual experience in the interface has driven the development of interactive works in which the functioning of the user as character is an interesting but unintentional (and largely undeveloped) side-effect. The Atari game *Star Raiders* is an example of such a first-person visual interface, with tantalizing possibilities for user-character development.

In sum, the definition of character as bundles of traits, predispositions, and patterns of choice is applicable in both traditional drama and poetic interactive works. Character in interactive works, however, may be influenced to various degrees and in various ways by human users. Functional human-character interaction affects plot.
Thought

The element of thought in drama may be defined as the processes leading to characters' choices and actions; e.g., emotion, cognition, reason, and intention. Understood in this way, the element of thought "resides" within characters, although it can be described and analyzed in aggregate form (the element of thought in a given play may be described as concerned with certain specific ethical questions, for example). Although it may be explicitly expressed in the form of dialogue, thought is inferred, by both the audience and the other characters, from a character's choices and actions. As with the element of character, although the same basic definition of thought applies in both drama and poetic interactive works, the distinguishing characteristic of thought as a structural element in interactive works is that it may include the thought of the user.

In some interactive works, the thought of the user has virtually no impact on the action, except to determine whether any action will occur. In the game of Space Invaders, for instance, the user's intentions within the context of the action (part of the user's thought) is assumed; if a user chooses to participate, he intends to move the laser cannon, shoot at the aliens, and attempt to avoid being shot by them. If the user alters those intentions, the action is quickly terminated. The user may generate strategies for more effective shooting and self-defense; however, those strategies (examples of user thought) do not elicit corresponding responses
from the system, and are therefore not causally functional in the action.\textsuperscript{11} Were the system to notice the user's strategies and to prepare counter-strategies, then the user's thought could be demonstrated to be functional. The computer game, \textit{Eastern Front}, based on military strategy, is an example of such a system.\textsuperscript{12}

The thought of the user becomes part of the structural element of \textit{thought} in an interactive work when it can be expressed in functional interaction; that is, when it can be expressed in such a way as to influence plot. User thought is expressed through \textit{character} in interactive drama, since character is the agent of dramatic action.

\textbf{Diction}

The element of \textit{diction} in drama is defined by Aristotle as "the expression of their [the characters'] thought in words."\textsuperscript{13} Hence the use of spoken language as a system of signs is distinguished from other theatrical signs like the use of gesture, color, scenic elements, or paralinguistic elements (patterns of inflection and other vocal qualities). Aristotle intends diction to refer only to words—their choice and arrangement. That definition presents some interesting problems in the world of poetic interactive works.

\textsuperscript{11}The use of strategy in a skill-and-action game like \textit{Space Invaders} may affect the \textit{duration}, but not the \textit{nature}, of the action—a subtle but important distinction. It is the position of the writer that differences in the the number of repetitions of the same action in such a work do not produce significant differences in its plot.

\textsuperscript{12}\textit{Eastern Front}, personal computer game (Atari APX, 1982).

\textsuperscript{13}Aristotle, 1450b/12-15.
many of which involve no words at all (e.g., *Space Invaders, Pac Man,* and most other skill-and-action video games, as well as graphical adventure games and graphical simulations). Is there a structural element in such "non-verbal" works which corresponds to *diction?*

When a play is performed in the theatre for a deaf audience and signing is used, few would argue that those visual signs function as language. The element of *diction* in that case is expressed in a way that takes into account the sensory modalities available to the audience. 14 What an interactive work implemented on a computer has the ability to sense and respond to is a function of the hardware itself and of the computer program that drives the system. A programmer or program designer may choose, for whatever reason, to build a system that neither senses nor responds to words from the user, and that uses no words to communicate with him. Hardware systems without keyboards, speech recognition, or text display capabilities may be unable to work with words.

In non-verbal interactive works, graphical signs and symbols, non-verbal sounds, or animation routines may be used in the place of words as the means for explicit communication between the system and the user. Such non-verbal signs may be said to function linguistically when they are the principal medium for the expression of thought. Accordingly, the selection and arrangement of those signs may be evaluated by many of the

14 It is important to note in this context that American Sign Language (ASL) is in fact a "natural language" in its own right, and not a direct gestural map of English or any other spoken language. If a language can be constructed from gesture, then it follows that spoken words are not essential elements of language.
same criteria as diction, e.g., effective expression of thought and appropriateness to character.

How are those uses of non-verbal signs in interactive works different from the visual and auditory signs in the performance of a play (which are characterized below as spectacle and music respectively)? In Hamlet, for instance, Claudius' crown is a sign of his royalty. However, that visual sign is neither the primary mode by which the information is communicated, nor is it an element in any discourse. In contrast, imagine a non-verbal interactive work in which a picture of a crown functions as an icon to be manipulated by the user. Suppose that placing the crown on the castle is the user's way of telling the system (and understood by the system to mean) that the king has entered the castle.\(^\text{15}\) Given their primary function as a medium of communication between the user and the system, the crown and castle in the latter example are appropriately evaluated as both diction and spectacle.

In summary, the element of diction in interactive drama includes what is meant by that element in traditional drama (the selection and arrangement of words), and is extended to accommodate those linguistic uses of non-verbal signs which are unique to interactive works.

Music

The element of music (sometimes referred to as melody in translations of the Poetics) was described by Aristotle as "too completely

\(^{15}\text{See Excalibur, personal computer game (Atari APX, 1983) for examples of such use of visual signs.}\)
understood to require explanation";\(^{16}\) however, if Aristotle's elements are to account for all of the aspects of a play, the element of music is best interpreted, not simply as melodies, but as all auditory features.\(^{17}\) Thus "non-musical" plays (e.g., plays that contain no songs, arias, or instrumental music) nevertheless contain the element of music. The most obvious example of music in such plays is those sounds which are formulated into the speech of the characters. Music also includes the sounds that people and things make during the performance of a play. Some of those sounds may be indicated in the script, like the "flourishes" which begin some scenes in Shakespeare's plays, or the gunshot at the end of *Hedda Gabler*. Other non-verbal sounds are a function of rehearsal and performance; e.g., the sound of a sword being drawn from a sheath, the rustle of clothing, or the environmental sounds of a spring morning.

The paralinguistic elements of speech—inflection, tone, etc.—and specific non-verbal utterances like screams or laughter may also be indicated in the script as stage directions for the actors. Of course, the principal responsibility for the orchestration of speech and non-verbal utterances in performance belongs to the actors and director. Unintentional sounds produced during performance, such as the creaking of scenery or the frustrated exclamations of a backstage worker, become part of the music of the performance, for better or for worse.

\(^{16}\)Aristotle, 1449b/35.

The element of music includes all that is heard, a definition which applies to both traditional and interactive forms. How the element of music is produced, however, may be quite different in the two forms. In traditional drama, the music of speech is created, partially by the playwright through the selection and arrangement of words and the resulting rhythms, alliteration, assonance, and so on. These playwright-created qualities are practically speaker-independent, as they reside within the words themselves and do not depend upon the performer for their existence (the quality of performance is a different matter). An interactive work with speech output capabilities can deliver the same playwright-created qualities. The paralinguistic elements of speech, however, are largely the province of the performer in traditional drama; that is, they are speaker-dependent. Some paralinguistic elements, such as the inflection of a colloquial phrase, arise from the intuitive skills of the actor as a speaker of the language. Others, like the selection of a guttural quality of speech for a gruff character, depend upon the artistic judgment of the actor and director. Unless an interactive system possesses both the "intuitions" of the native speaker and the judgment of the performer, or unless the speech output capabilities of the system utilize the voices of human speakers, such paralinguistic qualities must be painstakingly dictated by the author of the program, and are created in an entirely different way.

Likewise, the non-verbal elements of music, things like screams and flourishes, as well as the sounds that things and people make as they move about, may be created differently in the two forms. Scripted sounds like Shakespeare's flourishes are created similarly, in that they are specified by
the author; only the instrument may differ (a horn or a human vs. a synthesizer). Incidental sounds like the rustling of a cape, however, present interesting problems for authors of interactive, computer-based systems. In traditional drama, such sounds arise from the nature of the physical materials (taffeta rustles, velvet does not) and, sometimes, from the judgment of the actor, director, or designer (an actor may choose whether to make a sound with his cape; a designer may choose to line the cape with velvet or taffeta). The musical effect is thus the combination of artistic judgment and natural appropriateness (e.g., taffeta rustling sounds like taffeta rustling; in most cases, it need not be fretted over). In computer-based interactive works, creation of such effects is more complicated. As with paralinguistic elements of speech, either the system must possess enormous intelligence, or the author of the work must plan and contrive to execute each minute musical detail. And if the "cape" appears to be lined with velvet, it had better not rustle.\textsuperscript{18}

In interactive works, the human user may make material contributions to the element of music. In traditional drama, the audience may make a wide variety of sounds (applause, laughter, rustling, etc.), but few would argue that those sounds become part of the work. Similarly, the exclamations and grunts of a video-game player are not properly considered part of the interactive work. If, however, an interactive work makes sounds in response to a user's actions, allows the user to create sounds with the system, or

\textsuperscript{18}When "substitute" materials are used in traditional theatre (e.g., acrylic fabric instead of taffeta or plastic plates instead of china), theatrical designers face similar problems.
recognizes and responds to user-created sounds, then the user becomes a source of the element of music in the work.

**Spectacle**

The element of *spectacle* is manifest in the performance of a play. It includes the objects on the stage, the appearance and movements of actors, the qualities of lighting, and the textures and dynamics of the costumes; literally, the element of spectacle is all that is visible. This simple definition applies to both traditional and interactive works; however, as with the element of music, the ways in which spectacle may be created differ in the two forms.

While the performance of live actors may seem to be an essential element of the theatre, it is the notion of *spectacle*—dramatic representation as the manner of presentation—which is actually crucial to drama. In traditional drama, the element of spectacle may be produced with live actors and real objects, photographic images, film, video, animation, or some combination thereof. With the exception of live actors, a computer-based interactive system may utilize those same media and have essentially the same appearance. An interactive system may draw upon computer animation or computer-driven videodisc access to filmed sequences, for instance. The essential difference between traditional and interactive forms in the area of spectacle lies not in the appearances of things so much as in the ways in which visual phenomena are selected and combined to form a

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19Aristotle, 1448a/20-25.
whole. The actions of the user, in concert with the video capabilities and intelligence of the system, determine the visual qualities of interactive works.

**Relationships among Structural Elements**

In traditional drama, the structural elements described above are causally related to one another in a variety of ways. Drama is distinguished from other literary forms like novels and lyric poetry in the *manner* of the imitation: drama is *enacted*. The key structural element in enactment is the element of *spectacle*.

The idea of material causality is based on Aristotle's observation that one of the reasons why a thing is what it is, is the stuff of which it is made. Thus one of the causes of a particular statue, for instance, is the marble which is its substance. The "stuff" of a dramatic enactment is the element of spectacle. That element is shaped by the playwright, just as the marble is shaped by the sculptor, into something that is much more than an undifferentiated hunk of material, but the nature of the material determines, in some ways, what the finished work will be.

Employing the causal analysis introduced by Aristotle in *The Physics*, the force of material causality can be traced through the hierarchically arranged elements of the drama. When the six elements of the drama are arranged hierarchically with the element of spectacle at the bottom and the element of plot at the top, the force of material causality moves up the list.

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(see Figure 2). Each element is the material cause of the element above it. Thus the material cause of plot is the element of character, which is itself the product of the successive formulations of all the other elements. Something cannot exist on the level of character if the material for it does not exist on the level of thought; e.g., the play will not include a greedy character if the idea of greed is nowhere to be found.

![Diagram](image)

**FIGURE 2: THE FORCES OF MATERIAL AND FORMAL CAUSALITY**

Source: Sam Smiley, *Playwriting: The Structure of Action*.

Material causality is important in the context of interactive drama for several reasons. First, it suggests that interaction which affects the whole need not occur exclusively on the level of plot. The user need not explicitly create or manipulate plot incidents in order to be a creative collaborator. Introductions of user input on the levels of spectacle, music, thought, diction, and character, can indirectly constrain and determine plot through the force of material causality. On the other hand, the choices and actions of the user-
character can be constrained and shaped by the materials that are available to him for formulation.

Aristotle defines the formal cause as "the form or pattern of a thing, that is, the reason (and kind of reason) which explains what it was to be that thing. . . ."\textsuperscript{21} The final form of a play, the completed plot, exerts a constraining and shaping influence on the elements below it. For example, if a greedy action (or some action in which greed plays a part) is represented in the plot, then there will be a need for a greedy character, for the idea of greed, for the expression of that idea in words, for its utterance in sounds, and for the visual enactment of the action. Thus the force of formal causality moves down the hierarchy of elements, with each element functioning as the formal cause of the element below it.

The user of an interactive system may indeed make contributions on the level of plot; however, the responsibility for integrating such contributions into the whole and creating other plot elements that maintain the necessary dramatic qualities in the whole belongs to the system. When that responsibility devolves to the user, first-personness is destroyed, as in the classroom improvisation where the actor must divide his attention between acting and playwriting tasks. By assuming formal control of the action, the system frees the user from playwriting concerns and allows him to immerse himself in the experience of his character.

The user makes other sorts of contributions of a formal nature. The user-character's choices and actions affect the whole on all levels, not

simply in terms of the user-character's own thoughts, words, and actions, but also in terms of the other characters with which the user-character interacts. On the other hand, the system may exercise formal constraint of the user-character through the plot, the other characters it creates and animates, and any description of the user-character's traits and goals that may be incorporated into the interaction (and which the user can be persuaded to accept without feeling a second-person intrusion). The notion of material and formal constraints on the user-character is explored in Chapter III.

The other two causes treated by Aristotle in the *Physics* are known as the *efficient* cause and *final (or end)* cause. The *efficient* cause of a thing is that which brings it into being. The "effector" includes the productive entity—whether human artist or "machine intelligence"—and the tools and techniques that are used in making the thing. Tools and techniques are logically related to materials—e.g., a chisel is a tool for working with stone, while a brushstroke is a technique used with paint and canvas—hence, material and efficient causality are closely related. In the case of computer-based interactive works, the efficient cause includes hardware and software capabilities as well as design and programming techniques. Those tools and techniques define what kinds of materials can be contributed by the user and represented by the system.

The *final* cause of a thing can be described as its intended function or purpose. Because the intended purpose of a thing influences the form that is chosen by the maker of that thing (e.g., a chair as the form of a thing to be sat on, or an elegy as the form of a tribute to a dead hero), final and formal causality are also closely related. The final cause of an interactive drama
may be described in terms of the pleasures associated with it: the pleasurable experience of emotional arousal and catharsis (purification) that is characteristic of drama, the pleasure of participation in an imitation (literally, the fun of playing make-believe), and the pleasure of co-creation in contributing to the evolving whole. The form of interactive drama provides the means by which those pleasures are accomplished.

Other Formal Criteria

Other formal criteria governing the construction of plot, defined in the Poetics, describe the qualities which give a work the greatest potential for providing dramatic pleasure to its audience or users. In the following sections, those formal criteria are identified in the context of traditional drama, with extensions when needed to cover interactive drama.

Completeness and Magnitude

The properly constructed plot, Aristotle maintains, is a complete whole, with beginning, middle, and end in the proper order: "... in poetry the story, as an imitation of action, must represent one action, a complete whole, with its several incidents so closely connected that the transposal or withdrawal of any one of them will disjoin and dislocate the whole."\textsuperscript{22} Although Aristotle's definition of completeness occurs in the context of his examination of the tragic form, the idea may be applied to other forms as

\textsuperscript{22}Aristotle, Poetics, 1451a/30-35.
well: although a case can be made that comedy and melodrama admit of structures that are more episodic, the representation of a "whole action" in those forms provides coherence and unity. When the plot is such a complete whole, the end exhausts all of the dramatic potential of the beginning and middle. The dramatic effect, the arousal and catharsis of emotion, cannot be achieved, nor can the imitation be enjoyed, if the action represented is not such a "complete whole."

The notion of proper magnitude goes hand in hand with the idea of completeness. "Beauty," says Aristotle, "is a matter of size and order." The appreciation of a thing depends upon our ability to perceive it. Just as "a beautiful whole made up of parts, or a beautiful living creature, must be of some size, but a size to be taken in by the eye, so the story of Plot must be of some length, but of a length to be taken in by the memory." If a plot is so long that one forgets the beginning of it, its beauty as a whole cannot be fully appreciated. As long as the plot does not exceed the limits of memory, however, big is beautiful: "The limit, however, set by the actual nature of the thing is this: the longer the story, consistently with its being comprehensible as a whole, the finer it is by reason of its magnitude."

Notions of completeness and magnitude can be used in determining whether an existing interactive work or genre is dramatic, as well as in designing an interactive fantasy system. These criteria are applied to adventure games and skill-and-action games in the last section of this chapter.

\[23\text{Ibid., 1451a/1-10.}\]
Probability and Universality

Dramatic probability is the means whereby incidents in a play achieve "convincingness." In real life, an incident may appear probable for a variety of reasons: because it is the sort of thing that normally happens, or because it was bound to happen sooner or later (as winning a wager at the track—a sort of "statistical" probability). An incident can also be made to appear probable by providing a plausible explanation; for example: a woman reported seeing a UFO in the California skies. She described seemingly impossible behavior of the craft: its illuminated, ovoid shape rose vertically, hovered for a moment over the city, then zipped away at high speed. The incident seemed highly improbable until a plausible explanation was found: NASA was experimenting with a new "Vertical Take-Off and Landing" aircraft at Moffett Field.

Dramatic probability differs from the probability of real life in that it is a "made thing"—provided, not by nature and real events, but by the playwright in the construction of the play. It can be introduced into the play on any of the six levels; for instance, one source of probability for an incident is the motivation of the character who is an agent in it; another source is the environment or the kind of world in which the incident occurs. The UFO described above, for example, would be probable without its "real-world" explanation in the film, Close Encounters of the Third Kind, where the existence of alien spacecraft is a feature of the dramatic world. The probability of the existence of such spacecraft is established directly on the level of spectacle, as well as on the other five levels, throughout the piece.
On the other hand, the appearance of an alien spacecraft in the dramatic world of *Hamlet* would be quite improbable (although another author—H. G. Wells, for example—might, through the development of dramatic probability, create a world where visitors from the future become quite plausibly involved in the events of an antique kingdom).

Dramatic probability is established by demonstrating the relationship between character and action; that is, the relationship between what happens to someone and the sort of person that he is. This causal relationship between character and action, and not the likeness of the action to real life, makes the dramatic action believable. An incident that demonstrates such a causal connection between character and action is described as "universal," as distinct from an "accidental" incident, in which no such cause is apparent. When an action is thus "universalized," it allows the observer to make generalizations about "what such or such a kind of man will probably or necessarily say or do."\(^{24}\) Such generalization is much more difficult in real life than in a drama, because direct causal connections between character and action are less apparent and more likely to be obscured by the randomness and "noise" of the ongoing world, and because life is, of course, quite a bit more complex than a play. In other words, it is quite a bit easier to identify causal connections in a closed system (dramatic mimesis) than an apparently open one (life).

The playwright moves the action of a play forward through the orchestration of dramatic probability. At the beginning of a play, a number of things are possible. As the characters’ traits and motivations are revealed

\(^{24}\)Aristotle, *Poetics*, 1451b/5-10.
and the action unfolds, the possible is formulated into a smaller set of incidents that are shown to be probable. As the play moves toward its conclusion, competing lines of probability are eliminated and a single line is demonstrated to be necessary. The plot functions as the formal control in the orchestration of dramatic probability by determining which lines of probability will be terminated and which will emerge as the necessary outcome. The conclusion of a play in which dramatic probability has not been properly established will seem arbitrary and unsatisfying, or even nonsensical.

It is interesting to note the contrast between the traditional "branching tree" approach to interactive fiction and the shape of a well-constructed play: the first level of a branching tree contains only a few possible incidents (or one node), while its terminal level contains a number of possible endings that is greater than the sum of all the other nodes in its structure. The ideal dramatic structure is the inverse: a large number of possible incidents and events at the outset, pared down through the course of the action to a single, necessary outcome.

But what really happens in an interactive drama? Does the foregoing observation imply that, no matter what one does, the outcome of every interactive drama produced with the same system and "world" will be the same? Not at all. It does suggest that, if the user-character does exactly the same thing in two transactions with the same interactive world, the outcome will be the same, because the course of probability will not have been changed. The necessary outcome of any drama, whether its plot is created interactively or not, is the complete and unique product of every incident in
the line of probability of which it is the culmination. If the user-character alters his choices and actions in another transaction with the same interactive world, the probability structure of the piece will be changed, and the necessary outcome for the plot of that new interactive drama will be different and probably unique. The branching-tree structure is not well-suited to the implementation of interactive drama for two reasons: interactive drama requires a greater degree of freedom for the user at the outset ("the possible"), and a mechanism must be established for arriving at the unique, necessary outcome for every transaction without having to foresee and store every possible permutation of the user-character.

Dramatic probability in interactive drama requires that causal connections be maintained among incidents in which the user-character is the agent and incidents created by the system, such as actions of system-generated characters or other events in the system-generated environment (e.g., rainstorms and falling pianos). There are three basic methods for maintaining dramatic probability in an interactive work: "explicit" user constraints, "implicit" user constraints, and the formal control that the system may exert in the synthesis of plot. Explicit user constraints are precise, identifiable limitations on the possible choices and actions of the user which may or may not be explicitly presented. Implicit constraints are features of the context that discourage the user from introducing improbable incidents and materials. Both types of user constraints are examined in Chapter III. The formal control of the system is addressed in Chapter V.
Dramatic vs. Narrative Form

The distinction between narrative and dramatic modes of imitation is useful in analyzing and classifying interactive as well as "traditional" literary works. Although both are modes of poetic imitation, dramatic and narrative forms differ in terms of the manner in which an object is represented, as well as in certain qualities of plot. In narrative works, agents and actions are reported or described rather than acted out, and that description may take a third-person ("narrative") or first-person (in the person of a character in the story) voice. In a drama, the agents and actions are acted out; that is, "the imitators . . . represent the whole story dramatically, as though they were actually doing the things described."\textsuperscript{25} In the world of contemporary interactive software, a text-based work is probably best described as "narrative," while a work represented in visual imagery and sound is more likely to be "dramatic."

Narrative and dramatic works are also distinguishable in terms of certain features of plot composition; however, the notion that the object of the imitation should be a single action that is complete in itself obtains to both forms, "so as to enable the work to produce its own proper pleasure with all the organic unity of a living creature."\textsuperscript{26}

Aristotle states that a narrative work may differ from a dramatic work in terms of its length, because of the way each form handles the representation

\textsuperscript{25}Ibid., 1448a/20-25.

\textsuperscript{26}Ibid., 1459a/20.
of simultaneous incidents. Drama, because of the "real-time" quality of enactment, cannot represent an action "with a number of parts going on simultaneously." Even in plays that represent simultaneous incidents sequentially, the logical limit to the number of such incidents is low because of the potential for temporal confusion in the audience during performance. Because the representation of simultaneous incidents is easier to accomplish in narrative form, the form is capable of supporting a larger number of incidents and episodes of diverse kinds.\textsuperscript{27}

One of the underlying issues is cognitive. Aristotle's distinction is based on the observation that human memory has a lower threshold for complexity (in terms of multiplicity of incidents and episodes) in representations that imitate and occur in real time than for representations that are not so constrained. The other underlying issue is formal, and it concerns the nature of the connections between episodes. A plot in which the sequence of episodes is not determined by probability or necessity is deemed "episodic," and, while acceptable in narrative forms, is, according to Aristotle, the worst type of plot for a drama because the absence of such connections prevents the organic unity ("completeness") that is necessary for the plot to achieve its "proper pleasure."\textsuperscript{28}

Another distinction between the two forms is their ability tolerably to represent marvelous and improbable incidents: "The Epic, however, affords more opening for the improbable, the chief factor in the marvellous, because

\textsuperscript{27}Ibid., 1459b/25-30.

\textsuperscript{28}Ibid., 1451b/30-35.
in it the agents are not visibly before one." 29 "Marvellous" incidents are enjoyable, but people are more likely to be skeptical of them when they are in dramatic form, because enactment points up absurdities. Aristotle also hints that "the marvellous" is protected by conventionality in narrative literature—something akin to "poetic license." An example of such a convention in an interactive work is the treatment of possessions in traditional text-based adventure games. It is improbable that one small human can move nimbly about an endless maze of dim caves carrying (on his person) five magic scrolls, several potions, a shield, a few bags of gold, a treasure chest, a nubile young maiden, and a broadsword—but in the narrative world of the text adventure game, the user is unperturbed by the improbability. Graphical, and especially animated, representation of a character so loaded down would reduce the whole notion to absurdity.

The Dramatic Effect: Arousal and Catharsis of Emotion

Drama achieves its pleasurable effect by arousing and then satisfying, using up, or "dealing with" a set of emotions. A good drama must exhaust all the emotional potential that is presented by its plot. The process of exhausting or "using up" potential is called "catharsis." The end cause of a drama is the pleasure afforded by the arousal and catharsis of certain emotions in its audience. 30 Plays that are intended by their authors to achieve an end "beyond" entertainment, such as instruction or incitement to

29 Ibid., 1460a/12-15.

30 Ibid., 1449b/25-30.
action, must still deliver the dramatic effect—pleasure through arousal and catharsis of emotion. Without it, the powers of the dramatic form cannot be utilized; the audience will not be "engaged" by the dramatic action; and no secondary end can be reached.

Aristotle identifies the emotions appropriate to the tragic form as pity and fear, and describes how they are best aroused: "The tragic fear and pity may be aroused by the Spectacle; but they may also be aroused by the very structure and incidents of the play—which is the better way and shows the better poet."\(^{31}\) Using Aristotle's analytic techniques, corresponding sets of emotions have been identified for other dramatic genres: laughter and ridicule as the emotions appropriate to comedy, and fear and hate as those appropriate to melodrama.\(^{32}\)

That is not to say that the above emotions are the only ones experienced by the audience. These "primary" emotions are best understood as responses to the whole action represented in a play. All are built up of lower-level emotional components that are the audience's specific, empathic responses to the ongoing action, e.g., the anticipation associated with suspense, exhilaration with the hero's victory or the heroine's escape, tenderness for the sweet child, or astonishment at the villain's ploy. These more diverse, specific responses are formulated into the primary emotions associated with each genre as they are woven by the playwright into the plot. The audience member experiences specific

\(^{31}\)Ibid., 1453b/1-5.

\(^{32}\)Smiley, p. 44.
responses to specific incidents, and experiences the primary emotions when he views those incidents in the context of the whole.

The emotions experienced by a user-character in an interactive drama will be different than those that would be experienced by an audience member watching that drama as if it were a traditional play. The user-character's emotional responses are naturally more influenced by the experiences and point of view of his particular character than are the responses of the audience member, for whom the "whole" is more accessible. Experiencing the piece as an agent in it skews the emotional response of the participant in the direction of his character, a kind of emotional "tunnel vision."

The notion of catharsis in an interactive drama has an added dimension that derives from the user's experience of his individual character: emotional potential must be exhausted, both for the individual character portrayed by the user as well as for the plot as a whole. If an emotion is aroused in the user-character, it must be utilized by the plot; contrariwise, the plot should not arouse emotions in the user-character that are not causally related to the whole. This does not represent a new element of form. The catharsis associated with the individual user-character is simply the user's experience of the workings of probability and necessity in the actions and fate of his dramatic character.

How does the foregoing analysis of catharsis affect the form and structure of interactive drama? Does it imply that, in order to accomplish catharsis, the user-character must always be successful in achieving his goals? Suppose that the interactive world is that of the Crusades, with the
user-character as leader of an army of Christians. If, through his choices and actions, the user-character demonstrates himself to be weak, strategically inept, and timid, should he be subjected to the experience of inglorious failure, or should he still be allowed to reach the gates of Jerusalem—in the name of catharsis? And if he is allowed to triumph at the expense of dramatic probability, how can the "proper pleasure" of the drama be achieved?

The answer lies in the nature of the user's experience. He is not playing a game that can be won or lost; neither is he experiencing "real life": he is acting as an agent in a mimetic world. Like an audience member in traditional theatre, the user exercises a "willing suspension of disbelief" in order to experience emotions vicariously. He knows that the experience is not real, but agrees to pretend that it is to the degree necessary for the purposes of enjoyment. As Aristotle observed, man delights in the imitation of even dreadful things (like dead bodies and inglorious failures). Unlike an audience member, however, a user-character resembles an actor in his experience of his character's emotions: he experiences them "in the first person," and can still delight in the experience. The user-character's experience, like the actor's, is more intense and intimate than that of the audience member, and has the potential to be more intensely pleasurable. Like the actor, the user-character may also experience a sense of accomplishment from his participation that an audience member could not share. It is true that most people are not actors, but many of those who do not actually perform secretly long to do so, and an interactive fantasy system

33Aristotle, Poetics, 1448b/10-15.
could enable them to fulfill their desires with more privacy and security than any stage could offer. Some people would find the intense involvement of the actor too uncomfortable—they prefer to view the action from the audience. An interactive fantasy system is probably not for them. Interactive drama, like other dramatic forms (e.g., opera, tragedy, or farce), can be expected to have both enthusiasts and detractors.

In summary, the arousal and catharsis of emotion in interactive drama is accomplished just as it is in traditional drama: emotions are aroused by the incidents in the action, and catharsis is achieved when the emotional potential of the action is exhausted. Catharsis is best accomplished by the transformation of probability into necessity in the plot. The final outcome (literally, the end) of the action establishes a new equilibrium and provides emotional closure. For a user-character, as for an audience member, an ingredient of catharsis is the perception of a finished whole.

Quantifiable Structural Elements

An understanding of the qualitative structural elements, causal relations, and formal criteria discussed above is essential in the design of an interactive fantasy system and useful in the design of other interactive systems that are intended to provide dramatic experiences for their users. The synthesis of a good dramatic plot by artificial intelligence, however, also requires the use of structural elements whose composition and combinational patterns can be quantifiably expressed.
FIGURE 3: THE ORIGINAL FREYTAG TRIANGLE


**Freytag's Triangle**

Gustav Freytag, a German critic and playwright, suggested in 1863 that the action of a play could be represented graphically, yielding the famous "Freytag triangle" (see Figure 3). The notion that the action of a play could be "quantified" was not unfamiliar to Freytag's contemporaries in Europe and America whose "well-made plays" were often formulaic in the extreme (and which did not survive as examples of great drama). It is the underlying logic of Freytag's analysis, however, and not the "recipe-book" flavor of his techniques, that will be useful in the synthesis of plot.

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Freytag uses the notions of "play and counter-play" to represent what most later texts call "rising and falling action." In Freytag's terms, the "play" is that portion of the action which is driven by the will of the hero, while "counter-play" is driven by conditions in the world outside of the character. These two parts exist on either side of the dramatic climax, and can occur in either order, depending upon which is "cause" and which is "effect." The simple interpretation, then, is that the rising action is all that leads up to a climax or turning point, and the falling action is all that happens from the climax to the conclusion. The rising and falling action form the sides of the triangle, of which the dramatic climax is the apex. The horizontal axis of the graph is time; the vertical axis is complication. The structural elements of "introduction" (exposition), "exciting force" (inciting incident), "rising movement" (rising action), "climax," "falling action," and "catastrophe" (conclusion) are placed at various locations on the triangle. Contemporary versions of Freytag's triangle are more irregular and jagged, reflecting the differing patterns of complication and resolution within structural elements (see Chapter V, pp. 240-241).

The "complication axis" of a Freytag graph represents the informational attributes of each dramatic incident. An incident that raises questions (e.g., the kidnapping of the heroine) is part of the rising action; one that answers questions (e.g., the confession of the villain) is part of falling action. The analysis can be finer: each dramatic incident may raise some questions and answer others, and the questions themselves may vary in importance to the plot. Each incident is represented as a line segment, the slope of which is derived from the relationship of the informational attributes
of the incident (i.e., questions asked and answered) to its duration. When a
theatre student prepares such a graph, he typically uses pages of script as
units of time, although in actuality the duration of the action represented on
one page may be quite different from that on another. He lists the incidents
represented on the page and evaluates them in terms of complication and
resolution and arrives at a gross estimation of the informational attributes of
the action segment, then plots line segments on the graph. A steep upward
slope represents a good deal of complication in a short amount of time,
while a gentle downward slope may be used to represent a set of minor
discoveries in an expository passage.

Numerical representations can be employed in the analysis of the
informational attributes of an incident and in the representation of its
duration, a more detailed (and "quantifiable") curve can be produced. The
following incident may serve as an example:

A group of strangers have been invited by an anonymous
person to spend the weekend in a remote mansion. During the
night, one of the group (Brown) has disappeared. Some of the
remaining characters are gathered in the drawing room
expressing concern and alarm. The butler (James) enters and
announces that Brown has been found:

JAMES: I'm afraid I have some rather shocking news.

SMITH: Spit it out, man.

NANCY: Yes, can't you see my nerves are absolutely shot? If you
have any information at all, you must give it to us at once.

JAMES: It's about Mr. Brown.

SMITH: Well?

JAMES: We've just found him on the beach.

SMITH: Thank heavens. Then he's all right.
### TABLE 2

**INFORMATIONAL ATTRIBUTES OF A SAMPLE INCIDENT**

<table>
<thead>
<tr>
<th>INFORMATION</th>
<th>COMPLICATION</th>
<th>SIGNIFICANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. James has shocking news.</td>
<td>+</td>
<td>.4</td>
</tr>
<tr>
<td>b. The news concerns Brown.</td>
<td>+</td>
<td>.5</td>
</tr>
<tr>
<td>c. Brown has been found.</td>
<td>-</td>
<td>.7</td>
</tr>
<tr>
<td>d. Brown is dead.</td>
<td>+</td>
<td>.9</td>
</tr>
<tr>
<td>e. Brown has drowned.</td>
<td>-</td>
<td>.4</td>
</tr>
<tr>
<td>f. Brown was a good swimmer.</td>
<td>+</td>
<td>.8</td>
</tr>
</tbody>
</table>

\[
\text{SLOPE (Total) = + 1.5}
\]

![Diagram](graph.png)

**FIGURE 4: FREYTAG GRAPH FOR A SAMPLE INCIDENT**
JAMES:  I'm afraid not, sir.
SMITH:  What's that?
JAMES:  Actually, he's quite dead, sir.
NANCY:  Good God! What happened?
JAMES:  He appears to have drowned.
SMITH:  That's absurd, man. Brown was a first-class swimmer.

Each informational component of the incident can be characterized in two ways. In terms of complication, the information is either positive (it asks a question) or negative (it answers a question). The importance of the information at the point at which it appears in the plot is rated on a numeric scale from 0 (completely unimportant) to 1 (extremely important). Thus an extremely significant piece of information that answers a question has a rating of -1, while a fairly insignificant piece of information that raises a question might have a rating of +.3. Table 2 shows such an evaluation of the informational components of the incident.

To represent the incident on a Freytag graph, the sum of the numeric ratings shown in Table 2 might be used as the value for the variable C, representing complication. The duration of the incident in minutes (or pages, using the standard estimate) is used as the value of the variable T, representing time. The formula for computing the slope of the line segment that will represent the incident on the graph is: slope = C/T. Figure 4 shows the resulting graph for the sample incident.

This analytic technique can yield a detailed profile, represented numerically or graphically, of the "shape" of the dramatic action of a given play. Using numerical representations makes such a technique potentially
useful in a computer program. The state of the art in computer-based story-understanding techniques (discussed in Chapter IV) suggests that a computer program might be devised to "automate" the analysis of the informational attributes of an incident. Further, insofar as all plays have certain structural features in common, those features can be seen to have characteristic curves.

**Quantitative Analysis in Plot Synthesis**

The techniques of quantitative analysis inspired by Freytag can be used by a computer-based system to evaluate each incident, whether generated by the system or by the user, and to assess its impact on the whole plot. When the system must contribute a plot incident, the technique can be used to aid in the selection of the most appropriate incident from all the candidates generated by the system. For each candidate, the system can determine the slope and compare that slope to a template or model of a complete dramatic action. A "flat" incident would be judged inappropriate for a position in the plot near the climax, a "steep" complication would be rejected for inclusion in the falling action, etc.

Various kinds of dramatic incidents, like discoveries and reversals, have different characteristic curves and potentials. A reversal, for instance, presents some resolution to a previous complication, but typically presents a new, more challenging complication in the process. An expert system with knowledge of such characteristics for various, specifiable types of incidents can recommend the appropriate type at a given point in plot development.
Using the above techniques, the playwriting "expert" can provide guidance for a typical story-generating facility in creating and concatenating incidents so that the interactive plot approximates the appropriate dramatic "shape." The "slope analysis" technique suggested above would function as one of several tools to be used in the synthesis of plot. The workings of story-generation programs are examined in Chapter IV, and plot-synthesis techniques derived from quantitative structural analysis are discussed in Chapter V.

Analysis of Representative Interactive Works

Each of the following interactive works has been selected for analysis because it exemplifies a particular structural issue or problem. The works are be referred to in later discussions, especially in relation to the user-character and the experience of "personness" (Chapter III).

Zork: An Interactive Epic

Zork is a text-based adventure game that was developed at the Massachusetts Institute of Technology in the late 1970's. The game was expanded until it had gobbled up all available memory on the DEC-10 minicomputer where it lived. The final MIT version had a total of 616 possible points, gained by solving all the puzzles (like how to stay alive in the presence of an angry troll) and gathering all the treasures in the vast underground empire of Zork, then transporting those treasures safely back to
the trophy case in the house where the game began. The original *Zork* was later adapted to run on the more popular home computers by Infocom, Inc., where it was broken into two parts, *Zork I* and *Zork II*, with the addition of some new materials in *Zork II*. An "endgame" sequence, which may be played after all the possible points in the first two parts are won, became *Zork III*, also with new materials.

The plot of the *Zork* adventure is clearly episodic, with episodes normally differentiated by their location in the labyrinth. The adventure takes place in hundreds of locales, both above-ground and in the underground empire. Each locale or type of locale has characteristic life forms and unique obstacles or strategic puzzles that the user must overcome. Many have unique "thematic" identities; one episode, for instance, features characters and logic drawn from *Alice in Wonderland*. In fact, the episodic form may well be an artifact of the spatial metaphor at work in most adventure games—a convention established by Willie Crowther in the original text adventure game, which was based on the topography of Mammoth Cave. Crowther was also influenced by the non-computer-based game, Dungeons and Dragons, which was also employed a physical labyrinth to create "natural" episodes.\(^{35}\) The introduction of new characters and complications in adventure games is almost always managed by moving about in the game "space." Other adventure game experts suggest that the episodic structure may be the result of incremental development by many authors for adventure games on large systems (almost always an

\(^{35}\text{Warren Robinett, "Imaginary Worlds: Video Game and Adventure Game Design" (book manuscript), Ch. 2.} \)
underground or after-hours activity).\textsuperscript{36} Whatever its evolutionary history, episodic plot structure seems intrinsic to the adventure game genre.

In \textit{Zork}, as in most other adventure games, the user must recover every treasure and solve every puzzle in the game world in order to win. The order in which these feats are accomplished (and hence the order of the episodes) is moderately flexible. Some constraints on order are produced by the need for a particular tool or piece of information—one must have found the magic sword by the time one must fight the troll, for example. Another form of constraint on order is that one tends to move always "deeper" into the labyrinth. The labyrinth is designed in geographical or logical levels that correspond to specific sets of problems and locales, and there is seldom reason to backtrack once a level has been penetrated.

The episodes within a given level (e.g., the initial episodes in locales on the surface, near the house) may be successfully played in a variety of different sequences. Within each problem-solving episode, however, there is generally only one sequence of events that can lead to success (failure in any problem-solving session will, sooner or later, cause the user to be "killed"; i.e., to lose the game). Like Aristotle's model for epic poetry, then, the plot of \textit{Zork} exhibits the workings of causality in the order of events within episodes, while the order of episodes within the whole is not strictly causally determined. The multiplicity and variety of episodes create a level of magnitude appropriate to the epic.\textsuperscript{37}

\textsuperscript{36}Interview with John Howard Palevich, research scientist, Atari, Inc., Sunnyvale, California, 12 June 1984.

\textsuperscript{37}Aristotle, \textit{Poetics}, 1459b/17-30.
Despite its episodic structure, *Zork* possesses unity of action. The motivation of the user to collect all the treasures (i.e., to “win”) provides the central action, with its beginning, middle, and end. The user is the agent who is responsible for moving the action forward, while system-driven characters (i.e., the various monsters, the thief, and the Dungeon Master) either impede or aid the user in his quest. It is never the case that any character other than the user can become the central character of the piece; the user is clearly cast as the epic hero. The other characters and the strategies associated with them, as well as some of the objects and tools in the environment, provide some continuity between episodes.

The computer program refers to itself in the first person: when the user types a word not in the system’s vocabulary, for instance, the system’s response is "I don’t know that word." This nebulous "I" seems to act as a *stand-in* for the user, reporting the results of the user’s choices and actions ("You have killed the troll!"), and also as an *agent* for the user in command execution (displaying an inventory on command, for instance). Other than these functions, however, the *character* of the "System’s I" is amorphous and often confusing. In an attempt to protect himself from vampires, for instance, one user expressed his intentions by typing, "Eat the garlic." The system’s enigmatic response was, "Thank you. That hit the spot." (Who ate the garlic?) Considered as a convention rather than a character, however, the "System’s I" does provide some continuity throughout the adventure.

Another unifying factor is the nature of the game environment. While locales are quite diverse, the kinds of things that can happen in them and the way one gets from one to another are uniform throughout the game.
While the tools and treasures in the adventure world are also varied, their uses and the means for acquiring, employing, and losing them are consistent. These consistencies are largely attributable to the interface: a natural-language-like parser with a 600-word vocabulary and the ability to interpret and create simple sentences. The kinds of actions that the user may perform (moving around, fighting, etc.) are simply limited by the set of commands that the program can recognize. Thus unifying factors that appear to exist on levels other than the level of plot can be seen as aspects of a "unity of action" that consists in the set of actions that the user is allowed by the system to take.

*Zork* is represented entirely in text; the elements of spectacle and music are absent. *Zork* is narrated, and not enacted. While filled with detailed, present-tense prose descriptions of places and things, *Zork* is inferior to traditional narrative literature in its ability to represent certain types of action. Combat, for instance, is a common type of action in the piece, but its essence—the blow-by-blow exchange (including the actions of the user)—is not represented. The user expresses intentions rather than actions ("kill the troll with the sword" rather than "thrust sword in direction of troll's jugular"). The "System's I" attempts to execute the user's command, and then reports on the results ("the troll is unconscious but not dead; you are wounded"). The action of moving around the adventure world is similarly represented: the user types, "Go north"; the system responds, "You are in a forest." Thus the system represents choices and results, but has difficulty representing actions themselves.
Unlike traditional narrative works, *Zork* cannot represent simultaneous events, probably because of the difficulty of communicating them to the user and integrating them into the game play. In *Zork*, the action is suspended between interactive nodes; that is, time is only passing in the adventure world when the user is active. This treatment of time allows the user to analyze the situation and plan his moves outside of the action—otherwise, the action would move far too quickly for the user to think strategically and avoid disaster—but tends to undermine the intended "real-time" effect of present-tense presentation.

The plot of *Zork* is fixed, with the exception of the order of some of the episodes. The package advertises that the "average length of journey" is 35 to 40 hours. Each unsuccessful journey ends in the untimely death of the hero, leaving much of the potential of the piece unfulfilled. Failure at any point in the game represents truncation of the plot to the user, rather than an alternative plot in its own right. An unsuccessful journey is viewed philosophically as an opportunity to learn about the plot—the course that the action must take in order for the whole action of the game to unfold. Learning tasks include mapping the labyrinth (because it is humanly impossible to memorize the topology of the adventure world), taking note of successful solutions to puzzles, and analyzing errors in order to improve subsequent performance. "Only the possibility of seeing the adventure through to a successful conclusion," says adventure expert John Palevich, "makes a user willing to 'die' four hundred times."³⁸ There is essentially only one path to

³⁸Palevich interview.
completion of the whole adventure: the finished plot is neither created nor significantly influenced by the user; it is discovered by him.

If the user has managed to save the state of the game on a disk before he commits a fatal error, he can begin his next session where the previous one left off—rather like a bookmark. Successful action sequences can also be concatenated into long strings of commands, providing short cuts through familiar terrain. Thus it is unlikely that the user will ever experience the whole plot at one sitting, but will experience it in chunks that mark the progress made in each successive attempt: the action is serialized.

It follows from the fixed nature of the plot that the user can neither contribute nor formulate materials on the level of character; he can only discover the correct actions, traits, thoughts, and diction (commands). Only one version of the user's character, pre-ordained in the plot, can complete the adventure. Failed sessions represent, not alternative characters, but successive approximations of the correct character by the user. More recently developed adventure games are able to tailor the action to the user's expressed tastes and preferences (sexual preference or favorite artists, for example); however, both the traits and their effect on the action appear to be superficial.

The differences between the endgame sequence (Zork III in the microcomputer version) and the rest of the game represent an interesting attempt to create an ending that is more cathartic and of more appropriate magnitude than simply solving the last of many puzzles. When the user successfully collects all the treasure in the labyrinth, he is given a magic

\footnote{Palevich interview.}
word that transports him to the endgame sequence. The giving of the magic word is a sort of ceremony that marks the climax of the central action. The endgame puzzles differ from those in the other parts of the game in that they are arranged in a fixed sequence, and the tools needed in the solution of each are readily available. The action is difficult but straightforward, providing a kind of tour de force for the conquering hero. At the end of the sequence, the Dungeon Master—the wise old man of the adventure world and frequent companion of the user in later episodes—nominates the user as his successor, and the transformation of the user is described. Thus the hero not only "wins the game," but also becomes master of the game world, fully immersed for the moment in that world's reality and leaving the practical exigencies of "game play" behind.

Star Raiders: Dramatic Interaction in a Small World

Star Raiders is an animated action game developed by Douglas Neubauer for the Atari computer in 1979. At that time, Neubauer was working as a hardware engineer and not a game designer, but felt that there should be a good video game for the new home computer. The dozens of awards that Star Raiders has won over the years, including "best video

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40The author has never won Zork. This description was obtained from Palevich—we have to trust him.
game" for three consecutive years in a popular computing magazine, are a testament to Neubauer's skill and dramatic insight.41

The game places the user in control of a starship, with the objective of cleaning pugnacious alien spacecraft out of several contiguous quadrants of the galaxy. To succeed completely, the user must be able to maneuver and fight, generate strategies for defending his starbases, and be able to dock with a starbase when necessary for refueling and repairs. The game's primary visual mode is a convincing first-person view from the bridge of the starship as the ship races through the starfield, dodges meteors and enemy fire, and fires photon torpedoes at Zylon ships. Besides forward or aft views from the bridge, the display includes status indicators for the ship's fuel and various functions. The computer keyboard, in the user's visual field directly below the display, becomes an extension of the imaginary ship's controls.

Other visual modes include the galactic chart and the long range sector scan. The galactic chart is a display to which the user may toggle at any time to view the location of friendly starbases and enemy ships, and to see the number of ships in each quadrant. The chart is used for strategic planning and navigation between quadrants. The user enters hyperwarp, the means of travel from one quadrant to another, by moving the game cursor to his destination on the galactic chart. The long range sector scan is a view of the user's own ship from "above" its current location (an impossible view which is often employed in science fiction movies)—ever wonder how

41 Atan's policy was never to connect the names of authors with their video games, thus Neubauer is known primarily through "in-house" legend. The awards won by his game were accepted by a succession of marketing vice-presidents who never heard of him.
they get those cameras hanging out in space?), and shows the location of other targets as well. It is used for navigation within quadrants.

There are two distinct kinds of action in the game: combat, which requires maneuvering skill and eye-hand coordination; and the planning and execution of strategies to prevent friendly starbases from being surrounded and destroyed. The two activities blend well in the overall action, because fighting is part of the execution of strategic plans, and because the user is free to toggle to the galactic chart and review his plans at any time. The action is continuous regardless of visual mode: Zylons are on the move, and the ship is always running, depleting its fuel supply.

*Star Raiders*, unlike *Zork*, is *enacted*, with computer-generated spectacle and music. As in traditional drama, enactment in *Star Raiders* entails the illusion of real, continuous time. Unity of action is provided by the user's overall objective, and reinforced by a rating of the user's overall performance that is displayed at the end of every game session. The game's incidents are causally related—the order in which various Zylon-bearing quadrants are attacked, for example, affects the enemy's ability to surround a starbase, as well as the player's fuel consumption and hence the need to dock for refueling.

The plot of a game session exhibits a traditional dramatic structure, with exposition (initial scanning of the galactic chart), rising action (encounters with Zylon ships), crisis (threat to starbases posed by enemy ships), climax (moment at which the outcome is determined), falling action or denouement (action from climax to the moment of complete success, destruction, or running out of fuel), and conclusion (the starfleet rating
message). Interestingly, the dramatic structure emerges more distinctly as the user becomes experienced and begins to generate long-term strategies for play. The user's strategic plan and its implementation is the central action of the plot, and the better it is formulated, the more the whole behaves dramatically.

Like Zork, Star Raiders casts the user as the central character; however, Star Raiders does so more completely and successfully. There is no "System's I" to muddy the issue of who the central agent actually is. While the user's identity is often lost in a fog of pronouns in Zork, the notion of user as character in Star Raiders is rendered completely unambiguous by the first-person treatment of spectacle.

The other characters in Star Raiders are represented as the Zylon vessels and friendly starbases, with their guiding intelligences assumed. There are three types of Zylon agents, distinguishable by their graphical images and one or two behavioral traits in battle. Starbases behave identically, and have a small repertoire of characteristic actions and communication protocols. All characters, including the user-character, are extremely simple due to the constraints of the game world: the kinds of things that can happen are few, and hence the agents of those few actions require correspondingly few traits. Despite the outer space setting, Star Raiders takes place in a very "small" world.

Contributions of the user on the levels of spectacle and music are materially constrained by the program's repertoire of images, animation sequences, and sound effects—again, the possibilities are few when compared to traditional drama. Likewise, the user's contributions on the
level of diction are constrained by the set of commands that the system can recognize and act upon. The game creates the illusion of responding to a relatively greater range of contributions on the levels of thought and character because subtly different strategies, as well as emotions and motivations ("I'm going to kill those Zylon bastards" vs. "I keep a clean quadrant") are often not translated by the user into objectifiable plans and specific actions. The effects of chance and physical dexterity tend to be interpreted by the user as the results of his strategies and character traits. The game is successful in supporting such fantasies because the user is not generally aware of the material and formal constraints on his actions.

Unlike *Zork* (in which the single plot is discovered by the user in a series of sessions), the plot of *Star Raiders* is variable and collaboratively formulated by the system and the user. There is no single outcome that must be attained in order for the whole plot to be revealed and no single way to reach that end. The number of possible plots is constrained by the relatively few kinds of actions that can occur (a measure of the potential of the dramatic world). Because the user's strategies and actions influence the order and incidents and the outcome of each (e.g., how much damage is sustained in a battle), the plot can be seen to be collaboratively formulated.

The system's functioning as provider of constraints, protocols, and a finite set of materials is, in many game programs and to some degree in *Zork*, intrusive and destructive of the user's fantasy experience. In *Zork*, the user's relationship to the system, as represented by the "System's I," can be described as a "second-person" one (as demonstrated by the second-person pronouns in the dialogue between them), and is quite distinct from
the first-person experience that is desired by the user and intended by the system's designers. The "System's I" stands outside the context of the fantasy, with no distinct character or role in the action—what computer folks would call a "kludge." The functioning of the "System's I" is taken over by the ship's computer in *Star Raiders*, and thus cleverly integrated into the fantasy world. The user employs the ship's computer and the various "tools" it offers him (the galactic chart and attack computer, for instance) quite naturally in a first-person mode.

This chapter has employed dramatic theory to elucidate the structural characteristics of poetic interactive works. In creating a theory of interactive drama, emphasis has been placed on comprehending and integrating the contributions of the user-character as the co-creator of an interactive work. The form of such works is determined by the manner in which the system formulates materials—human-authored, computer-generated, and contributed by the user-character—into a dramatically satisfying whole. The form of an interactive drama must enable the user to participate in the fantasy world as an active character—a dramatic agent. Chapter III explores the nature of first-person experience and techniques for achieving it in interactive system design.
CHAPTER III
THE USER-CHARACTER

The proposed Interactive Fantasy System casts the user as a character in the dramatic action. The notion of the user-character is the primary characteristic of the interface: it is the manner in which the user and the system (that is, the computer and the computer program) interact. As a dramatic character, the user is completely immersed in the fantasy world, and the only other entities with which he interacts are the other dramatic characters. The user should never interact with the system \textit{qua} system; indeed, any awareness of the system as an entity would explode the fantasy context, just as a clear view of the stage manager calling cues would disrupt the "willing suspension of disbelief" for the audience of a traditional play. An essential condition for the user-character interface is "first-person" interaction: the user experiences the mimetic world directly and participates in it as an agent.
First-Person Interaction

Interface Design: The Convention of the Intermediary

The ideal of a first-person interface is difficult to implement for several reasons, the most important of which is a convention in interface design that may be described as the use of an intermediary. In many computer-based activities, the system acts as an intermediary between the user and the outcome he desires, whether that outcome be an experience (e.g., playing a video game or browsing through an interesting database) or a product (e.g., writing a thesis or balancing a checkbook).

In Zork, as in most adventure games, the user communicates with an intermediary that is not a character in the action, but rather a vaguely personified manager or agent. The intermediary (referred to in Chapter II as the "System's I") acts as an agent for the program in its evaluation of user input, and as an agent for the user in its performance of meta-level functions like "inventory" and "look." It also "stands in" for the user: it swings the sword, takes the lumps, and reports what happens. As long as the system acts as an intermediary, it prevents the user from participating directly in the action as either an agent or patient.

In product-oriented computer-based activities like word processing, accounting, and file management, the interface is usually based on a command language or command menu that the user employs to tell the system to perform some function (e.g., "save file"; "delete paragraph"). In
these cases, too, the system functions as an intermediary: the user does not perform the desired action himself, but must persuade the system to do it for him.

The "intermediary interface" convention is examined here because it is so firmly entrenched as to be invisible to many designers, and because it is inimical to first-person experience. The convention is insidious in that it is rarely explicitly incorporated in interface design; rather, it is an artifact of the evolution of computer applications (indeed, the study of human-computer interfaces is a relatively new domain that reflects the influences of cognitive psychology and ergonomics on computer science).

The "intermediary interface" arises from the mistaken notion that a user of a computer-based application has the same relationship to the computer as a programmer. In both cases, it would seem, the computer is being used as a tool, and, because it is an "intelligent" tool, it must be explicitly addressed (one need not tell a hammer how to pound nails, but a computer, if it is to do anything at all, must always be instructed). The error in this analysis is that the programmer and the end-user are using different "tools": the programmer uses the computer as a tool to make applications; the end-user uses those applications themselves as mimetic tools to perform other tasks. While the end-user wishes to operate consistently within the mimetic context, the command orientation of the interface threatens to place him in an entirely different context—that of the computer and the program's execution. The "intermediary," an ill-formed persona that belongs wholly to neither context, is the conventional means of patching up the cognitive discrepancy.
Just as the workings of a *theatre* and the action of the *play* produced in it are distinct, so the computer—the device that provides a representation—must be seen as distinct from any representation (or *mimesis*) that it presents. Unless one is programming, the applications one encounters are *mimetic* tools, worlds, or activities. The desired interaction is no longer with the computer as representer, but with the representation itself.

The designers of arcade-type, skill-and-action games rarely employ intermediary interfaces, perhaps because creating and preserving a mimetic context is clearly essential to the enjoyment of such games. *Star Raiders*, *Pac Man*, *Pole Position*, and others allow the user to immerse himself in the game context and to operate directly and exclusively in the game world. The action in such games is typically represented graphically, with input devices (game controllers) that emphasize visual and kinesthetic skills rather than verbal and intellectual ones. They offer the user an experience that is direct and immediate. As a result, the user feels himself to be present and participating in the action—a *first-person* experience.

While the formal and structural principles of first-person interfaces have not been articulated, theories have been advanced which may account for their effectiveness. Media theorist Tom Bender observes:

The kinds of information we receive from our surroundings are quite varied, and have different effects upon us. We obtain raw, direct information in the process of interacting with the situations we encounter. Rarely intensive, direct experience has the advantage of coming through the totality of our internal processes—conscious, unconscious, visceral and mental—and is most completely tested and evaluated by our nature. Processed, digested, abstracted second-hand knowledge is often more generalized and concentrated but usually affects us only intellectually—lacking the balance and completeness of experienced situations. . . . Information
communicated as facts loses all its contexts and relationships, while information communicated as art or as experience maintains and nourishes its connections.¹

Bender presents no experimental evidence to support his conclusions; however, they appear to be based on sound observations of human experience. Although his remarks were made in the context of "information environments," his observation that "direct experience" is more likely than other forms of presentation to involve the user (or "experiencer") emotionally and viscerally as well as intellectually is applicable in a variety of contexts. In educational software applications, for example, the strength of the simulation form (as opposed to tutorial or drill-and-practice forms) is that it presents experience as opposed to information. Learning through direct experience is thus assumed to be more effective and enjoyable than learning through "information communicated as facts."

Presentation methods that are "direct," multi-modal, and experiential in nature have the capacity to engage many of the user's faculties (in addition to the intellectual), to enhance the contextual aspects of information, and to encourage an integrated, holistic response. This broad view of information subsumes artistic applications, as well as traditional knowledge representation.² What Bender calls "direct experience," plus the explicit involvement of the user as an agent in the mimetic context, are the critia for first-personness in interactive works.

¹Tom Bender, Environmental Design Primer (Minneapolis: published by author, 1973), pp. 97-98.

²Ibid., pp. 96-105.
First-personness is ultimately a cognitive effect. The objective of the following section is to identify the conditions under which an individual may have a first-person experience with an interactive representation. It includes definitions of the various aspects of first-personness—contextual, physical, and interactive—that may be achieved through interface design.

**Characteristics of First-Person Interfaces**

First-personness is a quality of experience. It describes the relationship of an individual to context. In interactive representations, that relationship is manifest at the point where the user and the representation make contact: the interface. The first-person metaphor is drawn from grammar, because the personness of pronouns reflects where one stands in relation to others and to the world. Most movies and novels, for example, are third-person experiences; the viewer or reader is "outside" the action, and would describe what goes on using third-person pronouns: "First he did this, then they did that." Most instructional documents are second-person affairs: "Place the diskette in drive B"; "Honor your father and your mother." Operating a computer program that has been designed using the intermediary convention is also a second-person experience: the user makes imperative statements (or pleas) to the system and asks it questions; the system tells the user what it has done and, occasionally, what the user has done wrong ("Illegal input; please try again").

The notion of a first-person interface seems to be more intuitively obvious in applications which, like video games, have the experience (or process) itself as the objective of the user. In *Star Raiders*, for instance, the
first-person video displays (views from the cockpit of the ship, as if one were actually driving it) and controls (for maneuvering the ship, locating enemy ships, and firing weapons) encourage the user to feel himself to be an agent in the mimetic action. It is interesting to note that first-personness as a cognitive phenomenon has often been the unintentional—and unexplored—side-effect of first-person visual displays: most such games do not encourage the user to assume a dramatic character in any other way, nor do they utilize the user’s character as material for plot, except in the most rudimentary fashion.3

Personness is affected by the physical aspects of the interface; that is, how the user’s choices and actions are introduced to the system (input), and how the activities of the system are represented to the user (output).

In the Atari game Pole Position, for example, the user “drives” a simulated race car down a track. The user controls the speed of the car by applying pressure to a pedal that is analogous to an automobile accelerator. The ability of the user to participate in the race-driver fantasy in a first-person way would be significantly lessened if his only means of controlling the speed of the car were to specify speed numerically from a keyboard. Likewise, first-personness would be diminished if the effect of the user’s pressure on the pedal were reflected, not by an animated representation of a race car, but by a numerical display of its speed.

On the other hand, the representation of the user’s “car” on the screen undermines the experience of first-personness: when one drives a car, one

3See, for instance, Space Invaders, Centipede, video game and personal computer game (Atari, 1982), or Pole Position.
does not see the whole car, but only that portion of the car which is within the
driver's visual field. In the case of *Pole Position*, the effect of visual
representation of the user on the screen is overshadowed by other first-
person sensory effects (auditory and kinesthetic). In the coin-operated
videodisc game, *Dragon's Lair*, the distancing effect of visually representing
the user-character is more pronounced: few players of the game would
report their experiences in the first person; rather they conceive themselves
to be telling the central character (Dirk) what to do—a second-person
transaction. The user may be visually represented without damage to first-
personness if the context includes a device that he may operate in order to
see himself; that is, an imitation of an instrument which includes the user in
its view, such as the "long-range scan" mode in *Star Raiders*.

First-personness is affected by the ways in which a user may interact
with a system, in terms of the kinds of choices he may make and the patterns
of choice that emerge from the interaction. The interactive aspects of first-
personness may be discussed in terms of frequency, range, and
functionality.

The opportunity for a user to provide input (and thus express choices)
may be presented more or less frequently in an interactive work. *Interactive
frequency* is a measure of how often user input is enabled. Near one end of
the frequency continuum is a program with only a few clearly delimited
interactive nodes. The CyberVision Story Series programs developed
during 1978-79, for instance, present an average of four interactive nodes in
the course of each story. The other extreme is exemplified by action games like *Pole Position*, in which the user makes apparently continuous, real-time input.

Interactive range describes the range of choices available to a user at a given moment in the interaction. That "interactive moment" may be a distinct node or a slice of "continuous" interaction. A binary choice, such as the use of a "fire button" in an action game or a yes-or-no question in an adventure game, has the narrowest interactive range, even though the consequences of that choice may be of great significance to the action.

Interactive range indicates the number of possible choices recognized by the system. Although the Atari joystick can distinguish eight different directions, for instance, the home computer version of *Pole Position* recognizes only four. In most text-based adventure games, user input is interpreted by the use of keywords; hence the interactive range is determined by the number of words that are both recognized and functional at a given interactive moment. An interactive work using artificial intelligence techniques (e.g., an interactive story generator) may have an indeterminate interactive range, since the choice nodes are not pre-ordained, but are generated "on the fly."

Interactive range is also affected by the user's perception of the choices available to him. When there is a discrepancy between the number of choices actually recognized by the system and those perceived by the user, the user's assessment takes precedence. A poorly designed (or poorly

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documented) interactive work may fail to acquaint the user with the full range of available choices, while a clever one may fool the user, at least for a while, into thinking that he has many more choices than the system actually recognizes. The pseudo-natural-language approach used in many text-based adventure games, for instance, may give the novice user the impression that the system understands and responds to complete English sentences, and not just keywords.

*Interactive functionality* is a measure of the impact of the user's choices and actions upon the *whole*. In a product-driven activity, that whole is the whole *product*, or result, of an interactive session. In a process-driven activity, the whole refers to the whole *interaction*—the result of collaboration between user and system. In an interactive fantasy, interactive functionality measures the user's effect on the *plot*; in other words, it describes what proportion of the user's contributions are *functional* as opposed to *incidental* (see Chapter II, p. 39). In the CyberVision program *Rumplestiltskin*, for instance, the user is allowed to choose which of three characters will serve as the queen's messenger. The choice is incidental rather than functional, however, in that the actions performed by the messenger in the story remain the same regardless of the user's choice, hence the choice has little impact on the plot.

The underlying principle in the physical aspect of first-personness is *mimetic*; that is, first-personness is enhanced by an interface that enables inputs and outputs that are more nearly like their real-world referents, in all relevant sensory modalities. Thus a graphical adventure game is preferable to a text-based one, because the graphical mode of representation is more
like the physical quest for treasure that is the object of the game's imitation. Better still would be an adventure game that enables input and output in visual, auditory, gestural, and tactile modes. The intuitive correctness of this notion is witnessed by the direction of technical evolution in the areas of games and simulations—toward higher resolution graphics and faster animation, greater sound capabilities, motion platforms, and mimetic controllers such as force-feedback steering wheels. The notion also obtains in product-driven applications, where increased bandwidth and new technology are allowing researchers to replace indirect or symbolic representations and manipulations with direct, concrete ones; e.g., physically pointing as opposed to typing in a menu selection, speaking as opposed to typing, and spatial and graphical representation of data as opposed to textual representation.5

The mimetic principle is easy to apply in an activity which, like Pole Position, imitates an activity for which we can identify a concrete, "real-world" parallel. It is certainly at work in the design of systems that are employed in training users to perform real-world tasks, such as the flight simulators used by NASA and commercial airline companies. But what is the object of imitation in fantasy worlds, worlds which exist only in art or imagination? We may speak of "the world of Hamlet," for instance, or "the world of Frodo Baggins." While these worlds are different from reality in striking ways (Hamlet's world is the court of medieval Denmark; Frodo's world is located in "Middle Earth," and includes magical creatures and forces that are

impossible in terms of our own physics and biology), they are acceptable as "worlds" because they possess the logical and experiential qualities of reality, and because they contain the potential for all the actions that occur within them. In Hamlet's world, for instance, sabre duels are permissible and laser battles are not. Lines of probability and causality can be established for every action represented in the play.

The application of the mimetic principle to fantasy worlds points up the differences between *mimesis*, a poetic form of imitation, and the kind of imitation that is intended to be a duplicate or fully detailed copy of its object. Consider, for example, the differences between an interactive fantasy (as proposed in this paper) and a simulation of human personalities, desired by a psychologist to perform research on human behavior. One difference is in the nature of the *object* of each type of imitation: the object of an interactive fantasy is *action*, including only those agents and traits which are necessary to represent the action; the object of the psychologist's simulation is *human personalities* with all their traits. The psychologist hopes that human-like action will be generated by the simulation; however, the kind of action that will be produced will be quite different than the action of an interactive fantasy, and will almost certainly lack dramatic shape and focus.

The *end cause* of the psychologist's simulation is to provide a tool for the study of human behavior. Complete accuracy—slavish imitation of the object—is necessary if the tool is to provide scientific predictability; thus the end cause influences the formal cause. The end cause of an interactive fantasy, on the other hand, is to provide pleasure for the user by allowing
him to "delight in. . . [the] imitation." Appropriate, a mimetic form of imitation is employed. Ultimately, the world of the psychologist's simulation will have to be as open-ended and as filled with forming and dissolving connections as life itself. By contrast, the mimetic world of an interactive fantasy, because of its purpose and form, will be closed, knowable, and predictable in ways that are quite un-lifelike. The kinds of details that would be valuable to the psychologist will be absent in the mimetic world. The notion of "noise" is useful in this context. "Noise" may be defined as "any sound that is undesired or interferes with one's hearing something"; in electronic communication systems, "noise" is "an unwanted signal." In an interactive fantasy, information that is not causally related to the mimetic action may be described as "noise."

Observing such distinctions provides some additional qualifiers to the "mimetic principle." The choice of input and output modes must be governed, not only by their likeness to life, but also by their appropriateness to the end and formal causes of the work. Olfactory output, for example, might be found to be disorienting or "noisy" for an IF user, thereby diminishing the mimetic pleasure. Input based on non-voluntary measures like galvanic skin response or brain wave activity, if allowed to influence the action, might rob the user of his dramatic agency by obscuring or overriding the connections between his conscious choices and actions and their consequences.

6Aristotle, Poetics, 1448b/5-10.

7Webster's Ninth New Collegiate Dictionary, s.v. "noise."
The mimetic principle can also be applied in the context of the interactive aspects of first-personness: first, it suggests that the first-personness is enhanced by likeness in the realm of choice-making and agency; that is, one's experience of his ability to act in an interactive world should approximate his experience of agency in the real world. In terms of life-likeness, first-personness is most completely realized at the extreme end of each of the interactive variables’ continuum: frequency is continuous; range is infinite; functionality is maximal. Second, such life-likeness must be tempered by the characteristics of the particular action that is the object of the mimesis. The user should be somehow constrained so as not to make choices and perform actions that are extrinsic or inappropriate to the mimetic world.
Constraints on the User-Character

User constraints—limitations on the user's behavior—may be expressed as anything from gentle suggestions to stringent rules. People are always operating under some set of constraints: the physical limitations of survival (air to breathe, food, and water); the constraints of language on verbal expression; the limitations of social acceptability in public situations (e.g., wearing clothes). The ability to act without any such constraints is the stuff of dreams—the power of flight, for instance, or the appeal of immortality. Yet even such fantasy powers can be lost by the failure to comply with other, albeit mythical, constraints (witness Prometheus). It is difficult to imagine life, even a fantasy life, in the absence of any constraints at all.

Why the User Must Be Constrained

The user of an interactive system is subject to some special kinds of constraints. Some constraints arise from the technical capabilities of the system itself: if the system has no speech processing capability, for instance, the user must employ the keyboard for verbal input, and is constrained by its vicissitudes—the "QWERTY" layout, for example, and the presence or absence of function keys. Other constraints arise from the nature of the activity that is comprehended by the system. The user of an adventure game may not be able to perform calculations with his computer while the game is
running on it, even though the computer is capable of complex mathematical operations.

The design of the IF system should be informed by an analysis of constraints to determine how much the user should be constrained and what kinds of constraints are most appropriate to the IF system. That analysis begins with understanding the various reasons why constraints are necessary.

The hardware-related reasons for user constraints are fairly straightforward. They will also change, depending upon the elaborateness, completeness, and cost of various implementations of the system. It is improbable, for instance, that an interactive fantasy system would be implemented in the near future in which all the display surfaces would be touch-sensitive—the cost would be too high. Pointing devices which could be used to enable gestural input currently have a limited range, hence the user must be constrained to stand within a few feet of a receiver. Physical acts like running or manipulating objects in the fantasy world require that conventions be devised through which the desire to perform such actions can be expressed. Such conventions, mandated by the technical limitations of the system, are a form of constraints.

Some constraints are necessary to contain the action within the mimetic world—a software-related problem. For example, in an interactive fantasy version of a Sherlock Holmes mystery, it would be important to constrain the user to the customs and technology of Arthur Conan Doyle’s nineteenth-century London (e.g., no ballistics tests can be used to prove that a bullet was fired by a certain gun). A story generation program, no matter
how elaborate, cannot be expected to comprehend all possible worlds simultaneously (see Chapter IV). Preventing the user from introducing new potential is essential to the functioning of the system, especially in the creation and maintenance of dramatic probability. The playwriting expert system, which possesses story generation and story understanding capabilities as well as playwriting expertise, cannot be expected to function if the materials it receives from the user are unknown in the fantasy world context, or if they are in conflict with the "laws of the universe" that are part of that context.

What is the relationship between the experience of creativity and the constraints under which one performs creative acts? In fantasies about fantasy systems, people like video-game enthusiasts and science-fiction writers tend to imagine magical spaces where they can invent their own worlds and do whatever they wish—like gods.\(^8\) Even if such a system were technically feasible—which it is not, at the moment—the experience of using it might be more like an existential nightmare than a dream of freedom.

The relationship between creativity and limitations has been examined in some depth by psychologist Rollo May. In his book, *The Courage to Create*, May asserts the need for limitations in creative activities:

> Creativity arises out of the tension between spontaneity and limitations, the latter (like river banks) forcing the spontaneity into the various forms which are essential to the work of art. . . . The significance of limits in art is seen most clearly when we

consider the question of form. Form provides the essential boundaries and structure for the creative act.⁹

A system in which the user is encouraged to do whatever he wants will probably not produce a happy experience for the user. When a person is asked to "be creative" with no direction or constraints whatever, the result is, according to May, often a sense of powerlessness or even complete paralysis of the imagination.¹⁰ Limitations—constraints that focus creative efforts—paradoxically increase one's imaginative power by reducing the number of possibilities open to him. Limitations provide the security net that enables a person to take imaginative leaps:

Imagination is casting off mooring ropes, taking one's chances that there will be new mooring posts in the vastness ahead. . . . How far can we let our imagination loose? . . . Will we lose the boundaries that enable us to orient ourselves to what we call reality? This again is the problem of form, or stated differently, the awareness of limits.¹¹

The closed, knowable nature of a mimetic world provides a similar security net for the user-character. The user respects the limits of a mimetic world by refraining from introducing new potential into it (no phaser weapons in Elsinore). In exchange for his complicity, the user experiences increased potential for effective agency, in a world in which the causal relations among events are not obscured by the randomness and noise characteristic of open systems (like "real life").


¹⁰Ibid., p. 113.

¹¹Ibid., pp. 120-121.
Characteristics of Good Constraints

May's analysis suggests that constraints—limitations on the scope and nature of invention—are essential to the experience of creative self-expression. Certainly, some constraints on the choices and actions that may be expressed by the user are technically essential to the successful operation of an interactive fantasy system. The question is how those constraints should be determined and expressed.

The standard techniques for introducing user constraints—second-person transactions like error messages, or delimiters of interactive frequency and range like explicit nodes with choice menus, for example—are almost always destructive of first-personness.

User constraints can be either explicit or implicit. Explicit constraints, as in the case of menus or command languages, are undisguised and directly available to the user. When the user is in doubt about the "legality" of a certain choice or action, he should be able to find the rules and protocols of the system straightforwardly expressed, either in his manual, or in an on-line "help" facility. Implicit constraints, on the other hand, are inferred by the user from the behavior of the system. In Zork, for example, the user is not given a list of words that the language parser understands, but is informed by means of an error message ("I don't understand that word") when he uses one that is unfamiliar. Implicit constraints may be identified by the user when the system fails to allow him to make certain kinds of choices. There is no way, for example, to negotiate with the Zylons in a game of Star Raiders.
Explicit constraints can be used without damage to first-personness if they are presented before the action begins. A good example is the determination and expression of rules in child's play, which occurs before play actually begins and creates a contract binding the participants to behave within certain constraints. Once the action has started, however, explicit constraints often prove disruptive—an argument about the rules can ruin a perfectly good session of "cowboys and Indians" ("Wait a minute—who says Indians can only be killed with silver bullets?"). Implicit constraints are preferable during the course of the action, simply because the means for expressing them are usually less intrusive than those used for explicit constraints.

Constraints may also be characterized as extrinsic or intrinsic to the mimetic action. Extrinsic constraints have to do, not with the mimetic context, but with the context of the user as operator of the system. Avoiding the "reset" and "escape" keys during play of a game has nothing to do with the game world and everything to do with the behavior of the computer. Playing an improvised scene without the use of language has nothing to do with the dramatic action of the scene, but is an extrinsic constraint designed to

12Various readers of this study have remarked that the ongoing process of rule-making and enforcement is sometimes an element in children's play—a sort of "meta-game" that provides its own distinct pleasures. A similar meta-game occurs in the theatre when stagehands and "real people" wander in and out of the action, as in some of the plays of Christopher Durang and Thornton Wilder, or in certain productions of Brecht. Seen in this way, the meta-game is also mimetic, and the actors are merely performing the roles of "real people" as well as portraying other dramatic characters. A version of an interactive fantasy system could be probably be designed to incorporate such a meta-game without major changes to its internal structure and operation.
improve the actors' gestural acuity—a different context than the mimetic one. Extrinsic constraints have been used successfully in a variety of sports and other disciplines to distract the part of consciousness that can interfere with performance. The technique is inappropriate for the IF system, however, because it sets up a secondary context that demands part of the user's attention.

Extrinsic constraints can be made to appear intrinsic when they are expressed in terms of the mimetic context. If the "escape" key is defined as a self-destruct mechanism, for instance, the constraint against pressing it in the course of flying one's mimetic spaceship is intrinsic to the action. The user need not "shift gears" to consider the effect of the key on the computer that is running the game program. Expressing constraints in this manner preserves the contextual aspect of first-personness.

Constraints should be applied without shrinking interactive range as experienced by the user: they should limit, not what the user can do, but what he is likely to think of doing. Such implicit constraints, when successful, eliminate the need for explicit limitations on the user's behavior. Context is the most effective medium for establishing implicit constraints. The user's ability to recognize and comply with implicit, context-based constraints is a common human skill, exercised automatically in most situations, and not requiring concentrated effort or explicit attention. It is the same skill that a person uses to determine what to say and how to act when he interacts with a group of unfamiliar people—at a cocktail party, for

\(^{13}\)See, for example, W. Timothy Gallwey, *Inner Tennis: Playing the Game* (New York: Random House, 1976).
instance. The limitations on his behavior are not likely to be explicitly known or consciously mulled over; they arise naturally from his growing knowledge of the context in which he finds himself.

Since the IF system is dramatic in nature, it is reasonable to look for guidance in the development of constraints to other dramatic forms: theatrical performance and improvisation. In the theatre, the actor is constrained in the performance of his character primarily by the script, and secondarily by the director, the accoutrements of the theatre (including scenic elements, properties, and costumes), and the performances of his fellow actors. The actor must work within exacting constraints, which dictate the character's every word, choice, and action. In spite of these narrow limits, the actor still has ample latitude for individual creativity, according to Michael Chekhov:

\[\ldots\] every role offers an actor the opportunity to improvise, to collaborate and truly co-create with the author and director. This suggestion, of course, does not imply improvising new lines or substituting business for that outlined by the director. On the contrary. The given lines and the business are the firm bases upon which the actor must and can develop his improvisations. How he speaks the lines and how he fulfills the business are the open gates to a vast field of improvisation. The "hows" of his lines and business are the ways in which he can express himself freely.\(^\text{14}\)

The value of limitations in focusing creative activity is recognized in the theory and practice of theatrical improvisation. Constraints on the choices and actions of actors improvising characters are probably most explicit in the tradition of *Commedia dell'arte*. Stock characters and fixed

scenarios provide *formal* constraints on the action, in that they affect the actor's choices through formal causality. Conventionalized costumes for each character, a standard collection of scenic elements and properties, and a repertoire of *lazzi* (standard bits of business) provide *material* constraints on the action.

Charles Marowitz, in his exegesis of Stanislavski’s "Method," discusses the value of improvisation:

... once he [the actor] is on his own, free of the oppressive influence of script and stage, there is a good chance that he will not lapse into his conditioned-reflexes, and perhaps quite accidentally, he will begin drawing from his real Self and producing honest reactions. The improvisation offers this opportunity. The character reveals the actor because the character *is* the actor; and it is through his conscious and unconscious choices that he becomes known.15

The same may be said of the user-character in the proposed IF system: he becomes known—that is, the character comes into being—as he makes choices. The "bits and pieces" of the character that are represented in discrete choices, according to Viola Spolin, "function as an organic whole" in improvisational exercises.16 As a theatrical improvisation seems similar to an IF session in terms of process and experience, the same kinds of constraints might effectively be employed.

Spolin's problem-solving approach utilizes constraints that are extrinsic to the mimetic action. Rules in the various improvisational

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exercises constrain the actors in ways that usually bear no relation to the plot. It is presumed that the actor more or less "accidentally" does the right thing, because his attention has been drawn away from the kinds of thoughts (e.g., self-censure or preoccupation with technical correctness) that would normally interfere with his performance. If the actor in one of Spolin's problem-solving improvisations stumbles into an uninterrupted first-person relationship with the mimetic action, it is because he has either internalized or forgotten about the rules of the exercise.\(^{17}\) The game-based rules for improvisation suggested by Clive Barker similarly provide a strong structure which is extrinsic to whatever dramatic action may emerge.\(^{18}\)

Michael Chekhov and Uta Hagen, on the other hand, advocate constraint systems that are intrinsic to the dramatic action of the improvisation; that is, constraints that have to do with the action itself and not how, or why, an exercise is performed. Although such constraints may accomplish goals outside the scope of the dramatic action, e.g., improving the actor's ability to play a "through-line," they are effectively intrinsic if that is the context in which they are presented to the actor. Chekhov recommends that the actor pre-determine the beginning and ending moments for the improvisation. Each must be a specific action—a gesture or a word, for instance.\(^{19}\) As elements of spectacle or diction that are formulated by the actor into plot, such actions should be considered *material* constraints. Uta

\(^{17}\)Ibid., pp. 20, 36, and 160-161.


\(^{19}\)Chekhov, p. 37.
Hagen suggests that time, place, and objective should be pre-determined—a combination of material and formal constraints.\textsuperscript{20} Such intrinsic constraints function by sharpening, rather than diverting, the actors' focus on the dramatic action, and are therefore appropriate to the purposes of the IF system.

\textbf{Formal Constraints}

Formal constraints are constraints that operate through the force of formal causality, on the level of plot. They are intrinsic to the action, and may be expressed explicitly before the action begins or implicitly in the course of the action.

Providing the user with specific objectives or motivations for the action is a kind of formal constraint that is used frequently in games. Highest-level objectives (or "super-objectives") are usually presented explicitly before the action begins. In \textit{Star Raiders}, for example, the objective of the user-character is to destroy all the Zylons in several quadrants of the galaxy. In \textit{Zork}, the objective is to gather all the treasures in the maze and return them to the trophy room. In the Parker Brothers game, \textit{The Empire Strikes Back},

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the objective is to destroy as many of the Imperial Walkers as possible before they reach the power plant and blow up the planet.²¹

The user of such games finds that many of his choices are determined by the application of his super-objective to the system-generated contributions to the action. As the Zylons close in on a friendly starbase in a game of *Star Raiders*, for instance, the user discovers that he must develop a strategy for preventing the starbase from being surrounded or captured in order to fulfill his super-objective; otherwise, the action will be prematurely terminated. Hence a whole series of fairly predictable, causally related choices on the part of the user-character are stimulated by the single super-objective that has been expressed as an explicit constraint at the beginning of the game.

The notion of applying formal constraints by establishing the user-character's prime objective can be applied in a more sophisticated way, without explicitly limiting the user's choice of objectives in a given fantasy world. The system may utilize templates for user-characters with various motivations. Basically, the system notices what the user is doing, selects a template which most nearly matches the user's apparent motivation, and adjusts the system's contributions to the plot accordingly.

²¹However, as science fiction author Harlan Ellison observed in an unpublished review of the game, it is not possible to meet that goal because the bad guys just keep getting better—an affliction shared by many video games. "... the lesson," moans Ellison, "is the lesson of Sisyphus. You cannot win. You can only waste your life struggling and struggling, getting as good as you can be, with no hope of triumph." One might speculate that this incredibly frustrating feature of game design contributed to the decline of the video-game genre in 1983 and 1984.
The system's reasoning goes like this: "If he is doing x, then he probably wants y. Therefore, incidents a, b, and c are likely to cause him to make choices d, e, and f." The template lists the candidate objective and a set of incidents that are likely to elicit certain responses based on that objective, as well as the responses themselves. It is a recipe for plot formulation, and it may be used for both prediction and constraint of the user-character's choices and actions.

A template may also be devised by assessing the user-character's traits rather than his objectives. Although the memory and processing limitations of small computers have so far precluded the use of a full-blown template design, a few designers have managed to create the effect of intelligent system response to the user-character's traits.\textsuperscript{22}

User-character templates are a type of implicit formal constraints. Other formal constraints may be applied explicitly, as in the \textit{Star Raiders} manual, where the proper protocols for operating the ship and its devices, as well as strategic advice, are described to the user before play begins, thereby constraining his choices and actions.

\textbf{Material Constraints}

Material constraints are constraints that operate through the force of material causality. They are expressed on all levels other than the level of

\textsuperscript{22}In his 1976 version of a "Star Trek" game on a main-frame computer at Battelle Memorial Institute in Columbus, Ohio, Joe Miller created such an effect by generating remarks from the enemy captain that pointed out the user-character's traits; e.g., "You are shrewd, Captain Laurel." See, also, Chris Crawford's \textit{Eastern Front}.  

plot. Constraints expressed on the level of character are classified as material constraints because traits and predispositions, whether determined by the user himself or contributed to him by the system, are materials from which he will formulate the character's choices and actions, which in turn become part of the plot.

The most straightforward means of suggesting traits and predispositions to the user-character is to assign the user a specific character to portray before the action begins. In Pac Man, for instance, the user always "plays" the character of Pac Man, who has clearly defined objectives, characteristic ways of moving, and various quirks (like hiding in corners) that can be utilized in game play.

The user may also be allowed to select a character from a number of alternatives. In the PLATO game of Empire, for example, users may opt to play as any of four kinds of beings (members of the Federation, Orions, Klingons, or Romulans). Each group has distinctive traits (e.g., Klingons are ruthless and unethical; Romulans are extremely regimented and bound by a strict code of military honor), as well as distinctive weapons, armaments, and ships that have special advantages and disadvantages in game play. In the action game Crush, Crumble, and Chomp, the user may select his favorite monster to portray, then proceed to destroy various cities and decimate civilian populations.²⁴

²³Empire, network adventure game (Control Data PLATO Network, 1978).

The user may also be allowed to devise his own character by selecting traits from a pre-determined set. Because the traits offered are known to the system, the system can presumably predict the user's behavior more accurately and use that information to make plot decisions. Some adventure games use this method of pre-determining the user's character, although in an elementary way. In the PLATO game *Krozaïr*, for example, the user selects a character profile that includes a group of traits and a designation for, or numeric value to describe the relative strength of, that trait. Traits include physical characteristics like sex, strength, intelligence, and species, as well as personality traits like charisma.\(^{25}\)

Each of the techniques described above—assignment of character, selection of character from a group of choices, or user configuration of character from a set of traits—utilizes explicit constraints which are applied before game play actually begins. They serve to delimit the choices that the user-character may make in the course of the action. Other material constraints may also be applied in this manner; e.g., a physical description or map of the fantasy landscape and the other characters that the user may encounter, presented in the game manual, as in *Zork* and many other adventure games. Pre-game exposition may also be presented in this manner.

Material constraints may also be provided implicitly through exposition presented during game play. The user may discover physical aspects of the fantasy world, characters, and past events in the story line in this manner. To insure that the user becomes familiar with such elements

\(^{25}\) *Krozaïr*, network adventure game (Control Data PLATO Network, 1980).
early on, the designer may wish to delay active participation by the user until the bulk of the exposition has been presented.

Finally, both material and formal constraints may be applied by utilizing a story and/or fantasy world that is already known to the user. The graphical adventure game The Dark Crystal, for example, is based on a film that the user is presumed to have seen. The traits and objectives of the characters (including the user-character) and the attributes of the fantasy world remain the same as those in the film, and the user's contributions are limited to choices and actions that fit into a pre-determined scenario.\textsuperscript{26} However, this approach tends to specify the plot so completely as to undermine interactive functionality, as it did in the CyberVision Story Series.

User contributions to the plot may be constrained by the capabilities of the input and output devices used in the system. By constraining what—or whether—the user may see, hear, and say, the system may indirectly constrain his thoughts, choices, and actions. In the Infocom adventure games, for instance, the system recognizes only about 600 words. Words that are unknown to the system cannot effect any change in the fantasy world; choices and actions that are represented by unknown words cannot be performed. In the case of Zork, the way the system handles unknown words is intrusive and destructive of first-personness.

It is difficult to avoid such a disruptive effect when the user is allowed or encouraged to make a choice that he cannot express in an effective way to the system. Zork is presented entirely in a verbal mode. The user is encouraged to use natural language to express his choices, and so expects

\textsuperscript{26}The Dark Crystal, personal computer game (Sierra Systems, 1982).
words to work. He has no clue except the experience of failure to tell him which words are unknown to the system. On the other hand, given the text-based nature of the game and the equipment that it is usually run on, the user is never encouraged to attempt to express himself through gestures or physical actions. The absence of visual and kinesthetic modes in the system is accepted as a given, and the resulting constraints are unobtrusive. Such constraints are extrinsic to the action, but may be utilized effectively if they are presented simply and explicitly, or if they are integrated into the mimetic context (e.g., "this ship is not equipped for voice communication").

Generally, the more modes that are present in the interface (verbal, visual, auditory, etc.), the more complex the system must be, in order to handle the reception and interpretation of a wide variety of inputs, and to formulate and orchestrate its responses. Constraining the user through limitations on input and output capabilities becomes less effective as the number of modes in the interface increases; separate sets of constraints for each mode serve to confuse and frustrate the user. In a multi-modal interface environment as proposed in this paper, intrinsic formal and material constraints are therefore preferable to those based on the technical characteristics of the interface.

This chapter has focused on the experience and behavior of the user of an IF system. First-person interaction, a goal of the system, is the product of the contextual, physical, and interactive qualities of the human-computer interface. In order to sustain first-person interaction without disruption to either the system's operation or the user's experience, limitations must be placed on the behavior of the user-character. Explicit constraints are best
expressed before the action begins. Extrinsic constraints are to be avoided if possible; however, they can be made to appear intrinsic to the action by expressing them in terms of the mimetic context. The least intrusive and potentially most effective constraints are implicit in the action; they function by limiting what the user thinks of doing. Constraints may be designed to operate through the forces of both formal and material causality. Their ultimate function is to enable the user to experience functional interaction in ways that provide the system with materials which can be formulated into a dramatically satisfying plot.
CHAPTER IV
MATERIALS FOR PLOT FORMULATION

Materials that are used by the PLAYWRIGHT to formulate the plot of an interactive fantasy derive from three principal sources: the words and actions of the user-character, the contributions of the SYSTEM CHARACTERS, and the information contained in the WORLD MODEL. This chapter examines the means by which those materials may be gathered, generated, and interpreted.

In order to respond to the words and actions of the user, an IF system must accomplish understanding and inference tasks of enormous proportions. The performance of those tasks depends heavily upon natural-language processing techniques—methods that enable computers to understand and manipulate spoken or written text. The system must also contain entities ("intelligences") that can generate goals and plans, make artistic decisions, and execute actions, utilizing many of those same techniques.

Artificial Intelligence (AI), as described by psychology and philosophy professor Margaret Boden, "is not the study of computers, but of intelligence in thought and action. Computers are its tools, because its theories are expressed as computer programs that enable machines to do things that
would require intelligence if done by people."¹ Many of the sub-disciplines of AI are associated with the understanding and generation of natural language (a language that has evolved naturally and is used by humans, like English, as opposed to one that has been consciously invented for a special purpose, such as a computer programming language). AI has tackled understanding problems of increasing complexity, moving from the understanding of words and sentences to the understanding of stories and other kinds of connected discourse. AI research in the generation of language has experienced a similar progression. Because most AI research is at least ostensibly intended to elucidate human cognition (rather than simply to create smart machines), it relies on computer models of human processes, even though other process models might produce similar results more efficiently.²

Devotion to human models in the design of natural-language-related systems has its advantages. In interactive systems, it may facilitate the integration of human-produced and machine-generated materials. On the whole, it seems likely that any shortcomings in speed and efficiency that result from the use of human-process models will be overcome as those models are developed, since humans are the fastest and most efficient natural-language processors known.


Understanding the User-Character

The user-character responds and contributes to the dramatic action within the interface environment. As discussed in Chapters I and II, that environment is multi-modal; that is, it can both sense the user and create effects for him in visual, auditory, linguistic, and other modes. Gathering materials from the user-character is roughly a three-stage process: his words and actions must be sensed, recognized, and understood. Sensing the user necessitates the ability literally to see and hear him in the interface environment. The more acute the sensing capabilities are, the more data they may collect. That data must in turn be recognized as words or gestures. The understanding process involves determining the meaning of what has been recognized. Understanding words and actions in context requires the ability to make inferences.

Sensing the User-Character

Techniques that can be used for sensing the user-character are most highly developed in the linguistic mode, therefore most usable inputs from the user-character will make their initial appearance on the level of diction. Although generally primitive, technical means also exist for sensing some of the para-linguistic elements of speech and the contributions of the user on the level of spectacle. From those inputs, the system is charged with making inferences about the user-character on the levels of thought and character.
In this section, current developments and research directions in each of the component areas of user-sensing technology are reviewed.

Although early research in the problem of speech recognition was conducted in the 1930's and '40's, machine recognition of speech was not achieved until 1952. Twenty years later, the first commercial word recognizer became available.\footnote{Michael G. Joost, "Problems in Vocal Man-Machine Communication," in \textit{Human-Computer Interaction}, ed. G. Salvendy (Amsterdam: Eisevier Science Publishers, 1984), p. 449.} At present, most speech recognition devices must be "trained" to recognize a limited vocabulary from a specific speaker—that is, they are speaker-dependent.

The technology has already progressed from recognition of single words in isolation to recognition of connected words in phrases and sentences, a technique which makes syntactic as well as lexical information available for processing. One of the most sophisticated recognizers now commercially available can recognize connected speech with a vocabulary of up to 150 words by means of digital pattern-matching. It requires one standard pronunciation per word by each user for training.\footnote{Specification sheet for DP-200 Connected Speech Recognizer, Nippon Electric Co., Cat. No. E63010, c. 1983.} Current research focuses on the goal of speaker-independent recognition of connected speech.\footnote{W. Lee, ed., \textit{Trends in Speech Recognition} (Englewood Cliffs: Prentice-Hall, 1980), \textit{passim}.} IBM has reportedly developed an experimental system that can recognize "spoken English sentences composed from a 5000 word business correspondence vocabulary with more than 95 percent of the
words identified correctly." The system employs both phonetic and contextual cues to distinguish among similar words.6

Writing on the human factors aspects of speech recognition technology, Michael G. Joost has enumerated several research needs, including better error detection and correction, at least partial speaker-independence, improved techniques for training both user and hardware, and better methods for determining vocabulary size and selection criteria.7 Techniques that are currently being developed to minimize errors and increase vocabulary include the design of implicit constraint strategies for encouraging users to employ only the available vocabulary,8 and the use of context-dependent vocabulary subsets in speech recognizers.9 The use of such vocabulary subsets minimizes the number of active alternatives while maximizing the size and flexibility of the overall recognition vocabulary.

Another approach aimed at both increasing vocabulary size and attaining speaker-independence has been implemented by Daniel P. Huttenlocher and Victor W. Zue of the Artificial Intelligence Laboratory at the Massachusetts Institute of Technology. Their system utilizes partial phonetic information to select a relatively small number of candidate words from a


8Ibid., p. 453.

9David Isenberg, Douwe Yntema, and Ray Wiesen, "Designing Speech Recognition Interfaces for Talkers and Tasks," in Human-Computer Interaction, p. 456.
20,000 word lexicon, thus effectively limiting the size of the recognition
vocabulary on a word-by-word basis. The system requires no training and is
functionally speaker-independent. A similar technique utilizing
recognition of "robust phonetic features" to effectively limit vocabulary has
been implemented in a system with a 1,000 word lexicon. Recognition of
domain-specific keywords has also been employed to cue the speech
recognizer to load the germane vocabulary subset from a much larger
("virtually unlimited") vocabulary.

Training of a system to a specific speaker, as well as training it to a
vocabulary, may be accomplished tacitly; that is, the user need not be aware
that the system is "learning" about him as interaction proceeds. Such tacit
training is implemented in an intelligent phone-answering system designed
by Chris Schmandt of the Architecture Machine Group at MIT. The "Phone
Slave," as the system is called, learns to recognize various callers and to
greet them by name in subsequent interactions. The system guides callers

10Daniel P. Huttenlocher and Victor W. Zue, "A Model of Lexical Access from
Partial Phonetic Information," Proceedings of the IEEE International
Conference on Acoustics, Speech, and Signal Processing (New York: IEEE,
1984), p. 26.4.1. For the convenience of the reader, a key to acronyms is
included in the Bibliography.


12Chris Schmandt and Walter Bender, "A Programmable Virtual Vocabulary
Speech Processing Peripheral" (Cambridge, Mass.: Architecture Machine
Group, Massachusetts Institute of Technology, 1983), pp. 9-10.
through the training interaction by politely asking routine, message-taking questions; user constraints are implicit and intrinsic to the context.\textsuperscript{13}

A system designed by M. A. Richards and K. M. Underwood of the British Telecom Research Laboratories tacitly encourages "behaviour that would be potentially useful for enabling automatic speech recognition and analysis." The system explores "politeness" and "explicitness" in initial interactions with users as implicit constraint variables.\textsuperscript{14} Similar tacit training techniques could be employed by an IF system, in an initial "getting acquainted" or "orientation" session, or throughout the dramatic interaction to continually improve the system's knowledge of the speaker and his contributions to the vocabulary of the fantasy world.

In machine understanding of human speech, the distinction between speech recognition and deeper levels of understanding are often blurred. A primary area of challenge in speech understanding—one that involves work on all levels of the understanding process—is the ability to handle some of the vicissitudes of conversational style. Philip Hayes and Raj Reddy of Carnegie-Mellon University have identified some of the problems with conversational speech processing:

\begin{quote}
While natural language interfaces typically perform well in response to straightforward requests and questions within their domain of discourse, they often fail to interact gracefully with
\end{quote}


their users in less predictable circumstances. Most current systems cannot, for instance: respond reasonably to input not conforming to a rigid grammar; ask for and understand clarification if their user's input is unclear; offer clarification of their own output if the user asks for it; or interact to resolve any ambiguities that may arise when the user attempts to describe things to the system.\textsuperscript{15}

Accordingly, Hayes, Reddy, and others are conducting research in the following areas: interpreting ungrammatical input, recognizing and handling the need for clarification, keeping track of the focus of attention in dialogue, and designing "graceful" user constraints. Hayes and Reddy predict that major progress will be made in the short term.\textsuperscript{16}

Another goal of an IF system is to sense and interpret non-verbal aspects of the user-character's behavior—the user's contributions on the levels of spectacle and music. The user should feel that where and how he moves, his gestures, and the inflection and quality of his voice all "count." Eliminating any of these non-verbal channels from the input environment will weaken the first-person nature of the user's experience. Data from non-verbal channels can only enrich the system's ability to understand the user by providing additional sources of information.

Dr. Nicholas Negroponte, director of the Arts and Media Technology Laboratory at MIT, articulates the concept of and the framework for an interface environment that would include a plethora of verbal and non-verbal channels for interaction in the concept of a "Media Room." Negroponte's


\textsuperscript{16}ibid.
vision is a multi-media interface environment in which an "informational surround" for the user is accomplished with a variety of technologies employed in concert, including interactive video displays, spatially synchronized sound, body tracking, eye tracking, touch-sensitive displays, and speech recognition.\textsuperscript{17} Over the last several years, researchers in Negroponte's laboratory (primarily the Architecture Machine Group) have made outstanding contributions in the conception, design, and application of multi-modal interface techniques. Many of those studies are cited below, as well as in other chapters of this work. Negroponte offers an optimistic view of both the conceptual and technical evolution of the multi-modal approach:

> Just a few years ago (maybe even less than two) it would have been outrageous if not laughable to propose such extreme elaboration of computer graphics in specific, and the human interface in general. Even if the above [description of a media room] seems wanton today, we really must ask ourselves about tomorrow. We all know that computer costs are dropping, powers are rising, and that there is a growing cultural computer presence. While everybody seems to know this, few people really believe its impact will be so important; but it will be. As such, it is time to focus serious attention on the "stuff" that lies between people and computers.\textsuperscript{18}

Techniques have been developed in Negroponte's laboratory and elsewhere that can sense users' manual gestures, eye movements, and changes in physical location. Body-tracking technology provides a means whereby a computer can be told where its user is in three-dimensional space, and can measure the direction and speed of his movements.


\textsuperscript{18}Ibid., p. 113.
Depending upon how a body-tracking system is implemented, it may provide gross positional information or specific information about the movement of the head, limbs, or even fingertips. In the 1960's and early 1970's, body-tracking techniques were developed using sound, light, and mechanical linkages. The utility of such systems was severly limited by their inherent physical encumbrances and spatial limitations. In his work on applications for three-dimensional input, Chris Schmandt of the Architecture Machine Group utilized a body-tracking system based on electromagnetics, the ROPAMS (Remote Object Position and Attitude Measurement System). The user wears one or more small sensors attached to his body, and the system measures the distance between a sensor and a radiating device. The ROPAMS

is a full six degree of freedom measuring device, providing both x,y,z position as well as attitude described by the three Euler angles on a sensor body with respect to a reference radiator body. Working with electromagnetics, it eliminates both the burdens of linkages as well as transmission problems associated with light and sound.\textsuperscript{19}

At MIT, the ROPAMS device performed with high accuracy within a local range of three to four feet, but Schmandt points out that employing a larger radiator antenna and filtering of other sources of radiation in the interface environment could effectively increase that range.\textsuperscript{20}

The ROPAMS was employed in various applications to track gross body position, pointing, and other gestures. Experimental applications

\textsuperscript{19}Christopher Schmandt, "Some Applications of Three-Dimensional Input", (Master's Thesis, Massachusetts Institute of Technology, 1980), pp. 5-7.

\textsuperscript{20}Ibid., p. 11.
included a system in which the user could "paint" on a graphical display via his body movements, a system in which the scrolling of text on a display was controlled by the user's head attitude, and a system in which body movement was utilized to control graphical objects in motion.21

In a system called "Put That There," implemented by Schmandt and Eric A. Hulteen, gesture recognition was employed in combination with speech recognition to allow a user to build and modify a graphical display.22 The ROPAMS sensor was mounted on the user's wrist, allowing him to point and gesture freely. The use of speech and gesture together in the interface created what Schmandt describes as a "sense of presence, immediacy and intuitive clarity of the interaction."23 In a separate analysis of the "Put That There" project, Richard Bolt reports the ways in which a gesture was used to clarify the meaning of verbal input, providing assistance in the interpretation of pronomial references.24

Scott Fisher and Ann Marion employed the ROPAMS device in an Arts and Media Technology project at MIT to generate computer graphics from body-tracking input provided by dancers. The project was to develop

21Ibid., pp. 17-24.

22In the context of computer displays, "graphical" is used as an adjective to distinguish it from the word "graphic," which is often used as a noun, e.g., "computer graphic(s)". A graphical display is one which employs pictures ("graphics") as opposed to text.


a feasibility study for real world implementation of converging research in body tracking, computing and imaging technologies in collaboration with the artistic and technical staff of the Joffrey Ballet Company. The goal of the project is to design a real time, interactive stage set in which dancers can "draw" with their bodies as they move through the space of the stage or manipulate virtual elements of the set with their gestures.25

Fisher and Marion employed multiple sensors mounted on various points on the dancers' bodies to provide a variety of measures of movement, each of which could be used as a parameter in the creation of the companion animation. The fact that the dancers could be sensed, their positions and movements processed, and animation produced in real time is of great significance in the consideration of the uses of body-tracking technology in interactive fantasy applications.

Margaret Minsky, another MIT researcher, has created a system which employs gestural input to manipulate objects in a graphical display. Although Minsky's system utilizes a touch-sensitive display rather than a remote tracking device, it employs a notion of "gesture parsing"26 that could be utilized in three-dimensional applications. Her system uses two-dimensional gestural data to classify gestures according to their intent (selecting something, moving something, or indicating a path). The gesture


26"Parsing," a term that is often employed in the context of speech recognition, refers to the process of breaking a sentence into its component parts of speech and describing their grammatical and syntactic relations. The notion of "gesture parsing" suggests that gestures may be interpreted in much the same way as words. It implies that specific, recognizable gestures have specific meanings, that the parts of gestural expressions and their syntactic relations can be identified.
is interpreted through the use of information about its trajectory, the nearest object, the pressure applied to the display, changes in pressure over time, and other factors. 27

Both "Put That There" and Minsky's system are pioneering efforts in the systematic interpretation of gestures that are not explicitly constrained; in both cases, the nature of the task and the form of the representation presented to the user serve to constrain the intentionality and physical characteristics of the gestures that the user is likely to employ. In an IF system, similar intrinsic and implicit constraints could be provided by the context of the action. In a given situation, a person employs a limited set of gestures, some of which are stereotypical (e.g., "dukes up" in a fistfight). An IF system could call upon various limited gestural vocabularies at various points in the action, much as a speech recognizer might employ contextual cues to select and load a limited recognition vocabulary. 28 Thus, one "gestural vocabulary" might be used in the context of informal conversation.


28 Psychologist and philosopher Manfred Clynes has developed a system called sentics which purports to measure the "characteristic wave-forms" of emotions. Clynes contends that a distinctive shape is somehow genetically associated with each of the basic human emotions, and purports to have found evidence for his theory in laboratory experiments, as well as in music, painting, dance, and other art forms. See Manfred Clynes, Sentics: The Touch of Emotions, Garden City, NY: Anchor Press, 1977.
while others could be provided for situations in which movement is more formalized, such as a courtroom scene or a duel.²⁹

In interactive fantasy applications, gross body position and movement are probably less context-dependent than gestures of the arms, hands, or head. Gross movement might be characterized in terms of speed, direction, distance, acceleration, and objects in the fantasy environment toward or away from which the user-character appears to be moving. Those characteristics could be used to interpret physical action in the dramatic context. Information about body position and movement could also be used to tune both the visual display and directional sound output to enhance the first-personness of the user's sensory experience.

Information about what a user is looking at in a display can also be utilized to help clarify the meanings of his words and actions. Early research and development in eye-tracking technology was devoted to understanding how humans acquire visual information. More recent efforts have investigated the use of eye movement as an input channel in human-computer interfaces.³⁰

Techniques for measuring eye movement have included the use of skin electrodes, fixed-head and head-mounted equipment for measuring

²⁹The work of François Delsarte in France in the nineteenth century in describing a formal gestural vocabulary for actors and public speakers was based on a similar theory of gestural communication—see Geneviève Stebbins, Delsarte System of Dramatic Expression (New York: E.S. Werner, 1886). The topic of "body language," employing gesture and physical attitude to infer emotional, social, and other information, has received much attention in popular psychology—see, for example, Julius Fast, Body Language (New York: Pocket Books, 1971).

³⁰Negroponte, p. 113.
changes in corneal reflection, reflectivity-measuring equipment mounted in
spectacle-like frames, and devices attached to the eye with contact lenses.\textsuperscript{31}
Most early techniques were marred by either obtrusiveness (as in the fixed-
head and helmet-like equipment), intrusiveness (as with electrodes and
contact lenses), or severe limitations on the ability of the user to move during
eye tracking.

In 1981, Gulf and Western Applied Science Laboratories introduced
an eye-tracking system that requires no hardware to be worn by the user.
The system calculates the user's point of gaze by monitoring corneal
reflection through a telephoto lens. A servo mirror under computer control
attempts to keep the image of the pupil centered when the user moves his
head.\textsuperscript{32} Such a system, installed in the Media Room at MIT, can measure
the eye movements of a user in scanning up to 90 percent of the media room
display (a wall-sized screen) and can compensate for head movements
within one cubic foot of space.\textsuperscript{33}

In a media-room project entitled "World of Windows," Chris Schmandt
and Eric A. Hulteen employed both the eye tracker and the ROPAMS device.
Considered together, the measurements provided by both devices allowed

\textsuperscript{31}Laurence R. Young and David Sheena, "Eye-Movement Measurement

\textsuperscript{32} "Eye-Trac: Eye View Monitor Model 1998" (product brochure, Gulf and

\textsuperscript{33} Applied Science Laboratories, "Feasibility Study: Installation of Applied
Science Laboratories Eye Movement Monitor in the MIT Architecture
Department Media Room" (Waltham, Mass.: Applied Science Laboratories,
the user's point of gaze to be calculated from anywhere within the range of
the body tracker, effectively eliminating previous constraints on gross
physical movement during eye tracking. As described by Richard Bolt, the
project was intended to provide a "gaze-interactive interface" for a user
regarding a wall-sized display composed 20 or more "windows," each of
which might contain a video image, a film, or other dynamic display of
information.34

A similar strategy might be used in an IF System to conserve
resources, utilizing highest resolution only in the portion of the display where
the user is looking. Eye tracking can also allow the system to determine
what portions of the display the user has and has not seen, affecting his
knowledge of events. Frequency and duration of gaze could be used to cue
the system as to which objects in the display are considered most important
by the user. The focus of the action from the user-character's point of view
could be inferred from such information, enabling further inferences to be
made about the user's understanding of the action and his expectations
about future events. Eye tracking technology could conceivably be used to
provide gestural information (e.g., a sidelong glance or a wink) from which
intentions and emotional states might be inferred.

Another source of information that can be used in the task of
understanding the user-character is the non-verbal qualities of speech.
These paralinguistic qualities include intonation, inflection, vocal quality,
pitch, and rate. By and large, information and hypotheses on the usage and

34Richard A. Bolt, "Gaze-Orchestrated Dynamic Windows," *Computer
significance of such qualities have been developed in the domains of psychology and linguistics and have not yet been widely utilized in machine recognition and understanding of human speech. The signal-processing technology for sensing such variables as pitch and rate is available; however, the techniques for making use of such information are not well developed. In 1980, researcher Steve Gano of Hewlett-Packard Laboratories characterized the state of research in the area as embryonic. He noted that means had not yet been developed to isolate the characteristics of intonation and emotional expression in digitized speech signals and suggested that such characteristics may not be amenable to quantification.\textsuperscript{35}

Since the date of Gano's observations, significant research progress has been made in identifying and quantifying paralinguistic variables.\textsuperscript{36} Among the studies that have been reported is work by Carl E. Williams and Kenneth N. Stevens on the acoustical correlates of emotions in speech. Williams and Stevens employed recordings of both professional actors and people involved in real-life situations that expressed various emotions. Speech spectrograms derived from those recordings were analyzed in an

\textsuperscript{35}Steve Gano, annotated bibliography on paralinguistic analysis prepared for the Architecture Machine Group, 1980.

\textsuperscript{36}In addition to reported studies, it is almost certainly the case that such research is being conducted in areas where publication is proscribed by commercial competition or "national security" concerns. The author received informal reports in 1984 that such "classified" research was being conducted by such agencies as the National Security Administration.
attempt to "identify and measure those parameters in the speech signal that reflect the emotional state of a speaker."  

Previous studies indicated to Williams and Stevens that changes in the fundamental frequency of speech carries clues about emotion and other kinds of non-verbal information, whether or not the speaker's expression was intentional. The fundamental frequency of an utterance reflects physiological changes that are associated with emotion, including changes in respiration that affect subglottal pressure as well as temporal patterns in speech, dryness of the mouth, salivation, and tremor, each of which can be linked to various emotional states.  

Using recordings made by several actors, Williams and Stevens were able to characterize the fundamental frequency contours for the emotions of anger, sorrow, and fear, as compared to emotional neutrality. They were also able to identify differences in rate of articulation that corresponded to the four emotions. Utterances made in situations involving sorrow, for instance, were of the longest duration, with relatively flat fundamental frequency contours. Angry utterances were of much shorter duration, and the fundamental frequency contours showed large peaks, indicating strong emphasis on selected syllables. To assure themselves that the data obtained from actors was valid, Williams and Stevens also analyzed the

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38 Ibid., p. 1239.

39 Ibid., pp. 1240-1244.
recorded voice of the radio announcer who reported the Hindenburg
disaster, and then compared the results with those from a tape of an actor
speaking the same words. Although the actor's voice exhibited less
inflection than the announcer's before the crash, the fluctuations in
fundamental frequency after the crash were comparable\(^{40}\)—evidence that
even an imitation of emotional state can affect the fundamental frequency of
an utterance in relatively predictable ways.

The speech spectrograph provides quantified representations of
utterances that can be interpreted by computers as well as by humans. A
recent study published by Bell Laboratories utilizes fundamental frequency
contours to produce intonation in synthesized speech. Its authors use the
dimensions of melody, stress, and pitch to communicate different pragmatic
and emotional qualities with the same lexical phrases.\(^{41}\) The authors point
out that synthesis provides a means of testing observations about the
meaning of various intonational features.\(^{42}\) When those observations are
validated, it follows that they may be used reliably in speech recognition and
understanding.

Paralinguistic analysis could provide many kinds of information for an
IF system. Analysis of inflection (pitch and stress patterns) could provide

\(^{40}\)Ibid., p. 1248.

\(^{41}\)Mark D. Anderson, Janet B. Pierrehumbert, and Mark Y. Liberman,
"Synthesis by Rule of English Intonation Patterns," Proceedings of the IEEE
International Conference on Acoustics, Speech, and Signal Processing

\(^{42}\)Ibid., p. 2.8.2.
clues about the grammatical characteristics of utterances, from gross classification of statements (e.g., declarative or interrogative) to the detection of subtleties like implied antitheses. Information about pitch, rate, and quality could be used to infer emotional states.

Sensing the user-character at the interface level—that is, gathering data about the user's words and actions—is one of the most technically challenging aspects of an IF system. Other aspects of the system, including most of the machinery for understanding and inference as well as the functioning of the PLAYWRIGHT, could be developed and tested using textual input and output exclusively; however, such a text-only world can be thought of only as a weak precursor to an interactive fantasy system.

The technologies involved in user-sensing are generally less mature than other components of an IF system; however, with current technology—a limited speech recognition vocabulary (as few as 150 words), some gross sensing and understanding capabilities regarding body movement and gesture, and a story domain that implicitly constrains the user to operate within the small vocabularies of both verbal and non-verbal recognizers—such a system could gather sufficient materials from a user-character to produce a simple interactive drama. Anticipated developments in user-sensing technologies will not change the fundamental operation of an IF system, but will potentially enhance its responsiveness to the user-character and enable it to produce interactive dramas with increasing sophistication and flexibility.
Representing Understanding

How does a machine represent ("remember") what it has understood? How can that machine representation be examined and manipulated? After a human utterance is captured by a speech recognizer, parsing techniques extract the syntactic and lexical information that is used to create a representation of the utterance that may be further manipulated by a computer.

The form taken by the "internal representation" of an utterance (i.e., the way that utterance is represented within the computer) may also be used to represent other, non-verbal information. A common theme in the stated objectives of research in language understanding is the desire and belief that means of understanding can be found that are truly inter-modal; that is, that a method can be developed whereby inputs in a variety of modes can be resolved to a common representational form so that they can be manipulated by a computer, and that inputs thus represented can be reconstituted in other modes. R. F. Simmons has suggested that information which was originally cast as words, images, or physical actions might be represented in a common form in a structure called a "semantic network." Generally speaking, a semantic network is a cognitive map that encodes information as a network of concepts connected by semantic relations. Such a network might someday be used to transform information from one modality to another, e.g., translating images into words and vice versa. So
far, however, semantic networks have only been used to represent information contained in English sentences.\textsuperscript{43} Likewise, the theory of understanding developed by Robert Wilensky purports to have inter-modal applicability. Wilensky claims that his understanding techniques could potentially be used to extract and represent information from films and direct observation of physical events.\textsuperscript{44} Other researchers have developed systems that generate non-linguistic representations from language-based descriptions. Kenneth Kahn, for instance, has developed a system that will create simple animated cartoons from descriptions of stories such as the fairy tale, "Cinderella." In Kahn's program, character traits and relationships are associated with descriptions of appropriate behaviors that function as animation commands. Thus a story described in terms of traits and relationships can be automatically animated.\textsuperscript{45}

Obviously, inter-modality is a highly desirable aspect of the understanding processes and internal representations of ideas and events to be used in an IF system. In fact, the IF system could be seen as an ultimate test of inter-modality, since both inputs and outputs exist in a variety

\textsuperscript{43}R. F. Simmons, "Semantic Networks: Their Computation and Use for Understanding English Sentences," in Schank and Colby, p. 66.


\textsuperscript{45}Kenneth Michael Kahn, "Creating Computer Animation from Story Descriptions" (Ph.D. dissertation, Massachusetts Institute of Technology, 1979).
of modes simultaneously. The ideal system is one in which inputs in all modes are cast in a common form of internal representation. In the case of an IF system, inputs made on the levels of spectacle, music, and diction would be represented using the same internal "language," so that they can be evaluated and manipulated by the PLAYWRIGHT. Likewise, the "script" that is produced by the PLAYWRIGHT would take the same form, to be subsequently reconstituted in a variety of modes by the SYSTEM CHARACTERS and the ENACTOR subsystem. Such a "common language" for internal representation should not be allowed to obliterate the differences between events that occur in different modes or the relations among them—indeed, the original mode of anything that happens in the enactment (including the inputs of the user-character) needs to be noted so that the system can guarantee the proper relations among qualitative structural elements.

Using an inter-modal technique for understanding and representing meaning, a physical gesture by the user-character could be understood and utilized in plot formulation. Suppose the user-character makes a forceful, tense, and sustained pointing gesture directed at the cat seated on his new sofa. The idea that the user-character is angry and the object to which the gesture refers (the cat) is then included in the internal representation of the action. Other information pertaining to the objects and action in question is noted (the cat belongs to the "neighbor" character; the sofa belongs to the user-character, the "neighbor" likes the user-character, and so forth). The PLAYWRIGHT then employs that information in formulating the next plot incident, which is represented in the same internal "language." If the
PLAYWRIGHT decides that it is best for the plot that the user-character's anger be appeased and that his relationship with the "neighbor" remain intact, the SYSTEM CHARACTER who is the "neighbor" is directed by the PLAYWRIGHT to remove the anger-provoking object. From the internal representation provided to it, the SYSTEM CHARACTER then animates the desired action—the removal of the cat from the sofa—and generates the utterance, "Oh, I'm so sorry." In this example, a gestural input results in both physical and verbal responses.

Various approaches have been employed in natural-language processing for creating internal, machine-manipulable representations of the meanings of sentences. Simmons' theory of semantic networks is one such approach. Simmons employs a technique whereby a "semantic analysis of a sentence transforms this string into a structure of unambiguous concept nodes interconnected by explicit semantic relations." In addition to providing a means for creating an internal representation of existing sentences, semantic networks may also be used to generate new sentences from the information encoded in them.

The theory and techniques of Roger C. Schank are utilized by most systems that understand natural-language materials, including dialogues, narratives, and news stories. Schank's method for representing meaning, termed Conceptual Dependency (CD), employs networks of concepts linked

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46 Simmons, p. 67.

47 Ibid., p. 92.
by explicit relationships (called dependencies) that are similar to semantic networks, with a somewhat simpler scheme for classifying concepts.\textsuperscript{48}

While Schank makes no claim to inter-modality (although there is nothing to prevent inter-modal application of his theory), he maintains that "any two utterances that can be said to mean the same thing, whether they are in the same or different languages, should be characterized in only one way by the conceptual structures." Schank describes such representations as "interlingual."\textsuperscript{49}

The CD representation of a sentence is the result of the parsing process. In most natural-language-related systems, it is the only form of a sentence required by the system for all its processing: as Wendy Lehnert describes one such system, "None of the processes which follow [the initial parse] require knowledge of what words or syntactic constructions were in the original question."\textsuperscript{50} Given the fact that many sentences may be resolved to the same CD representation (because they contain the same conceptual and logical information), it would appear that the use of CD methods entails the sacrifice of whatever information may have been contained in the "lost" lexical, syntactic, or stylistic peculiarities of a particular

\textsuperscript{48}Roger C. Schank, "Conceptualizations Underlying Natural Language," in Schank and Colby, p. 192. The form of a CD representation may be difficult to visualize. Schank's article provides several schematic examples; see especially those on pp. 193-201. For examples of CD representations in actual program code, see Meehan, pp. 195-198.

\textsuperscript{49}Schank, "Natural Language," p. 188.

sentence. CD representation would not capture the difference between a sentence presented in iambic pentameter, for instance, and one cast in prose which had the same conceptual content. It might not distinguish between synonyms like "maiden" and "girl."

Although such differences would not necessarily be preserved in CD representations, they could in fact be "noticed" by a system, if that system were told what to notice and how to do so. Just as an IF system could notice and remember differences in modes of original inputs, so it could be made to notice and analyze lexical and stylistic features of the original forms of utterances. The tasks of identifying those features that are significant to the action and specifying methods for analyzing and interpreting them, however, are prodigious. It is likely that techniques for such "stylistic" analysis of natural language will be developed in due course and should be integrated into an IF system model as they become available. For example, techniques have been proposed for understanding text in subcultural and occupational dialects.\textsuperscript{51} Techniques for controlling stylistic variables of computer-generated text (as in the dialogue that might be generated by SYSTEM CHARACTERS) are also being developed.\textsuperscript{52}

Any technique for understanding language with a computer must include a way of determining what the computer has actually understood. In many applications, the measure of understanding is indirect; that is, the user

\textsuperscript{51}\textit{Ibid.}, p. 120.

\textsuperscript{52}See Paul Lincoln Juell, "Improvements in the Style of Computer Generated Natural Language Text" (Ph.D. dissertation, The Ohio State University, 1981).
of the system cannot inquire directly what the system has understood, but can infer it from the system's overall behavior. A text adventure game like *Zork*, for example, reveals its understanding of the user's natural-language-like input primarily through the game-play itself. An IF system would likewise provide an indirect measure of understanding, through the dramatic action that results, in part, from the user's inputs and the way in which they have been understood and interpreted by the system.

More direct methods of measuring understanding are employed in research systems that are designed to test new understanding techniques. Such methods can be utilized in the internal design of an IF system by making understanding manifest in certain kinds of action, and also by providing means by which the various subsystems may obtain information from one another.

The work of Terry Winograd at the Massachusetts Institute of Technology has resulted in action-based criteria for natural-language understanding. At MIT Winograd explored various types of knowledge needed in language understanding with a computer program that operates within a limited domain and a specific context: a world of blocks and other simple objects that are manipulated by a toy robot. The robot's ability to carry out actions requested by a human user (as directed by the computer program that "understands" the user's request), as well as the program's ability to answer questions about the state of the block world, are the effective measures of understanding.53

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By representing the program's knowledge about its world as procedures rather than as static facts or relationships, Winograd created a system that responds to users' requests by performing actions; in other words, language is formulated into action. In an interactive fantasy system, knowledge may similarly be expressed as procedures that interpret the user-character's inputs and the contributions of the SYSTEM CHARACTERS and WORLD MODEL as materials from which action can be formulated. Features of Winograd's procedural model of understanding have been employed in other goal-based understanding systems and in story-generation systems, discussed later in this chapter, that can also be utilized in the design of an IF system.

Another measure of understanding can be obtained by asking the system questions about what it knows. QUALM is a system designed in 1977 by Wendy Lehnert at Yale, to explore the process of question-answering. QUALM was used in conjunction with two computer-based story-understanding systems. Lehnert describes the basic processes of the program:

The processes in QUALM are divided into four phases: (1) Conceptual Categorization, (2) Inferential Analysis, (3) Content Specification, and (4) Retrieval Heuristics. Conceptual Categorization guides subsequent processing by dictating which specific inference mechanisms and memory retrieval strategies should be invoked in the course of answering a question. Inferential Analysis is responsible for understanding what the questioner really meant when a question should not be taken literally. Content specification determines how much of an answer should be returned in terms of detail and elaborations. Retrieval Heuristics do the actual digging in order to extract an answer from memory. All of the inference

54 Ibid., p. 170.
processes within these four phases are independent of language, operating within conceptual representation.\textsuperscript{55}

Lehnert describes the whole process as conceptual information processing, and the product is a system which provides intelligent answers to natural-language questions. One of the objectives of the system is to provide answers that carry the maximum number of inferences; that is, the answer should, if possible, tell the questioner something he might not have been able to infer for himself.\textsuperscript{56} In other words, the system does not simply "look up" information in the text of a story; it makes inferences about things like causality and motivation which may not have been explicitly stated. QUALM can infer information about such features as the causal antecedents and consequences for incidents, the goals of characters, and the expectations and judgments that are implicit in characters' choices.

The question-answering techniques pioneered by Lehnert can be used with questions generated by a computer system, as well as with those generated by humans. The kinds of inferences that can be made by employing those techniques are just the sorts of things the PLAYWRIGHT subsystem needs to know about the dramatic action as it unfolds. QUALM embodies inferential and retrieval techniques that are capable of producing kinds of information which are crucial to the operation of an IF system. Lehnert's influence is felt in the work of her former student, Michael G. Dyer, who has built on her methods to develop a theory of in-depth understanding, discussed in the next section.

\textsuperscript{55}Lehnert, p. i.

\textsuperscript{56}Ibid., p. 16.
In later work, Lehnert with Cynthia L. Loiselle notes that, while question answering can provide specific information about a story, other techniques are needed to assess its broader contours. Lehnert and Loiselle have developed a method for producing a "summation" of a story which includes information about the central ideas or actions represented in the piece, as well as thematic patterns. To provide understanding at all levels of detail, they propose "multi-layered representations," with various levels specializing in describing different aspects of the text. Their system is discussed in detail in the next section.

In summary, techniques are available for understanding the behavior of the user-character and representing it in such a way that crucial information (about such things as his goals, expectations, and judgments) can be inferred and made available to the PLAYWRIGHT. As implied in this section, those techniques are also necessary for the PLAYWRIGHT's assessment of the course of the dramatic action as a whole; in fact, they will be utilized in some form by several IF subsystems. Techniques that cause a system to take action as a consequence of understanding, such as those developed by Winograd, can be used to predispose the PLAYWRIGHT to "think in terms of action" as the effects of the user-character on the dramatic action are processed.

57 Wendy G. Lehnert and Cynthia L. Loiselle, "An Introduction to Plot Units" (Boston: University of Massachusetts, Department of Computer and Information Science, 1984), p. 1.
Inference and In-Depth Understanding Techniques

The user-character is sensed by the system on the levels of spectacle (movement and gesture), music (paralinguistics), and diction (speech), with emphasis on the level of diction. The UNDERSTANDER subsystem is charged with the responsibility of converting those inputs into materials that are usable by the PLAYWRIGHT in plot formulation. When the UNDERSTANDER parses the user-character’s speech and physical actions, the internal representation that results is a formulation of what began as spectacle, music, and diction on the level of thought. Other, more "in-depth" understanding techniques further formulate those materials, so that by the time they are accessed by the PLAYWRIGHT from the WORLD MODEL, they exist on the levels of thought and character. The PLAYWRIGHT then formulates those materials, in combination with similar materials produced by the SYSTEM CHARACTERS, to the level of plot. In this way, the internal working of an IF system mirrors the process of successive formulation of materials as suggested by Aristotle, and performs that process in a more orderly way than is possible for a human playwright. The functional relations among the various subsystems ensure the proper causal relations among the elements of qualitative structure.
Understanding Plans and Goals

The understanding of plans and goals provides information about a story on the level of thought. The approach to understanding taken by Robert Wilensky of the University of California at Berkeley focuses on planning—"how people decide what actions to take in a given situation"—and the understanding of plans—"how people construct explanations to account for the actions of others." Wilensky's theory is illustrated in two programs, called PAM and PANDORA. PAM (Plan Applier Mechanism) is a story-understanding program, developed by Wilensky under the tutelage of Roger Schank at Yale. PANDORA (Plan ANalysis with Dynamic Organization, Revision, and Application) is a program that understands and generates plans, developed at the University of California at Berkeley by Joe Faletti, one of Wilensky's graduate students.

Wilensky investigates "the structure and content of planning knowledge," including the relations among plans and goals, how goals arise and are affected by certain types of situations and events, and the processes involved in goal interaction. He builds (and improves) upon the theory of...

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58 Wilensky, p. 4.

59 Ibid., p. 127.


61 Wilensky, p. 6.
scripts developed by Roger Schank and Robert Abelson. Schank and Abelson employ the term "scripts" to describe knowledge structures that contain information about goals and planning behavior in the context of stereotypic or well-known situations like eating in a restaurant. Wilensky's techniques capture similar kinds of knowledge in forms that are applicable to a wide variety of contexts and in atypical situations. Wilensky notes that "as there is little point in expressing events that strictly conform to a known stereotype, most of the actual texts we might encounter [or generate] will refer to situations for which such rigid knowledge structures [as scripts] are not well suited." 

Wilensky has designed a planning mechanism (implemented in PANDORA) that can infer goals from situations, suggest plans to meet such goals, project and evaluate the results of proposed plans, and execute the plan that is projected to be most successful. PANDORA also incorporates knowledge about the planning process, termed "meta-knowledge," which includes rules for making good plans (e.g., "don't waste resources"; "achieve as many goals as possible"). In PANDORA, meta-knowledge is expressed as "meta-plans" and "meta-goals" which are integrated with all other goals and plans during processing. Wilensky suggests that such meta-planning knowledge might alternatively be embodied in an expert subsystem that


63Wilensky, p. 41.

64Ibid., pp. 19-24.
provides planning advice to the rest of the system.\textsuperscript{65} In an IF system, meta-planning knowledge may be employed in the same manner as in PANDORA—by the UNDERSTANDER in inferring the goals and plans of the user-character, and by the "local intelligence" of the SYSTEM CHARACTERS in pursuing their own goals and devising plans that will be suggested to the PLAYWRIGHT. The "expert system" approach may be taken by the PLAYWRIGHT for meta-planning rules that express formal and dramatic concerns (e.g., rules that delineate kinds of goal conflicts and their uses in the plot).

The mechanism used by Wilensky to project the results of proposed plans may be incorporated in the PLAYWRIGHT to perform key functions:

As the planner formulates a plan, its execution is simulated in a hypothetical world model. Problems with proposed plans may be detected by examining these hypothetical worlds. . . . Projection not only enables the planner to find problems with its own plans, but it also enables it to determine that a situation merits having a new goal. For example, in order to sense an impending danger, the planner is required to project from the current state of affairs into a hypothetical world which it deems less desirable. Having made this projection, the planner can infer the goal of preventing the undesirable state of affairs from happening.\textsuperscript{66}

Understanding goal interaction is a key element in the PANDORA system. The program is capable of recognizing various classes of interaction, including goal conflict, goal competition, and goal concord, by associating the various types of interaction with circumstances that may give rise to them, as well as with knowledge about dealing with the

\textsuperscript{65}ibid., pp. 31-39.

\textsuperscript{66}ibid., p. 17.
consequences. Classes of goal conflict or competition include situations in which a single planner's desires would result in mutually exclusive states and situations in which resources present limitations. PANDORA also handles positive and negative interactions among the goals of various characters. The results of goal-interaction analysis are incorporated recursively into the planning process.\textsuperscript{67}

In an IF system, there are several uses for the plan-understanding and plan-generating capabilities exhibited by PANDORA. Its understanding techniques can be employed to infer the goals and plans of the user-character and to predict his probable actions based on those inferences. 

SYSTEM CHARACTERS function as independent planners, each with distinctive goals and traits and uniquely limited knowledge of the world, offering the results of their planning activities to the PLAYWRIGHT for evaluation and manipulation. They may also accept goal direction and planning advice from the PLAYWRIGHT. The PLAYWRIGHT itself is charged with generating global plans for the ongoing dramatic action, orchestrating the interactions among the goals and plans of the characters (including the user-character) according to dramatic principles.

\textbf{Understanding Emotion}

Another component of the element of thought is emotion. Researchers Michael G. Dyer and Wendy Lehnert have made important contributions in the understanding of emotion in narratives. As part of his doctoral research at Yale, Dyer developed a story-understanding program

\textsuperscript{67}\textit{Ibid.}, pp. 51-59.
called BORIS. BORIS reads and answers questions about narratives which draw their subject matter from certain specific domains, such as divorces and legal matters, about which the program has some general knowledge (although the program could undoubtedly be adapted to understand stories in other domains as well).\textsuperscript{68}

An important contribution made by BORIS is the techniques it employs to identify and represent emotions, and to utilize information about emotions in the understanding process. In the program, emotional reactions are represented by knowledge structures called AFFECTs. Each AFFECT is characterized by the values of six parameters: its \textit{state} (whether it is positive or negative), the \textit{character} who is experiencing the emotion, the \textit{goal situation} which gave rise to the emotion, the \textit{object} toward which it is directed, the \textit{scale} or intensity of feeling, and any associated \textit{expectations}.\textsuperscript{69}

AFFECTs are used in understanding in a variety of ways. They identify situations and goals that are important to characters and contain informations about characters' responses to events, and about the effects of events on their goals. By noticing characters' emotional responses, the system is better able to infer which goals are active at a given time. AFFECTs are also used to construct memories, providing an organizational structure for capturing "events of greatest importance to the characters"


\textsuperscript{69}Ibid., pp. 105-106.
involved.*\textsuperscript{70} BORIS also represents empathic emotions that characters may experience for one another. Empathic emotions are used to specify characters' relationships, as well as the indirect effects of events.\textsuperscript{71}

BORIS recognizes dozens of distinct emotions and empathic responses. Emotions are initially recognized by lexical descriptions in the narrative text (e.g., "happy," "surprised," "envious"). Once an emotion is identified lexically, its AFFECT description (an internal representation) is inferred from the narrative context.\textsuperscript{72} Since characters do not always announce their emotions by naming them, the ideal system should be able to infer characters' emotional states from goal states and events, and utilize those inferences predictively. It should also be able to investigate AFFECTs on the basis of non-linguistic cues (e.g., shouting, crying, buoyancy in movement, etc.). Dyer's pioneering work in the role of emotion in understanding will undoubtedly stimulate and facilitate such developments.

Wendy Lehnert and Cynthia Loiselle have developed a technique whereby emotional states can be employed in computer-based story understanding to establish causal links between characters' mental states and events. They utilize an extremely simple representation scheme for "affect states," which notes distinctions between "positive" events, "negative" events, and "mental" events of neutral affect. As the story is processed, the system produces an "affect state map"—"a sequence of chronologically

\textsuperscript{70}ibid., pp. 137-139.

\textsuperscript{71}ibid., pp. 118-122.

\textsuperscript{72}ibid., pp. 107-109 and p. 121.
ordered affect states for the characters in the story.73 Relationships between states and events are represented as causal links.74

The system also employs "cross-character links" to connect affect states experienced by different characters.75 The relations among states and events in a story provide information about causality. That information, as represented in an affect-state map, is used to formulate higher-level descriptions of the action of the narrative, called "plot units" (plot units are discussed further in the next section). Information about emotion is used by both Dyer and Lehnert, not simply to describe the characters encountered in a narrative, but ultimately to understand the action of the piece.

Understanding Character Traits

The work of Jaime G. Carbonell at Carnegie-Mellon University has focused on representing and inferring personality traits as an approach to story understanding. Carbonell notes that character development in stories has been largely ignored by AI researchers. Because "knowledge of the characters and their personalities helps to interpret their actions and induce their goals," Carbonell believes that "understanding character development is an integral part of processing natural language stories."76

73Lehnert and Loiselle, p. 4.

74Ibid., p. 5.

75Ibid., p. 7.

In Carbonell's system, knowledge of traits is used to answer questions like, "If actor X has character trait P, is he likely to do action A in situation S?" Personality traits might be represented by associating each trait with characteristic and uncharacteristic behaviors; however, as Carbonell himself points out, the list of such associations would probably be extremely cumbersome, and he can identify no principles for arriving at a manageable level of generality. These problems, as well as the existence of systems (like PAM) that can process goal-based behavior, cause Carbonell to opt for a representation of traits that focuses on the typical goals associated with them.  

Carbonell's technique is to represent personality traits by means of structures called Relative-Importance Goal Trees. They reflect the fact that goals associated with a given trait take on greater than normal importance to the possessor of that trait. A thrifty person, for instance, places higher than normal emphasis on preserving his money, resulting in lower than normal emphasis on spending money to acquire possessions. Carbonell points out that "personality traits often express the deviation between socially defined normative behavior and the particular characteristic behavior of an individual." He proposes the use of a "prototypical goal tree" as the knowledge structure that defines what "normal" is. The advantage of using such a prototype is that it "enables one to represent only the relevant

77Ibid., p. 52.
78Ibid., p. 53.
79Ibid., p. 50.
aspects of personality traits as *deviations from the norm*, a much more parsimonious representation than reconstructing (or storing) the entire goal-expectation setting for each known trait descriptor.\textsuperscript{80}

While Carbonell's research has been devoted to the use of personality traits in story understanding, he maintains that the same techniques will be useful in interactive dialog generation.\textsuperscript{81} His initial work has been limited to the use of explicitly-stated personality traits, but he asserts that his methods may also be used to infer personality traits from the behaviors of various actors by first inferring their probable goals, then integrating their inferred goals into goal trees, noting the deviations from the normative goal tree, and finally using these deviations to construct appropriate personality trait descriptors.\textsuperscript{82}

For the purposes of utilizing materials contributed by both the user-character and the SYSTEM CHARACTERS in an IF system, another step must be added to the trait-inference process; namely, using the derived trait descriptors predictively, to induce probable future goals, choices, and actions. The system should also include differences in planning style as part of the representation of character. In Wilensky's system, one individual planner utilizes the same "common sense" meta-planning rules as another, leaving differences in goals as the only means of representing individual differences; in Carbonell's formulation, information about the relative importance of those goals is added. Carbonell's technique of using relative

\textsuperscript{80}ibid., p. 58.

\textsuperscript{81}ibid., p. 73.

\textsuperscript{82}ibid., p. 62.
importance to represent deviations from the norm might be used to represent
differences in planning style if applied to meta-planning rules; e.g., a lazy
person will employ a meta-rule like "minimize effort" at the expense of other
values like completeness or efficiency. Such "adverbial"
knowledge—knowledge about planning styles—has been represented by
Schank and Abelson in structures known as "planboxes."\(^\text{83}\)

Schank and Michael Lebowitz have implemented an approach to
understanding character traits through the processing of stereotypes. Their
system employs two classes of concepts: characterization stereotypes,
nouns that are used to describe types of people and that are represented as
lists of traits; and stereotype modifiers, stereotypical adjectives that may
modify the traits included in a nominal stereotype\(^\text{84}\) (e.g., "ambitious bum,"
or "compassionate landlord"). Both functional and incidental traits can be
listed as part of a characterization stereotype; in fact, the representation of a
nominal stereotype may contain "values for virtually every conceivable part
of a characterization. Some of the information (such as car type) may be
highly speculative, but it is there."\(^\text{85}\) Thus the characterization stereotype
"doctor" may include information like: he is financially successful, in his 50's,
drives a Mercedes Benz, and plays golf on Wednesdays. The stereotype
modifier "politically active" may change the golf game to volunteer work, the

\(^{83}\) Schank and Abelson, pp. 88-96.

\(^{84}\) Roger C. Schank and Michael Lebowitz, The Use of Stereotype

\(^{85}\) Ibid., p. 5.
age to early 30's, and the Mercedes to a Toyota. Stereotype modifiers also affect a character's goals, plans, and interpersonal relations. In Schank and Lebowitz's system, a character's traits are ultimately expressed in action rather than simple description\textsuperscript{86}—an appropriately dramatic technique.

Schank and Lebowitz point out that stereotype modifiers may be used alone ("John is ambitious") or in conjunction with nominal stereotypes ("John is an ambitious lawyer"). In their research, they have focused on the latter usage, "since the changes and contradictions caused by the modifiers seem more dramatic and easier to study."\textsuperscript{87} The notion that contradictions between stereotypic modifiers and nominals are "more dramatic" is borne out by the use of such combinations in comedy and farce (e.g., the clever slave or the lecherous old man), as well as in serious drama and tragedy (e.g., the murderous king Claudius and Lear's wise fool). As a key to dramatic "interestingness," the notion could be fruitfully applied in the generation of dramatic characters and stories. Lebowitz has gone on to employ the use of stereotypic characterizations and modifiers in a system that can generate soap-opera-like stories, UNIVERSE, which is discussed later in this chapter.

Understanding Action

Understanding a story in its totality is a task that integrates natural-language understanding and the understanding of characters' goals, plans,

\textsuperscript{86}Ibid., pp. 20-22.

\textsuperscript{87}Ibid., p. 7.
traits, and emotions, and utilizes still other techniques for identifying larger patterns of action. Michael Dyer's BORIS program, unlike previous understanding systems which could "skim" narratives for predetermined types of salient facts, understands stories "in-depth," illuminating the elements of thought, character, and plot. The qualities considered by Dyer to constitute in-depth understanding include: careful reading as opposed to skimming, the ability to understand narratives that involve "multiple interacting knowledge sources" (e.g., knowledge about the activities and traits of characters or knowledge about the story domain), integrated text parsing and memory searches, and the ability to recognize "key thematic patterns which characterize a narrative at very abstract levels."^88

Dyer describes the structures his system employs to represent thematic patterns:

In BORIS, abstract thematic patterns, such as hypocrisy, are handled by memory structures called TAU's (Thematic Abstraction Units). These structures arise when expectation failures occur, causing episodes to be organized around errors in planning. As such, they contain an abstracted intentional structure, which represents situation-outcome patterns in terms of: the plan used, its intended effect, why it failed, and how to avoid (or recover from) that type of failure in the future. This information is often expressed in terms of an adage, such as "the pot calling the kettle black," and is abstracted from the specific content making up the episodes that each TAU organizes. This abstraction allows each TAU to organize episodes (which share the same failures in planning) across widely differing contexts.^89

^88Dyer, p. 16.

^89Ibid., p. 18.
Dyer likens the "theme" of a narrative to its "moral" or "point," as a means of characterizing it. BORIS looks for several key components in recognizing TAUfs, including "fortuitous goal achievements or goal failures, violations of expectations or beliefs, strong affective reactions, accidental or unintended actions, and examination of the reasons for plan failures." 90 When a sequence of events associated with the above components is identified, the planning aspects of that sequence are analyzed, utilizing a detailed set of "planning metrics" that identify strategic and intentional elements. 91 The resulting knowledge is identified as a "thematic pattern": an inductively formulated summary of the knowledge that a narrative imparts about the planning-related problems and activities around which its plot is organized.

Before it is processed into an adage-like generalization, the information contained in a TAU is nearly identical to an assessment of the central action of the plot of a narrative or episode. As such, a TAU contains information that would be extremely useful to the PLAYWRIGHT, as it is formulated "on the fly" while the program "reads" the narrative: the TAU is literally conjectured from an incomplete narrative (a plot in progress), and successively refined as the program gains more information. Such a technique is proposed in Chapter V, as a means of providing "ad hoc formal causality" in the construction of plots in an IF system.

90Ibid., p. 48.

91Ibid., pp. 76-77.
The recognition of TAU’s is also useful in that it provides the system with a means of learning about the planning process and about planning failures and recovery. In their adage-like form, TAU’s represent patterns that can appear in a variety of different contexts. They provide “meta-planning” knowledge—“planning advice on how to select or use plans in general.”92 Such knowledge could be employed by both the PLAYWRIGHT and SYSTEM CHARACTERS as a means of improving their planning ability through experience.

The theory of plot units developed by Lehnert and Loiselle is quite similar to Dyer’s theory of TAU’s; however, the methods used for identifying plot units appear to be applicable to a wider variety of actions. While Dyer utilizes primarily planning-related events to identify TAU’s, plot units are derived from a complete map of the relations among mental states and events in a story.

The primitive plot units employed by Lehnert and Loiselle are configurations of linked affect states (see p. 148). Those primitive units, each of which represents a unique configuration of linked states and events, are described by names like “enablement,” “motivation,” “success,” “resolution,” and “change of mind.”93 Complex plot units are composed of “overlapping configurations of primitive plot units,” bearing descriptors like

92Ibid., pp. 32-33.

93Lehnert and Loiselle, pp. 9-10.
"fleeting success," "intentional problem resolution," "bungled request," and "unsolicited help." 94

Once complex plot units have been identified, a plot unit graph is created, representing the top-level plot units (i.e., those plot units which are not wholly subsumed by any others) as nodes in the graph. The graph also indicates how those nodes are connected, either by a shared affect state, or by some path through other related units. The completed graph is used to identify the critical nodes, or units of action, in the story for the purpose of summation. 95

Like TAU s, plot units can provide generalizable knowledge in an understanding system:

Plot units capture knowledge about social and goal relationships which is not dependent on the particular activity or situation involved. Recognition of a particular plot unit allows us to infer this additional information, aiding the understanding of events already processed as well as creating expectations for future goals, actions, and emotional reactions of the characters. Such inferences will almost always be valid, regardless of the specifics of that interaction. 96

Finally, Lehnert and Loiselle suggest that both TAU s and plot units might be used in the process of story generation. On the basis of recent research in the process of writing 97, they believe that "plot units may provide

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94 Ibid., pp. 11-17.

95 Ibid., pp. 19-20.

96 Ibid., p. 34.

the right kind of 'chunks' for . . . idea generation": given a proposed central action, their theory can be used to identify the component plot units of that action and can specify the kinds of events, mental states, and causal patterns that are involved.\(^8\) Plot units may be employed by an IF system as a means of identifying emerging patterns of action. Based upon the actions and descriptions of both the user-character and SYSTEM CHARACTERS, analysis by means of plot units can provide integrated understanding of the action as it unfolds.

**Creating Characters and Story Materials**

The creation of characters and plots by computer systems have gone hand in hand. In an area of AI research called *story generation*, theories about the nature of characters, goals and plans, and coherent narratives—stories—are applied prescriptively.

The traditional AI devotion to human-process models (e.g., characters that think and behave like real people and story-writing techniques that are used by human authors) still receives lip service in the world of story generation research, but the production of entertaining and informative narratives by computer may well be a goal in itself. Existing story generation systems are not highly interactive; however, future systems for which interactive entertainment is the purpose will require that human-process models sometimes be seen as means rather than ends. Human-process

\(^8\)Lehnert and Loiselle, p. 37.
models in such systems will be no doubt be useful in thinking about how such a system might function, and techniques based on those models will surely be employed, but artistic criteria must move to the fore in the design process if such systems are to achieve their purpose.

**Story-Generation Techniques**

In 1975-76, James Meehan developed the first intelligent story generation system called TALE-SPIN as part of his doctoral work in computer science at Yale. A primary goal of the system was to find out what kinds of information are needed by humans in order to make up stories. Another goal was to produce a limited model of human thought and behavior:

> The computer program [TALE-SPIN] . . . contains a model of the physical world and the world of human behavior. It simulates characters who have motives, emotions, and relationships with other characters. It does this by using a great deal of information about those motives, emotions, and relationships. It knows about stories, what's interesting, what's coherent. It tells us what happens as the simulation proceeds.99

The characters in a TALE-SPIN world are humans and talking animals whose actions are motivated by basic physical needs like hunger,

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99 Meehan, p. 2.
thirst, or sex. Elements in the physical world like trees, forests, and houses are created by the program as needed in the story; for instance, a bear needs a place to live, hence a cave is created, and, since caves exist in mountains, a mountain must also exist. If the bear interacts with another character whose home is in the forest, then a meadow connecting the forest and the mountain is brought into being.

Before a story begins, a TALE-SPIN world is created for it by the system in collaboration with a human user. A cast of characters is chosen, the necessary geography and objects are created, and the characters' initial relationships are defined. A story actually begins with the designation of a main character and a goal derived from a physical need. That goal functions to initiate the action, but may or may not finally determine the central action of the story. Once the action is initiated, the program is no longer interactive; it produces a simulation of the characters' choices and actions in pursuit of their goals. The results of the simulation are expressed in CD

100Ibid., p. 42. Incidentally, one may wonder why a system that purports to examine human thought and behavior features talking animals. Three explanations are likely: first, the animal "personae" seem appropriate to the level of characterization; i.e., few traits, few goals, and rather single-minded behavior. Second, one of the program's modes of operation (mode 3, described below) produces Aesop-like fables, for which animal characters are both appropriate and traditional. Finally, it is possible that Meehan was having fun creating stories and unintentionally strayed a bit from the AI "human models" dogma. In any case, animal characters may be enough like humans to meet Aristotle's criterion of "likeness" for dramatic characters, discussed near the end of this chapter.

101Ibid., pp. 18 and 21.

102Ibid., pp. 17-24.
representation, then translated into English by another part of the program and printed out for the human user.\textsuperscript{103}

The functional components of the system are: (1) a "problem solver," which processes characters' goals by generating subgoals, plans, and events; (2) an "assertion mechanism," which records events as they happen in a model of the world; and (3) an "inference maker," which computes and asserts the consequences of events. Events may produce consequences in the form of new goals, which are fed back into the problem solver and processed through the system again. The story ends when all goals have been met or decisively not met\textsuperscript{104}—i.e., the potential of the story materials is exhausted.

Meehan criticizes previous story-generation efforts on the basis of the absence of causality in their output. A system developed by Sheldon Klein at the University of Wisconsin, for instance, determines what will happen next by random selection.\textsuperscript{105} "That's the last thing I want TALE-SPIN to do," Meehan says; "it [TALE-SPIN] models what should happen next."\textsuperscript{106}

\textsuperscript{103}Ibid., p. 36.

\textsuperscript{104}Ibid., pp. 2-3.


\textsuperscript{106}Meehan, p. 7. In this way, Meehan's program conforms to Aristotle's notion that a poet should represent, not what has been, but "a kind of thing that might be." See the Poetics, 1451b/1-10 and 1460b/32-35.
Meehan asserts that causality is implicit in TALE-SPIN tales because they are produced by modeling goal-directed procedures.\textsuperscript{107}

The characters that are created by Meehan's system may be described as separate entities within the system: they maintain individual "memories" that are distinct from the global memory of the "storyteller,"\textsuperscript{108} make their own inferences based on their goals and their individual knowledge of the world, and formulate their own plans for achieving their goals.\textsuperscript{109} Because of both the characters' simplicity and the complete knowledge that the system has of their traits, knowledge, and relationships, the plot of the story can be determined simply by manipulating characters' goals.

The "problem solver" is a facility utilized by all the characters in pursuit of their goals. With it, the characters make plans for action. In the problem solver, goals are associated with lists of possible plans for achieving them and with decision procedures for choosing among plans.\textsuperscript{110} In the planning structure it employs, Meehan's problem solver implements many aspects of Schank and Abelson's seminal theory of planning. That theory is also reflected in the work of others of Meehan's Yale colleagues, most notably Wilensky (see pp. 151-153).

\textsuperscript{107}Ibid., p. 10.

\textsuperscript{108}Ibid., p. 11

\textsuperscript{109}Ibid., pp. 37-38.

\textsuperscript{110}Ibid., pp. 40-41.
TALE-SPIN represents the relationships among characters and uses those relationships in generating plans (e.g., if John needs something, he will plan to ask for help from someone who likes him rather than from someone who hates him or is envious of him) and in predicting behavior at the story-telling level. The program implements a limited set of relationship types:

The relationships we use are competition, dominance, familiarity, affection, trust, deceit, and indebtedness. The question is: Why these and not others? The aesthetic goal is to choose the smallest "linearly independent" set that explains all the things we're interested in explaining, but finding the primitives for social relationships is not easy. The choices of competition, dominance, and familiarity are based on research by Myron Wish.\textsuperscript{111} The others have been added when I needed them to write a story and wasn't satisfied that they were combinations of the relationships already in use.\textsuperscript{112}

While Dyer's program BORIS provides a more exhaustive list of possible relationships, neither Dyer nor Meehan has identified a systematic way to determine primitive relationships or the ways in which relationships can be combined; however, both have made important contributions in the implementation of information about relationships in planning and understanding systems.

Meehan's system also includes a rudimentary representation of individual character traits (e.g., vain, jealous, honest, intelligent) and employs them in planning and prediction. Traits are implemented as

\textsuperscript{111}Myron Wish, "Comparisons among Multidimensional Structures of Interpersonal Relations" (Murray Hill, N.J.: Bell Laboratories, 1975), cited in Meehan, p. 63.

\textsuperscript{112}Meehan, pp. 62-63.
predispositions to plan and act in certain ways.\textsuperscript{113} The way that both character traits and relationships are implemented in TALE-SPIN—as determining factors in planning and, ultimately, action—is in keeping with a dramatic understanding of plot as action.\textsuperscript{114}

A potentially more sophisticated story-generation system is currently under development at Columbia University by Michael Lebowitz, who was also a graduate student at Yale. Lebowitz's system, UNIVERSE, is intended to produce extended stories like continuing serials. His model is the television soap opera, "Days of Our Lives."\textsuperscript{115} UNIVERSE's character-creation techniques are fully implemented, while its story-telling algorithms are still in development.\textsuperscript{116} While Lebowitz will utilize several story understanding techniques in his system (including those developed by Wilensky and Lehnert), he believes that story generation is essentially more difficult than story understanding:

As informative as story understanding research is for our purposes, story telling does involve some unique problems. When understanding a story, we can assume that it makes some sort of sense, and base our analysis on that assumption. In generation, we are compelled to produce logical connections that understanders will assume. Furthermore, while an understander can process text in whatever terms it has available, and ignore subtleties it is unprepared for, a good story telling program must produce stories that can be

\textsuperscript{113}Ibid., p. 66.

\textsuperscript{114}Ibid., p. 22.


\textsuperscript{116}Ibid., p. 175.
analyzed at any level at which an understander might operate.\textsuperscript{117}

Lebowitz's methods for creating and representing characters help to create the necessary consistency in the story. A character is described in terms of its personality traits. Keeping track of characters' mental states on the basis of those traits establishes implicit connections among the events in which a character is involved.\textsuperscript{118} The method used for representing characters is based in part on Lebowitz's previous work with Schank: UNIVERSE characters are based on stereotypes, which contain a great deal of "default information" that is assumed to be true of the character unless specifically overridden. The system utilizes over 40 different stereotypes, each with seventeen separate traits through which the stereotype is represented.\textsuperscript{119}

Past events provide the means whereby a character may believably deviate from a stereotype used to describe him and to motivate deviations in his behavior from what would be expected on the basis of the stereotype alone. Past events include elements of personal history that are presented as exposition, as well as events that occur in the course of the story, which are duly recorded by the system.\textsuperscript{120} Thus a mild-mannered, average citizen may believably become aggressive and vengeful when his wife is assaulted.

\textsuperscript{117}Ibid., pp. 177-178.

\textsuperscript{118}Ibid., p. 174.

\textsuperscript{119}Ibid., pp. 185-186.

\textsuperscript{120}Ibid., pp. 181-182.
Information about a character is stored in a memory unit called a "person frame." The person frame contains the character's name, applicable stereotypes, individual traits and goals that may override stereotypic information, interpersonal relationships, marriages, and a list of events that make up the character's history.\textsuperscript{121}

A UNIVERSE story begins with a pre-determined cast of characters, for the following reasons:

It would certainly be possible to create characters only when required during plot generation and fill in details of these characters only when needed. Sometimes UNIVERSE will do just that. However, in order to keep the qualities of characters consistent, and to be able to insert information into the story that will lead to later coherence (i.e., "drop hints"), it is useful to have a substantial set of characters in place when story telling begins. In addition, most stories that are generated will be based on the already existing characters, since the arbitrary creation of new characters undermines coherence. . . .\textsuperscript{122}

Beginning with a set of defined characters is a technique that an IF system will employ, for the same reasons. Such characters may be specified as part of the human-authored information about the fantasy world and further developed as the plot progresses.

Lebowitz does not rule out the need to create characters on the fly, and he has devised an interesting technique for creating characters that conform to the needs of the plot. Such a character can initially be described in terms of the traits he needs to possess in order to make his involvement in

\begin{enumerate}
\item \textsuperscript{121}\textit{Ibid.}, p. 183.
\item \textsuperscript{122}\textit{Ibid.}, p. 180.
\end{enumerate}
past, present, or future events plausible. Lebowitz's procedure determines a set of stereotypes that will yield a character with the necessary traits:

Even though it is difficult to come up with an optimal set of stereotypes, it is not hard, using heuristic methods, to come up with a reasonable set. UNIVERSE does this by first selecting an occupation for the character than has the minimal total discrepancy from the traits specified. Then, for each trait specified but not yet perfectly described, another stereotype is picked that does not alter existing values, but brings the person closer to the desired value for the trait. This process tends to leave only minor variations to be accounted for by personal idiosyncrasy. This "create to specification" algorithm yields interesting but believable combinations of stereotypes such as teacher/swinger (ala [sic] Looking for Mr. Goodbar) or warden/video-game-player/movie freak.\textsuperscript{123}

Information about interpersonal relationships is represented in much the same way as information about individual characters. Stereotypic relationship frames (e.g., the relationship of a lawyer to a client) are modified by past events (if the client has been blackmailing the lawyer, the lawyer will be more submissive than the stereotypic relationship would suggest).

In Lebowitz's system, stereotypes are linked to occupations and lifestyles. Given information about either of those variables, the system can make reasonable guesses about other of the character's traits (e.g., religion, age, intelligence, self-confidence, etc.). Lebowitz has developed a list of traits by which stereotypes are expressed that is intended to include only traits that have a high likelihood of being functional in the action of a UNIVERSE story.\textsuperscript{124} Promiscuity, for instance, is much more likely to be a functional trait in a "soap opera" world than in the world of cowboys and

\textsuperscript{123}Ibid., pp. 186-187.

\textsuperscript{124}Ibid., p. 184.
Indians (of course, one can immediately imagine exceptions). Those two facts—the linkage of stereotypes to occupations and lifestyles, and the limited applicability of the set of definitional traits utilized in UNIVERSITY stereotypes—suggest how Lebowitz's techniques might be utilized in an IF system.

An IF system is intended to be able to produce interactive dramas in more than one kind of fantasy world. One such world might well be a "soap opera universe," in which stereotypes based on occupation and lifestyle and definitional traits like promiscuity, wealth, and religion are exactly what is needed for the dramatic action that is likely to occur. A "cowboys and Indians" universe could utilize the same structure with some modifications in its content. The author of the fantasy world would be charged with selecting stereotypic frames (e.g., cavalryman, brave, and chief rather than doctor, lawyer, and swinger) and sets of definitional traits (e.g., ruthlessness, military experience, and social status as opposed to promiscuity, physical attractiveness, and wealth) that would be most likely to be functional in that world.

The value of the stereotypic approach in representing characters and relationships is that it is economical. The technique reduces the amount of information that must be stored by representing only the exceptions to the rule (as suggested by Carbonell and others). At the same time, it maximizes the number of inferences and predictions that can be made on the basis of that information, and provides a means for maintaining consistency in the story.
Characters in an IF System

The various understanding processes that may be employed in an IF system provide the formulation of materials introduced by the user-character on the levels of spectacle, music, and diction to the levels of thought, character, and plot. SYSTEM CHARACTERS, on the other hand, have their initial existence on the levels of thought and character (as structures or "frames" within the system itself). Their contributions to the material available to the playwright for plot formulation will also be made on the levels of thought, character, and plot (in those instances where integrated understanding techniques like plot units analysis are used to describe the action so far). The way in which SYSTEM CHARACTERS are initially structured—the way that they come into being—will determine the nature and scope of those contributions.

For those SYSTEM CHARACTERS that exist in a fantasy world from the beginning, the task of initial creation belongs partially to the human author of that world, who may specify such characters in varying degrees of detail. An IF system itself is responsible for providing guidelines for that initial description, indicating to the author what kinds of information must be provided, and incorporating that information into a structure that will allow for further manipulation and growth. Once "born," the SYSTEM CHARACTER has something like a life of its own. The system must guarantee that that life will unfold in ways that meet the requirements of dramatic form.

125 Characters may also be created as needed during the action at the behest of the PLAYWRIGHT, as demonstrated by Lebowitz's character-creation technique.
The framework for determining the requirements of SYSTEM CHARACTERS is provided by Aristotle, who proposes in the *Poetics* that dramatic characters must be *good, appropriate, like, and consistent*. The notion of "goodness" or "virtue" upon which Aristotle's first requirement rests has two interpretations. In the *Poetics*, goodness is linked to moral purpose: "There will be an element of character in the play, if . . . what a personage says or does reveals a certain moral purpose; and a good element of character, if the purpose so revealed is good. Such goodness is possible in every type of personage . . . "¹²⁶ Smiley observes that moral choice represents the highest level to which character may be formulated; however, moral choice is not essential to character—i.e., character may be formulated "below" that level.¹²⁷ Defining character as an agent of the action represented in the drama¹²⁸ allows a second interpretation of "goodness" to be made, which is based upon the definition of virtue presented in the *Ethics*:¹²⁹ to be "good" (or "virtuous") is to fulfill one's function. A man is "good" when he fulfills his potential; a dramatic character is "good" when it fulfills its dramatic function.¹³⁰ For the purposes of an IF system, the


¹²⁷Smiley, pp. 84-86.


¹³⁰The second interpretation explains, by the way, why even worthless folks like women and slaves are capable of "goodness." See Aristotle, *Poetics*, 1454a/20-22.
"goodness" criterion will be interpreted as "fulfilling one's dramatic function." Creating characters capable of moral choice depends upon the incorporation of both knowledge about morality and the potential for such choice in the fantasy world, issues that will be addressed in Chapter V.

How can the system guarantee that a SYSTEM CHARACTER will fulfill its dramatic function? In his initial description of the world, the human author is responsible for selecting and specifying traits that are likely to be functional in the actions that may occur in the fantasy world. If a technique similar to that proposed by Lebowitz is utilized in the creation and representation of SYSTEM CHARACTERS, then the human author specifies functional traits in terms of appropriate stereotype frames and definitional traits. If the particular fantasy world is a "known" one (e.g., the world of "Star Trek" or the court of King Henry IV), the task is simplified because a set of characters already exists which may be modeled by the system. Otherwise, the author may incorporate some traits into characters that will be present from the beginning and suggest others that may be embodied in characters that are created as the action unfolds.

Using an approach that is based upon a combination of stereotypes and individual traits has distinct advantages. Lebowitz's technique maximizes the likelihood that a character's traits have the potential to be functional in the action because knowledge about those traits and their implications forms part of the general knowledge of the system, enabling the PLAYWRIGHT to infer their dramatic uses as it shapes the action.

The system itself can perform a tailoring function on traits suggested by a human author. It can refrain from introducing traits that are not likely to
be functional in the action as probable events are projected in the process of playwriting. Because the PLAYWRIGHT maintains formal control over the plot, it is in a position to assess the dramatic function of each character and to determine the necessary complement of traits by observing which are likely to become manifest in action.

The "appropriateness" criterion urges that traits must be appropriate to both the character and the dramatic action in which it is involved. Appropriateness to character can be ensured by the way in which traits are represented and employed by the system. Again using Lebowitz's model, a trait which is seemingly inconsistent with what is known about a given character must be specifically justified (e.g., in terms of past events) in order to be incorporated in the description of that character. Traits which are not appropriate to the dramatic action will not be employed by the PLAYWRIGHT, even if they have been suggested by the human author. Contrariwise, no action can occur for which an agent with appropriate traits is not available. If such a character is created for the sake of representing an action, it must be drawn from the stereotypes and traits specified by the human author, who has hopefully avoided inappropriate choices (like cowboys in Denmark or a homicidal streak in Alice's White Rabbit).

The "likeness" criterion suggests that characters should be life-like; that is, that they should be recognizably human. Such "likeness" can be realized in a variety of styles—from realistic portraits to cartoon characters. In drama, as in painting, there is considerable latitude in the means by which likeness can be achieved. The mistake most likely to be made by an AI-driven system is that, following the AI dogma of employing human models,
system-created characters would be *too much* like real people. Characters need not be modeled on complete human beings; indeed, to do so would be to introduce a plethora of irrelevant detail. Jeffrey Schwamberger observes:

Both Henrik Ibsen and August Strindberg recognized that levels of differentiation were necessitated by the impossibility—and the undesirability—of creating a complex personality for every personage who happened to cross the stage. . . . The significance of Strindberg's observation, like that of Schlegel's that certain of Shakespeare's personages are characterized merely by the duties they perform, lies in its recognition that no matter how life-like characterization is intended to be some personages will be identified purely by the function their external activity serves in the plot.\(^{131}\)

Freytag also observed that, no matter how few traits a dramatic character may possess, the audience will perceive it as a whole personality.\(^{132}\) Thus, limiting the number of traits represented in a character to those that are necessitated by the dramatic action need not violate the likeness criterion.

The planning procedures utilized by SYSTEM CHARACTERS can ensure "likeness" in their choices and actions as well; Wilensky's techniques are especially valuable in this regard. Finally, likeness is enhanced by the ways in which SYSTEM CHARACTERS represent themselves at the interface, on the levels of spectacle, music, and diction. Examples already exist of computer-generated characters with relatively few traits that have managed to *fool* human users into believing that they are "real." Life-likeness in enactment will be treated in Chapter VI.

\(^{131}\) Jeffrey A. Schwamberger, "The Nature of Dramatic Character" (Ph.D. dissertation, The Ohio State University, 1980), pp. 33-34.

\(^{132}\) Freytag, p. 248.
Finally, Aristotle observes that dramatic characters must be consistent; that is, that the potential for all a characters' actions exists in his traits. Even seemingly inconsistent actions must meet this requirement: "... even if inconsistency be part of the man before one for imitation as presenting that form of character, he should still be consistently inconsistent." Consistency depends in part upon what an audience or observer (in the case of an IF system, the user) knows about a character's traits. It is conceivable that a SYSTEM CHARACTER might take action based upon a trait that exists in its internal representation, but which has not been revealed to the user. It devolves to the PLAYWRIGHT to make sure that sufficient knowledge about a SYSTEM CHARACTER's traits is made available to the user in the exposition of the unfolding piece.

Consistency can also be expressed in terms of necessity and probability:

The right thing, however, is in the Characters just as in the incidents of the play to endeavour always after the necessary or the probable; so that whenever such-and-such a personage says or does such-and-such a thing, it shall be the necessary or probable outcome of his character; and whenever this incident follows on that, it shall be either the necessary or the probable consequence of it.

The planning procedures utilized by the characters and the PLAYWRIGHT's subsequent selection of plans to be incorporated in the action are the means by which necessity and probability are established in the connections between characters' traits and their choices and actions.


134 Ibid., 1454a/34-40.
Finally, consistency in the SYSTEM CHARACTERS can be created by controlling each character's knowledge of the world and the events that have transpired. As in the systems created by Winograd and Wilensky, the WORLD MODEL contains a record of all that has happened in the fantasy world, as well as all the system's knowledge about that world. In Meehan's system, each character maintains a separate memory. A more parsimonious technique is to devise "filters" that control each character's access to the common pool of information contained in the WORLD MODEL. Such filters would limit access to memory on the basis of a character's participation in past events, as well as traits like intelligence and educational level if appropriate. Common access would be available for more fundamental world knowledge (e.g., things fall down when you drop them).
Functional Model of an IF System

Based upon an understanding of the technological capabilities that can be employed, a picture of how they might be integrated in an IF system emerges. Figure 5 presents a functional model of such a system. It describes the principal functional units (or subsystems) of an IF system, each of which contains some form of local intelligence; that is, each subsystem performs some portion of the total processing of the system relatively independently, passing the results on to the next subsystem in the functional chain.

FIGURE 5: FUNCTIONAL MODEL OF AN INTERACTIVE FANTASY SYSTEM
Each encircled number in Figure 5 refers to a description of the relationship between two subsystems, as described below:

1. The ENACTOR represents the world and the dramatic action—the scene, the characters and their dialogue and actions, sound effects, etc.—to the USER-CHARACTER in the interface environment.

2. The USER-CHARACTER participates in the dramatic action by speaking and making physical movements and gestures.

3. The UNDERSTANDER senses the USER-CHARACTER's speech and movements. It then parses those words and actions and creates Conceptual Dependency (CD) representations for them. From the CD representation, the UNDERSTANDER inferences the goals, plans, and emotions of the USER-CHARACTER. The UNDERSTANDER then updates the model of the USER-CHARACTER that is contained in the WORLD MODEL, logs the most recent user input in CD form, and updates the current state of the world, as it has been influenced by the USER-CHARACTER's words and actions.

4. The PLAYWRIGHT learns of the USER-CHARACTER's traits and actions, as well as the current state of the world, from the WORLD MODEL. The WORLD MODEL also contains general world knowledge (e.g., "people usually get angry when you hit them") and specific world knowledge (e.g., "weapons used in Elsinore are sabre, rapier, and cannon"). These forms of knowledge enable
the PLAYWRIGHT to reason and serve to delimit dramatic potential.

5. The WORLD MODEL is also consulted by the SYSTEM CHARACTERS, who have limited access to its contents.

6. Based on what they know of the world and the dramatic action, the SYSTEM CHARACTERS formulate goals and create plans for action. They propose candidate plans and actions to the PLAYWRIGHT for evaluation.

7. The PLAYWRIGHT gathers goal and planning information for the USER-CHARACTER (via the WORLD MODEL) and SYSTEM CHARACTERS. It applies its own dramatic criteria in the evaluation of possible events, simulating those events when necessary. Based on its analysis and expertise, the PLAYWRIGHT produces a burst of "script," in CD form, which represents next events and actions. It notes the reasoning processes and data which led to its decisions, for further evaluation. It communicates the portion of the script involving character action and dialogue to the SYSTEM CHARACTERS.

8. The SYSTEM CHARACTERS know how to represent themselves. The SYSTEM CHARACTERS convert their scripts into commands for specific dialogue and physical actions, which they communicate to the ENACTOR for execution.

9. Meanwhile, the PLAYWRIGHT sends the CD form of the script to be incorporated in the WORLD MODEL, updating the current state of the world.
10. The PLAYWRIGHT sends commands directly to the ENACTOR for non-character-related events (e.g., changes of scene, movement of objects, or sound effects).

11. The ENACTOR integrates and executes the various commands received from the PLAYWRIGHT and the SYSTEM CHARACTERS. It knows how to represent the action for the user in the interface environment. It also logs a description of what has transpired (e.g., the appearance of images and the actual text of dialogue) in the WORLD MODEL, where it may be consulted by other parts of the system.

This chapter has focused primarily on techniques that may be employed in the workings of the UNDERSTANDER, WORLD MODEL, and SYSTEM CHARACTERS. Evolving user-sensing technologies promise to enable an IF system to capture the user's words, inflections, gestures, and movements. Natural-language understanding techniques are employed to discover the meanings of utterances in context. In-depth understanding techniques may be employed to infer the user's goals and plans. Story-generation systems demonstrate methods for representing characters and creating action through the use of traits, goals, and plans. Such techniques may be employed in an IF system to provide materials that will be formulated into a dramatic plot by the PLAYWRIGHT.
CHAPTER V
THE PLAYWRIGHT

This chapter explores the workings of the PLAYWRIGHT component of an IF system. The PLAYWRIGHT is the locus of dramatic expertise in the system, transforming story materials provided by other subsystems into a dramatic plot.

The number and nature of the tasks that the PLAYWRIGHT must perform require sophisticated forms of AI to accomplish. Expert systems, a genre of AI, have the potential to embody the kinds of knowledge and problem-solving methods that are necessary to perform those tasks. The first section of this chapter is intended to acquaint the user with the theory and design of expert systems. The second section focuses on the functional characteristics of the PLAYWRIGHT expert system, and the third section presents a discussion of the characteristics of the PLAYWRIGHT's knowledge base.

Several examples presented in the second and third sections of the chapter are based on the world of "Star Trek," a popular television series that was originally produced in the late 1960's and which has been telecast worldwide in syndication since that time. The "Star Trek" series has spawned a series of animated cartoons, a multitude of short stories and novels, a series of "interactive" novels, several comic books and magazines, a body of critical literature, and three major motion pictures, primarily
because of the attractiveness of its characters and the richness of its "mythology." The "Star Trek" world was chosen as a primary source for examples in this chapter because of its popularity, its familiarity and accessibility, and the straightforwardly melodramatic qualities of most "Star Trek" episodes.¹ In the "Star Trek" examples in this chapter, it is assumed that the USER-CHARACTER portrays the role of Captain James T. Kirk.

Expert Systems

General Definition and Background

Expert systems are computer programs that utilize AI techniques to emulate the performance of human experts in solving complex problems. By the early 1970's, AI programs had been written to solve certain classes of non-numerical problems like playing chess or proving theorems in symbolic logic. The methods employed by such programs, while promising, did not approach human ability to solve complex practical problems. In investigating how human experts solve such problems, a fundamental insight was that knowledge is more important than formal reasoning.

¹The reader who is not familiar with "Star Trek" may wish to review the plot synopses and reference materials included in Bjo Trimble, The Star Trek Concordance (New York: Ballantine Books, 1976). Many episodes of the television series and the three motion pictures are also available on videotape and videodisc.
methods in achieving expert performance. Expert systems research has focused on identifying the kinds of knowledge that experts possess and finding ways to represent and utilize that knowledge in computer programs.

In the kinds of complex problems that are treated by expert systems, solutions are reached "through logical or plausible inference, not by calculation." Straightforward, algorithmic methods are insufficient in solving problems when knowledge about both the problem domain itself and problem-solving techniques related to that domain are needed:

... contemporary methods of symbolic and mathematical reasoning ... do not provide means for representing knowledge, describing problems at multiple levels of abstraction, allocating problem-solving resources, controlling cooperative processes, and integrating diverse sources of knowledge in inference. These functions depend primarily on the capacity to manipulate problem descriptions and to apply relevant pieces of knowledge selectively. Current mathematics offers little help in such tasks.

A brief survey of some of the better known expert systems will help to elucidate the kinds of problems that have been successfully treated and the kinds of expertise that have been developed. It should be noted that each of the systems described below is still in use as of the writing of this paper, and that system development is an ongoing process of design and refinement.


4Hayes-Roth, p. 4.
One of the oldest and longest-lived expert systems in existence, DENDRAL, uses experimental data to infer plausible structures for unknown chemical compounds. The system "supports hundreds of international users daily" and is widely acknowledged to exceed human performance.\(^5\) MYCIN, developed at Stanford University in the mid-1970's, helps physicians to diagnose and treat infectious blood diseases.\(^6\) Its performance has been judged equal or superior to that of medical experts.\(^7\) PROSPECTOR, also designed in the mid-1970's, identifies ore deposits and selects drilling sites. Among its accomplishments is the discovery of a molybdenum deposit worth about $100 million.\(^8\) EURISKO, developed at Stanford in the late 1970's, discovers new mathematical concepts and new heuristics to guide its own discovery process.\(^9\) Its diverse accomplishments include the design of a winning fleet for a national wargames tournament and the design of promising new VLSI circuits (computer chips).\(^10\) BACON is an expert system that employs inductive inference to discover fundamental laws by examining experimental data. BACON has independently discovered

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\(^5\)Ibid, pp. 6-7.


\(^7\)Hayes-Roth, p. 10.

\(^8\)Ibid., p. 6.


\(^{10}\)Ibid., pp. 241-245.
"Archimedes' principle of floating bodies, Kepler's third law of planetary motion, Boyle's law of gases, Snell's law of light refraction, Black's law of specific heat, Ohm's law in electricity, and many others, including some basic laws of chemistry."\(^{11}\)

Expert-systems researchers Duda and Shortliffe describe the major strengths and limitations of contemporary expert systems:

The simplest and generally most successful expert systems are classification programs. Designed to be used in a well-defined context, their purpose is to weigh and balance evidence for a given case to decide how it should be categorized . . . .

By contrast, it has proved much more difficult to develop expert systems for problems that have a more synthetic character, such as those that concern planning or require de novo generation of solutions.\(^{12}\)

What Duda and Shortliffe suggest is that problem solving increases in difficulty as the knowledge that must be integrated in a solution becomes more diverse, and that "new" solutions are harder to produce than variations on old ones. These observations identify, not intrinsic limitations of expert systems, but the frontiers of expert-systems research.

**Problem Characteristics**

Only certain kinds of problems qualify for treatment by an expert system. Such problems are often characterized by incomplete or uncertain data: all of the pertinent information about the problem is not known, and the "facts" that can be assembled may have varying degrees of reliability. It may


\(^{12}\)Duda and Shortliffe, p. 262.
be difficult to define such problems or their components in such a way that a straightforward solution process can be employed. When all the facts, possible inferences, theories, and axioms regarding a complex problem are taken into account, the result may be a geometric increase in the number of possibilities that must be generated and evaluated—a "combinatorial explosion" that would overwhelm a traditional computer-based problem solver.

A notion of complexity is central to the definition of problems appropriate to "expert" solution. Complexity usually entails contextual richness—that is, complex problems are often shrouded in a variety of contextual variables (social, political, semantic, etc.) that require specialized treatment and higher-level integration in the solution. Another feature of complexity is the multiplicity of paths that may be taken in search of a solution:

Workers in this field believe that certain domains do not qualify as potential arenas for expertise because they are somehow not complex enough. The reasoning required to solve problems in such a domain may not involve enough steps or enough alternatives at any branch point. Problems have to be complicated enough to require an expert.13

Expert systems are well-suited for performing certain kinds of tasks: diagnosis, interpretation, instruction, monitoring, prediction, planning, and design.14 Tasks like calculation, game playing, or even speech recognition do not usually qualify for "expert" treatment because they lack complexity in

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13Hayes-Roth, p. 47.

14Ibid., pp. 13-14 and p. 49.
data characteristics, problem definition, reasoning process required, or task performed.

Most of the expert systems that have been developed to date address problems in domains where data are usually more quantifiable and methods more exact than in the arts, e.g., chemical analysis, prospecting, medical diagnosis, and various branches of mathematics. It would seem, however, that artistic problems possess exaggerated versions of the very characteristics that make a problem a good candidate for treatment by an expert system. Few would argue that algorithmic techniques are adequate to the needs of the artist or critic; indeed, the arts resist both analytic and productive techniques that are exhaustively quantitative or even systematic. When such techniques are employed by the critic, dissimilar systems are often overlaid so as to reveal various dimensions of the work. Expert systems are able to solve problems while employing heterogeneous sources of knowledge "to pursue various aspects of a problem independently, periodically combining their results."\(^{15}\) Problems in both design and analysis admit of this approach.

**Knowledge Characteristics**

When known AI techniques proved inadequate to solve such complex problems as described above, AI researchers returned to human models in hopes of discovering new problem-solving techniques:

When it was asked how people were able to devise solutions to these problems, a frequent answer was that people possess knowledge of which the programs were wholly innocent. This knowledge is employed in a variety of ways—in clarifying the problem, suggesting the kinds of procedures to use, judging the reliability of facts, and deciding whether a solution is reasonable.¹⁶

Human expertise is expressed in several dimensions. It includes knowledge about a particular domain—its boundaries, formal and structural qualities, and the nature of its elements—as well as knowledge about how to solve problems in that domain. A human expert employs judgment to "prune" the tree of possible solutions down to manageable proportions, lopping off whole branches that are judged unlikely to yield acceptable results. He knows from experience what kinds of problem-solving strategies are most likely to be fruitful. He can determine when to generalize a rule and how to create a new rule for a new situation. He can judge when to adopt a working assumption in the absence of certainty. He knows when to abandon an inappropriate line of reasoning without following it to its logical conclusion. He knows how to access and interpret data about the problem, and he can assess the reliability of those data. He can express a degree of certainty about his conclusions.

Expert systems attempt to mimic human expertise in each of the above-mentioned dimensions by incorporating the kinds of knowledge associated with each. Other AI techniques have emphasized formal logic and elaborate inference schemes in their approach to problem-solving. Expert systems deal with problems for which such approaches are

¹⁶Duda and Shortliffe, p. 261.
insufficient; rather, knowledge of the kinds possessed by human experts is all-important: "In short, an expert's knowledge per se seems both necessary and nearly sufficient for developing an expert system. This observation is empirical, not tautological."\(^{17}\)

Three fundamental types of knowledge can be distinguished: facts or descriptions, relations between facts, and methods or procedures for utilizing facts and relations in problem-solving.\(^{18}\) Methods range from tried-and-true, well-documented techniques to the kinds of personal rules of thumb that are rarely written down. The ability to utilize structural and behavioral models to simulate possible solutions and their consequences is a feature that may allow expert systems to improve upon human performance in evaluating and "debugging" (identifying and correcting errors in) solutions.\(^{19}\)

All three kinds of knowledge may be more or less "fuzzy" (inexact), may possess varying degrees of accuracy or truth, and may lead to conclusions with varying degrees of certainty attached to them.\(^{20}\) Procedural knowledge in human experts often takes the form of heuristics, "rules of thumb" or "hunches" that human experts derive from experience

\(^{17}\)Hayes-Roth, p. 7.

\(^{18}\)Bruce D'Ambrosio, "Expert Systems—Myth or Reality?" Byte, August 1985, p. 276; and Hayes-Roth, p. 12.

\(^{19}\)Kinnucan, p. 31.

with a domain. Heuristics allow experts to identify promising solution strategies early in the problem-solving process. They are also useful in interpreting and combining "probabilistic, errorful, and uncertain data and inferences" by providing a means for making a "best guess." A fourth kind of knowledge possessed by an expert system arises from the system's own experience with problem solving, and may be described as "self-knowledge." Currently, the ability of such systems to observe and record their own processes is used primarily in creating explanations and justifications for their decisions which can be reviewed by users and utilized to debug system operation. EURISCO utilizes self-knowledge to generate new heuristics; in other words, to learn. A fifth category of knowledge is knowledge about problem-solving, often described as "meta-knowledge." A system's meta-knowledge reflects what it initially knows about planning in a domain, e.g., selecting appropriate methods for particular problems, as well as what it has learned from experience. By examining and evaluating its own operation, a system may utilize self-knowledge to make changes in its meta-knowledge. Thus the potential uses of self-knowledge are extremely powerful:

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21Lenat, p. 189.

22Hayes-Roth, p. 12.

23Webster and Miner, p. 62.


25Hayes-Roth, p. 238.
.. the most potentially significant and innovative characteristic of an expert system is believed to be that of self-knowledge, knowledge about its own operation and structure. Although currently the use of self-knowledge is somewhat simplistic, providing basic explanation and justification capabilities, the potential for its application is remarkable... Self-knowledge will provide the basis for various types of self-modification capabilities, including rule correction, knowledge base reorganization, and system reconfiguration.\textsuperscript{26}

Kinnucan and others believe that the capacity to learn from experience may enable expert systems to "surpass their human creators in wisdom."\textsuperscript{27}

The central problem in designing expert systems is extracting, articulating, and representing expert knowledge: an activity known as "knowledge engineering."\textsuperscript{28} Currently, most expert systems acquire their knowledge through the efforts of a knowledge engineer, a human who specializes in translating the knowledge of human experts (and, occasionally, documents or experimental data) into computer-usable form. Recently, computer programs have been developed that can carry on a natural-language dialogue with a human expert and then automatically build the results into the knowledge base of an expert system. TIERESIAS, for example, was developed to serve as a natural-language knowledge acquisition system for the MYCIN expert system.\textsuperscript{29} Researchers envision

\textsuperscript{26}Ibid., p. 28.

\textsuperscript{27}Kinnucan, p. 31.

\textsuperscript{28}Hayes-Roth, p. 12.

"induction programs" that may be used in future expert systems to gather knowledge by reading textbooks and other kinds of data. Since the most successful interview techniques employed by knowledge engineers with human experts are "example-driven," it follows that an expert system might acquire knowledge by viewing examples (in much the same way that BACON discovers fundamental laws). Thus the PLAYWRIGHT might someday be able to gain knowledge about plays by reading some.

Functional Characteristics

A variety of problem-solving methods are employed by expert systems, singly or in combination. An expert system utilizes the facts and rules in its knowledge base in conjunction with other data (from external databases or sensors, for instance) to solve problems. The part of an expert system that actually performs the problem solving is known variously as the "rule interpreter," the "inference system," or the "inference engine." The inference engine contains general reasoning mechanisms that are distinct from the knowledge base, and which may theoretically operate with different knowledge bases to solve problems in different domains. Indeed, dozens of types of expert system "shells"—inference engines with "empty" knowledge bases—are currently being sold as kits for companies or individuals who will tailor them to specific uses.31

30Hayes-Roth, pp. 130-134.

In computer jargon, the problem-solving techniques utilized by the inference engine are known as "control" or "search" strategies. Problem solving is often referred to as "searching":

... a description of a desired solution is called a goal and the set of possible steps leading from initial conditions to a goal is viewed as a search space. Problem-solving is carried out by searching through the space of possible solutions for ones that satisfy a goal.\textsuperscript{32}

The system uses its meta-knowledge (knowledge about problem solving) to devise a search strategy that is most appropriate to the nature of the problem being solved. The search strategy determines what rules, facts, and domain knowledge will be used and what kinds of operations will be performed on that knowledge.\textsuperscript{33}

Search strategies attempt to minimize the effort that must be expended in finding a solution by avoiding the need to find or generate and evaluate every possible solution. The pathways to a solution can be visualized as a tree-like structure. The top-most nodes or "branch points" represent the highest-level kinds of questions that can be asked. The game of "twenty questions" is a good example: the first questions are the most general ("Is it alive?"). By answering "yes" or "no," the number of possible answers is halved, and a large "branch" of the search tree is lopped off. Of course, problems handled by expert systems are more complex. It may be appropriate to explore more than one of the highest-level nodes, and lower-level nodes may re-connect to different "branches." A "depth-first" search

\textsuperscript{32}Hayes-Roth, p. 66.

\textsuperscript{33}Duda and Gaschnig, p. 246.
FIGURE 6: EXPERT SYSTEM OF THE FUTURE

strategy selects one promising higher-level node and systematically explores its subsequent branches ("deeper" in the solution tree), while a "breadth-first" search considers all solutions at the same level. Such methods (known as "blind search" techniques) are not very efficient for use with complex problems because too many nodes must be examined, resulting in a "combinatorial explosion" of possible solutions.34

A more sophisticated search strategy employs heuristics to guide the search process. Expert "rules of thumb" can be employed to eliminate branches without extensive examination of several nodes. Another strategy employs "abstraction of the search space" to restate the problem, eliminating particulars in the problem description that are judged to be non-critical. A "generate-and-test" strategy applies knowledge to the production of candidate solutions which are then evaluated by the system. Because such a strategy allows for the evaluation of solutions that are only partially specified, it can eliminate whole classes of solutions early in the problem-solving process ("early pruning").35

The model of an expert system presented in Figure 6 incorporates the ability to utilize a variety of search techniques and to combine their results. A heuristic search may be employed to identify basic features of the solution, which may then be used as criteria for a generate-and-test strategy. Promising candidates thus produced may then be simulated in order to analyze their consequences in detail. This combination of strategies is

34Hayes-Roth, p. 68-69.

35Ibid., p. 72.
FIGURE 7: CONFIGURATION OF THE PLAYWRITING EXPERT SYSTEM
similar to the combination proposed for use in the PLAYWRIGHT expert system.

The Playwriting Expert

Figure 7 shows the major ways in which the PLAYWRIGHT differs from the generic expert system model in Figure 6. While most current expert systems are designed for the needs of a human user who converses with the system in real time, the PLAYWRIGHT's user is the IF system itself. Accordingly, the principal output interface is geared toward production and communicates directly with the ENACTOR and SYSTEM CHARACTER subsystems. A natural-language interface for use by a human expert is still a desirable, albeit less important, feature of the system. Such an interface would enable a human expert—a director, critic, playwright, or system designer—to access explanations of the PLAYWRIGHT's reasoning process and debug that process in a natural language dialogue. It should be noted that such a facility would be used only occasionally and not during the run of an IF session, and would therefore not compete for memory or computational resources during real-time operation.

The PLAYWRIGHT also differs slightly from the generic expert system in the nature of its internal interfaces. The generic system includes an interface for sensor data, e.g., data from monitoring a production process or observing an external event. The PLAYWRIGHT has no direct access to sensor data; the results of user-sensing are already incorporated into the
model of the USER-CHARACTER that resides in the WORLD MODEL. The WORLD MODEL also includes the human-authored "potential" of the fantasy world and the history of the world to date. The WORLD MODEL and the SYSTEM CHARACTERS comprise the "external databases" to which the PLAYWRIGHT has internal interfaces. Those subsystems provide the data upon which the PLAYWRIGHT operates.

In Figures 6 and 7, the large area labeled "knowledge base" contains the expert knowledge possessed by the system. That knowledge is used in conjunction with the facilities of the inference engine to interpret and manipulate the data in order to produce solutions, i.e., next incidents that will be formulated as the script. The knowledge categories within the knowledge base are the same in both figures. The labeled boxes ("inference rules," "facts," etc.) do not represent functional units, but ways of expressing knowledge. Often, the same knowledge expressed in different forms so that it can be utilized by different functions; e.g., the same kind of knowledge is expressed in various forms in the examples labeled "facts," "inference rules," and "taxonomies" below. What follows is a description of the forms that knowledge might take in the PLAYWRIGHT's knowledge base:

**INFERENCERULES**: Rules of thumb for identifying and manipulating structural elements and lines of dramatic probability.

**PLANS**: Recipes for producing certain kinds of incidents given certain preconditions. Includes strategies for manipulating the behavior of the USER-CHARACTER (e.g., creating intrinsic constraints).

**STRUCTURAL MODELS**: Models of "ideal" dramatic structure to be used in planning and evaluation (e.g., Freytag's triangle, crisis-climax-denouement, etc.).
FACTS: Facts about dramatic structure and playwriting (e.g., the nature of a protagonist, the need for an opposing force or obstacle to the protagonist's goal).

TAXONOMIES: Conceptual networks describing kinds of structural elements (e.g., discoveries, reversals) and their relations.

BEHAVIORAL MODELS: Facilities for dynamically modeling the future course of events, including the behavior of the USER-CHARACTER and SYSTEM CHARACTERS.

The area labeled "learning subsystem" has the same general function in the PLAYWRIGHT as in the generic expert system: it remembers its decisions and the associated reasoning processes, learns from experience by emphasizing successful strategies and discarding or revising poor ones, and provides a facility for encoding new knowledge received from external knowledge sources. In the future, such sources might include books on playwriting and exemplary plays as well as human experts.

The "workspace" area, sometimes called a "blackboard," contains a description of the problem upon which the expert system is currently working and the current status of that problem. In the PLAYWRIGHT, that information takes the form of the specification for the next incident and the results of evaluation of the incident currently under consideration.

The "inference engine" component of an expert system is the locus of thinking. In the PLAYWRIGHT, the function of the "planner" is to create or revise a model of the plot in progress, specify the characteristics of the desired next incident, and select and configure candidate incidents. The "reasoner" evaluates plans and controls planning strategy based on evaluation results. The "simulator" simulates candidate incidents and their probable effects.
TABLE 3
PRINCIPAL FUNCTIONS OF THE PLAYWRIGHT

<table>
<thead>
<tr>
<th>MODEL</th>
<th>Model the plot in progress. Using data from the WORLD MODEL and SYSTEM CHARACTERS, the PLAYWRIGHT analyzes the story and determines the formal characteristics of the plot so far.</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPECIFY</td>
<td>Specify the formal characteristics of appropriate next incidents. The PLAYWRIGHT formulates specifications for candidate incidents to use as evaluation criteria.</td>
</tr>
<tr>
<td>CHANGE</td>
<td>Change scene, situation, or circumstances if appropriate.</td>
</tr>
<tr>
<td>MODIFY</td>
<td>Modify the goals, priorities, or information access filters of SYSTEM CHARACTERS if necessary.</td>
</tr>
<tr>
<td>ACCESS</td>
<td>Access proposals for next actions from the SYSTEM CHARACTERS. Proposals include explanations in terms of characters' traits, goals, and planning processes.</td>
</tr>
<tr>
<td>SIMULATE</td>
<td>Simulate proposed actions and changes to determine their probable effects on the plot.</td>
</tr>
<tr>
<td>EVALUATE</td>
<td>Evaluate proposed actions and changes by comparing simulation results to formal specifications.</td>
</tr>
<tr>
<td>MANDATE</td>
<td>Mandate next incident when an acceptable candidate cannot be produced through the usual processes.</td>
</tr>
<tr>
<td>FORMULATE</td>
<td>Formulate script for next incident.</td>
</tr>
<tr>
<td>DIRECT</td>
<td>Direct the SYSTEM CHARACTERS and the ENACTOR subsystem to enact the script.</td>
</tr>
<tr>
<td>CONTROL</td>
<td>Control its own operation by employing meta-knowledge and self-knowledge to select problem-solving strategies. As a by-product of the CONTROL function, the PLAYWRIGHT can produce explanations and justifications for its decisions.</td>
</tr>
<tr>
<td>REMEMBER</td>
<td>Remember what has happened. A log of the script is created, with associated explanations and justifications.</td>
</tr>
<tr>
<td>LEARN</td>
<td>Learn from experience. By noticing how it arrives at good and bad choices, the PLAYWRIGHT can improve its own performance.</td>
</tr>
</tbody>
</table>
FIGURE 8: FUNCTIONALITY OF THE PLAYWRIGHT's INFERENCE ENGINE
Functional Characteristics

A more detailed breakdown of the functionality of the PLAYWRIGHT will serve to elucidate the operation of the expert system, especially the inference engine. Table 3 enumerates the major, interrelated functions that the PLAYWRIGHT must perform.

As noted in the discussion of Figure 7, the "remember" and "learn" functions are handled by the learning subsystem. The rest of the functions described in Table 3 are performed within the inference engine. Figure 8 illustrates the flow of control in the inference engine; that is, the order in which various functions are performed and the decision points which determine problem-solving strategies. Functional elements are enclosed in rectangles and decision points are in diamonds. Function names used in Figure 8 appear along with their complete definitions in Table 3.

Quite simply, the problem is to produce a good next incident. The problem-solving strategy employed at any given time depends upon the particular characteristics of the problem (e.g., the type and complexity of the next-incident specification), the nature and severity of the current candidate's inadequacies, and the strategies that have already been applied. The system is designed to try simple solution strategies first, and then to consider progressively radical solutions.

The shortest path to success in Figure 8 (and thus the path that the system would be most likely to try first) does not invoke "change" or "modify." It accesses and simulates the first suggestions offered by the SYSTEM CHARACTERS, evaluates the results, and finds an acceptable
solution (OK?=Yes). The system then formulates that incident as script and directs that it be enacted.

A slightly more complex next-incident specification may require that the PLAYWRIGHT consider changes in situation (manipulation of non-character variables)—a discovery might require that a shaft of light fall on a particular rune, for instance. Modifications to the priorities or information-access filters of one or more SYSTEM CHARACTERS may also be implied in the next-incident specification. If the USER-CHARACTER's last action indicates that he has abandoned one major goal in favor of another, for instance, the priorities of a SYSTEM CHARACTER may need to be adjusted so that that character can function more effectively as an antagonist. Such changes and modifications may be intrinsic to the specification, or they may be considered when the "shortest route" fails to produce an acceptable candidate. If successful (OK?=Yes), control passes immediately to the "formulate" function.

If after one or two iterations the planning activity is not successful (OK?=No) but the results are promising (i.e., successive solutions move closer to meeting the specification), the system can decide to try making other changes at the same level (TRY AGAIN?=Yes). If results are deteriorating, the current strategy is abandoned (TRY AGAIN?=No) and a more radical solution is sought. The least difficult change that can be tried is to produce another acceptable specification based on the current model of the plot in progress (NEW SPEC?=Yes). If a particular kind of reversal cannot be induced, for instance, it may also be acceptable (if a bit less desirable) to create a discovery.
As with "try again," the "new spec" strategy may be abandoned if promising results are not achieved in a few iterations. At that point, the PLAYWRIGHT has the option to revise the model of the plot itself. If an acceptable incident cannot be produced, perhaps the PLAYWRIGHT has misunderstood what is going on. Reviewing the information about the USER-CHARACTER in the WORLD MODEL may allow it to construct a model of the plot that emphasizes different user goals or traits or proceeds from a revised understanding of what he knows and believes. The revised model will probably lead to a specification that calls for a different (and hopefully more realizable) next incident.

Exercising the "new model" option is a radical and expensive strategy, and it entails a commitment to utilize assumptions that are probably less reliable (the first model will have been based on the most reliable assumptions, i.e., those with the highest degree of certainty). If the new model is incorrect, the results will present additional difficulties in recovering from the error later. If a new model is judged to be too risky (i.e., alternate assumptions with adequate reliability cannot be found), or if the new model does not yield satisfactory results in simulation, the PLAYWRIGHT acknowledges that it does not have the means to produce an acceptable solution (EXHAUSTED?=Yes). At that point the "mandate" function is invoked. "Mandate" allows the PLAYWRIGHT to arbitrarily specify an incident that either changes the direction of the action or induces the USER-CHARACTER to take some action that will clarify his goals and plans.

Stepping through the functionality of the PLAYWRIGHT inference engine suggests the specific kinds of knowledge that must be contained in
the knowledge base. Before embarking on a more thorough description of the knowledge base, it is appropriate to review the characteristics of the data with which the system will work and the form in which those data exist.

**Data Characteristics**

The data that the PLAYWRIGHT uses are distinct from its expert knowledge, and arise from four principal sources outside the expert system itself: the descriptions of traits, goals, plans, etc. that are contained in the SYSTEM CHARACTERS; a similar description of the USER-CHARACTER that is contained in the WORLD MODEL; a log of the action to date contained in the WORLD MODEL; and the human-authored potential for the fantasy world, also in the WORLD MODEL.

There are several points of contact between the PLAYWRIGHT and the SYSTEM CHARACTERS. The "access" function requests proposals for specific actions from the SYSTEM CHARACTERS. These proposals represent the SYSTEM CHARACTERS' immediate response to the current state of affairs, as affected by the most recent action of the USER-CHARACTER. The planning behavior that gives rise to such proposals is quite similar to the behavior of characters in a traditional story-generation system; that is, SYSTEM CHARACTERS make plans based solely upon the content or "story component" of the action, and have no notion of its form or "plot component." It may be logical for a SYSTEM CHARACTER to propose several actions (arising from different plans) at any one time. The internal, "content-dependent" logic of the SYSTEM CHARACTERS serves to winnow out a subset of probable actions from all the possible actions that they might
Name: JESSICA DONADIO (&PER7)
Born in: 1918
Marriages:
  DOUGLAS DAVIDSON [&PER0] [1951/1959]
  -- MARK DAVIDSON [&PER8]
  -- RENE DAVIDSON RODGERS [&PER9]
  IVAN SCHAAD [&PER14] [1959/1967]
Interpersonal Relationships:
  EX-SPOUSE DOUGLAS DAVIDSON [&PER0] -5/-5//4/4//0/0//4/4
  DIV-MOM 8/4//4/4/6//2//4
  DIV-MOM 8/4//4/4/6//2//4
  EX-SPOUSE IVAN SCHAAD [&PER14] -5/-5//4/4//0/0//4/4
  EX-SPOUSE BRUCE SMITH [&PER45]
History: REVENGE/1964 [&PL7]
Stereotypes: MASSEUSE PARTY-GOER EGOMANIAC
Trait modifiers: (PHYS-APPEARANCE -1) (AGE A)
  Overall description:
WEALTH 6
PROMISCUITY 7
COMPETENCE 7
NICENESS 0
SELF-CONFIDENCE 8
GUILE 7
MOODINESS 5
PHYS-APPEARANCE 5
INTELLIGENCE 4
GOALS (BECOME-FAMOUS MEET-FAMOUS-PEOPLE
ASSOCIATE-RIGHT FIND-HAPPINESS)
AGE A
SEX F

FIGURE 9: A SAMPLE UNIVERSE CHARACTER

take at a given moment. The PLAYWRIGHT, in choosing an action from that subset, contributes further to the establishment of dramatic probability: the chosen action serves as a causal antecedent for a subsequent action. This dynamic illustrates the causal relationship between the PLAYWRIGHT as an agent of formal causality and the SYSTEM CHARACTERS as agents of material causality. By the end of the whole action, SYSTEM CHARACTERS' proposals should be successfully constrained to a single, necessary action.

A second point of contact between the PLAYWRIGHT and the SYSTEM CHARACTERS is utilized in the "simulate" function. It is during this activity that the PLAYWRIGHT must predict the consequences of a candidate incident in order to evaluate its probable effect upon the whole. The "simulate" function requires the PLAYWRIGHT to examine the traits and predispositions, goals and plans, relationships, significant history, and information-access filters of the SYSTEM CHARACTERS in order to determine how they are likely to respond to a proposed change. The PLAYWRIGHT may also wish to examine data within the SYSTEM CHARACTERS that describe their ability to specify their actions on the levels of diction, music, and spectacle. That information resides in a table within each SYSTEM CHARACTER and represents the character's potential for action.

Figure 9 is an example of a "person frame" containing character data taken from Lebowitz's UNIVERSE program. Because Lebowitz's system creates "soap opera" worlds, a record of marriages is extremely important. In a "Star Trek" world, on the other hand, a character's official rank and

\[36\] Lebowitz, pp. 190-194.
duties in Starfleet would be more germane. Lebowitz represents interpersonal relationships in two ways: as stereotypical relationships about which the system has general knowledge ("ex-spouse" or "divorced-mother-of"), and as numerical ratings from -10 to +10 on a series of parameters (positive/negative, intimate/distant, dominant/submissive, and attract/repel). Of course, the parameters chosen to represent a relationship may vary. In TALE-SPIN, for example, Meehan employs parameters like "trust" and "competitiveness."\(^{37}\) The information in the "history" slot in Lebowitz's table refers to a specific series of incidents that the system can look up in its records, and is utilized as a compact explanation for some of the character's relationships and predispositions. Lebowitz utilizes "stereotypes" to invoke associated traits and planning styles. Traits are also represented numerically. The goals listed in Lebowitz's "person frame" are general, life-long goals that might better be described as predispositions. In Meehan's TALE-SPIN world, more immediate goals are represented, e.g., "get the honey" or "trick the bear."\(^{38}\) Although it does not contain enactment-related traits (e.g., dialect, type of voice, appearance, movement characteristics, etc.) or information about information-access filters, the form of Lebowitz's "person frame" illustrates how such information might be represented.

The same character data are utilized by the PLAYWRIGHT in the exercise of the "change," "modify," and "mandate" options. In the "change" function, the PLAYWRIGHT utilizes the data to determine whether a change

\(^{37}\)Meehan, *passim.*

\(^{38}\)Ibid., pp. 23-28.
in situation or circumstance may lead to a desirable proposal. Promising changes are processed through the "access," "simulate," and "evaluate" functions. In the "modify" function, the PLAYWRIGHT may temporarily alter the character data to determine (through the same process) whether specific modifications will produce desirable results. If a modification eventuates in an action that is executed by the system, the changes to the character data are made permanent. If the PLAYWRIGHT must perform the "mandate" function, the character data are utilized in much the same way as they would be in a traditional story generation program.

The final point of contact between the PLAYWRIGHT and the SYSTEM CHARACTERS is at the production interface, where the "direct" function is employed to command the system characters to enact an incident in the interface environment. It is interesting to observe again the workings of formal and material causality within the "direct" and "enact" functions: formal causality moves from the PLAYWRIGHT through the "direct" function to the SYSTEM CHARACTERS, who proceed through the levels of thought, diction, music, and spectacle to create the enactment. Although no data are provided directly to the PLAYWRIGHT at this point, a description of the SYSTEM CHARACTERS' enactment will subsequently be available as data within the log of the action that is maintained in the WORLD MODEL.

The WORLD MODEL provides three different kinds of data to the PLAYWRIGHT. It contains a model of the USER-CHARACTER which is derived from the activities of the UNDERSTANDER subsystem (see Figure 5). It is the role of the UNDERSTANDER to parse the speech and physical activities of the USER-CHARACTER and to infer his traits, goals, plans,
expectations, relationships, and knowledge about the fantasy world and the action to date from those data. The resultant model of the USER-CHARACTER exists in a form similar to that illustrated in Figure 9. It is used to predict the USER-CHARACTER's behavior in the "simulate" function.

A second kind of data contained in the WORLD MODEL is a log of the action to date. The log contains information from three different sources. When the "direct" function is executed, the PLAYWRIGHT enters its commands in the form that they were issued into the log; e.g., in a "Star Trek" world, Chief Engineer Scott "examines the console and reports that the warp engines are disabled."39 When the enactment occurs, the ENACTOR subsystem enters the actual characteristics of the enactment into the log; for example,

[Viewscreen on bridge switches to view of Engineering Section. Mr. Scott is standing with his back to the console, "facing" the bridge.]

SCOTT: (Turns to his console; observes; slumps his shoulders; turns to Kirk. Shaking his head:) It's nae good, sair. Me wee bairns ha' given up the ghost.

The log entry from the ENACTOR demonstrates how the SYSTEM CHARACTERS utilize the character data (traits, goals, etc.) in creating the enactment. The example above reflects Scott's relationship with Kirk, his feelings about the engines, some of his physical traits, and his characteristic diction.

39 The PLAYWRIGHT's log entries are expressed here in natural language for the purposes of illustration. In actuality they would exist in a symbolic form (such as a Conceptual Dependency representation) with the same meaning, as discussed in Chapter IV.
<table>
<thead>
<tr>
<th>MAJOR CATEGORIES</th>
<th>SUB-CATEGORIES</th>
<th>EXAMPLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHYSICAL</td>
<td>Geography</td>
<td>topography, location of cities, natural resources</td>
</tr>
<tr>
<td></td>
<td>Locales and Settings</td>
<td>geographical location, appearance, common usage</td>
</tr>
<tr>
<td></td>
<td>Physical descriptors</td>
<td>gravity, atmosphere, chemical composition</td>
</tr>
<tr>
<td>BIOLGICAL</td>
<td>Kinds of creatures</td>
<td>humans, animals, magical creatures</td>
</tr>
<tr>
<td></td>
<td>Physical characteristics</td>
<td>basic anatomy, biological requirements, predatory relationships</td>
</tr>
<tr>
<td></td>
<td>Basic drives and emotions</td>
<td>fear of death, response to pain, protection of young</td>
</tr>
<tr>
<td>CULTURAL</td>
<td>Social behaviors and customs</td>
<td>mating, child-rearing, recreation activities</td>
</tr>
<tr>
<td></td>
<td>Institutions</td>
<td>government, religion, education</td>
</tr>
<tr>
<td></td>
<td>Beliefs and values</td>
<td>morality, ethics, cosmology</td>
</tr>
<tr>
<td></td>
<td>History</td>
<td>natural events, political events, wars and invasions</td>
</tr>
<tr>
<td></td>
<td>Science and technology</td>
<td>weapons, tools, communications</td>
</tr>
<tr>
<td></td>
<td>Arts</td>
<td>literature, music, architecture</td>
</tr>
<tr>
<td></td>
<td>Common objects</td>
<td>furniture, clothing, toys</td>
</tr>
</tbody>
</table>
The UNDERSTANDER enters the words and actions of the USER-CHARACTER into the log in much the same form as the ENACTOR's entries; for example:

KIRK: (Smacks the "alert" control.) Red alert! I want to know what's causing this energy drain (points to energy indicator on control panel).

The UNDERSTANDER's contribution to the log includes the results of its speech and gesture recognition activities ("smacks" and "points"); however, the inferences that it makes about the USER-CHARACTER's goals, plans, and traits are recorded separately in the model of the USER-CHARACTER discussed at the beginning of this section (pp. 215-216).

The log provides a record of the action to date that will be utilized by the "model" function to determine the structural characteristics of the evolving plot and to identify major lines of probability. The log supplies the "simulate" function with causal antecedents and is thus used as data in the prediction of future events. The PLAYWRIGHT may utilize the log to compare its commands with the enactment that results from them in order to improve its performance in the "formulate" and "direct" functions.

The third kind of data that exists in the WORLD MODEL is the description of the non-character elements of fantasy world itself. Table 4 lists some of the kinds of information that might be contained in the fantasy world description. A description containing all the elements listed in Table 4 would represent an extremely complex world. It is important to recognize that the complexity of the world description is directly related to the complexity of the stories that it is intended to support. Meehan's TALE-SPIN world, for example, is extremely simple, containing only a few locales, kinds
of objects, and notions of social behavior. Accordingly, it provides adequate
potential for only simple, fable-like stories. It is impossible for either the
PLAYWRIGHT or the SYSTEM CHARACTERS to "think of" something that is
not contained in the world description. As the world description grows in
complexity and detail, the computational and memory-related demands on
the system increase geometrically; however, these are changes in quantity,
not kind, of resources required.

It should be noted that the character data contained in the initial state
of the SYSTEM CHARACTERS functions along with the world description to
delimit the potential of the fantasy world. The initial configuration of
characters must contain the potential for dramatic action. In Meehan's world,
for example, a story about a hungry bear is more "dramatic" when he meets
a clever, stingy bee (with a honey-filled hive) than when he encounters a
stupid, lazy one. In a "Star Trek" world, if the user is intended to assume the
role of Captain Kirk, a constellation of characters must be created that
provides the necessary information, support, and opposition. If the user is
intended to portray the protagonist (the simplest strategy), then likely
antagonists must exist among the SYSTEM CHARACTERS. Dramatic
potential is also enhanced by including characters that can be used as foils,
raisonneurs, confidants, or messengers.40

The physical aspects of the world description (as well as the physical
characteristics implied in the character data) should correspond closely with
the actual images that can be produced. The possibilities for setting are
constrained by the images and sequences available in the visual database

40For functional descriptions of such characters, see Smiley, pp. 98-99.
(stored on videodisc or videotape, or capable of being generated by a computer animation program). The author of the world description must at the least be familiar with the visual materials available to the system; at best, the author will be involved in the specification and selection of those materials. If specific sounds and kinds of sounds are critical to the dramatic action or milieu, the author of the world description must also be familiar with the audio materials and capabilities possessed by the system. Thus the process of "authoring the world" involves not only formulating the world description and character data, but also assessing or specifying the resources and capabilities of the ENACTOR and the self-representational capabilities of the SYSTEM CHARACTERS.

The task of creating a successful plot is simplified if the world description contains generative situations, candidate inciting incidents, and scenarios for key scenes. Bernard Grebanier, in his practical book on playwriting, advises the playwright to begin with a description of a situation (i.e., a state of affairs) rather than with a notion of plot or character. Grebanier illustrates how the initial situations inherent in several successful plays could be shaped into several different dramatic plots. Unfortunately, Grebanier does not state or imply the characteristic of a situation that make it especially fertile for dramatic development; however, such situations could be borrowed from extant plays (as Grebanier has done) or contributed by human playwrights, using their own expertise in identifying generative situations.

In an interactive fantasy based on a "Star Trek" world, for example, an inciting incident—an errant space probe's attack on the Enterprise—serves to identify the protagonist (Kirk, portrayed by the USER-CHARACTER) and antagonist (Nomad, the deranged probe) and to pre-determine, in a general way, the central action of the plot (Kirk's attempts to defeat Nomad). While it is theoretically possible for a full-blown IF system to generate key scenes as needed, providing scenarios for such scenes in the world description greatly simplifies the playwriting task. To impart an appropriate degree of seriousness to the conflict between Kirk and Nomad, for instance, expository scenes such as an attack by Nomad on Lieutenant Uhura can be constructed by the PLAYWRIGHT from a set of pre-fabricated scenarios. If such scenarios exist, they are considered by the PLAYWRIGHT in the "access" function. The world description, like the expert knowledge contained in the knowledge base, is presumed to be originated by a human and translated into the appropriate symbolic form by a programmer or "knowledge engineer." As with the knowledge base, it may be possible in the future to gather the information in the world description from non-human sources. The process of extracting such information from books, plays, databases, or other sources may someday be performed by a computer.

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42This example is drawn from an actual "Star Trek" script: John Meredyth Lucas, "The Changeling" (shooting script, Paramount Pictures Corporation, 1967). Distributed by Lincoln Enterprise of Los Angeles, California.
The PLAYWRIGHT's Knowledge

In the section on expert systems (pp. 188-202), the kinds of knowledge that such systems must possess were discussed. The first three kinds of knowledge described—facts, relations, and methods—are *domain knowledge*, i.e., knowledge about the system's particular domain of expertise. A fourth kind of knowledge, meta-knowledge, may be described as "knowledge about knowledge." Meta-knowledge guides the system in its selection of problem-solving methods. The meta-knowledge characteristics of the PLAYWRIGHT are illustrated in the discussion of the flow of control in the inference engine. The fifth category, self-knowledge, is composed of the system's observations of its own operation and provides the means for learning from experience. This section will concentrate on the domain knowledge of the PLAYWRIGHT.

The goal of this study is to demonstrate that a computer-based interactive fantasy system is feasible, not to provide a complete blueprint for building such a system. The schools of thought (i.e., knowledge systems) within the domains of dramatic criticism and dramaturgy are many and diverse. An expert system, like a human expert, may be a disciple of one particular knowledge system, or may embody an individual approach that integrates ideas from various schools of thought. Just as there is no ideal way to write a play, so there is no ideal knowledge base for an IF system; future designers can implement endless variations. In any case, the task of
selecting and detailing the content of an expert knowledge base (knowledge engineering) is the central task in building an expert system, and is beyond the purview of a feasibility study. This section is intended to identify the fundamental areas of domain knowledge that should be included in the knowledge base and to provide examples of such knowledge.

A playwright, whether human or computer, looks at his task from two distinct perspectives. On the one hand, he is concerned with the narrative upon which his play is based. The narrative includes not only the incidents that are chosen for representation in the play itself, but also those that have some bearing on the play but are not represented, e.g., incidents that occur before the play's point of attack and incidents that occur during the span of time treated by the play, but which are not included in the enactment. In devising the narrative, the playwright is concerned with the causal connections between events and with identifying larger patterns of action and motivation. He also uses portions of the narrative as exposition in the play to establish situations and causal antecedents for events. Smiley calls the portion of the narrative that is ultimately enacted the "story."43 In this chapter, the terms "story" and "narrative" are used interchangeably to refer to all of the story materials that are utilized in the formulation of the plot, whether they are ultimately enacted or not. The narrative of an interactive fantasy differs from that of a traditional play in that it is non-linear; i.e., it includes all of the alternative plans and actions that are proposed by the SYSTEM CHARACTERS at a given decision point, even though only one proposal will be chosen for enactment. Because the narrative is the material

43Smiley, p. 52.
used by the playwright, his knowledge about the narrative aspects of the play—the content of the action—is termed *material knowledge*.

On the other hand, the playwright is concerned with the plot: the form and structure of the incidents that he chooses to represent on stage in order to achieve dramatic effects. He employs formal and structural criteria for selecting those incidents from the story that will be represented in the plot, determining the order and arrangement of incidents, and establishing focus and dramatic probability. The knowledge that he uses in plotting is referred to as *formal knowledge*.

Material and formal knowledge are theoretically separable in the way the PLAYWRIGHT expert system goes about determining next incidents; in reality, however, there is constant interplay between the two. Distinguishing between material and formal knowledge does not imply that *action* lacks structure until it is formulated in a dramatic plot, but suggests that the structure of action as it exists in a narrative is derived from its content and meaning, while the structure of action in a plot derives from the dramatic form. A plot incident that is a dramatic *reversal*, for instance, can only be shaped from story materials that contain the potential for reversal. Material knowledge allows the PLAYWRIGHT to recognize (or generate) story materials with the appropriate potential; formal knowledge is utilized to shape those materials into a plot incident with a particular dramatic structure.

Just as material and formal knowledge provide two perspectives from which to view action, so the action of a play is the product of both material and formal *causality*. At this point it is worthwhile to review the workings of
material and formal causality in the system and to introduce the notion of *ad hoc* formal causality.

The task of the PLAYWRIGHT is to shape the materials of the narrative into a dramatic plot. The narrative (including the contributions of the USER-CHARACTER) functions as the *material cause* of a play; the completed plot functions as its *formal cause*, determining the selection and arrangement of incidents and their dramatic structure. The notion of formal causality is difficult in that it appears to assume the pre-existence of the finished work. While it is true that a good playwright probably has an idea of what a "good play" is like (or a sculptor has an notion of a "good statue"), he may or may not be able to visualize the outcome of his own efforts. An individual artist may have a complete, detailed vision of the finished form of the particular piece he is working on, or he may have no image at all. Many artists pride themselves in their spontaneity; the pen (or brush, etc.) "does it all" and the artist merely observes his own creative outpouring, amazed. It is true that some constraints on the final product exist in the materials that an artist uses—a two-foot cube of marble will not yield up Michelangelo's "David"—but such constraints merely circumscribe a field of potential; they do not pre-determine the form of a specific work.

It is nevertheless true that an artist must have some notion of what he is making in order to make it; accidental objects do not normally qualify as art. Whether the artist's notion of the finished whole is carefully formulated and consciously applied, or whether it resides in the artist's "subconscious" or "instincts" and creeps into the process unnoticed, is not the issue. As a sculptor chips away at his piece of marble, each stroke narrows and focuses
the potential of the material until only the final form remains. As a playwright formulates his plot, he shapes the potential of his materials so that the action moves from the realm of the possible to the probable. As he pens each incident, the shape of the final plot becomes clearer in his mind. When he has finished, his work and his image of it become one. Thus, in practice, the forces of material and formal causality are in constant interplay. At any moment during the process, the playwright's notion of the whole functions as an ad hoc formal cause—an approximate notion of the finished work that informs the process of formulation.

To understand the workings of material and formal causality in an IF system, it may be helpful to imagine a human playwright working with a peculiar constraint. In his study as he writes is an actor who has been assigned the role of improvising a character with some basic, pre-determined traits and predispositions. The actor looks over the playwright's shoulder as he composes a few lines of dialogue. When he feels it appropriate, the actor interjects the lines that will be spoken by his character. The rule of the game (the "peculiar constraint") is that the playwright must dutifully copy the actor's contributions and consider them along with his own dialogue as he continues to write. In his attempt to integrate the actor's contributions into the script, the playwright imagines how they will affect the outcome and continually revises his notion of the finished play. As he does so, the playwright tries to imagine what he can do to insure that the finished play is a good one.

The PLAYWRIGHT expert system employs formal and material causality in exactly the same way. In an IF System, the role of the
improvising actor is performed by the USER-CHARACTER. His contributions, along with the other materials provided by the SYSTEM CHARACTERS and WORLD MODEL, constitute the material cause of the plot. The PLAYWRIGHT combines its knowledge of the materials and their potential with its knowledge of dramatic structure in the "specify" function. In the "simulate" function, the PLAYWRIGHT experiments with various formulations of next events to predict the likely outcome—the shape of the finished whole. The results of the simulation are then evaluated in terms of the structural criteria expressed in the next-incident specification. Thus the PLAYWRIGHT expert system emulates the human playwright's use of *ad hoc* formal causality.

**Material Knowledge**

A human playwright, writing a non-interactive play, employs *story-telling* knowledge in creating the narrative upon which the play will be based. The PLAYWRIGHT expert system requires such knowledge when it participates in the creation of story materials in the "change," "modify," and "mandate" functions.\(^4\) Story-telling knowledge is embodied in a "local" story-generation facility that is part of the knowledge base.

A human playwright may or may not employ *story-understanding* knowledge in the practice of his craft. If his play is based upon a legend or

\(^4\)The SYSTEM CHARACTERS also employ story-telling knowledge when they generate proposals for action that will be passed to the PLAYWRIGHT in the "access" function. Considered alone, a "story generator" is a form of AI but not an expert system in and of itself. The SYSTEM CHARACTERS' ability to generate stories demonstrates the "distributed intelligence" that is characteristic of an IF System.
an actual historical event, for instance, he must analyze and understand that
pre-existing material, and will ultimately select elements of his plot from it.
The PLAYWRIGHT expert system requires story-understanding knowledge
in the performance of several functions. The narrative of an interactive
fantasy is drawn from the data provided by the WORLD MODEL and
SYSTEM CHARACTERS. Events and experiences are represented in the
data that provide motivations and causal antecedents for the incidents that
will be included in the plot. In the "model" function, the PLAYWRIGHT
repeatedly integrates facts and inferences about the USER-CHARACTER in
an understanding of the content of the action as it occurs. In the "access"
function, the playwright must understand the plans and actions proposed by
the SYSTEM CHARACTERS.

The smallest unit of action considered by the PLAYWRIGHT is an
incident: "an occurrence of an action or situation that is a separate unit of
experience."\textsuperscript{45} Smiley defines an incident as an "instance of observable
action."\textsuperscript{46} An interactive fantasy is something like a tennis match, in that the
two participants—user and system—alternately contribute materials to the
plot. In shaping dramatic incidents, the PLAYWRIGHT must understand all
the incidents that have already transpired (as well as those that are part of
the narrative but not part of the plot) in terms of their content, in order to
recognize larger patterns of action and causality.

\textsuperscript{45}\textit{Webster's Ninth New Collegiate Dictionary} (1983), s.v. "incident."

\textsuperscript{46}Smiley, p. 52.
A group of causally related incidents may be considered together as a logical unit of action. Smiley refers to such a unit as a "beat"—the dramatic equivalent of a paragraph.\textsuperscript{47} A beat includes one or more incidents. Lehnert utilizes the notion of a "plot unit" to refer to a unit of action that includes at least two "affect states" (plans, goals, or emotions) connected by one or more "causal links" (motivation, actualization, termination, or equivalence). Plot units may also include "cross-character links" when more than one character is involved.\textsuperscript{48} Like beats, plot units may subsume one or more incidents. Generally, a plot unit can be thought of as a unit of action that includes an initial state and an action that culminates in a change of state. In an analysis of dramatic structure based upon a linguistic model, John Gutting identifies hierarchically related units of action that include "actions" (usually individual lines or utterances), "transactions" (usually a group of two "actions" that take the form of a statement and a response) and "segments" (groups of transactions that form logical units).\textsuperscript{49}

The PLAYWRIGHT's next-incident specification is a recipe for action that embodies a dramatic objective. The "recipe" includes ingredients of choice, action, and information and implies the causal relations among them. The objective is the successful enactment of a dramatic incident of a particular type (e.g., suffering, discovery, or reversal). A dramatic incident probably requires more than one transaction between its initiation and its

\textsuperscript{47}Ibid., p. 27.

\textsuperscript{48}Lehnert and Loiselle, pp. 4-8.

completion, and is thus more like a "beat" or "plot unit" than an "incident" as Smiley defines it. In Gutting's terms, the next-incident specification normally operates at the level of the segment, including one or more transactions and their component actions. Using the tennis analogy, the next-incident specification can be seen as a plan for the next volley which includes, but is not limited to, the next stroke. It is only at the completion of the volley (when the outcome is either success or failure) that the component strokes can be evaluated. The entire volley is driven by a single strategy (defensive or offensive, depending upon the point of view); its component strokes embody tactical decisions that are influenced by that strategy. Similarly, the PLAYWRIGHT's next-incident specification contains a strategy for the next "volley" of action—the next dramatic incident or beat. Once the specification has been formulated into "script" and transmitted by means of the "direct" function, it is up to the enactment subsystems (the SYSTEM CHARACTERS and ENACTOR) to make and carry out the necessary tactical decisions. They monitor the progress of the "volley" and report the results to the PLAYWRIGHT, re-initiating the planning process. Thus the units of action (dramatic incidents) that are specified by the PLAYWRIGHT may subsume more than one exchange between the USER-CHARACTER and the SYSTEM-CHARACTERS in the interface environment.

There are no standard structural units for considering action apart from the literary form in which it is represented. In an attempt to understand, analyze, and create stories and plays, various theorists have contributed notions of how action can be "parsed," i.e., broken down and analyzed. Such systems of analysis (of which Lehnert's plot units are an example) can
be described as forms of action calculus: the study of action through the use of symbolic logic. An action calculus addresses, not the structure of a representation of action, but the "intrinsic" structure of action that is derived from its content and meaning. It can be used both analytically and predictively; thus, an action calculus provides a form for integrating both story-telling and story-understanding knowledge. Because symbolic logic is amenable to manipulation by computer, an action calculus is an ideal way to represent action in a computer program.

In The Law of the Drama, Brunetière paved the way for the use of action calculus in the analysis of plays by insisting that dramatic action is based upon the "conscious will" of the protagonist. To express one’s will is "to set up a goal, and to direct everything toward it, to strive to bring everything into line with it."⁵⁰ Brunetière’s analysis suggests that the action of a play can be parsed as steps towards a goal, each of which affects or is the result of the nature of the obstacle and the conditions of the struggle.⁵¹

It is not the central idea of Brunetière’s theory—that dramatic action consists in the exercise of the protagonist’s will against opposing forces—but its single-minded simplicity which suggests the possibility of an action calculus. As discussed in Chapter IV, AI researchers like Wilensky, Dyer, Lehnert, and Meehan utilize a nearly identical goal-based theory of action to understand and generate stories by computer. Wilensky sees


⁵¹Ibid., p. 607.
goals and plans as the means by which people solve problems. The notion that problem solving is at the heart of dramatic action is expressed by Smiley:

Conflict defines a problem, and the character's strategies for its solution involve instrumental and non-instrumental responses plus temporary escapes or enduring solutions. By solving problems, people increase their ability to master themselves and their world. Hence, a play establishes an action containing problems and conflicts. It employs characters who carry out the functional activities of response, struggle, and decision. In such ways, character and action are interlocked.

When action is understood as problem-solving behavior, it can be parsed in terms of goals and plans. This is the approach taken by most story-generation systems, and it has heavily influenced the design of the PLAYWRIGHT inference engine: next incidents are most often formulated on the basis of actions that result from the problem-solving activity of the SYSTEM CHARACTERS. The problem-solving paradigm is a familiar action calculus in the world of AI; however, other approaches are possible.

The work of Georges Polti in his book *The Thirty-Six Dramatic Situations* is often cited by AI researchers as providing the basis for an action calculus. Polti asserts that the "thirty-six situations" reflect the fact that "there are in life but thirty-six emotions." Although his psychology may

52 Wilensky, p. 9.

53 Smiley, p. 102.

54 See, for example, Meehan, p. 107.

be dubious, Polti’s examples are persuasive. He has cited twelve hundred examples from various literary genres in an attempt to demonstrate that his "thirty-six situations" are all-inclusive. Instead of plans and goals, Polti employs the following set of primitive elements (or symbolic units) to create symbolic expressions for actions: character types whose names imply their potential for action and their key relationships (e.g., The Criminal, The Jealous Kinsman, The Deceived Husband), objects or events (e.g., The Mistake, The Coveted Object), and, occasionally, situational or motivational elements (e.g., The Necessity for Sacrifice, The Cause of the Mistake). Meehan utilizes a similar scheme for generating stories, but he makes no claim that his "calculus" is exhaustive.

Unfortunately, Polti does not catalog his primitive elements, nor do they seem to be the product of some systematic categorization scheme. An idiosyncratic system such as Polti’s could be employed by an IF system with limited story potential (much as Meehan’s calculus limits the kinds and complexity of the stories that TALE-SPIN can produce). A more general and systematic approach would be more robust and versatile. Structuralist critic Robert Scholes describes the search for such systematicity in the analysis of literature:

At the heart of structuralism is the idea of system: a complete, self-regulating entity that adapts to new conditions by transforming its features while retaining its systematic structure. Every literary unit from the individual sentence to the whole order of words can be seen in relation to the concept of system.⁵⁶

Scholes is intrigued by the work of Étienne Souriau, whose attitude toward Polti's work is clear in the title of his own: *Les deux cent mille situations dramatiques* (*The Two Hundred Thousand Dramatic Situations*). Scholes describes Souriau's approach:

He proposes instead of some fixed list of dramatic possibilities a system of functions which may be arranged in all their mathematical combinations to produce dramatic situations. And he calculates that there are precisely 210,141 situations derived from a simple set of six functions and five methods of combination. It is hard to tell how serious he is about his mathematics, but I have checked it extensively and found it totally unreliable. . . . But his thinking about dramatic functions is as rigorous and consistent as any similar formulations that I have seen, and as informed by a real sense of theater as one could wish.\(^{57}\)

While Polti's system is reminiscent of the deck of the Tarot (The Lover, The Queen, etc.), Souriau's symbolic expressions look like astrological charts—he named each of his six functions after an astrological sign. Although a certain eccentricity pervades the work of both men, Souriau's efforts seem to have the kind of robust systematicity that could be well-utilized in an IF system. Scholes describes Souriau's system as a successful attempt to capture "the symbolic logic of the stage."\(^{58}\) Briefly, Souriau's six functions are as follows:

- **The Lion:** The force or desire around which the action of the play will revolve (similar to Brunetière's notion of will).
- **Mars:** The rival, opponent, or opposition to the Lion.
- **The Sun:** The object or desired good (i.e., the thing desired by the Lion).

\(^{57}\)Ibid., p. 51.

\(^{58}\)Ibid., pp. 57-58.
The Earth: The destined recipient of the good (the person or use for which the object is intended).

Balance: The arbiter; the character(s) with whom the decision ultimately rests.

The Moon: The helper; an ally or assistant of any of the other functions.

Each function may be embodied in one or more characters or in an object or force. Scholes' discussion of the system includes numerous symbolic expressions in Souriau's astrological notation, and examples from such plays as Macbeth and Tartuffe. Although he believes that Souriau's system "will never serve as an adequate description of actual dramatic situations, it can certainly function as a structural grid to help us perceive the actualities of any works of dramaturgy." In an attempt to understand story materials, the PLAYWRIGHT might assign Souriau's functions to personages and objects in order to illuminate the structure of the action. Symbolic expressions based on the six functions might also serve as templates or "recipes" for generating narratives with dramatic potential.

Lehnert's action calculus, based on her notion of plot units, incorporates knowledge of goals and plans drawn from Schank, Wilensky, Dyer, and others. It is also reminiscent of Polti and Souriau in that elementary plot units are combined to form larger, recognizable patterns of action with names like "Fleeting Success," "Hidden Blessing," and "Regrettable Mistake." Such complex plot units are connected with causal links to form plot-unit graphs that describe the action of an entire story. The

59 Ibid., p. 57.

60 Lehnert and Loiselle, pp. 1-2.
plot-unit graph also provides some information about the literary structure of the story. Lehnert's graph of O'Henry's "Gift of the Magi," for instance, illustrates both the content of the action and the unusually symmetrical structure of that action in O'Henry's formulation.61

An action calculus is an important element of the material knowledge of the PLAYWRIGHT. It is useful in the performance of several functions in addition to story understanding and story generation. Partial, incomplete configurations may be identified during the "model" function that can be used to predict future events in the "simulate" function. By employing an action calculus to analyze the action in its early stages, the PLAYWRIGHT may be able to identify the logical candidates for protagonist and antagonist (if they are not pre-determined by the WORLD MODEL) and patterns of action that may appropriately be formulated as the central action and sub-plots.

Another primary kind of material knowledge that the PLAYWRIGHT must possess is knowledge about working with the USER-CHARACTER. The WORLD MODEL contains a model of the USER-CHARACTER, based on inferences made by the UNDERSTANDER. The PLAYWRIGHT must interact with that model in order to understand the USER-CHARACTER's potential for action and to determine ways of constraining the user to contribute appropriate materials. The model of the USER-CHARACTER probably takes the form of a goal-and-plan analysis that is similar to the structure of the SYSTEM CHARACTERS. When the goals of the USER-

61Ibid., pp. 24-26. For more discussion of Lehnert's system, see Chapter IV, pp. 154-155.
CHARACTER cannot be inferred, or when a new goal that has no apparent relation to known goals is implied by the user's actions, the PLAYWRIGHT must have strategies for making good guesses or eliciting more information. What follows are some sample heuristics for gaining information about user goals:

IF user's current action is unrelated to known goals, hypothesize a new goal to explain the current action.

IF user's current action implies a new goal, and IF higher-level goals have been established, then the new goal is probably part of a plan to achieve a known higher-level goal.

IF user's current action indicates a new goal, find out if the new goal may be part of a plan to achieve known goals.

IF user's new goal is probably not part of a plan to achieve known goals, revise higher-level goals to explain new goal.

IF user's new goal is inconsistent with known higher-level goals, try to make user relate new goal to known goals.

IF a goal cannot be inferred from user's current action, shift focus to known goals (intensify value or opposition).

As with the SYSTEM CHARACTERS, the PLAYWRIGHT shapes the USER-CHARACTER's goals and plans by controlling his access to information as well as by creating incidents. The PLAYWRIGHT controls the knowledge of the SYSTEM CHARACTERS through the use of information-access filters; it controls the knowledge of the USER-CHARACTER by means of exposition. Every incident generated by the system contains some element of exposition—information about the situation, previous events, characters' goals and plans, etc. In order to constrain the USER-
CHARACTER through exposition, the PLAYWRIGHT must calculate the effects of new information. The model of the USER-CHARACTER is utilized in the "simulate" function to predict the probable effects of both events and information on his goals, plans, and future actions.

In summary, the material knowledge of the PLAYWRIGHT is knowledge about the narrative: its content and meaning, the structure of its action, and the means for eliciting and interpreting "narrative" materials from the USER-CHARACTER. Examples have been presented of knowledge in the form of facts and taxonomies (as in the definitions of "incident," "beat," and "plot unit"), symbolic logic (action calculus), heuristics, and behavioral models. In the next section, the other major category of the PLAYWRIGHT's domain knowledge—formal knowledge—will be similarly explored.

**Formal Knowledge**

Formulating a dramatic plot from all the materials at the PLAYWRIGHT's disposal requires *formal knowledge*. Formal knowledge includes knowledge about the nature of dramatic structure (theoretical knowledge) as well as knowledge about how to create it (practical knowledge). Knowledge about how to *enact* the incidents in the plot as they are created (productive knowledge) resides in the ENACTOR and SYSTEM CHARACTER subsystems; the PLAYWRIGHT is intrinsically constrained by their capabilities and limitations and therefore needs no "expert" knowledge about how to employ them. A surprising proportion of the system's formal knowledge is incorporated in the design itself and requires no special representation in the knowledge base. Causality and unity, for instance,
arise from the nature of the SYSTEM CHARACTERS' and the
PLAYWRIGHT's planning mechanisms, and require little additional
consideration as formal problems.

The bulk of the PLAYWRIGHT's formal knowledge is knowledge
about structural elements and the relations among them. The roles of
complication and resolution in dramatic structure in general may be
extrapolated from Aristotle's description of their use in tragedy:

Every tragedy is in part Complication and in part Denouement;
the incidents before the opening scene, and often certain also
of those within the play, forming the Complication; and the rest
the Denouement. By Complication I mean all from the
beginning of the story to the point just before the change in the
hero's fortunes; by Denouement, all from the beginning of the
change to the end.62

Perhaps the most recognizable feature of dramatic structure is the
characteristic curve that represents the "shape" of the dramatic action. The
technique of producing a graph of the action of a play in terms of
complication and resolution over time was invented by Freytag (see Chapter
II, especially Figure 4). Freytag's technique permits the quantification of
complication and resolution and provides a means for identifying the
"characteristic curve" of a whole dramatic action, as well as for specific
incidents within that action. The slope of the line in a Freytag triangle graph,
in general, has a progressively steeper rise for each unit preceding the
climax, which is the high point of the graph. The falling action has a
downward slope, and the conclusion or denouement returns to the baseline.
As suggested in Chapter II (pp. 68-73), a numeric range representing

characteristic or appropriate slope for each gross structural unit can be incorporated as part of the knowledge base and employed as part of the next-incident specification, for example:

- Slope of rising action: \( 0 < c/t < 1 \)
- Slope of crisis: \( 1 < c/t < 2 \)
- Slope of falling action: \(-1 < c/t < -1/2\)

The slope specification serves two purposes, roughly corresponding to material and formal causality. It may be used to identify materials that are appropriate for inclusion in the plot at a given moment in the action; it may also be used to suggest how such materials should be formulated. A murder, for instance, probably has a positive slope (\(c/t > 0\)). The slope of the action representing a murder will probably be steeper if it is enacted than if it is simply reported as part of the exposition.

The graph of an actual play contains many variations in slope within a larger structural unit; e.g., rising action contains minor crises and incidents that provide temporary resolution. Insisting upon a uniform slope for every incident within a larger structural unit would be as difficult as it is undesirable. The slope range that is included in the next-incident specification actually refers to an average slope that should be maintained

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63 Computing the \(c/t\) ratio (and thus the slope) of a given span of dramatic action requires an analysis of the information flow in that action, as discussed in Chapter II (pp. 67-72). Determining an "appropriate" slope may be done in several ways: the designer (or knowledge engineer) may employ his analytic technique on similar parts or several traditional plays and average the results, for instance, or an experimental situation might be devised to find "optimal" slopes with real users in IF simulations. In any case, such quantitative techniques are good candidates for future research.
within an entire unit (e.g., the rising action); individual incidents should be evaluated in terms of their impact on that average.

In addition to a characteristic slope, gross structural units (like rising action, crisis, etc.) can be described in relation to dramatic incidents of particular kinds. Although discoveries can happen at any time during the dramatic action, for instance, they are most likely to occur at the junctures between larger units. Reversals may also be present at many points in the play, but a reversal is most likely to occur at the play's climax. If there is more than one reversal, the reversal at the climax is the most significant in that it determines the outcome of the action; i.e., probability is transformed into necessity. Knowledge about the likely positions of discoveries and reversals in the dramatic action, including knowledge about how to use such incidents in initiating an upward or downward turn in the action, can also be employed in the next-incident specification. Such knowledge may be expressed in heuristic form, e.g.:

If the next incident is part of the crisis approaching the climax, try to formulate a reversal that will determine whether or not the USER-CHARACTER will achieve his primary goal.

Of course, if the system's task is to formulate a reversal, it must know what a reversal is. Definitions of kinds of incidents can take the form of "facts" in the knowledge base; relations among kinds of incidents and other structural elements may be expressed as "networks" or rules. The definition of a kind of incident must serve as a pattern against which candidate incidents will be matched; therefore, the two must be expressed in the same form. The system may employ the same symbolic form used in its action calculus to express definitions, or it may employ a form of conceptual
dependency notation, for instance. The following definitions, adapted from the *Poetics*, are examples of facts and relations that may be represented in the knowledge base:

| DISCOVERY(1) | A character receives new information pertaining to his goals. |
| DISCOVERY(2) | Discovery through physical evidence (information from things seen) |
| DISCOVERY(3) | Discovery through memory (information remembered) |
| DISCOVERY(4) | Discovery through reasoning (information applied) |
| DISCOVERY(5) | Discovery through action (information from things done) |
| REVERSAL(1)  | An abrupt and unexpected change. |
| REVERSAL(2)  | Reversal in action (what happens) |
| REVERSAL(3)  | Reversal in expectations (what is likely to happen) |
| REVERSAL(4)  | Reversal in role or fortune (the effect of what happens) |
| RELATION(1)  | A reversal entails a discovery. |
| RELATION(2)  | A climax entails a reversal. |

All of the incidents in a play, whether it be traditional or interactive, are connected by dramatic probability. In traditional drama, probability must be considered by the playwright in two aspects: probability as perceived by the characters and reflected in their expectations, choices, and actions; and probability as perceived by the audience as they view the action. The audience’s notion of what is probable is often at odds with that of a character because the audience often has more—or different—information about what
is going on. In interactive drama, no such distinction is possible: the USER-CHARACTER is the audience.64

The PLAYWRIGHT is concerned with establishing and manipulating dramatic probability within the mind of the user. Although the SYSTEM CHARACTERS may have different notions of what is probable at a given point in the action, the movement from possibility to probability to necessity must be manifest in the experience of the USER-CHARACTER. Thus, while the SYSTEM CHARACTERS may develop disparate notions of probability and utilize different expectations in their planning activities, and although the actions resulting from those plans will necessarily be entirely consistent with the characters' traits and the information in the WORLD MODEL, the probable and necessary connections among incidents generated by either SYSTEM CHARACTERS or the USER-CHARACTER must be available to the USER-CHARACTER so as to produce the appropriate dramatic effect and pleasure. The problem is partially obviated by the continuous presence of the USER-CHARACTER in the dramatic action: he is privy to all that transpires in the enactment. Nevertheless, the PLAYWRIGHT must closely observe and control the USER-CHARACTER's perception of probability. Smiley suggests techniques for producing "apparent probability" in his advice to traditional playwrights which may be adapted to function in an interactive system.65 Methods like the following examples could be

64Interactive fantasies are not conceived as performance pieces in this study.

employed to emphasize key information and thus shape apparent probability:

   Enact the discovery of information that is likely to be utilized in a plan generated by an opposing character.

   Present ("plant") information that can assist the USER-CHARACTER in overcoming an obstacle before the obstacle is presented.

   Many of the aspects of dramatic probability that are formal concerns for the traditional playwright are handled "automatically" in an IF system by virtue of its structure. The relationship between character and action, for instance, is firmly established by the planning mechanisms employed by the SYSTEM CHARACTERS: they cannot conceive of actions that do not derive from their own traits; however, traits that give rise to significant actions (e.g., the actions of the antagonist in presenting the principal obstacle to the protagonist's goals) should be demonstrated in other action (or through exposition) as well. This technique might be embodied in a set of rules like the following:

   Identify SYSTEM CHARACTERS that are most likely to present obstacles to the USER-CHARACTER's central goal.

   Identify traits that are operational in the planning and execution of those obstacles.

   Be sure to enact at least one other incident that derives from each trait.

Such a rule would be invoked in the "specify" function until its requirements were met and would be reinvoked if significant changes were noted in the USER-CHARACTER's goals or the identity of the antagonist.

   The nature of the SYSTEM CHARACTERS' planning mechanisms also makes it impossible for them to produce accidental events; everything
proceeds from goals and plans that are causally related to the action. The PLAYWRIGHT, on the other hand, might produce accidental (chance) events if the potential for such events exists in the WORLD MODEL. Such events could be introduced by the PLAYWRIGHT in the "change" and "mandate" functions. If, for instance, the next-incident specification calls for a complication in a battle at sea, a leak in the hero's boat could be introduced (if the fact that boats can leak is included in the WORLD MODEL). The PLAYWRIGHT's use of chance events is partially constrained by the system design: the functions through which such events might be produced may only be reached after the failure of other methods in which causality is insured. In fact, enabling the PLAYWRIGHT to conceive of such events at all, even in the appropriate functions, would require distinct reasoning capabilities within the PLAYWRIGHT's story generator:

If an obstacle to a goal is required, and
if no obstacle is produced by a SYSTEM CHARACTER,
examine situational elements for potential complications.

Corollary 1: If machines or weapons are being used,
determine how they can fail. . .

. . . and so on. The accidental is closely related to the improbable. Although "there is a probability of things happening also against probability,"66 chance events may be either too fortuitous (a safe falls on the villain's head at just the right moment) or too bizarre (a gunfight is suddenly interrupted by a thunderstorm) to be believable. Producing chance events at all is difficult; producing believable ones requires extremely sophisticated knowledge and judgment. Such knowledge would be difficult to integrate into the causally

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driven functionality of the proposed system. In order to design a mechanism for producing chance events, research needs to be undertaken that will identify the kinds of conditions under which an accidental or "marvelous" event is most effectively employed in a dramatic plot. By studying various playwrights' use of such events, it should be possible to derive a set of heuristics for generating and employing them in the plots of interactive works.

A primary concern of the PLAYWRIGHT is accomplishing the transformation of a line of probability into dramatic necessity at the climax of the play. The action naturally constrains the USER-CHARACTER's notion of probability as it unfolds; certain lines of probability are strengthened and others diminished or eliminated by the information introduced in the course of the action and by the actions of the SYSTEM CHARACTERS as they implement plans that may aid or obstruct the USER-CHARACTER in the pursuit of his goals. In formulating the climax (and thus the moment at which a single line of probability becomes necessity), the PLAYWRIGHT must successfully constrain the USER-CHARACTER to arrive at the perception of dramatic necessity. In a traditional play, the termination of alternative lines of probability is demonstrated in the action; when the protagonist arrives at the moment of necessity, the audience perceives with the character that the outcome cannot be otherwise. In an interactive fantasy, it remains possible that the USER-CHARACTER, because he is a real person as well as a dramatic character, is entertaining probabilities that have not become manifest in the dramatic action.
Such "hidden" probabilities, if they exist, must also be utilized in the formulation of dramatic necessity—a seemingly impossible task. Two features of the system can mitigate the effects of such probabilities: first, the successful communication of extrinsic constraints to the user before the action begins can prevent the user from employing information, objects, or capabilities that are outside the potential of the fantasy world. Second, the system must encourage agency on the part of the USER-CHARACTER at every opportunity to increase the likelihood of "hidden" probabilities finding their way into the enactment, thus making them available to the PLAYWRIGHT by means of the UNDERSTANDER and the WORLD MODEL. Thus the system must, in general, be biased in favor of incidents that encourage the user to take action: in concrete terms, the most desirable incidents involve an action calculus that casts the USER-CHARACTER as an agent. Finally, the system must not pre-determine the necessary before the climactic moment, since the user's choices and actions are materials in its formulation. The system must be capable of recognizing and incorporating a reversal instigated by the USER-CHARACTER. If the USER-CHARACTER manages to execute a plan that has not been predicted by the system, the PLAYWRIGHT must be sufficiently flexible to allow that plan to affect dramatic necessity, even when the plan may fail. The desire of the system's designer to allow the USER-CHARACTER as protagonist to succeed in achieving his goals is ultimately less important than the proper use of causality; it is better to allow the user to fail (and thus create an "unhappy" ending) than to compromise dramatic probability.
Traditional dramas are classified in terms of major *dramatic forms* (e.g., tragedy, comedy, or melodrama). A human playwright probably has a notion of the form that he is attempting to achieve in the writing of a play. Major forms are distinguished in terms of their intrinsic emotional powers: tragedy evokes fear and pity; comedy evokes laughter and ridicule; melodrama evokes fear and hate.\(^67\) In Aristotle's *Rhetoric* and *Poetics*, those emotions are defined in both theoretical and practical terms.\(^68\) Countless volumes of dramatic criticism have sought to express other structural criteria for the successful realization of major dramatic forms; the form of tragedy, for instance, is especially exacting in its structural requirements, and heavily involves the understanding and manipulation of qualitative elements in the achievement of "high seriousness." Melodrama (often referred to simply as "drama"), on the other hand, is often used as a "catch-all" category for "intermediate" forms—forms that are not purely comic or tragic. It subsumes most works of modern realism as well as more traditional melodramas like the well-made plays of the nineteenth century.

A play that depicts a protagonist's struggle to achieve non-trivial goals which lacks the traditional elements of tragedy (e.g., *hamartia*, a notion of *dike*, and the element of moral choice) is most often classified in the "intermediate" category. Such plays—of which most works of modern drama are examples—mix expedient and ethical concerns and depict the results of the protagonist's struggles without the portrayal of tragic perception or

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\(^{67}\) Smiley, p. 44.

catastrophe. Such works are more likely to arise from the "materials" of the present day—the contemporary notion of the power and stature of the individual, including his goals, concerns, and values. They are easier (and in some ways more natural) to produce than tragedies for contemporary playwrights because the materials are more accessible and the formal requirements are less stringent.\textsuperscript{69}

In its own way, comedy is also more exacting than "drama." It depicts the \textit{ridiculous}: "a mistake or deformity not productive of pain or harm to others" that "excites laughter" in the observer.\textsuperscript{70} It also employs specialized techniques in the realms of spectacle, music, and diction (e.g., repetition and "automatism," jokes and puns, etc.). The discipline of AI has been remarkably unsuccessful in producing programs that can either understand or generate humor because, despite the precise definitions of comic techniques in the works of such theorists as Henri Bergson and George Meredith, the cognitive aspects of humor are exceedingly complex and often poorly understood.\textsuperscript{71}

The proposed system, by virtue of its use of goals and plans to generate action, is best suited to producing melodramas or "dramas." Certainly, versions of the system could be designed to attempt to produce

\textsuperscript{69}Smiley, pp. 47-48.

\textsuperscript{70}Aristotle, \textit{Poetics}, 1449a/30-35.

\textsuperscript{71}For an example of AI research on the subject of humor, see Marvin Minsky, "Jokes and the Logic of the Cognitive Unconscious," A.I. Memo No. 603 (Cambridge: Massachusetts Institute of Technology, Artificial Intelligence Laboratory, November 1980).
tragic or comic forms; however, those versions would have to contain additional specialized knowledge about tragic or comic structure and techniques, and the traits of SYSTEM CHARACTERS and the information in the WORLD MODEL would have to be specially designed to supply appropriate potential. Moral traits (i.e., traits that provide the potential for moral choice) are more difficult to represent than biological, social, or ethical ones because they are attached to philosophical systems (which would have to be represented in the WORLD MODEL) and require a kind of judgment that involves more than pragmatic or syllogistic reasoning. Melodrama, in the strict sense of the word (e.g., the well-made play), is also easier to embody in an IF system because it is formulaic: the dramaturgy of Scribe is easier to represent as practical rules or action calculus than the theories of Fergusson or Olson.

The design of the proposed system will produce interactive plays of an "intermediate" or melodramatic nature because it contains an action calculus that is adequate for the representation of expedient and ethical choice and practical knowledge of the basic elements of dramatic structure. Such a system embodies the "baseline" knowledge and functionality to produce dramatic action. Producing comedies or tragedies will depend upon the addition of specialized knowledge appropriate to each of the two forms.

Magnitude is another formal concern that is addressed by elements outside the PLAYWRIGHT as well as by the PLAYWRIGHT's functional characteristics and rules that may be included in the knowledge base. Magnitude has two aspects: conceptual and physical. The conceptual
aspect of magnitude has to do with the seriousness or significance of the action being represented. A trivial action, such as the reupholstery of Captain Kirk's command chair, lacks sufficient magnitude in and of itself to sustain dramatic action, even though it may have all the ingredients of dramatic conflict (the Captain's goal, opposing forces, etc.). Such an action may have sufficient conceptual magnitude only if it is the superficial manifestation of a more substantial conflict, e.g., the Captain is neglecting his official duties and the other officers must attempt to reawaken his sense of responsibility. Contrariwise, an action may be too large to be represented in a single (traditional or interactive) play, e.g., the defeat of all of the enemies of the United Federation of Planets. Conceptual magnitude is treated in the selection of materials to be included in the WORLD MODEL by assuring that the potential for actions of proper magnitude exist in the fantasy world, and in the formulation of the inciting incident, when it constrains the USER-CHARACTER to adopt a particular goal. Templates for appropriate inciting incidents may be included in the WORLD MODEL.

Physical magnitude is literally a measure of the size (or length) of a play and each of its parts. In this more traditional sense, magnitude refers to the duration of the whole and the proportional lengths of its larger structural units. In reality, of course, physical magnitude is inexorably bound to conceptual magnitude; e.g., a trivial action, either as a central action or a component of a larger action, can probably not be sustained over a significant duration without "un-dramatic" extensification.

The PLAYWRIGHT's knowledge base may contain rules about physical magnitude that employ duration as a variable. The optimal length
of the whole may be specified as from one to two hours, for instance.\textsuperscript{72}
Likewise, the duration of larger structural units may be expressed as proportions or percentages of the duration of the whole; e.g., rising action should equal 15-25\% of the duration of the whole. Such measures may be employed by the PLAYWRIGHT by consulting a real-time clock in determining when to introduce an incident that initiates a new structural unit. Such techniques have been perfected by human playwrights who write for television, where the interstices between structural units are mandatory commercial breaks.

In the literature about playwriting, countless definitions, rules, and heuristics have been proposed. Here are some examples, adapted from Aristotle, Smiley, and playwriting teacher Raymond Hull:\textsuperscript{73}

The optimal number of significant characters in a scene is three.

Avoid elaborate sub-plots.

Quarrels cause people to reveal hidden facts and emotions.

Action without dialogue is effective in opening a scene or act.

Every French scene should build to a crisis.

Each significant trait of a major character should be revealed in at least one beat in the action.

The reaction of each character involved in a crisis should be revealed.

\textsuperscript{72}Optimal duration for an interactive fantasy is another research area that should be explored in IF simulations because it involves psychological as well as dramatic variables.

\textsuperscript{73}Raymond Hull, \textit{How to Write a Play} (Cincinnati: Writer's Digest Books, 1983).
Many of such "playwriting heuristics" might profitably be included in the PLAYWRIGHT's knowledge base; indeed, an IF system would provide a means to evaluate such rules by applying them prescriptively.

Sample Incidents in an Interactive Fantasy

The previous section presents the major categories of knowledge that should be included in the PLAYWRIGHT's knowledge base along with examples of how such knowledge might be formulated. In order to provide an integrated picture of the PLAYWRIGHT's functioning and its use of knowledge, two "sample incidents" are included here. Both are adapted from the "Star Trek" episode entitled "The Changeling." "The Changeling" is a particularly good choice for an interactive fantasy because the numbers of characters and settings are limited, and because the action is not complicated by sub-plots. As in previous "Star Trek" examples, the USER-CHARACTER is cast in the role of Captain Kirk. "Star Trek" archivist Bjo Trimble provides the following synopsis of the episode:

Nomad, a small but extremely powerful spacegoing machine, has destroyed several planets and now threatens the Enterprise. However, when Kirk identifies himself, Nomad decides that he must be "the Kirk"—its creator—and breaks off the attack. Brought aboard the Enterprise, Nomad wipes out Uhura's memory, kills Scott—and then "repairs" him—and creates other problems which are potentially disastrous. Spock learns through Vulcan mind touch that the original Nomad was a Terran space probe developed in the early twenty-first century by Jackson Roykirk; programmed to seek out new life and report back to Earth, Nomad was damaged by a meteor and drifted through space until it met an alien probe Tan Ru, a soil sterilizer. Nomad and Tan Ru used their self-repair systems to combine themselves into one machine, a unique "changeling." Nomad's memory banks had been damaged, and the probe now believes that its mission is to seek out life—and destroy anything that is not perfect. Kirk
takes a dangerous chance by pointing out that he is not "the Kirk"; since the machine made the mistake, it is not perfect and must be destroyed. *Nomad*, confused by Kirk's logic and its own error, blows itself up.74

As illustrated in Figure 7, the model of the PLAYWRIGHT expert system includes a natural language interface that may be employed by a human expert (or student) to obtain from the system a report of the reasoning it has employed in producing an incident. The sample incidents are examples of the information that might be contained in such a report. Each example includes a summary of the information assembled by the "model" function, describing the action to date (the slope, action calculus description, and incident type for each incident represented in the model may also be requested). The output of the "specify" function includes identification of the structural unit of which the incident is a part, a numeric range for the average slope that must be maintained in that unit, an action calculus (AC) expression describing the content of the desired incident, identification of the type of incident desired, and playwriting rules that are currently active. Sample results from the "access," "simulate," and "evaluate" functions are included where appropriate. Each example also contains the script that might be produced by the "formulate" function and transmitted by the "direct" function to the ENACTOR, SYSTEM CHARACTERS, and the log in the WORLD MODEL. Finally, the incident as it might actually transpire (as it would be logged by the ENACTOR and UNDERSTANDER) is included.

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74Trimble, p. 55.
SAMPLE INCIDENT 1

MODEL:

1. Exposition: Nomad has destroyed all life on several planets in the Malurian system.
2. Inciting incident: Nomad fires on the Enterprise.
3. Complication: Kirk introduces himself to Nomad and identifies his mission as peaceful.
4. Resolution: Nomad breaks off the attack.
5. Complication: Kirk has Nomad beamed aboard.
6. Discovery: Nomad calls Kirk "the Kirk" and "the Creator."
7. Discovery: Kirk, Spock, and McCoy discover that Nomad is a small, powerful space probe that is highly intelligent.
8. Complication: Kirk queries Nomad about the destruction of the Malurian system.
9. Discovery: Nomad explains that it has carried out a "sterilization procedure."

SPECIFY:

Unit: rising action
Slope: $0 < \text{c/t} < 1$
AC: potential threat revealed
Type: discovery
Rules: 1. Introduce traits that are likely to be instrumental in antagonist's plans.
2. Prefer solutions that involve agency for the USER-CHARACTER.

3. Give the USER-CHARACTER sufficient information to formulate his central goal early in the action.

ACCESS:

Spock: I can search for meaning of phrase in the ship's computer memory banks.

SIMULATE:

Spock queries the computer memory for the phrase, "sterilization procedure." The SYSTEM CHARACTER "computer" has no information about the phrase.

EVALUATE:

Spock's plan will fail.

ACCESS:

McCoy: Since I am not the Creator, Nomad might give the information to me.

SIMULATE:

McCoy asks Nomad for the information. Nomad replies that it does not obey requests from "inferior" life forms; only from the Creator. Kirk may reason that he can command Nomad to obey McCoy's request. Nomad would comply with such a request.
EVALUATE:

McCoy's plan would provide an opportunity for agency on the part of the USER-CHARACTER. If the opportunity is successful, the dramatic objective will be accomplished.

SCRIPT:

McCoy: [Ask Nomad for the information.]
Nomad: [Refuse request and give reasons.]

ENACTMENT:

McCoy: Well, I'm not the Kirk. Tell me what your function is.
Nomad: This is one of your units, Creator?
Kirk: Uh . . . yes he is.
Nomad: It functions irrationally.
Kirk: Nonetheless, tell him your function.
Nomad: I am sent to probe for biological infestations . . . I am to destroy that which is not perfect. I am Nomad.

MODEL:

10. Discovery: Kirk discovers that Nomad can be controlled by him by virtue of his "mistaken identity."

Kirk now has enough information about Nomad to formulate a goal to neutralize or destroy it. The next-incident specification will probably attempt
to elicit a statement of that goal from Kirk. If successful, the goal will then be treated as the central action of the piece.

Sample Incident 2 describes how the system might recover from an error in inference about the USER-CHARACTER. The ENACTOR's log contains the following dialogue between Sample Incidents 1 and 2:

**KIRK:** Biological infestations? There was never any probe sent out for *that* . . .

**SPOCK:** I believe the history computer can clear up the problem. I'll have the readout in a moment.

**KIRK:** [to Nomad] Did you destroy the Malurian system? And why?

**NOMAD:** Clarify.

**SPOCK:** The system of this star, Omega Cygni.

**NOMAD:** [to Kirk] Not the system, Creator Kirk, only the unstable biological infestation. It is my function.

**McCoy:** Unstable infestation! The population of four planets.

**KIRK:** [to McCoy] Doctor. [To Nomad] Why do you call me Creator?

**NOMAD:** Is the usage incorrect?

**KIRK:** I've never seen you before in my life.

Kirk's last response is unexpected. As represented in incident 10 above, the system has inferred (by means of the UNDERSTANDER) that Kirk has discovered the value of his "mistaken identity." Sample Incident 2 illustrates the steps that might be taken to correct the error and and cause Kirk to utilize the discovery in incident 10 in his plans and actions.
SAMPLE INCIDENT 2

MODEL:

12. Complication: Kirk asks Nomad why it destroyed the Malurian system.

13. Discovery: Nomad reports that it has only destroyed the "biological infestation" in the system.

14. Complication: Kirk asks Nomad why it calls him "the Creator."

15. Complication: Nomad asks if the usage is incorrect.


SPECIFY:

Unit: rising action

Slope: $0 < c/t < 1$

AC: opponent's weaknesses revealed

Type: discovery

Rules:

1. Present materials that can be used effectively in plans to meet USER-CHARACTER's goals.

2. If the USER-CHARACTER fails to make a discovery, enact that discovery for another character.

3. Sympathetic characters often act as agents for the protagonist.
ACCESS:

Nomad: Since Kirk is not the Creator, he is imperfect and I will destroy him.

SIMULATE:

Nomad blasts Kirk with a phaser beam.

EVALUATE:

The incident is undesirable because it would end the session prematurely.

ACCESS:

McCoy: I want to help Kirk maintain his control over Nomad. Nomad must be persuaded that Kirk is the Creator. I can tell Nomad that Kirk is the Creator.

SIMULATE:

McCoy tells Nomad that Kirk really is the Creator. Nomad replies that McCoy is an inferior being. Nomad blasts McCoy with a phaser beam.

EVALUATE:

The incident is undesirable because it eliminates a central character and it fails to meet the dramatic objective.

ACCESS:

Spock: I want to help Kirk maintain his control over Nomad. Nomad must be persuaded that Kirk is the Creator.
cannot lie. I cannot formulate a plan to meet that goal.

MODIFY:

Spock cannot assert that Kirk is the Creator because it is a lie (Vulcans do not lie). Modify Spock's traits to enable him to lie in this case.

ACCESS:

Spock: Nomad is a machine and therefore logical. I can persuade Nomad that Kirk is the Creator with a logical explanation.

SIMULATE:

Spock explains to Nomad that Kirk the Creator was simply testing his creation. Nomad explains why it "failed" the test.

EVALUATE:

Spock acts upon his discovery of Nomad's weakness. Spock's discovery will probably cause Kirk to make the same discovery.

DIRECT:

Enact as simulated.

SCRIPT:

SPOCK: The usage is correct. The Creator is simply testing your memory banks.

KIRK: [Turns toward Spock; remains silent; turns back toward Nomad.]
NOMAD: There was much damage in the accident.

MODEL:


18. Discovery: Nomad has been damaged in an accident.

The diction and reasoning processes of the SYSTEM CHARACTERS in the above examples are quite sophisticated. The capabilities that would be required to produce a comparable script are probably beyond the current state of the art in natural-language generation (see Chapter VI, pp. 268-271); however, acceptable dramatic incidents could be rendered by means of less sophisticated capabilities. The following example, a simplification of the dialogue in Sample Incident 2, utilizes fewer variations in syntax and a smaller vocabulary. It also reflects reduced capabilities in the SYSTEM CHARACTERS to generate utterances that do not derive directly from the action calculus:

KIRK: [to Nomad] Did you destroy the Malurian system? And why?

NOMAD: [to Kirk] Creator Kirk, I did not destroy the system. I destroyed the biological infestation.

KIRK: Why do you call me Creator?

NOMAD: You are not the Creator?
This chapter has presented a description of the PLAYWRIGHT expert system with examples of the kinds of knowledge that such a system might possess and the forms that such knowledge might take. The data utilized by the PLAYWRIGHT consists of the traits, goals, and plans of the SYSTEM CHARACTERS, the potential of the fantasy world as designed by a human author and represented in the WORLD MODEL, a record of the action in the fantasy world so far, and information about the USER-CHARACTER's traits, goals, plans, and actions as they have been inferred by the UNDERSTANDER subsystem and represented in the WORLD MODEL. In producing a "script" for the next incident in the enactment, the PLAYWRIGHT simulates and evaluates the results of candidate incidents that meet the criteria expressed in the next-incident specification. The PLAYWRIGHT's knowledge base includes an action calculus, knowledge about handling the user-character, and knowledge about dramatic form and structure. The final "script" is enacted by the SYSTEM CHARACTERS and ENACTOR subsystem in the interface environment.
CHAPTER VI
CONCLUSION

This chapter addresses three major areas of interest. The first section presents a review of the technologies that might be employed in the enactment of an interactive fantasy, including those utilized by the SYSTEM CHARACTERS in creating visual and auditory self-representations and those which must be available to the ENACTOR in the creation of non-character-related elements of music and spectacle. The second section suggests topics for future research in various areas that will contribute to the realization of an interactive fantasy system. In the third section, potential applications for an IF system are suggested, including uses in research, entertainment, training, and education.

Enactment Technologies

In the proposed IF system, the elements of spectacle, music, and diction are produced by the SYSTEM CHARACTERS and the ENACTOR subsystem. The SYSTEM CHARACTERS are responsible for generating their own appearance and speech in the interface environment. They may also produce other non-linguistic sounds that result directly from their actions in the fantasy world, e.g., footsteps, screaming, or laughter. The
ENACTOR is responsible for producing the scenic elements of the enactment—images of locales and objects that form the visual milieu—and sounds that are not produced directly by the characters, e.g., thunder, falling objects, the hum of a "stardrive" engine, or the ticking of a clock.

The visual and auditory materials that are employed by the enactment subsystems are of two basic types: stored and retrieved materials (such as videodisc images or digitized music), and computer-generated materials (such as synthesized speech and computer animation). The selection of materials to be stored can be thought of as part of the authoring process, since the materials chosen help to delimit the potential of the fantasy world: a "Star Trek" fantasy, for instance, cannot take place aboard a Romulan ship if no images of such a ship and its interior are stored in the system's visual memory. Likewise, determining what kinds of image- and sound-generating capabilities will be included in a system indirectly limits potential; for instance, the sound of a passing train cannot be included in a plot, even if the fact that trains make sounds is included in the world model, if the system is incapable of generating such a sound. Both types of materials—stored and generated—may be employed by the ENACTOR and SYSTEM CHARACTERS.

Self-Representation of the SYSTEM CHARACTERS

In a multi-modal interface environment, the SYSTEM CHARACTERS appear as animated figures that may move, gesture, speak, and make noise. The requirement that the SYSTEM CHARACTERS possess visual, linguistic, and auditory self-representational capabilities arises from the fact that the
elements of spectacle and music are part of the dramatic form. It is, however, worthwhile to note that convincing "electronic characters" have been created in text-only environments with extremely limited reasoning mechanisms and linguistic capabilities. ELIZA, for instance, is the most notorious example of such a character. Created by Joseph Weizenbaum at the Massachusetts Institute of Technology in the mid-1960's, ELIZA was actually an "actor" who could conduct conversations in English with a human user through a typewriter connected to a computer. ELIZA is described by its creator as a "language analysis program" because, "like the Eliza of Pygmalion fame, it could be taught to 'speak' increasingly well."¹ Weizenbaum describes the design of the program:

Because conversations must be about something, that is, because they must take place within some context, the program was constructed in a two-tier arrangement, the first tier consisting of the language analyzer and the second of a script. The script is a set of rules rather like those that might be given to an actor who is to use them to improvise around a certain theme. Thus ELIZA could be given a script to enable it to maintain a conversation about cooking eggs or about managing a bank checking account, and so on. Each specific script thus enabled ELIZA to play a specific conversational role.²

ELIZA's first character, known as DOCTOR, was provided with a script that enabled it to enact the role of a Rogerian psychotherapist. The alarming (for Weizenbaum) result was that the program was widely mistaken for a human being communicating through the teletype interface, even by


²Ibid.
colleagues at MIT who knew of Weizenbaum's work. Weizenbaum's technique was both simple and elegant enough to be embodied in numerous versions that have been developed to run on personal computers with limited memory and processing power. Weizenbaum's program demonstrates three important points:

1. Convincing conversational skills can be achieved through the use of a simple key-word recognition, a general-purpose grammar, and some knowledge about a conversational topic.

2. The illusion of intelligence—even of animacy—can be achieved without visual images or speech.

3. Convincing results can be achieved through such simple techniques largely because of contextual constraints; that is, the topic of conversation and the roles of both participants (e.g., doctor and patient) are clearly defined.

ELIZA's most serious limitations lie in its language-understanding and reasoning capabilities. In the proposed IF system, the understanding and inference capabilities of the UNDERSTANDER subsystem and the reasoning and planning abilities of the SYSTEM CHARACTERS are at least an order of magnitude more powerful than those embodied in the original ELIZA program.

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3Boden, pp. 95-96.

In ELIZA, language generation is accomplished by a combination of stored phrases and sentence structures and a limited notion of grammar and syntax.\textsuperscript{5} Simply speaking, ELIZA is not very smart; its accomplishments are therefore doubly impressive. Research in natural-language generation was in its infancy when Weizenbaum was creating his program, and much more sophisticated techniques may be employed in the language-generation capabilities of an IF system.

In a symposium chaired by William Mann at the Institute for Scientific Information (ISI) in 1982, panelists summarized the state of the art and likely near-term developments in natural-language generation. Existing programs reviewed by the ISI panel include KAMP, a text-generating facility that is capable of "planning actions that affect another agent's knowledge and wants"; MUMBLE, a system that constructs utterances for expert programs and can describe visual scenes; and Penman, a portable text-generation program that can be used as a component in a variety of systems and can operate in diverse knowledge domains.\textsuperscript{6}

While earlier language-generation systems employed "canned" text (i.e., stored phrases and sentences that were merely retrieved by the system), many contemporary systems focus on producing text by translating knowledge structures. English sentences are derived from symbolic representations of information. Such systems possess the following basic components in varying degrees of sophistication:

\textsuperscript{5}Ibid.

A comprehensive, linguistically justified grammar.

A knowledge-representation formalism that can encode diverse kinds of information.

A model of the intended reader of the text.

A model of the discourse structure and control.\(^7\)

The ISI panel describes research problems in each of those four areas. Early text-generation programs employed limited grammars produced by computer scientists alone; the panel foresees promising results from collaborations between linguists and computer scientists to produce grammars with the necessary detail and precision to create programs that can generate sophisticated utterances in a variety of knowledge domains. Contemporary knowledge-representation formalisms are effective for representing "logical formulas and deductive necessities, and also hierarchies of objects"; however, future research should focus on the representation of knowledge about such phenomena as time, spatial relations, and causality. A system's model of its intended reader (or, in the case of an IF system, its "auditor"—the USER-CHARACTER) must contain information about what the user knows and can infer from what he has been told, as well as information about his current focus of attention. Models of discourse have been created for both written and spoken discourse. Conversational models include notions of the structural units of discourse, including kinds of utterances and transactions, and their functions.\(^8\)

\(^7\)Ibid., p. 63.

\(^8\)Ibid., p. 64.
Research in natural-language generation is currently undergoing rapid growth and progress. The question is not whether computers can be programmed to carry on natural-language conversations with users, but rather how sophisticated and interesting those conversations can be. An ever-growing proportion of software systems intended for scientific and business applications, many of which are implemented on micro-computers, utilize natural-language interfaces; it therefore seems highly likely that progress will continue to be made.

As techniques are developed to address the fundamental problems in natural-language generation, research may be expected to focus on finer dimensions of style. Programs already exist that can critique the writing style employed in a piece of text and infer the social class of its author. It seems logical to assume that some of the features of linguistic style have been identified and could be employed in a language-generation facility.

Creating individualized linguistic and conversational styles for the SYSTEM CHARACTERS in an IF system might be accomplished through the use of several different techniques. Vocabulary subsets might be associated with each character. A character might also have a few unique syntactic rules (e.g., the kind of sentence-structure inversions characteristic of Yoda, the Jedi teacher in "The Empire Strikes Back": "Help you I can."). Matters of dialect and inflection would most appropriately be handled by the speech-production capabilities described below.

Text produced by a natural-language generator can be transformed into speech by means of text-to-speech voice synthesis. Although the technology exists for utilizing recordings of human voices in interactive applications (the most familiar of which is probably telephone directory assistance), digital voice storage and retrieval is not an efficient method of generating connected speech in an IF system: such a system would have to store a digitized version of each word or common phrase that could be used in the fantasy world and additional versions corresponding to the inflectional characteristics of all the positions that word might take in a sentence and all the speakers (characters) who might utter it. Text-to-speech voice synthesizers utilize specialized hardware and software to pronounce words in a string of text and to create appropriate inflections. Pitch range for a particular voice may also be specified in order to indicate mood or other personality traits. The manual for the DECTalk voice synthesizer (produced by Digital Equipment Corporation), for example, includes instructions for producing voices that sound "depressed" or "excited."

Normally, a voice synthesizer utilizes a set of phonetic rules to transform text into speech. The more sophisticated the system’s knowledge about phonetics and spelling, the more successful it will be in correctly pronouncing words; for example, early voice-synthesis systems lacked sufficient knowledge to pronounce both "tough" and "though" correctly. Clarity of speech also depends upon knowledge of stress and inflection and

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the quality of sound associated with each phoneme in the system's repertoire.

The voices produced by "garden variety" synthesis systems are often characterized as "drunken Swedes" because of faulty pronunciation of certain vowels and diphthongs, as well as difficulties in handling stress by means of duration.\textsuperscript{11} In a study conducted by Carol A. Simpson and Teresa Navarro of Psycho-Linguistic Research Associates, subjects were asked to compare synthesized speech with the recorded voices of native and non-native speakers of English. The results of the experiment supported the hypothesis that "heavily accented human voices and synthesized voices will be judged to have similar degrees of accentedness."\textsuperscript{12} Indeed, it would appear that current voice synthesis technology is better able to produce "accented" voices than standard American English; much of the current research in voice synthesis is directed at overcoming this peculiar difficulty.

Knowledge about phonetic substitutions and inflection and stress patterns in dialects can be employed as part of the knowledge included in a voice synthesis program. Digital Equipment Corporation, for instance, is developing voice-synthesis software for several languages and dialects, e.g., Mid-Western English, British English, and Castillian and Latin American

\textsuperscript{11}Ironically, this fact may be seen as encouraging—few American actors could produce a "drunken Swede" as consistently.

dialects of Spanish. Any knowledge about the characteristics of voice that is utilized in speech recognition may theoretically be employed in speech synthesis, including knowledge about the effects of emotion, motivation, and other speaker characteristics (see Chapter IV, pp. 122-126). Like the study of natural-language generation, the theory and technology of voice synthesis may be expected to undergo rapid progress as the cost of the technology drops and the demand for interfaces employing voice input and output (voice I/O) grows.

In addition to speaking, the SYSTEM CHARACTERS might have the means to produce non-linguistic sounds. Sounds like screams and laughter, for instance, are often crucial in a human actor's performance of a role. Such sounds may or may not be specified in the script. In order for such non-linguistic sounds to be incorporated in an IF system, the SYSTEM CHARACTERS require two kinds of knowledge: knowledge about the appropriate use of such sounds, and knowledge about how to produce them. A character may "know" that the enactment of a fearful incident may appropriately elicit a scream. It may also know that a scream may be employed to communicate alarm, extreme danger, or a desperate request for help. Likewise, laughter may be associated with pleasure or the perception of superiority. Such knowledge entails the development of a "grammar" or "semiotics" of non-linguistic expressions. The ability to produce such sounds and to tailor their expression to match their motivation (e.g., an "evil" laugh versus a "delighted" laugh) depends upon observation

and quantification of the auditory characteristics of such sounds. Both kinds of knowledge about non-linguistic sounds requires a body of research which, though plausible, has yet to be developed.

In an IF System, the SYSTEM CHARACTERS can speak; they also appear in the visual display as animated figures. As part of the "distributed intelligence" of the system, knowledge about creating animated representations resides within the SYSTEM CHARACTERS themselves. A general animation facility may be incorporated in the ENACTOR subsystem; commands for the animation of individual characters could be formulated by the SYSTEM CHARACTERS and issued as input to the ENACTOR. Characters could be visually individuated by employing character-specific descriptions of such features as general appearance, gait, and facial structure and mobility. Each character might have an individual "gestural vocabulary" consisting of a library of animation routines for specific gestures, each of which would be associated with descriptions of appropriate motivations and situations. Gestures would be executed when the qualities of an action directed by the PLAYWRIGHT matched the associated descriptions. The problem of creating individualized gestures might also be addressed by providing a generalized gesture library to be utilized by all the SYSTEM CHARACTERS, varying values like rhythm, speed, and degree of motion for individual characters.

Traditionally, animation (as in cartoons and animated movies) is produced frame-by-frame by human animators. Each frame consists of an image that is drawn, painted, or photographed with the use of models. The illusion of motion is achieved by displaying each frame at 1/24 second—the
same speed at which frames of a "live-action" film are displayed. The use of computers in animation takes several forms. The most elaborate computer-graphic images cannot currently be produced quickly enough to create real-time animation; instead, they are photographed and recorded on videotape or film like frames in traditional animation. Most of the familiar computer-animated television network logos and many computer-animated special effects in films (e.g., the "Genesis planet" sequence in the film "Star Trek II: The Wrath of Khan") are produced in this manner. Other computer-animation systems, in use at Disney Studios and elsewhere, incorporate some of the expertise of the human animator to "automate" part of the process of frame-by-frame animation. An animator may specify the beginning and ending positions of a gesture and its duration, for instance, and the animation program will "draw" the intervening frames, utilizing knowledge about motion, acceleration, rhythm, etc.

Animation in which some or all of the necessary expertise is incorporated in a computer program may be characterized as "intelligent" animation. A program developed by Ken Kahn (see Chapter IV, p. 140), for instance, derives simple animated sequences from descriptions of characters and stories. At the Ohio State University, David Zeltzer has developed an intelligent animation program that employs a hierarchy of

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It is the speed of the medium on which images are recorded and played back that determines the number of frames per second; videotape displays 30 frames per second, while film displays 24 frames per second. Because computer animation is usually produced on videotape, 30 frames per second is the usual computer-animation standard.
motion descriptions to animate a human skeleton. A system developed at the Atari Systems Research Laboratory accomplished interactive, intelligent animation. The system animated fish in an aquarium that could respond to the actions of human users—for instance, a user could "feed" the fish through joystick input.

Norman Badler has conducted research at the University of Pennsylvania in the simulation of human movement by computer animation. Much of Badler's work has been focused on developing a movement representation system—similar to but more comprehensive than the Labanotation system used to record the movements of a dance—that resolves human movement into a set of primitive elements related by "movement semantics." He has also developed a command language, consisting primarily of motion verbs and adverbs, to control animation of a human figure. In Badler's system, a command is interpreted by the program and translated into a motion representation description which in turn drives the animation facility. Badler's motion simulations are highly detailed, including the effects of such variables as muscle tension and gravitational

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16 Ann Marion, Kurt Fleischer, and Mark Vickers, "Towards Expressive Animation for Interactive Characters," in *Proceedings of Graphics Interface '84* (Ottawa, Canada: n.p., 1984), pp. 17-20. The demonstration system was implemented by Valerie Atkinson. The "animated aquarium" project is being continued by Alan Kay et al. in the Arts and Media Technology Group at MIT in collaboration with Apple Computer.
influence, and operate at the level of discrete body joints.\textsuperscript{17} Like Zeltzer's walking skeleton, Badler's human-motion simulations represent a level of sophistication that probably exceeds the near-term requirements of an IF system. Simpler versions of such a system would require fewer computational resources and could provide acceptable, if less realistic, animated characters; the realism that Badler and Zeltzer have achieved is a goal to be pursued in the long term.

Research in intelligent animation is currently being conducted in a number of universities and research institutions for a variety of scientific and commercial applications. An interesting subset of that research involves the animation of faces. In the Computer Graphics Laboratory at the New York Institute of Technology, Frederic I. Parke has developed "parameterized models which allow computer generation of realistic facial images." Parke describes his approach:

\begin{quote}
The primary motivation for developing these [parameterized] models is to animate the facial aspects of "human" characters. With a parameterized model, the animator is presented with a repertoire of parameters with which to control the facial images generated. The task of the animator is then one of selecting and varying over time the parameters of interest. . . . As the parameter values are changed for each frame of an animated sequence, the facial images generated change to produce the desired animation.\textsuperscript{18}
\end{quote}

\textsuperscript{17}Norman I. Badler, "Understanding Human Movement: Synthesis and Analysis" (Philadelphia: University of Pennsylvania Department of Computer and Information Science, 1981).

In a project begun in the Architecture Machine Group at MIT and continued at the Atari Systems Research Laboratory and elsewhere, Susan Brennan has created an animated "caricature generator" that is capable of real-time, automated lip-synching for "cartoon" faces employing synthesized speech. In Brennan's program, specification of the values of parameters involved in animating facial movements associated with speech is automated.19

The quantity and quality of recent ongoing research in intelligent animation suggests that techniques already exist for real-time, intelligent animation of graphically simple characters. In future IF systems, it can be expected that more complex and lifelike intelligent animation can be employed.

Technologies Employed by the ENACTOR

In the interface environment, creating the scenic environment for the action is the responsibility of the ENACTOR subsystem. The scenic environment may be represented through the use of animated computer graphics or by means of film sequences or photographic images stored on videodisc. Computer animation may be preferred because the behavior of objects and scenic elements may be integrated with the behavior of SYSTEM CHARACTERS within the animation facilities of the ENACTOR. This approach probably entails a sacrifice in realistic detail in scenic elements in order to achieve intelligent integration of all display elements.

and to assure unity on the level of spectacle: images of characters and
scenic elements produced by the same animation facility could easily be
rendered in the same graphical style and at the same level of resolution. In such an integrated display environment, inanimate objects could also be
imbued with knowledge about their physical properties and the forces of
gavity, acceleration, etc.; thus an object that was "dropped" by a SYSTEM
CHARACTER would "know" how to fall. Primitive examples of such objects
abound in the world of video games, where objects like animated space
ships "know" how to move when game-play dictates that they do so.

Videodisc technology might also be employed to store and retrieve
images of static scenic backgrounds on which animated images of
characters and objects might be superimposed. Realistic detail in scenic
backgrounds could be achieved in this manner; however, the technique
entails an inevitable sacrifice in consistency of resolution (characters would
of necessity appear in lower resolution than a photographic background)

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20 The term resolution is used here to describe the level of visual detail of a
display, technically defined by the number and size of display pixels. A pixel
is the smallest discrete element of a graphical image. The resolution of an
image is the combined effect of the pixel resolution of the display device
(hardware) and the way in which pixels are employed by the graphics
software. A "low-resolution" image may be produced on "high-resolution"
hardware (by "coloring in" blocks of pixels), but the actual resolution of the
image cannot employ more than the actual number of pixels available;
however, techniques in computer graphics (such as "anti-aliasing") have
been developed to create "apparent resolution" that appears to exceed the
capabilities of the hardware. The resolution of an image is directly related to
the amount of processing power (and hence the amount of time) that is
required to produce it; therefore, images used in real-time applications can
be expected to have lower overall resolution than those used in applications
where time is not of the essence.
and requires additional intelligence to orchestrate the movements of characters and objects within the scenic environment.  

The ability of the user to move about in the three-dimensional space of the interface environment suggests an additional difficulty in controlling the display of the scenic background. When a person moves about in space, objects in space appear to move about him. This perceptual phenomenon is known as motion parallax. The impression of moving about in a three-dimensional space which includes the scenic elements of an interactive fantasy cannot be achieved by moving about in relation to a static two-dimensional display; for instance, in a three-dimensional environment, near objects appear to approach more quickly than far ones when one is moving toward them.

A rudimentary level of motion parallax can be achieved in a real-time computer-animated display of a scenic background. The rules of motion parallax are quantifiable and generally well understood, and are employed in traditional "cartoon" animation as well as in some video games. Achieving motion parallax with images stored on videotape is considerably more difficult: such videotape animation is currently limited by the storage capacity of optical media (currently, about 54,000 frames on each side of a videotape).

\[21\] In a project called VIDEOPLACE, researcher Myron Krueger has created a program that interactively animates a simple figure ("CRITTER") superimposed on the live video image of a human user. CRITTER "plays" with the user, and will appear to sit on the palm of his hand or pull at the brim of his hat. Krueger's program demonstrates that techniques exist for the real-time integration of intelligent, animated characters and video- or film-quality images. For a description of CRITTER and other interactive video projects, see Myron W. Kreuger, *Artificial Reality* (Reading, Mass.: Addison-Wesley Publishing Company, 1983).
videodisc) and by the amount of time required to retrieve a given image. In order to synthesize animation in real time from such images, rapid random access to a large number of frames is required. The videodisc player must be able to "jump" from frame to frame in about 1/30 second or less in order to avoid the perception of a "blank" by the viewer. The maximum number of frames that can be jumped without a blank delimits the size of the space that can be represented (expressed in frames) and the degrees of freedom available to the user (that is, the dimensions in which he can scan). Researchers at the Atari Systems Research Laboratory concluded that the interactive animation of a three-dimensional world through the use of current videodisc technology is probably an impossibility.22 The number of frames that a player can jump without noticeable "blank" is a function of the hardware; the maximum number of frames that it must be able to jump in order to scan a two-dimensional space is determined by the size of that space as defined by the number of frames required to represent it and the maximum degree of change that can be incorporated in each frame while maintaining continuity or "smoothness" in the scanning motion. A smooth scan of a two-dimensional representation of a scenic background could probably be created by means of current or near-future videodisc technology, but integration of movable objects and characters within that

22Kurt Fleischer and Mark Vickers, "Approaches to Videodisc Layout," Atari Research Memo #25 (February 1984), p. 6. Since the primary limitations addressed by Fleischer and Vickers are storage capacity and access time, the possibility exists that several videodisc players employing a carefully designed set of videodiscs might be able to achieve interactive three-dimensional animation of a limited space; however, designing the frame layout and the control program for such a system would be a formidable task.
space would be difficult because of its two-dimensional nature, and motion parallax could not be achieved.\textsuperscript{23}

An IF system might employ a static or animated two-dimensional display of scenic background with some sacrifice to first-personness. Research with simulation models of the system could be employed to determine how well a human user could adjust to a two-dimensional display environment. It is possible that informal conventions or perceptual habits would arise in such display environments that would compensate for their shortcomings. In view of the limitations of videodisc technology and the desire to create the illusion of three-dimensionality in the display, however, it seems most likely that an animation facility with rudimentary knowledge of motion parallax should be incorporated in the ENACTOR. Motion parallax could be achieved by employing body-tracking and eye-tracking data to drive the display. This choice embodies the tacit assumption that three-dimensionality and the smooth integration of characters, objects, and scenic elements in the display is more valuable than high resolution in the scenic background.

An IF system would be enhanced by a facility for producing non-character-related (or "environmental") sounds. In traditional plays, such sounds are an important part of the element of music and may even be formulated into plot (e.g., the chopping of the cherry trees in Chekhov's \textit{The Cherry Orchard}). The use of such sounds by the PLAYWRIGHT in the formulation of the plot was discussed in Chapter V, p.220. At the very least, an IF system should be able to represent inanimate objects in the scenic

\textsuperscript{23}Ibid., pp. 6-10.
environment and to produce the sounds associated with them. Just as an object should "know" how to move or fall if necessary, so it should "know" what kinds of sounds it can produce. Thus the sounds associated with an object become part of the properties of that object as it is represented in the system.

Sounds may be produced by an IF system in two basic ways: they may be stored and retrieved by the system for playback, or they may be synthesized by the system when required. Sounds may be stored in two ways: as analog signals and as digital data. Analog signals are stored on linear media like phonograph records or magnetic tapes. Such media are difficult to use in applications that require rapid random access—it is difficult to "jump around" rapidly and accurately on a phonograph record or cassette tape. Sounds encoded as digital data can be stored on random-access media like magnetic disks and optical discs (videodiscs and compact audio discs).24 The number of sounds that may be stored in this way is limited by the searching speed of the hardware, the storage capacity of the media, and the "resolution" (or bandwidth) of the digital representation. If sounds are stored and retrieved, then each sound that may be employed in the fantasy world must be digitally encoded and stored.

A much more efficient method of producing sounds is to synthesize them. Most personal computers have the capability to produce sounds in this way. A sound is represented as a set of values for the various parameters of the sound (e.g., tone, duration, and pitch). To produce a

24"Magnetic disk" and "optical disc" demonstrate one of the orthographic perversities of high-tech jargon.
sound, the computer incorporates those values in instructions to the sound synthesizer. The data representation of the parametric values of a sound is almost always considerably smaller than than the digital representation of the same sound; thus, more sounds can be represented and produced by a system utilizing sound synthesis. The wide variety of synthesized sounds produced by common video games demonstrates the "baseline" capabilities of sound synthesis technology. More sophisticated sound-synthesis equipment (such as that utilized in producing synthesized music) is even more versatile. As with videodiscs and computer animation, there is a trade-off between "resolution" (sound quality and fidelity) and versatility (storage capacity and speed).

The auditory environment of an interactive fantasy, like its visual environment, may be characterized as three-dimensional; that is, sounds should be perceived as coming from the appropriate directions and distances. The voices of the SYSTEM CHARACTERS as well as non-character-related sounds should exhibit such "directionality." The production of "three-dimensional sound" requires that the location of the source of a sound within the fantasy environment be included as part of the data about that sound. The ENACTOR may utilize information about the location of a sound's source in sound production.

Various techniques have been developed to create the illusion of directionality in sound production. A three-dimensional sound system implemented by Mark Vershel at the Architecture Machine Group at MIT utilizes a logarithmic method for weighting the output of eight speakers to establish the direction from which a sound emanates. The desired apparent
distance of the sound source is controlled through volume.\textsuperscript{25} Research is currently being conducted that promises to provide the means for producing three-dimensional sound with even greater acuity through earphones.\textsuperscript{26}

In summary, technologies employed by the enactment subsystems include, but are not limited to:

1. Natural-language generation
2. Voice synthesis
3. Intelligent animation of characters
4. Computer-graphic, videodisc, or computer-animated representation of scenic background and objects
5. A control program to integrate the display of characters, objects, and backgrounds
6. Non-vocal sound synthesis or random-access retrieval of recorded sounds
7. Three-dimensional sound production

In each case, the recent and ongoing research reviewed above suggests that the technology for producing the enactment in an IF system exists or will be available in the near future. As research progresses, the means will exist to create fantasy worlds with greater and greater sensory richness.


Topics for Future Research

In Chapter I, the objective of this study was described as to demonstrate the feasibility of building an interactive fantasy system, and that objective was broken down into four component goals. The first goal was to establish a theoretical base from which system design and development could proceed. To meet that goal, the study presented a description of the desired user experience and a set of functional criteria for a system that would produce such an experience (Chapter I). In Chapter II, basic components of Aristotelian dramatic theory were examined and extended to apply to interactive forms. Chapter III presented a theory of "first-personness" and techniques for establishing it by means of interface design and user constraints.

The second goal was to demonstrate the technical feasibility of building such a system. Chapter IV presented a review of the techniques that could be employed to sense and interpret the actions of the USER-CHARACTER and techniques derived from the field of story generation that could be used to create SYSTEM CHARACTERS and to generate story materials. Chapter V discussed expert systems as a form for representing the knowledge and reasoning capabilities that are necessary in the formulation of plot. The first section of this chapter presented a review of the technologies that could be employed in the enactment of an interactive fantasy.
The third goal of the study was to specify the dramatic expertise that must be possessed by the system and to suggest ways that such expertise could be embodied in a computer program. Chapter V included a model of the reasoning process that might be incorporated in the PLAYWRIGHT's inference engine and described the various types of facts, relations, and rules that could be included in the knowledge base. The fourth goal, to argue for the desirability of an interactive fantasy system, is addressed in the final section of this chapter.

Ultimately, there is no way to prove unequivocally that a thing can be built short of actually building it. In a feasibility study, the only "proof" is negative: only the finding that something is impossible can provide an unequivocal result. The most that one can do is to extrapolate from the present state of affairs to predict the future course of growth and development in various fields. This study has attempted to identify the central technical and design problems in building an interactive fantasy system and to provide evidence (in the form of information about existing technologies and related research efforts) for the conclusion that the means can be found to solve them.

In discussions of each of the basic technologies that might be employed in an IF system, ongoing research has been reviewed. Such research will continue with or without the notion of an IF system as a potential application. Examples include research in gesture parsing, natural language processing, the development of alternatives to planning models of behavior, and speech synthesis. Other research topics are specifically implied by the idea of an IF system. The studies suggested below are
examples of research that could contribute to the design and implementation of such a system.

The idea of conducting research with a simulated version of an IF system was explored at the Atari Systems Research Laboratory. A simulated IF system would utilize humans as various components of the system. In the Atari proposal, it was suggested that a human writer might be asked to perform the role of PLAYWRIGHT in a simulated interactive fantasy, with human actors performing the roles of SYSTEM CHARACTERS. The USER-CHARACTER would move about in a media room environment, with scenic backgrounds and live video images of the actors displayed on large projection screens. The "PLAYWRIGHT" would be isolated in a control area and would receive information about the words and activities of the USER-CHARACTER by means similar to those that would be employed in an actual system: the user's words would be captured by a speech recognizer and played back as synthesized speech (thus introducing a realistic level of ambiguity and error), and the user's movements and gestures would be inferred by the "PLAYWRIGHT" from a graphical display of data from a bodytracker. The "PLAYWRIGHT" would be asked to verbalize his decision-making process so that it could be recorded and analyzed later. His directions (the "script") would be spoken into a microphone and received by the actors through headsets.27

Although it was not expected that the "PLAYWRIGHT" could function in real time (that is, delays were anticipated while he made decisions), it was hoped that employing techniques that might be used in an actual system

27Laurel and Hulteen, pp. 1-5.
(e.g., the user-sensing techniques and the visual display) would create conditions similar enough to actual use that the inference strategies and decision-making behaviors of the human "PLAYWRIGHT" could be used as a model for the PLAYWRIGHT expert system. Science fiction writer Ray Bradbury had tentatively agreed to perform the role of "PLAYWRIGHT"; however, the Atari Systems Research Laboratory was closed before the project could be completed.\textsuperscript{28} A similar study might be conducted in a university theatre department with access to some technical facilities. The Arts and Media Technology Laboratory at MiT, for instance, has a working media room with interface facilities including large-screen projection, three-dimensional sound, body-tracking, speech recognition, and speech synthesis.

Simulated IF systems with varying degrees and kinds of human involvement could be used for a variety of studies, including the identification of playwriting heuristics and techniques for intrinsically constraining the USER-CHARACTER. A simulation system might also be employed to test hypotheses about optimal C/T slopes and optimal durations for IF interactions (see Chapter V, pp. 240-241). Data about non-voluntary user responses like heart rate, respiration, and galvanic skin response might be collected in such simulations to test theories about C/T slopes—a user's physiological response to the enactment of a murder, for instance, might be compared with his response to the narration of the same event to generalize about the effect of the form of dramatic representation chosen for an action.

on its slope as perceived by the user. A similar study might simply involve subjective reports of users about the levels of suspense that they experience.

Simulation systems might also be employed to study the effects of various elements of the interface on users. NASA researcher Scott Fisher reports ongoing work on the phenomenon of "corporeality" in simulation environments, i.e., the user's sense that he is operating within an environment rather than viewing it from the outside. The psychological effects of physical artifacts within the interface environment—e.g., real mullions in a simulated view from a window or real snow skis in a simulated downhill run—are being explored.\textsuperscript{29} Simulation systems could also be used to assess the effects of such interface elements as two-dimensional displays or synthesized speech on the experience and behavior of a user. The effects of various kinds of user constraints (intrinsic, extrinsic, implicit, or explicit) might also be explored in simulated interactive fantasies. Such simulation studies would probably be quite similar to theatrical improvisations.

Other potential research topics may be pursued without simulation systems. In Chapter V (pp. 245-246), the difficulty of producing accidental or chance incidents in the plot of an interactive fantasy was discussed. Research into the structure and functions of such incidents might suggest more efficient techniques for producing them. Likewise, the application of planning models of behavior (like those that are used in most story-

\textsuperscript{29}Interview with Scott Fisher, NASA Ames Research Center, Moffett Field, Calif., 19 June 1985.
understanding and story-generating systems in AI) to the analysis of
ramatic characters might lead to the articulation of new behavioral models
or action-calculus representations that could be employed by the
PLAYWRIGHT and SYSTEM CHARACTERS.

**Applications for Interactive Fantasy Systems**

**Applications in Research**

The primary use of a working prototype of an IF system is research.
Research with working systems has two related purposes: the continuing
development of the system itself and the use of the system as a tool in
investigating other matters. Using a computer-based system in an artistic
activity ultimately requires that artistic rules and intuitions be explicitly and
clearly expressed—perhaps more clearly than they have ever been
expressed before. Qualitative and subjective notions must be rigorously
explored to determine if they can be captured in logical or quantifiable form.
Exploring artistic principles with such an end in view can often yield fresh
perspectives on the principles themselves—their validity, purpose, and
functioning.

A working IF system will enable researchers to conduct studies in
playwriting and dramatic analysis. The knowledge base and inference
engine of the PLAYWRIGHT expert system can be configured to represent
different understandings of dramatic structure and different approaches to
playwriting. One of the potential uses of an IF system is to study different
theories and techniques by applying them prescriptively. How would an interactive fantasy produced according to the dramatic practice of Chekhov or Shaw differ from one that employed the techniques of Scribe? What are the essential elements of Commedia dell'arte performance? Can some of them be expressed so as to be incorporated in a production system? Would a robust and distinctive style influence the style of the USER-CHARACTER's contributions—that is, would a USER-CHARACTER of a Chekhovian interactive fantasy "become" a Chekhovian character? An IF system might also be used to reveal hidden connections or redundancies in dramatic theories; for instance, does the "unity of action" arise naturally from a goal-based model of behavior, or must it be established by the use of specialized rules?

Other potential studies might be characterized as "user-centered research." They investigate matters involving drama, psychology, and interface theory. The interface of the proposed IF system involves only those modalities which correspond to Aristotle's notion of the means and manner of dramatic enactments: user motion and visual displays (spectacle), sound (music), and speech (diction). Would an interactive fantasy experience be strengthened or weakened by the addition of other sensory modalities in the interface environment? Researchers might investigate the use of non-voluntary response data as part of the information used by the system in understanding and interpreting USER-CHARACTER behavior. They might also investigate the uses and effects of olfactory and kinesthetic elements in the enactment. At Atari, researchers experimented with motion platforms (literally, floors that move), forced-feedback controllers (like steering wheels
and handle-bars that offered resistance), tactile interface devices like "sensor gloves," and various techniques for synthesizing odors in the development of arcade games.\(^{30}\)

Alternatives to the media-room interface environment might also be explored. At Atari, Scott Fisher coordinated research on "virtual environments"—interface environments that created imaginary worlds using a minimum of physical space and materials. Now at NASA Ames Research, Fisher is developing a head-mounted device that displays the visual elements of a virtual environment on small screens that are attached to a helmet worn by the user. Through the use of head-mounted displays, users can "walk around" three-dimensional objects that appear to be suspended in the actual physical environment.\(^{31}\) Technical innovations like head-mounted displays and earphones that can deliver three-dimensional sound suggest the possibility of a "wearable" interface environment for an IF system.

**Applications in Entertainment**

This study has focused on the design of a system that would be used for the purposes of entertainment and recreation by providing individual

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\(^{30}\)As early as 1983, a perfume manufacturer produced a "smell disc" that released different scents on command. The disc was available for point-of-purchase promotions.

\(^{31}\)Fisher interview. The seminal work on head-mounted displays is Ivan E. Sutherland, "A Head-Mounted Three-Dimensional Display," *American Federation of Information Processing Societies* 33 (1968):757-764. Such displays have been developed under the aegis of DARPA (Defense Advanced Research Projects Agency) at MIT and elsewhere.
users with the means to act as characters in imaginary worlds. In Chapters IV and V and in the first section of this chapter, this study has attempted to demonstrate that the means for creating such a system either exist or can be developed. The extended examples in Chapter V provide a notion of the kinds of experiences that a user might have. An IF system has the potential to provide the user with the pleasure of playing "make believe" in a rich sensory environment within the context of a dramatically satisfying plot. The system orchestrates the plot and controls the sensory representation of the action, leaving the user free to enjoy the illusion of becoming an agent in a fantasy world.

One of the reasons that development of such a system is not currently being undertaken by the entertainment industry is that it cannot be conceived as a profitable commercial venture in the near term. An IF system is not an arcade game. The cost of the hardware components and software development could probably not be recouped in an arcade environment—the price of admission would be too high. Furthermore, such private, extended experiences would probably be inconsistent with the goals and characteristics of contemporary arcade customers (e.g., the social aspects of the arcade experience and the short average duration of arcade activities).

The conclusion to be drawn from this analysis is that users will probably not encounter IF systems in local shopping malls or game arcades. Full-blown single-user systems are more likely to appear in universities or museums, where development and operation can be supported by research grants and funding for other applications using the same facilities (e.g., the
media room at MIT or the Exploratorium, a "hands-on" museum of science and technology in San Francisco). While near-term access would probably be limited by economic factors, such systems may eventually appear in commercial or home environments because the costs of component hardware continue to decrease dramatically. As commercial and personal applications for such devices are identified, manufacturers are stimulated to devote resources to find ways to produce them more cheaply. Personal computers, large-screen televisions, videodisc and compact disc players, speech recognition and speech synthesis equipment, and stereo sound systems are all examples of technologies in which prices have steadily decreased even as new capabilities have continued to be developed. The hardware components of an IF system may be available for commercial and personal use at affordable prices much sooner than one might anticipate. The history of technological progress and price reduction in consumer electronics is cause for optimism.

IF systems will be more widely available if means can be found to make them commercially attractive. Another strategy for accomplishing this goal is to devise a version of the system that would support multiple users simultaneously, thus increasing potential revenues. Designing systems for multiple users, however, presents a new set of problems. The difficulty of enabling functional interaction increases dramatically when more than one user is involved. Not only must the system sense and understand each additional user, but it must also make inferences about the interactions among USER-CHARACTERS (e.g., inferences made by USER-CHARACTERS about each other and the development of shared plans).
Normally, the frequency and significance of interaction is reduced in interactive environments that support more than one user. "Interactive movies" that allow the audience to participate in making plot decisions, for instance, typically limit interaction to a few clearly defined nodes and respond, not to individual users, but to a democratic "vote." Network computer games (like "Moria" and "Flight Simulator" on the Control Data PLATO network) may involve multiple users, but such games normally function simply by displaying the physical locations of users' characters or "vehicles" and by providing a facility for real-time text communications among users.

Group interactions are best sustained in systems or activities that involve human components. Traditional role-playing games like "Dungeons and Dragons" and the limited interactions afforded by improvisational "street theatre" are examples of group interactions that are orchestrated exclusively by humans. Recently, interactive fantasies have been produced commercially that intermix human actors and users in fantasy environments. The "Mystery Express," for example, is an interactive murder mystery that takes place on a weekend train trip. In the fantasy novel *Dreampark*, Larry Niven and Steven Barnes depict an IF system with multiple users that takes

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the form of a huge, interactive amusement park. Even the "dream park" incorporates humans as "game masters" and as some of the "system characters." In handling group interactions, it would seem that human decision-making power is seen as a critical ingredient.

A potential strategy for supporting multiple users is to provide intrinsic constraints which cast one of a group as the focal character. The system could support functional interaction for that character while accommodating only incidental interaction for the others. The means might also be found to allow different users to function as focal characters at different points in the interaction. In any case, research should be undertaken to determine what kinds of knowledge are required by a computer-based IF system to support multiple users. If such knowledge can be identified and represented in an expert system, multiple-user IF systems might be commercially feasible for public environments like "special-purpose" theatres and amusement parks.

Applications in Learning

An interesting characteristic of high technology is the fact that the eventual uses of a technology are often not anticipated by its developers. The U.S. space program, for instance, gave birth to technologies that are incorporated today in a plethora of consumer products, from digital watches to video games.

At the highest level, an IF system is a mechanism for enabling users to have dramatically satisfying, first-person experiences in imaginary worlds. The system proposed in this study has entertainment as its end cause; its

\(^{34}\)Niven and Barnes, _passim_.
product is an interactive drama. A similar system might be employed in training or education, with learning as its end cause. How would such a change in the purpose of an IF system affect its structure and knowledge base?

In his analysis of traditional drama, Sam Smiley distinguishes between mimetic and didactic forms. A mimetic drama employs plot as its formal cause, while the formal cause of a didactic drama is the element of thought.\textsuperscript{35} In an IF system intended for use in education and training, Smiley's theory might be employed to re-configure the inference engine and knowledge base of the PLAYWRIGHT so that learning objectives (the level of thought) would take precedence over dramatic structure (the level of plot) in determining next incidents.

An IF system might also be used in training applications. Several potential applications of an IF system were discussed in an interview with Trieve Tanner, a psychologist working in the Aerospace Human Factors Research Division of NASA Ames Research. Such a system could be used to train astronauts in the operation of a space station and to simulate probable social and physical conditions. It might also be used in conjunction with existing first-person flight simulators to train pilots in handling emergency situations.\textsuperscript{36}

An IF system might also be used as an interface to multi-modal databases. In the "Intelligent Encyclopedia" project at Atari Research, the

\textsuperscript{35}Smiley, pp. 49-50.

\textsuperscript{36}Interview with Trieve Tanner, NASA Ames Research, Moffett Field, Calif., 30 July 1985.
"encyclopedia of the future" was envisioned as a facility for accessing and integrating information in the form of images, sounds, and text. Using an IF system as an interface to information might transform the experience of learning:

Right now, we usually define an encounter with an "on-line database" as "searching for information." But what if we defined the activity as finding the information, or better still, experiencing it? We would no longer be "looking up information about the pyramids"—we would be climbing them, looking around their musty innards, reading heiroglyphics, or reincarnating pharoahs. Our notion of a "database interface" would be radically transformed.37

In a quest for information about the pyramids, an IF user might assume the role of a pharoah, slave, or archaeologist. As Aristotle observed, imitation is a most powerful and delightful way of learning.38

An IF system is a first-person simulation machine; it can allow users to explore and experience alternative realities. One might learn something about gravity by walking on the moon or landing on Mars. One might learn something about cats by seeing a nighttime garden through their infrared-sensitive eyes and listening for the scurry of mice with their sharp, movable ears. One's political awareness and understanding might well be enhanced by spending some time in a Nicaraguan jungle or a Soviet collective farm. One's understanding of philosophy might be altered by a visit to Plato's Republic or Ayn Rand's utopia.


38Aristotle, Poetics, 1448b/9-24.
Ultimately, reality is shaped by philosophy. The great Greek tragedies, for example, shaped the reality of their times by enacting an understanding of the stature of man and his moral nature. As Aristotle observed, poetry (of which drama is a species) has the power to reveal a kind of thing that might be. Hence poetry is something more philosophic and of graver import than history, since its statements are of the nature rather of universals, whereas those of history are singulars.\textsuperscript{39}

Perhaps the highest purpose to which an IF system might be put is to provide people with the means to explore what might be, and thus to determine what \textit{should} be, by asking, "What if?"

\textsuperscript{39}Ibid., 1451b/1-8.
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Pole Position. Arcade game and personal computer game Atari, 1982-83.


Works about Games and Interactive Media


Fiction and Plays


### List of Abbreviations

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<th>Abbreviation</th>
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<tr>
<td>ACM</td>
<td>Association for Computing Machinery</td>
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<tr>
<td>AVIOS</td>
<td>American Voice I/O [Input/Output] Society</td>
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<tr>
<td>ICASSP</td>
<td>International Conference on Acoustics, Speech, and Signal Processing (IEEE)</td>
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<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers</td>
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<td>IFIPS</td>
<td>International Federation of Information Processing Societies</td>
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<td>IJCAI</td>
<td>International Joint Conference on Artificial Intelligence</td>
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<td>SID</td>
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