2D SPATIAL DESIGN PRINCIPLES APPLIED TO 3D ANIMATION: A PROPOSED TOOLSET FOR FILMMAKERS

A Thesis

Presented in Partial Fulfillment of the Requirements for

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ABSTRACT

The visual design phase in computer-animated film production includes all decisions that affect the visual look and emotional tone of the film. Within this domain is a set of choices that must be made by the designer which influence the viewer’s perception of the film’s space, defined in this paper as “spatial design.” The concept of spatial design is particularly relevant in digital animation (also known as 3D or CG animation), as its production process relies on a virtual 3D environment during the generative phase but renders 2D images as a final product. Reference for spatial design decisions is found in principles of various visual arts disciplines, and this thesis seeks to organize and apply these principles specifically to digital animation production.

This paper establishes a context for this study by first analyzing several short animated films that draw attention to spatial design principles by presenting the film space non-traditionally. A literature search of graphic design and cinematography principles yields a proposed toolbox of spatial design principles. Two short animated films are produced in which the story and style objectives of each film are examined, and a custom subset of tools is selected and applied based on those objectives. Finally, the use of these principles is evaluated within the context of the films produced. The two films produced have opposite stylistic objectives, and thus show two different viewpoints of applying the toolbox. Taken
together, the two films demonstrate application and analysis of the toolbox principles, approached from opposing sides of the same system.

The organization of existing spatial design principles and the application of those principles to digital animation practice will benefit student and amateur filmmakers by providing reference and examples for spatial design decisions. Combining precedents from multiple visual arts disciplines, the proposed toolbox of principles presents seemingly instinctual knowledge of designers and filmmakers as an organized, visible resource for digital animation filmmakers.
Dedicated to all the teachers, past and present, who encouraged me to ask questions and seek answers.
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Due to the excellent community of instructors and fellow graduate students at ACCAD, my knowledge of digital animation developed further, my projects achieved greater success, and my time spent in the computer lab was infinitely more fun. Thanks to everybody.

Finally, I owe thanks to my family and friends, whose support has assuredly led to any past or future accomplishments I may enjoy.
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CHAPTER 1

INTRODUCTION

1.1 Digital animation: a unique opportunity to study spatial representation

Digital animation production (also referred to as 3D or CG animation) contains an inherent duality of representational space. Models are sculpted in three dimensions and arranged in a virtual 3D space, through which a camera can move freely along all three axes. The product of that work, however, is rendered as a flat, still image - a two-dimensional picture that only approximates motion if played in sequence at an appropriate speed. By contrast, in hand-drawn 2D animation, all artwork is created on flat 2D planes, but animators utilize visual techniques to promote the appearance of 3D space (multi-plane camera moves and character tones and highlights, for example). Film is “an utterly flat medium of presentation, insubstantial, without texture or material, and yet evoking, in a wafer, a fuller illusion of the physicality and exactness of human beings than any prior art.”¹

In live-action filmmaking, a director arranges physical objects and lights in front of the camera to achieve the desired look on the final film frame, while in 2D animation, flat drawings are carefully constructed to produce the appropriate final look. In digital animation, these two worlds combine, giving digital filmmakers the power to use either or both 2D and 3D elements to achieve their intended look.
1.2 What is “spatial design?”

Digital animation references the traditions and language of both 2D hand-drawn animation and live-action cinematography. Considerable overlap exists in the terminology of these disciplines, but there are few universally agreed-upon labels for the similar concepts found therein. In Dream Worlds, his book on animation production design, Hans Bacher defines visual development as “the early stage in production where all the different ways to translate a story idea into visuals are being explored.” This includes decisions about all areas of the film production pipeline: the overall visual concept of the film, the level of naturalism or abstraction, color choices, lighting, camera framing, composition, pacing, editing. In Film, Form, and Culture, Robert Kolker describes “the way space is organized and perceived in a film, including the way figure and background are composed … lighting and movement, the use of black and white or color, the distance between camera and figure—everything that happens within the frame, including the frame itself” as mise-en-scène. Within the larger categories of visual development and mise-en-scène, design subcategories can be delineated (background design, color styling, and lighting design are a few examples). The design choices that affect viewer perception of film space (causing it to seem deep or shallow, naturalistic or stylized, definite or ambiguous) form a subcategory defined in this research as “spatial design.”

1.3 Research Question/Thesis Focus

This thesis examines the traditional principles from graphic design and cinematography for spatial design and defines and applies a “toolbox” of 2D and 3D spatial design principles specifically adapted for 3D animation. This toolbox attempts to make the
filmmaker’s intuitive knowledge visible, and to organize it as a resource for digital filmmakers at the production design or visual development stage of the process. To explore and apply this toolbox, two short films were produced. For each film, the filmmaker used a custom subset of the toolbox to address each film’s specific story and style objectives. The first film, Goldilocks, Redirected, used 3D models and 2D artwork in combination to create 2D imagery, while drawing attention to the flatness of the film medium. The second film, A Litter of Perfectly Healthy Puppies Raised on Fried Pancakes, used 2D line art as a source to generate 3D animation, highlighting the illusion of depth produced. These two films have opposite stylistic objectives, and thus demonstrate two different perspectives of the toolbox. Taken together, the two films demonstrate a practice-based approach to the analysis of the toolbox principles.

1.4 Research Process

This paper documents the research process in the following steps: first, a literature and film search and review identifies principles from graphic design and cinematography that relate to spatial design. The literature search is constrained to sources detailing elements of graphic design and cinematography because those subjects have the most relevance to this study. The film search endeavored to seek out animated films with a unique approach to spatial design, especially ones that combine animation techniques or aesthetics to draw attention to the implied dimension, or apparent flatness, of the film space. The principles identified through the literature and film review are analyzed first in general, and then specifically in regards to the inherent qualities offered by 3D, in order to adapt them for use in digital animation. These principles are classified in a resource referred to as a “toolbox.”
Next, the stylistic intents of the two films in production are examined to determine what the visual look and emotional mood of each film should convey. Principles that will enhance viewer perception of the spatial properties necessary to support the stylistic intentions of each film are chosen for use. The principles are applied through the films’ production processes, and application is dictated by a combination of the films’ unique stylistic intentions and general qualities inherent to digital animation. In the first film, Goldilocks, Redirected, a comparative analysis demonstrates effectiveness of chosen principles in achieving the stated stylistic and spatial goals. The second film, A Litter of Perfectly Healthy Puppies Raised on Fried Pancakes, explores the toolbox principles further in generating a spatial environment markedly different from that of Goldilocks.

The research process documented in this paper follows a practice-based research methodology as defined by Carole Gray and Julian Malins in Visualizing Research; it centers around “making creative work as an explicit and intentional method for specific research purposes, for example gathering and/ or generating data, evaluation, analysis, synthesis, presentation, communication of research findings.”

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CHAPTER 2

PROPOSED “TOOLBOX” OF 2D AND 3D SPATIAL DESIGN PRINCIPLES

2.1 Introduction to toolbox categories

In this chapter, the toolbox principles will be defined in relation to spatial design in digital animation, and classified into categories of “tools” and “results.” The principles chosen for the toolset originate in the fundamentals of graphic design and cinematography. The writings of noted design educators Wucius Wong and Charles Wallschlaeger provided the primary sources of graphic design principles chosen for the toolset, while Cinematography: Imagemaking for Cinematographers, Directors, and Videographers by Blain Brown supplied the bulk of the cinematography principles. Brown was chosen as a primary influence for cinematography principles because of a clear and organized writing style, which helped clarify relationships between the design basics and the cinematography basics. In both cases, principles were chosen based on their ability to affect the spatial construction of an image. Once chosen, the principles were categorized based on their role in the image-making process, rather than their origin in graphic design or cinematography. This is because considerable commonality exists between principles of the two disciplines, and also because the toolset is used in relationship to the digital animation medium. The intended use of the
proposed toolset directs its organization into categories of “direct content tools” and “indirect composition results.” The toolset principles will be defined in this chapter. In the next chapter, existing animated films that provide context for this study will be analyzed and the toolbox principles at work in those films will be highlighted.

For clarity, toolset principles will be indicated in **bold type**. It should be noted that in some cases, multiple principles are combined into one tool (as in repetition, pattern, and similarity) because they are functioning the same way within the constraints of this spatial design study.

The first category, referred to here as “direct content tools,” comprises aspects of visual image design that are manipulated explicitly by the filmmaker to affect the resulting composition. **Overlap** is an example of a direct content tool, as the filmmaker can directly manipulate the amount of overlap between elements to enhance or reduce the illusion of depth in the scene and the overall scene composition. The second toolbox category focuses on evaluating rather than manipulating. It encompasses broader spatial design principles that are affected and determined by the use of the direct content tools. Adjustments to direct content tools cause results that can be expressed through the second category, here called “indirect composition results.” **Visual Hierarchy,** “the arrangement of visual elements according to their order of importance,” is an example of an indirect composition result, since changes to direct content tools like overlap will cause changes in the visual hierarchy of the frame. The filmmaker must then evaluate the resultant visual hierarchy and adjust direct content tools further, until the desired visual hierarchy is achieved. In Figure 2.1, the image on the left shows a frame with an unidentifiable shape in the center. The form is vague, and placed directly in the center, leading to a static and weak **visual hierarchy.** It is not clear
whether the shape represents a single object or multiple objects. If there are multiple objects, none are more important or spatially relevant than the others because they are the same color, value, texture, and size, and they are equidistant from the center of the frame. The result is that the viewer’s eye lands in the center of the image and is not directed around, through, or out of the frame. In the image on the right, value has been adjusted to produce overlap in the subject of the composition. It is now clear that there are two separate forms, and that one is in front of the other. The two shapes are defined by a visible edge and there is space between them, implying depth. The viewer’s eye is directed to the darker sphere on the left, since it is clearly in front of the rest of the composition. The image on the right has a clearer visual hierarchy than the image on the left, due to the use of overlapping elements.

Figure 2.1: Left image shows vague visual hierarchy, right image employs overlap to clarify visual hierarchy
2.2 Direct Content Tools

2.2.1 Color and texture

In addition to an obvious affect on the mood of an image, color and texture contribute clues to spatial depth. Since lighter shades of color appear to advance on a dark background (and conversely darker ones do on a light background), and warm colors advance while cool colors recede, color and value can be strategically used to suggest a level of depth. Based on the viewer's real-world experience, textures transmit perceptual information. A more detailed texture implies that the object is close, while less detail suggests that the object is further away from the viewer.

2.2.2 Contrast and differentiation

Contrast refers to opposite characteristics of two or more forms (black and white, large and small, etc) and suggests differentiation and often hierarchy among forms. The arrangement of light and dark areas within an image can also indicate spatial depth by suggesting real-world light and shadow relationships, and communicate information about the emotional tone of a scene.

2.2.3 Repetition, similarity and pattern

The use of "repetitive or similar elements" creates pattern and visual rhythm. Repetition, similarity and pattern also help create compositional unity.
2.2.4 Vertical and horizontal position

**Vertical position** in the frame can be used to show depth, where objects shown vertically above other elements are perceived as being further back in space. A precedent for this concept is found in Asian art, which has long depended on vertical position rather than linear perspective to convey spatial relationships.\(^3\) **Horizontal position** also affects perception. Reading from left to right is culturally mediated and affects how viewers perceive elements in an image.\(^4\)

2.2.5 Compositional angles and directional lines

Attributes of directionality and angled lines suggest motion in a still image. When the image is moving, the sense of motion can be enhanced or reduced through the use of **compositional angles** and **directional lines**.\(^5\)

2.2.6 Edge of the frame

The **edge of the frame** becomes a more prominent visual element when the contents of the frame are in motion.\(^6\) More significant to this study, the edge of the frame delineates the digital animator's conscious choice of what to show the viewer - the distinction between the “primary space” of the 3D scene and the “secondary space” of the picture plane.\(^7\) The framing of a 3D animation composition is the result of the filmmaker resolving the duality of 2D/3D representational space in a particular way, pursuant to the overall design of the film.

Brown points out that while creating a feeling of three-dimensionality projected onto a two-dimensional frame is a common goal of filmmaking, the opposite goal (to flatten the
perception of space) can be achieved using the same principles in a different way.\textsuperscript{18} These principles (generally called \textbf{depth cues}) are an important subcategory of the direct content tools.

2.2.7 Overlap

While vertical and horizontal position refer to an element's placement in the 2D space of the frame, \textbf{overlap} refers to one element occluding another element by being positioned visibly in front of or on top of it. Overlapping elements establishes that some objects are in front of other objects and thus closer to the viewer.\textsuperscript{19} Even if a flat form has no thickness, overlapping indicates that there is space between the objects and the picture plane.\textsuperscript{20}

2.2.8 Relative size

The \textbf{relative size} of objects or elements gives important visual clues about depth. According to Wong, larger size changes within an image result in a “deeper … illusion of spatial depth.”\textsuperscript{21} Comparative size can also be used compositionally to affect the viewer's perception of a particular element, as in “Hitchcock's Rule,” which states that “the size of an object in the frame should equal its importance in the story at that moment.”\textsuperscript{22}

2.2.9 Linear perspective

Formalized by Leonardo da Vinci, the method for representing objects in two dimensions as they would be perceived in three dimensions (based on the concept that
parallel lines converge at a point on the horizon) is known as “linear perspective.” Evidence of linear perspective can be a force for visual organization within a composition.

2.2.10 Foreshortening

Foreshortening is a form of visual distortion of an object whereby part of the object is shown disproportionately larger. This technique can convey information about the depth, size and position of the object.

2.2.11 Light and shadow, chiaroscuro

The amount and location of light or shadow in an image indicates an element’s position in space and its relationship to other elements in the composition. Lighting that creates strong contrasts is described as chiaroscuro. Popularized by Renaissance and Baroque era artists to model form through the use of light and shadow, chiaroscuro can be used in filmmaking to assist depth perception and add focus to the picture plane by occluding less important details in shadowed areas.

2.2.12 Atmospheric perspective

Perception of distant objects is affected by the characteristics of the intervening atmosphere. As an element gets further from the viewer, its level of visible detail, hue, and saturation of color are reduced. This mimics the atmospheric perspective found in real-world experience of distance, and thus implies depth.
2.2.13 Depth of field

**Depth of field** is a camera lens attribute used to direct the viewer to the focus of the composition. The depth of field indicates how much of the scene is in focus. If the depth of field is very shallow, only the subject will be in focus while objects in front of or behind the subject will be out of focus, contributing to a “detached, third person point of view for the shot”. This is sometimes called “selective focus” since the camera is selecting only the subject to focus on, isolating and intensifying viewer attention on the subject.

2.2.14 Lens angle

**Lens angle** is another camera attribute used to direct the viewer to the focal point of the image. It also gives the viewer implicit information about the subject. In a high angle shot, the subject will be far away from the camera and thus the viewer, contributing to a feeling of emotional distance from the subject and revealing a wide stage in which action can transpire. An eye level shot mimics the viewer's experience of the world and therefore leads the viewer to feel like part of the scene. A low angle shot is extremely unlike the viewer's customary outlook. This unusual point of view conveys anxiety or suspense, as the subject of the image is portrayed as unnaturally large and imposing. Tilting the camera lens with respect to the horizon also effectively communicates apprehension or unease, since the view is at odds with “normal” perspective. A filmmaker's choice of camera angle impacts the image composition, and also transmits information about the image's subject and the viewer's relationship to it.
2.3 Indirect Composition Results

2.3.1 Figure/ground relationship, positive and negative space

The relationship between **figure and ground** in a composition assists communication by confirming the subject of the composition, as well as helping illustrate spatial depth. Brown reminds us that “empty” areas of the frame also have visual weight, so the balance between **positive and negative space** affects viewer perception of the subject.32

2.3.2 Staging and silhouette

Clear **staging** calls for an idea to be presented in a way that is “completely and unmistakably clear.”33 Combining techniques of anticipation, timing, and contrast, staging helps direct the viewer’s eye to the pertinent action or expression. In pantomime, staging is especially important to story comprehension.34 Staging important action to the side of a character rather than the front (the animation principle of **silhouette**) is much clearer and more readable.35

2.3.3 Visual hierarchy

**Visual hierarchy** refers to the overall organization of visual elements with the intention to guide the viewer through the composition and direct his or her perception.36
2.3.4  Visual tension

Caused by the “interplay between balanced and unbalanced elements and their placement in the frame”, visual tension helps generate interest in a composition.37

2.3.5  Rhythm

Rhythm generates eye movement through image and directs the viewer along a path.

2.3.6  Unity, proportion and balance

For purposes of this study, these concepts have significant congruity. Balance and proportion are considered by the filmmaker and achieved through use of direct content tools such as vertical/ horizontal position, size change, and compositional angles and directional lines in service of a unified final image. Of course, the desired image may be deliberately unbalanced or out of proportion, depending on the goals of the filmmaker.

2.4 Summary

In this chapter, a literature search based in the writings of Wucius Wong, Charles Wallschlaeger, and Blain Brown generated a master list of graphic design and cinematography principles influencing spatial design. These principles are defined, classified and organized into a “toolbox” of 2D and 3D spatial design principles for use in digital animation. This toolbox (Table 2.1) is divided into two categories, labeled “direct content tools” and “indirect composition results.” Direct content tools, such as color, contrast, repetition, overlap, chiaroscuro, and depth of field are manipulated by the filmmaker to adjust the overall composition. Indirect composition results describe evaluative spatial design principles that are influenced and decided by the manipulation of direct content tools.
Examples of indirect composition results include **figure/ground relationship**, **visual hierarchy, unity**, and **balance**.

The toolbox principles were considered in studying a set of films demonstrating unique approaches to spatial design. The films selected for study combine 3D and 2D animation techniques to explore the feeling of dimensionality in the film space. They present unusual methods of representing space in animation, which provide useful context for this study. These films are analyzed with regard to the toolset principles in the next chapter.
2.2 Direct Content Tools
1. Color and texture
2. Contrast and differentiation
3. Repetition, similarity and pattern
4. Vertical and horizontal position
5. Compositional angles and directional lines
6. Edge of the frame
7. Overlap
8. Relative size
9. Linear perspective
10. Foreshortening
11. Light and shadow, chiaroscuro
12. Atmospheric perspective
13. Depth of field
14. Lens angle

2.3 Indirect Composition Results
1. Figure/ground relationship, positive and negative space
2. Staging and silhouette
3. Visual hierarchy
4. Visual tension
5. Rhythm
6. Unity, proportion and balance

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<td>13. Depth of field</td>
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Table 2.1: Toolbox categories and film subsets
CHAPTER 3

PROJECT CONTEXT: FILMS COMBINING 2D AND 3D SPACES

3.1 What is the context for this study?

One of the earliest examples of 3D animation used in combination with 2D animation is found in John Lasseter’s 1983 Where the Wild Things Are test, which he was motivated to explore for reasons of spatial design (specifically, to add depth to traditionally animated scenes).\(^3\) In the twenty-five years since, films like The Lion King and The Road to El Dorado have fully combined 3D animation and 2D animation, while films like Cool World and Who Framed Roger Rabbit have combined 2D animation with live action film, and films like Willow and The Lord of the Rings trilogy combine 3D animation and live-action film techniques. More interestingly, several films have been produced that not only combine 3D and 2D animation techniques, but also explore the very concept of the film space “being” three- or two-dimensional. Animators Raimund Krumme and Daniel Greaves have directed several short films that experiment with the viewer’s perception of spatial design and how it can affect the story and tone of a film. Jamie Caliri’s work on the title sequence of Lemony Snicket’s A Series of Unfortunate Events demonstrates a visual style that exploits the contrast between 2D and 3D space. Lasseter, Krumme, Greaves and Caliri’s films were selected for analysis because of their particular and unusual approaches to the portrayal of space in
animation. Their work will be examined, and their use of spatial design principles highlighted, in this chapter.

3.2 Where the Wild Things Are (John Lasseter, 1983): a literal combination of 2D and 3D art

After seeing early special effects scenes from Disney’s 1982 live-action feature Tron, John Lasseter (then a newly-hired Disney animator) was inspired by what he saw as the potential for “more dimension” in animation. To demonstrate this potential, Lasseter and fellow animator Glen Keane created a 30-second test clip based on the Maurice Sendak book Where the Wild Things Are. The test combines three-dimensional computer animated backgrounds with two-dimensional hand-drawn character animation, preserving the traditional squash and stretch look of the animation while taking advantage of the computer’s power to create the appearance of “realistic” 3D space and fluid camera movement. As the series of frames in Figure 3.1 shows, the scene’s dynamic camera moves convey a sense of linear perspective, and at times the lens angle is extreme enough to show foreshortening in the background objects. These spatial design principles, borrowed from graphic design and cinematography, are combined to add a deeper and more active sense of space to the animation. The vigorous camera motion serves the story by communicating a feeling of exuberance and play to the action of a young child chasing his dog. Spatially speaking, the exaggerated perspective of the foreshortened forms and unique camera angles help align the viewer’s point of view with that of the scene’s camera. The viewer is encouraged to feel a part of the onscreen action, as if he or she is experiencing and seeing the physical space along with the characters.
Lasseter considered the test to be a success, but as Disney management deemed the technique cost-prohibitive, the film was never completed. As a point of reference for this study, Lasseter’s use of 3D environments and camera moves demonstrates the spatial effects of **linear perspective**, **foreshortening**, and **lens angle**. Lasseter’s film is an early example of inquiry into spatial design in digital animation, and that inquiry continues through other filmmakers explored in this chapter and research such as this thesis.

Figure 3.1: Frames from 1983 vector test of *Where the Wild Things Are*, directed by John Lasseter.
3.3 Passage (Raimund Krumme, 1994): a study in figure/ground relationships

Independent filmmaker Raimund Krumme has created several award-winning short animated films that rely on the interplay between 2D and 3D spatial representation. Krumme creates a world “where the laws of perspective, and the characters both, are likely to break down at any given split-second and where each is able to manipulate the other.” His films “can easily be enjoyed solely for their inventiveness in pitting figure against figures and/or environment, with anything within the frame, be it body, object or landscape, vulnerable to spontaneous transformation or dissolution.”

In Passage, a simple black and white graphic style is used for the 2D character animation. Figure 3.2 shows a series of frames illustrating the film’s visual treatment. The white background and black figures encourage the viewer to perceive the scene as existing in a flat 2D pictorial space with a standard figure/ground relationship. As the animation progresses, the characters break the rules of a predictable scene space by interacting with the paper media, transitioning the scene from flat pictorial space to 3D physical space. The viewer’s “perception reflex” is triggered, resulting in surprise and amusement. The story being told relies on the contrast between 2D and 3D space, and takes advantage of the viewer’s expectations regarding consistent spatial representation. The lack of color and texture in the background and similarity of form in the two characters result in an ambiguous relationship between figure and ground, which is crucial to the story of this film.
3.4 *Crossroads* (Raimund Krumme, 1991): exploring depth cues

Like Passage, Crossroads “explores surreal distortions of space and/or size relationships. What appears to be flat surface in one sequence may turn out to be the side or even bottom of something in the next image. His [Krumme’s] new reality keeps audiences guessing.” In this film, animated camera moves are used to direct the viewer’s perception of the scene. As the camera moves around the scene, a line that is assumed to be ground begins to rise up and take shape, revealing itself as figure. As Figure 3.3 illustrates, Krumme challenges the viewer’s perception of space and depth by employing contour line to suggest linear perspective, and then changing the camera lens angle to execute a figure/ground reversal. Krumme also uses grayscale shading to indicate light and shadow relationships,
directing the viewer to perceive that some items are figures while others are ground. This sets up the eventual figure/ground reversal as well.

Figure 3.3: Frames from Crossroads, directed by Raimund Krumme

While working on a (later abandoned) feature film based on the children's story Harold and the Purple Crayon by Crockett Johnson, Krumme wrote the following about Harold’s experience of drawing: “the same drawings, looked at from another angle or dimension, are transformed into something new, with different dimensions in another spatial order.” The description aptly fits Krumme’s own work as well. His simple black and white line drawings and lack of background depiction help him to manipulate the viewer’s perception of space. By keeping the scenes simple, he can suggest spatial perspective with minimal drawn elements, and then easily adjust that perspective since the perspective cues are not rendered out in full.
3.5 *Flatworld* (Daniel Greaves, 1997): a direct contrast between 2D drawings and a 3D stop-motion set

![Frames from Manipulation, directed by Daniel Greaves](image)

In Daniel Greaves’ Oscar-winning short film *Manipulation* (1991), the physical hands of the animator are filmed folding and flipping the paper, as well as drawing, stretching and pushing the character around (Figure 3.4). The story is a playful battle between the artist and his apparently sentient creation, à la Chuck Jones’ *Duck Amuck*. Spatially, “the film’s juxtaposition of an animated figure and photorealistic setting give the antics an almost three-dimensional sense of space.” Like *Passage*, *Manipulation* adds another layer of foreground to the piece by drawing attention to the media of production. In addition to figure and ground, the surrounding three-dimensional environment is implied and even explicitly rendered at times. These films represent a unique method of spatial design, in which the film space is not contained by the boundary of the frame.

Greaves continues to explore the intersection of 2D and 3D space in his subsequent short film *Flatworld*, which combines stop-motion 3D sets with 2D-animated characters and
props. Figure 3.5 shows that as the 2D characters move through the 3D sets, they rotate in space and reveal that they are thin and flat, like sheets of paper. In creating the characters as flat 2D drawings, and making the street environment a physical 3D model, Greaves draws more attention to the incongruous and generally fantastic nature of the story.

Figure 3.5: Frames from Flatworld, directed by Daniel Greaves

Rather than implying 2D and 3D space like Krumme, Greaves sets his piece in an explicit 3D environment and uses 2D characters and props within it to draw the viewer’s attention to the two ways of representing space. To deepen the 3D set space further, shots are staged to take advantage of linear perspective (illustrated by the street receding into the
distance in the first row of frames in Figure 3.5), **compositional angles** (third row of frames in Figure 3.5), and **chiaroscuro** (second row of frames in Figure 3.5). The spatial design of this film relies on the **contrast** between the characters and the environment.

### 3.6 End Title Sequence, Lemony Snicket’s *A Series of Unfortunate Events* (Jamie Caliri, 2004): a 2.5D visual influence

The end title sequence of *Lemony Snicket’s A Series of Unfortunate Events*, designed by Jamie Caliri, presents flat 2D artwork in a 3D film space, producing a “2.5D” look. Caliri combines layered textures, abstract, hand-drawn characters, repeating patterns, and simple puppet-like models to create a visually interesting and evocative piece. In addition to demonstrating spatial design principles, this piece served as a visual style influence for *Goldilocks, Redirected*.

The graphic visual style presented in the end titles of *Lemony Snicket* breaks the rules of a consistent scene space predicated in the physics of the natural world. The hand drawn characters do not conform to realistic proportions or methods of locomotion, instead they are visually abstracted and animated in a style reminiscent of cut-out or stop-motion animation. Character movements are limited and simplified. The scratchy pencil line work on the characters reminds the viewer that these are drawings, not “real”, emphasizing the contrast between flat 2D space and realistic 3D space.

The environments are divided into several layers giving the shots visual depth, but these layers are not composited to provide convincing spatial depth. In other words, the motion of the layers in combination does not add up to a realistically predictable scene space, and as a result the characters can move through it in whimsical ways. In Figure 3.6, the
contrast of scale between the large dark figure and the small characters of the children leads to ambiguity in the relationship between figure and ground. Therefore, when the ledge the children walk on is revealed as the hat brim of the large silhouette character, the silhouette figure can lift the hat to bring the children tumbling down into his large hollow head. Other shots find the children unexpectedly in the palm of his hand, or driving past his face, trapped by his watchful eye. The eye is a recurring visual element, appearing throughout the sequence in textures and patterns to signify the ever-presence of the threatening silhouette figure.

![Frames from Lemony Snicket end title sequence, directed by Jamie Caliri](image)

Figure 3.6: Frames from Lemony Snicket end title sequence, directed by Jamie Caliri

Figure 3.7 shows two discontinuous frames from the sequence. In the image on the right, Caliri simultaneously uses the large dark shapes as foreground, background, and atmospheric elements. By varying the texture on the dark shapes, the lower piece reads as foreground, and the piece on the right side reads as background. Both pieces are angular, thin, and taper to pointed ends, suggesting a scary or threatening presence, and they blend in with the dark, shadowy vignette around the edges of the frame. This vignette creates
**chiaroscuro** and gives the image visual focus. It also adds to the mood of the shot, which is mysterious and creepy.

Figure 3.7: Frames from *Lemony Snicket* end title sequence, directed by Jamie Caliri

Using the dark figure to function at multiple depths in the composition is an unusual technique. Traditional animation takes pains to establish realistic spatial depth, often by following a visual convention based on linear and atmospheric perspective whereby distant items are smaller, less saturated, and lighter in color. Caliri’s creative use of this silhouette element draws attention to his non-conventional rendering of visual scene space. The dark figure also helps to frame the image, and it balances the bright disks in the upper left of the frame, the brightest items in the composition. The value difference between the dark figure and the rest of the frame generates a **value contrast** that, in addition to the **scale contrast**, implies a deeper space in the shot than would directly result from the use of flat cut-out layers. The dark vignette and silhouette figure cause the center of the scene space to telescope away from the viewer in perspective. In this way, Caliri creates three-dimensional depth in these compositions out of only two-dimensional flat elements.
The *textures* on the environment layers provide another visual cue that this space is not based in physical reality. They provide visual texture and interest, but they are in no way signifying realistic material substances – fabric patterns are used on a house exterior, and geometric patterns are used on ocean waves. The characters are repeatedly confronted by a silhouetted figure whose *scale* is not consistent with the main characters, which is another unrealistic cue. This figure's features are never revealed, as he is always shown in silhouette. The abstract visual treatment of this figure allows Caliri to surprise the viewer with *figure/ground* reversals, where a mountain in the landscape is revealed to be the silhouette figure's head, or a path that the characters walk on becomes his hat brim. These scenes convey the characters' anxiety as they try to escape the figure, and the returning threat of danger as he appears again and again out of the landscape.

The visual style of *Lemony Snicket* draws attention to the contrast between 2D and 3D space and demonstrates the storytelling power of simple graphic elements. The non-realistic use of space, *contrast* between flat layers and deep space (created in part by strong radial vignettes) and variety of *scale* and *texture* generate meaning and engage the viewer in trying to resolve the story as it plays out. Since the scenes are not representationally realistic or congruous, the viewer can't predict what will happen next. The visual style of this piece demonstrates several aspects of two- and three-dimensional spatial contrast, and in fact relies on the contrast between 2D and 3D space to inform the story.

### 3.7 Summary

This chapter establishes a context for this study by analyzing several films that present unusual approaches to the portrayal of space in animation. In 1983, John Lasseter
produced one of the earliest experiments in spatial design, combining three-dimensional computer animated backgrounds with two-dimensional hand-drawn character animation to create a 30-second test clip based on the Maurice Sendak book *Where the Wild Things Are*. Lasseter’s use of 3D environments and cameras produce *linear perspective* and *foreshortening* in the scenes, adding spatial depth and dimension to the animation.

Independent filmmaker Raimund Krumme has explored spatial design in several award-winning short animated films. In *Passage* and *Crossroads*, Krumme manipulates the viewer’s perception of space and depth by employing black and white contour line drawings with minimal background depiction to execute surprising *figure/ground* reversals. The visual style of these films eschews color and texture, causing the viewer to fill in missing spatial details and enabling Krumme to manipulate the viewer’s perception more easily.

Rather than using 2D animation to imply 3D spatial relationships like Krumme, filmmaker Daniel Greaves set *Flatworld* in a physical 3D environment, and animated 2D characters and props within it, drawing the viewer’s attention to the two ways of representing space. The 3D camera and sets create *linear perspective* and *compositional angles* in the scenes, increasing the sense of spatial depth. The spatial design of this film depends on the *contrast* between the characters and the environment.

A “2.5D” look results from the combination of flat 2D artwork and a 3D film space presented by Jamie Caliri in the end title sequence of *Lemony Snicket’s A Series of Unfortunate Events*. The visual style of *Lemony Snicket* draws attention to the difference between 2D and 3D space through the *contrast* between flat layers and deep space, a variety of non-realistic *scale* and *texture* applications, and deliberately ambiguous *figure/ground* relationships.
The films analyzed in this chapter were chosen to provide context for this project because they demonstrate a variety of techniques and approaches to spatial design in animation, specifically illuminating illusory depth or flatness. Studying the techniques used in these films provided examples of the toolset principles in action, contributing visual reference for the short films produced as part of this thesis (Goldilocks, Redirected and A Litter of Perfectly Healthy Puppies Raised on Fried Pancakes). In Goldilocks, Redirected, the 3D production environment is deliberately reduced to an illusion of compressed space through application of specific toolbox principles. The Pancakes film presents the opposite spatial design problem: it is based on James Thurber’s drawings, which consist of only the element of line, and through application of specific principles, a deep 3D space is created. In the next chapter, the production and analysis of these two films is documented.
CHAPTER 4

METHODOLOGY AND ANALYSIS

4.1 Overall project methodology

To explore and apply the toolbox described in Chapter 2, two short films were produced. For each film, a custom subset of the toolbox was chosen to address the specific story and style objectives presented. The first film, Goldilocks, Redirected, combines 3D models and 2D artwork to create 2D imagery, drawing attention to the flatness of the film medium. The second film, A Litter of Perfectly Healthy Puppies Raised on Fried Pancakes, takes 2D line art as a source to generate 3D animation, producing an illusion of depth. These two films have opposite stylistic objectives, enabling the filmmaker to adapt each of the toolbox principles to a 3D application.

4.2 Goldilocks, Redirected film production

4.2.1 Film overview and objectives

Since this film was created as part of an applied spatial design study, the design part of the process was to be the focus. Rather than writing an original script, an existing story, Goldilocks and the Three Bears, was chosen for the subject. Goldilocks, Redirected was designed as
a staged puppet show, to be acted out by jointed wooden puppet characters. This was a
deliberate design choice, made to explore ideas about how space is represented in two
dimensions versus three dimensions. Three-dimensional parameters were intentionally
removed or reduced in order to challenge the filmmaker to apply two-dimensional visual
principles in a way that would create depth within an illusion of compressed space. This
spatial goal affected all aspects of the production: the thickness of the models, the angles of
the camera, the movement of the characters, and even the original storyboards and editing
decisions.

4.2.2 Models

To begin the modeling process, cutout illustrations of Papa Bear and Goldilocks
(Figure 4.1) were generated. Using Autodesk Maya®, 3D models were built based on the
cutout designs.
The thickness of the models was important to the spatial design of the film, since the characters must appear to fit into the compressed film space. The models are meant to look like simple wooden puppets, and their animation is intentionally limited. Since the camera is locked to a front view, the models are not seen from all sides. The models should look as though they are constructed from thin pieces of wood, but since they are not shown from any side other than the front, the actual depth and dimensions was secondary to the perceived depth and dimensions. The best aesthetic result came from using simple polygonal shapes with a smooth edge bevel. The bevel catches light along the edge, making it evident that some pieces are in front of others. Overlapping these elements adds physical depth to the characters.
The characters and background layers were intended to cast shadows on the rear layers, and the segmented sections of the characters to cast shadows on each other as well. Since the camera was to be locked to the front view, and the actual depth of the pieces would not be seen, tests were attempted with the pieces made artificially thick, causing them to cast darker shadows on pieces layered beneath (Figure 4.2). Again, these cast shadows signify overlap, a crucial method of designating space in perspective.

Figure 4.2: Torso piece made thicker to cast a shadow

This led to the idea that perhaps the pieces should have a visible side edge. Experiments in pulling the sides of the shapes out to create this edge were conducted, including doing so in an unrealistic manner with some pieces showing the right edge, and some the left. This attempt was based not in visual logic, but in pursuit of visual interest.
However, conflicting visual cues resulted in viewer confusion. Based on these various experiments, the decision was made to render only characters and props in 3D and then composite them with the 2D background layers in Adobe AfterEffects®. This method allows for adding arbitrary drop shadows, which enhance the puppet show look, as well as vignettes and other lighting effects, without struggling with “true” lighting and shadows in Maya®. Since the aesthetic goal is a stylized, non-photorealistic lighting and shadow treatment, this workflow is effective and appropriate.

Though the arbitrary side edge treatment looked odd, giving the character a little bit of an edge (in addition to the bevel on the pieces) helped separate it from the background because the darkened edge indicates overlap. Goldilocks’s model was therefore adjusted to have side edges showing on the right and bottom edges of the pieces (Figure 4.3). This way the look is uniform, as if the light is coming from the upper right of the frame, but since the character will move and the edge will not, there will still be a subtle unreality, which supports the other visually “playful” elements – flat 2D looking characters, sculpted 3D props with forced perspective, and drop shadows that fit the compositions but not any actual lighting model reality.
Goldilocks, Redirected, explores the intersection of 2D and 3D space by emulating a staged puppet show. The characters are modeled out of thin, flat pieces of geometry to achieve an almost 2D appearance, but they are in fact 3D models animated in a 3D space. Because the camera is constrained to the XY plane, the character design has to accommodate this restriction. The characters never move along the camera’s Z axis, and they are never shown in profile or from the back. The character design thus has to be completely understandable and readable from just the front view (in silhouette). This design restriction would seem to reduce character complexity (and probably did), but it also raised unforeseen design challenges. One such challenge required modifying Goldilocks’ hand setup. Since the geometry must remain parallel to the XY plane, the thumbs will always point in or out, but as the arm joints rotate in Z, the direction that the thumbs point in changes. The result,
shown in Figure 4.4, is that they look correct when her hands are below her shoulder level, but after rotating the joints up, her thumb points away from her head, which looks awkward. If the model is set to have her thumbs point inward when rotated up by her head, then they will look awkward when her hands are down near her body and pointing out. To resolve this, her rig includes a control to flip the thumb direction as needed. This allows the animator to determine specific thumb direction without breaking the rule of the scene space.

Figure 4.4: Illustration of Goldilocks’ hand direction, which required an added controller to flip the direction of her hand as needed.
Another important factor in determining hand direction is the animation principle of silhouette action. John Lasseter states:

Another idea developed in the early days at Disney was the importance of staging an action in silhouette. In those days, all the characters were black and white, with no gray values to soften the contrast or delineate a form. Bodies, arms and hands were all black, so there was no way to stage an action clearly except in silhouette. A hand in front of a chest would simply disappear. Out of this limitation, the animators realized that it is always better to show an action in silhouette. Charlie Chaplin maintained that if an actor knew his emotion thoroughly, he could show it silhouette.57

In order to clearly stage the character's hands in silhouette, the additional directional control was necessary.

Rather than modeling explicit facial features (mouth, eyes, etc) for Goldilocks, only her head shape was modeled, without facial features, and her expressions were painted as different face textures to be animated (Figure 4.5). On an actual wooden puppet, the face would be painted on. Preserving this painted look, while allowing expressions to change as needed (without interpolating or inbetweening) maintains the desired aesthetic style. More importantly, using a 2D texture on a flat surface of a 3D model is a way to explore what level of dimension or depth is necessary for successful storytelling in a comprehensible space.
The three bear characters are modeled in thin, segmented pieces like Goldilocks, with one exception. Rather than having flat, stylized facial features, the bears have facial structure that projects out into the scene space (the muzzle, nose, and mouth). It is a visual signifier that they are nonhuman and different from her. To convey this distinction, the bears have additional facial geometry that is layered in front of the base head piece (Figure 4.6). The geometry is controlled using Maya® blendshapes to create the necessary expressions, as opposed to using painted textures to convey expressions like Goldilocks. The muzzle and nose overlap the head and cast shadows back on it, indicating that the bears’ skulls protrude out farther than Goldilocks’.
To create character textures, magazine photos were scanned in, enhanced in Adobe Photoshop®, and combined in layers with other images and patterns. The image textures are photographically rendered 3D surfaces, but they are applied as flat 2D coverings. This process emulates the graphic stylization demonstrated by Caliri in Lemony Snicket's textures: realistic texture sources blended with graphic patterns to produce stylized results. Goldilocks textures include some visual reference to “reality” (fabric textures on clothing, hair textures on hair) but they are layered with other sources and applied in ways that are not strictly realistic. For example, Goldilocks's hair texture is created from a scanned photograph of human hair, but as the last image in Figure 4.5 shows, the texture is flatly placed on the geometry and does not appear to wrap around the head in any realistic way. The pigtails extend down from the hair without connecting to the head accurately. The effect of applying 3D source textures in this flat 2D manner is to further compress the scene space. Rather than projecting forward into the space, the textures are flattened against the objects.
To create props (beds, chairs, etc) with intricate scrollwork or other details, vector curves were drawn in Adobe Illustrator®, which allowed maximum control over the shape of the curves. The final curves were imported into Maya® and beveled to create 3D geometry (Figure 4.7). This method allows for 3D models to be generated directly from 2D vector art, at the angle and perspective desired for the scene. This asset generation technique represents an intersection of 2D and 3D spaces as part of the production process, as opposed to the design process.

Figure 4.7: A) Scroll detail drawn with vector curves; B) curves beveled in Maya® to create 3D geometry; C) geometry in perspective view; D) bed prop with scroll detail geometry in wireframe view; E) bed prop in shaded view.
Unlike the flat characters, the props were fully modeled in three dimensions. The puppet characters fit into the visual logic of the stage-like environment, while the 3D props contrast with it and create a sense of false perspective. This adds to the playful, toy-like puppet show style. More importantly, the characters and flat environment layers reduce the spatial depth of the scenes, while the props extend it. The perspective on the props is often skewed to increase the effect of foreshortening in the image. The characters and sets compress the space, the props expand it slightly and skew the perspective, and the result is a "2.5D" image, between 2D and 3D.

4.2.3 Rigging

The spatial restrictions of Goldilocks, Redirected determined the quality of motion of the characters, and thus dictated the setup of their animation rigs. To make the desired motion quality of a jointed wooden puppet possible, a complex rig was developed including three separate joint systems. The first one permits the joints to be rotated parallel to the picture plane and animated using forward kinematics. The second one is dynamically driven, automating an expressive swinging motion in the limbs and a naturalistic-looking "settle" effect. The third joint system includes controls to switch between the FK and the dynamic skeletons, and it is this joint system that drives the visible geometry of the characters. This setup allows the animator to control joint placement precisely when necessary, while also taking advantage of software-driven dynamics. The result is a quality of motion that matches the viewer's expectation of a jointed wooden puppet. Sometimes the puppet appears to be in control of its own motion, and other times it appears to be influenced by natural external forces of velocity and gravity. Aesthetically, this quality of motion is important to the
success of the film. The motion demonstrated by the jointed wooden puppet characters evokes a shallow stage area and reaffirms that the action is taking place in a compact setting for the benefit of viewers directly in front of the stage. The spatial design of the film indicates a compressed space, and the flat puppet characters must fit into that space. They have room to move in X and Y, but cannot extend or move into Z space. The swinging and settling of the limbs convey the weight of the character, which is crucial to believable animation. The way that the animation can switch from the keyframe-driven skeleton to the dynamically-driven one showcases the occasionally uncontrolled motion of the limbs, which make it move like a puppet affected by the natural laws of gravity, rather than like a self-powered character that is merely styled to look like a puppet.

4.2.4 Environments

Early set designs were made up of completely 2D layers, the only exception being the characters, which were modeled in 3D to be very thin and look almost 2D. The result lacked visual interest (Figure 4.8). Visual depth was added in the form of additional overlapping set layers, patterned textures, and transparency.
Figure 4.8: Before and after set designs
To add another layer of spatial complexity to the scenes, the props were created in 3D. This extends the scene space at the center, where the props are featured, and helps to build depth. At the first level of the scenes, the stage-like environments are constructed of flat layers with patterns and **textures** to add visual complexity. Next, the characters have slightly more depth due to their actual 3D construction and edges showing on the lower right side (regardless of actual lighting in the scene). The props have more depth still as they are modeled in 3D with forced perspective. The additional depth of the 3D props suggests more space between the background layers, although the layers appear to be flat and dimensionless (see sample scene layers in Figure 4.9). The combination of 2D and 3D techniques used creates a playful, visually interesting space that challenges the viewer to distinguish between “actual” space and film space.

Figure 4.9: Goldilocks, Redirected scene levels

For Goldilocks, the film space was flattened as a design approach. After removing properties and parameters inherent to 3D production (like sculpted 3D modeling, realistic
light and shadow rendering, and 3-axis camera animation) from the production process, the visual goal was to create an illusion of 3D space out of flat 2D layers. Drawing on Caliri’s work as inspiration, experiments in depth, scale and pattern generate visual texture. Controlled variation in textures and colors is used to establish the compressed film space of Goldilocks. Texture patterns and relative sizes and scales are used non-literally to create spaces that are visually interesting, but do not conform to the viewer’s experience of reality. For example, stylized graphic textures are used on organic elements like grass and leaves. A bark texture is applied to the bear’s house at a large scale, to add detail in close shots and enable the viewer to see it in a wide exterior shot. Since a more detailed texture implies that the object is close to the viewer, using such a texture on an object in the background spatially compresses the environment. In a similar way, colors are used in expected ways (the sky is blue, the grass is green) but in interior scenes (Figure 4.10), warm colors used in the background appear to advance while the cooler foreground colors appear to recede. This visually compresses the film space.
The interior environments were designed to feel warm, cozy, welcoming, and protected. This reinforces the enclosed feeling of the rooms, and allows the wide exterior shot to provide sharp contrast – it is bright, cool, and a bit of a visual shock after the established (stylized) earth tones of the interiors (Figure 4.11). This contrast conveys a spatial change (from narrow, compressed interior space to wide open outdoor space) as well as an emotional change for the main character. Previously, she was exploring with confidence and now she’s stunned and confused. A contrast of size reinforces this emotional change. The interior shots showed her in scale to her environment, but outside she is dwarfed by it, signaling a loss of control and power over the events of the story.
Each environment includes a visual framing device (an arched wall edge, or curtains, for example) creating a proscenium arch and rendering the viewer a third-person observer. Proscenium staging is a cinematography concept derived from its use in theatre, where the arch defined the “fourth wall” between the actors and the audience. It indicates a division between spectator and actor, rather than inviting the spectator to identify with the actor. Goldilocks, Redirected is based on the story of The Three Bears, which is familiar enough that most viewers will recognize it, and enjoy anticipating what will happen next. The story is comprised of repetitive sequences that form a narrative rhythm, further assisting the viewer in predicting the next scene. Therefore, the proscenium visual framing reinforces the viewer’s natural reaction to the material. It also serves to focus the viewer’s attention on the center of the frame, where the action takes place. Since the camera is locked and does not move in 3D, the visual elements must move relative to the frame. Covering the edge of the frame makes it easy to slide set pieces around behind the character, adding visual interest to compensate for the static nature of the closed framing. This closed framing, shown in Figure 4.11:
4.12, further enforces the stage aesthetic of the piece. The viewer is clearly established as an observer of events as they are presented, not a participant in the action.

Figure 4.12: Frame from Goldilocks, Redirected, directed by Beth Albright.

From a design standpoint, the framing devices provide another visual level to the composition, which is constructed of several overlapping flat layers. This multilayered composition adds depth in the Z-axis direction, which contrasts with the flat appearance of the set pieces. The space is simultaneously being flattened and extended, creating visual interest.

As Figure 4.13 shows, the door to the bears’ house has a wood texture as its base, but a graphic pattern is stamped over that. The wood texture gives visual information about what the object is, and the extra pattern adds visual interest. As this film explores the intersection of 2D and 3D space, it was important to investigate ways of using various 2D textures in combination to create a sense of depth in the scenes. That sense of spatial depth is a matter of the viewer’s perception, since the viewer is in fact looking at a flat image.
Layering textures, especially with varying degrees of transparency, proved to be one way to influence the viewer's perception of a scene space. The layers indicate how elements overlap one another, which is a primary visual cue for understanding spatial depth.

Figure 4.13: Frame from Goldilocks, Redirected, directed by Beth Albright

4.2.5 Spatial analysis case study

To discover ways of presenting space in Goldilocks, Redirected, a spatial analysis study reconstructed one environment from the film ten times, exploring various graphic techniques to determine their potential for creating perceived three-dimensional visual space from two-dimensional art elements. Compositional design elements of contrast, similarity,
and **balance** are maintained in all ten images through a controlled use of additional visual techniques. Each image builds on the one before by including all previous techniques, and adding something new. Each technique is evaluated in regards to its effect on the picture plane and therefore its success in increasing the perception of three-dimensional space in the image.

Figure 4.14: Step 1 image of spatial analysis study

**Step 1: Monochromatic 2D Background Elements (Figure 4.14)**

The first example shows the “flattest” spatial presentation that remains consistent with the style of the film. The background and prop elements are all two-dimensional artwork. All elements are stripped of 3D visual cues, and the background **color** palette is uniformly warm and earth-toned. **Textures** are applied, but without regard to lighting or shadow, or relative scale. The background colors are monochromatic. The result is a flat-
looking image. The character stands out prominently against the background, but the environmental space has minimal depth. The effect is a “cartoony” looking image with very minimal perceived three-dimensional visual space.

Figure 4.15: Step 2 image of spatial analysis study

**Step 2: Color Shift on the Foreground Element (Figure 4.15)**

Changing the color on the foreground overlay piece takes some attention away from the character, but it helps to separate the foreground from the midground, adding depth to the scene. In Figure 4.14, it is clear that there is spatial depth between the table and the wall, because the character is between the two. In Figure 4.15, the contrast of color and value between the arch and the table visually separates the two and thus results in more perceived depth in the scene. The color change on the bowl prop causes it to come forward visually as
well, but this does not necessarily lead to greater perceived depth (unless the viewer
perceives the bowl floating in midair in the extreme foreground).

Step 3: Drop Shadows (Figure 4.16)

Adding drop shadows to each element of the scene helps anchor the elements in
space and separate them visually into planes. The design principle of overlap comes into
play here, as the shadows indicate that certain objects are in front of other objects, signifying
space between them. Although the visual elements are obviously flat, the viewer’s experience
with light and shadow in the physical world causes these drop shadows to translate into
increased perceived depth in the scene.

Figure 4.16: Step 3 image of spatial analysis study
Step 4: Transparency (Figure 4.17)

Here, transparency has been added to the curtains. In the previous examples, it was clear that the curtains had folds and wrinkles, but by making them transparent, overlapping sections are revealed. Again, overlapping elements add depth to the scene. It also makes it evident that there is something behind the curtains (the wall) and space between the two. The transparency of the overlapping sections makes the form of the curtains start to look sculpted, as if it actually projects into the scene space. The additional depth of the curtains adds perceived space to the scene.

Since the camera's viewpoint is locked to a front view in Goldilocks, there is no way to show objects receding into space and thus no sense of linear perspective. Therefore, overlapping objects is necessary to show the relationships of elements in space. In addition
to actually placing some objects in front of others, drop shadows and semi-transparent objects invoke the principles of overlap.

Figure 4.18: Step 5 image of spatial analysis study

**Step 5: Texture Scale (Figure 4.18)**

In this example, the scale of the **texture** on the wall, bowl, and arch has been adjusted to reflect more accurate proportions. In previous examples, the unrealistic scale of the **textures** provided conflicting visual cues about the space. Resolving the scale of the **textures** establishes the scale of the environment by showing the elements in correct scale to one another. Although the consistent use of scale makes for a more cohesive image, in this case it does not add perceived depth to the scene.
Step 6: 3D Prop Elements (Figure 4.19)

The bowl prop here is modeled, lit, and rendered in 3D. Adding three-dimensional objects adds depth and interest to the scene, and combines with the 2D elements to suggest a space that is playful, without being cartoony or juvenile. The effect of the “realistic” lighting and rendering on the bowl creates a contrast of texture with the other scene elements. The light and shadow sculpting the bowl give it more depth, and combined with the drop shadow on the foreground arch, perceived space in the midground area is extended.
Step 7: 3D Background Elements (Figure 4.20)

Taking that concept of texture one step further, the portrait on the wall is handled with a more dimensional look here. It’s more “realistic” based on the style of the film, and so adds another level of depth to the background. This prop fits into the environment style better, but as it is on the bottom-most level of the background, and does not project out from the wall very far, it does not add much perceived depth to the scene.
Figure 4.21: Step 8 image of spatial analysis study

**Step 8: Forced Perspective on Foreground Elements (Figure 4.21)**

To add more depth to the space, the arch and table elements are shown with their edges receding in perspective. The perspective is forced, but it still helps add dimension to the environment in connection with the principle of **foreshortening**. This technique could conceivably add depth to the scene, but in this case it looks more like an outline on the elements. To add perceived space, the edges would need to have lighting and shadow applied. This would clarify the sections of the arch edge, and render the top table edge grading back in perspective.
Step 9: Atmospheric Perspective & Vignette Shadow (Figure 4.22)

Atmospheric perspective is added to the background, and a radial vignette is added to darken the outside edge of the composition. The layer of atmosphere suggests space between the background levels, and the vignette (creating chiaroscuro) frames the subject and draws the eye to the center. Since dark areas advance and light areas recede, the radial vignette adds a feeling of depth in Z-space (thus increasing overall perceived depth).

Atmospheric perspective, commonly used in cinematography to show depth, is affecting the back wall, and it increases separation (and therefore perceived depth) between the wall and the character.
Step 10: Depth of Field (Figure 4.23)

A final example includes exaggerated depth of field to suggest deeper space in the environment, and also focus the viewer’s eye on the character. Depth of field is a basic principle of cinematography, and it is important to framing a scene. The falloff of detail behind the character increases perceived visual space in the image. A shallower depth of field helps achieve the goals of improved figure/ground, focus, and staging too. The film space for Goldilocks is very shallow, so it would be reasonable to expect that all the elements would be in sharp focus. However, when all elements are equally sharp and crisp, the visual hierarchy of the image is compromised. Deliberately softening focus on certain elements is one way to maintain the desired visual hierarchy and direct the viewer’s eye.

The techniques chosen for the final look of the production of the film are from about step 7. In addition to the techniques shown in step 7, the style for the film includes the
vignette introduced in step 9. **Atmospheric perspective** and **depth of field** are used as well, but to a lesser degree than what is shown in steps 9 and 10. While forced perspective is used on some prop elements in the film, it is not used on any foreground elements (as shown in step 8). This is because the film’s style generates spatial depth through the **contrast** between flat foreground elements and dimensional midground elements. The drop shadows, transparency, and dimensional or “realistic” lighting and modeling of objects in the midground expand the scene space, while the flat foreground layers frame the “stage” for the viewer. This false perspective adds visual interest, and the flat foreground layers also provide a more explicit proscenium arch, which reinforces the staged, storytelling aspect of the film.

4.2.6 Summary

**Goldilocks, Redirected**, a short animated film based on **Goldilocks and the Three Bears**, was designed as a staged puppet show, to be acted out by jointed wooden puppet characters. For this film, tools available in 3D animation like sculpted 3D modeling, realistic light and shadow rendering, and 3-axis camera animation were deliberately removed from the production design in order to investigate other ways of portraying 3D space. All stages of the production pipeline including modeling, texturing, rigging, and animation were affected by this spatial design choice.

Character models were built in 3D based on paper cutout illustrations. The models were built out of thin, segmented pieces, to resemble jointed wooden puppets. The sections of each model **overlap** and cast shadows on each other to indicate the shallow depth of the models. Since the camera was locked to the front view, characters would only be shown from
that angle, and needed to be completely clear in silhouette. Goldilocks’ facial features and expressions were painted as textures and animated. Alternatively, the three bear characters have facial geometry that extends forward into space.

Character and environment textures originated in scanned photorealistic images, which were then blended with graphic patterns to produce stylized imagery. Although the textures were based in 3D sources, they were applied as flat 2D layers, visually compressing the scene space to a “2.5D” image.

The props were fully modeled in 3D, unlike the flattened characters. The flatness of the characters and sets compresses the scene space, while the 3D props expand the scene space. The contrast between these two visual effects contributes to the “2.5D” nature of the image.

The animation of the characters was intentionally limited, and these limits (as well as the spatial design of the film) determined the quality of motion of the characters. To achieve the motion quality of a jointed wooden puppet, a layered rig was developed. The rig combines three joint systems: one driven by forward kinematics, one driven by dynamic forces, and the third blending the inputs of the other two to control the character’s movement. Using this rig, the character effects a quality of motion influenced by natural forces like gravity. This motion indicates a compressed, staged space.

The environments all include a visual framing device (such as side curtains or an arched wall edge) to create a proscenium. Combined with a camera locked to the front view, this establishes the viewer as an outside observer to the action and focuses attention on the center of the “stage.” The environments are built in several layers, each casting a shadow on those behind it to indicate physical space between them. The layers are textured with a
combination of photographic 3D images and stylized graphic patterns, and placed on flat set levels. These visual techniques reduce spatial depth to 2D, then add an illusion of depth resulting in a 2.5D image.

To determine which toolbox principles would be useful in creating the illusion of compressed film space required in Goldilocks, a case study examined ten versions of one of the film’s sets. The selected environment was reduced to completely flat 2D space and then built back up to an illusion of 3D space through use of specific direct content tools. Indirect composition results were evaluated at each of the ten steps to determine the overall spatial effect. Based on this case study, the following subset of tools was chosen for use in Goldilocks (numbers below correspond to those used in Table 2.1):

1. Color and texture
2. Contrast and differentiation
3. Repetition, similarity and pattern
6. Edge of the frame
7. Overlap
10. Foreshortening
11. Light and shadow, chiaroscuro
12. Atmospheric perspective
13. Depth of field

Once the 3D aspects of the piece were removed, the challenge was to build the space back up. To accomplish this, two-dimensional visual principles were applied specifically to this 3D animation piece, to add depth back into the flattened space. These principles represent a specific subset of the proposed toolbox of 2D and 3D spatial design principles, chosen to present an illusion of compressed film space layered with texture and pattern. More information about the final film is available online at http://accad.osu.edu/studentfilms/goldilocks/index.html.
Goldilocks, Redirected provided a test ground to apply the toolbox principles in ways that reduce spatial depth. After completing this film, a second film project was sought to explore the principles in a different way, removing the restrictions on camera motion and framing that Goldilocks had required. A Litter of Perfectly Healthy Puppies Raised on Fried Pancakes, one of six short animated films produced by ACCAD as part of a larger client project, was chosen because it allowed for a completely different approach to spatial design than Goldilocks had: rather than using surface qualities and compositional choices to add depth to a compressed film space, the spatial design of Pancakes requires restricted surface qualities such as color and texture but complete freedom of camera and framing. Instead of reducing 3D film space to an illusion of compressed space, deep space is created from a contour line art source. The production process of this film is documented in the next section.

4.3 A Litter of Perfectly Healthy Puppies Raised on Fried Pancakes film production

4.3.1 Project background

“Columbus is a town in which almost anything is likely to happen, and in which almost everything has.” –James Thurber

Thurber’s Dogs is a collaboration between three Columbus arts organizations: ProMusica Chamber Orchestra, Thurber House, and the Ohio State University’s Advanced Computing Center for the Arts and Design (ACCAD). In 1994, ProMusica and Thurber House commissioned Peter Schickele to compose a six-movement suite of music based on the writings and drawings of author James Thurber. The piece was then performed by
ProMusica in commemoration of the anniversary of Thurber’s 100th birthday. In January 2009, ProMusica will perform the piece again, marking ProMusica’s 30th Anniversary Season and the 25th Anniversary of Thurber House. For the 2009 performance, ACCAD is generating animation based on Thurber’s drawings and Schickele’s compositions to accompany the music. Six separate animated pieces will be created, and the first one in the series, titled A Litter of Perfectly Healthy Puppies Raised on Fried Pancakes, is the second film produced as part of this thesis research.

The primary visual influence for this film is the original artwork created by Thurber himself, from which the musical compositions are inspired. Thurber’s often-humorous cartoons relied on contour line, flat perspective and few textural details to convey expressive scenes, whether quirky or commonplace. As biographer Neil Grauer describes, “all of the characters Thurber drew were rendered with a remarkable economy of line that conveyed subtle expressions. A dot here, a centimeter of ink there, and full, intense emotions were evoked, or movement, graceful or awkward, was depicted.” Although Thurber’s minimalist drawings received praise and even comparisons to artists such as Picasso and Matisse, Thurber considered writing his true calling, and drawing merely a diversion.
Figure 4.24: Six dog cartoons drawn by James Thurber
4.3.2 Film overview and objectives

For Goldilocks, Redirected, production started with the possibility of a full 3D environment that was reduced to an illusion of compressed space through application of specific toolbox principles. The Thurber project presents the opposite set of spatial problems. The film is based on Thurber's drawings, which consist of only the element of line, and through application of specific principles, the illusion of a deep 3D space is created. Thurber's cartoons (examples shown in Figure 4.24) are flat drawings with few environmental cues and copious negative space. Three-dimensional form is implied with contour lines, which communicate information to the viewer by describing the edges of shapes. The viewer recognizes that a line indicates an edge in space, and accordingly perceives the object as a three-dimensional form.

![Figure 4.25: Untitled cartoon drawn by James Thurber](image)

Thurber utilized several contour line drawing techniques to communicate space and form in his drawings. Figure 4.25 shows a representative example of his drawing style. First,
linear perspective is suggested by the distant horizon line and faraway birds in silhouette. The dog’s position indicates perspective as well. Rather than draw the dog completely from the side view, Thurber shows its right front paw, positioned slightly above the left front paw because it is further back in space and nearer to the horizon (which is above the dog).

Overlapping folds on the dog’s ear show that the ear extends off of the head in space, and drapes over the front left leg. The ground plane is not rendered out in full, but a few scattered hatch marks indicate the grass texture of the grave. In a similar way, Thurber often leaves gaps between lines in his drawings (in this case, the paws) but he gives enough information about the object contours for the viewer to mentally fill in those gaps and perceive the whole object. Thurber's style is similar to Raimund Krumme's (Chapter 3) in that they both evoke meaningful scenes through minimal line work.

For this project, Thurber’s drawings must be animated in a 3D environment, while maintaining the charm and character of his line work and avoiding color, texture, and light and shadow. Therefore, the Thurber project in general, and A Litter of Perfectly Healthy Puppies Raised on Fried Pancakes specifically, has a clear set of stylistic goals to achieve. Chief among them is honoring Thurber’s personal drawing style, which is characterized by a use of contour line, a lack of shading, rendering, or texturing, non-realistic “cartoony” proportions, and limited background detail. As regards story goals, the narrative (or lack thereof) is flexible, with the important caveat that rather than fitting music to a planned animation, as is often the task of animated filmmakers, in this case animation must be carefully planned to support and enhance the music composed by Schickele.
4.3.3 Models

Since Thurber’s dogs are drawn in such a flat, linear style, it was challenging to model them in three dimensions. Studying the dog drawings reveals that while they share certain characteristics and stylistic details, almost no two drawings have the same proportions. For example, the ears always include an overlapping fold, there are usually wrinkles on the forehead, and the muzzle normally connects to the forehead at or near a 90 degree angle. However, when the dogs are lying down or sitting, their legs and paws are much shorter than when they are standing up. In standing and running poses, the rear legs are often lacking anatomically correct joint positions. Thurber generally draws the dogs’ heads in profile regardless of the orientation or position of the body, so there is no reference in his work for the overall skull form and construction. The first modeling problem was how to create one unified 3D dog model out of the multitude of different Thurber dog drawings. It needed to be able to move like a real dog, but still look like a “Thurber dog.” Early model tests attempted to collage several different Thurber drawings into one reference, and then build the model accordingly (Figure 4.26, top two images). The result matches Thurber’s proportions, but not those of an actual dog. The short legs make it look like a dachshund, and the size of the head relative to the short legs makes it look like a puppy. The bottom two images in Figure 4.26 show an effort to draw over that early model, suggesting more dog-like proportions and a more Thurber-like head shape.
As the dog model was being refined, development began on the rendering style. Remaining faithful to Thurber's black and white line work was crucial, so Maya® toon outlines were explored as a rendering treatment. Toon lines can outline a 3D object with a solid color based on the angle of the camera, emulating a 2D hand-drawn line. The toon lines were applied in conjunction with a surface shader on the body of the dog, causing it to
be solid white with no gray tones. This rendering treatment flattened out the 3D form by removing all interior detail sculpted by tonal shading. Careful attention had to be paid to the way body parts overlap and intersect, since those areas generate interior contour lines necessary to define the form. Often, the 3D model looked correct on its own, but once toon lines were applied it had to be adjusted to regain the desired shapes. Development iterated between modeling and rendering until both the necessary model qualities and visual style were achieved. Figure 4.27 shows the final dog model with a wireframe overlay (top), with default shading (center), and with toon lines applied (bottom).
Reducing the model to an outline affected animation and layout as well. The images in Figure 4.27 demonstrate that the same object can look very different with this toon.
rendering style applied. The dog looks softer, rounder, and friendlier with the toon line style.
In animation, frequent render tests were necessary to ensure that the motion was not getting softer as well. Poses and actions had to be exaggerated to read clearly after being condensed into a single line.

4.3.4 Story

Figure 4.28: Cartoon titled “A litter of perfectly healthy puppies raised on fried pancakes,” drawn by James Thurber

In addition to the original cartoon (Figure 4.28) and Schickele's music, the story for Pancakes was inspired by a section one of Thurber's short stories entitled "And So to Medve." It describes a mother dog who cared for large litters of pups with a practical and non-sentimental manner. This characterization and the upbeat nature of the music track led
to the idea of a no-nonsense mother dog, continuously flipping pancakes as swarms of puppies run through the scene in a kaleidoscopic pattern of repeating forms. As the storyboard was developed (Figure 4.29), contrasts of scale, repetition, and linear perspective were crucial in developing depth in the scenes.
The spatial design process for this film was different than that of *Goldilocks* because the toolbox was already established. The toolbox was developed concurrently with *Goldilocks* production, and as it evolved it was used to evaluate spatial design and help solve design problems. After finishing *Goldilocks*, the toolbox was complete, and the next objective was to apply it to another project from the beginning. So *Pancakes* production began with an awareness of the toolbox resource, and a desire to solve spatial design problems through applying toolbox principles. Some tools were applied globally over the whole piece, and others were applied locally to specific shots. The next two sections describe which tools were used and how they were applied.
4.3.5 Globally applied principles

The Thurber project requires that animation be generated to accompany existing music, so Fantasia 2000, an animated Disney film based on classical music selections, was examined as reference. “The Carnival of the Animals” sequence (sample frames shown in Figure 4.30) was particularly useful because it demonstrates principles of repetition, similarity, pattern, directional lines, and lens angle. The concept for Pancakes centered around herds of puppies moving through the frame in repeating patterns, and the aforementioned principles immediately resonated with those ideas. Additionally, the subject matter (a group of synchronized-swimming flamingoes) seemed well-suited for use as a reference for the multitude of lively, frolicking puppies in Pancakes.

Figure 4.30: Three frames from “The Carnival of the Animals” segment of Fantasia 2000, segment directed by Eric Goldberg

The “Pink Elephants” sequence in Dumbo provides another example of an animated musical sequence, one that is more abstract and less narrative-driven than “The Carnival of the Animals.” As the examples in Figure 4.31 show, this animation demonstrates repetition, similarity, pattern, relative size and perspective.
Additionally, “Pink Elephants” takes advantage of animated morphing as a storytelling device (Figure 4.32), which is a technique planned for use in all of the Thurber project animations. This stylistic decision was made in part to echo My World and Welcome To It, a 1969-70 television program based on Thurber’s writings and cartoons, presented in a combined animation and live-action format. Figure 4.33 shows the main character’s house morphing into his angry wife’s face. In this program, morphing was used to transition scenes as well as to add layers of meaning to the story. The frames in Figure 4.33 also illustrate how animated morphing causes a 2D line to be perceived as a 3D form by the viewer, although it is still a 2D line. The Thurber project emulates this perceptual shift by presenting 3D models rendered with 2D outlines that can turn in space like 3D objects. Although not an official toolbox principle, morphing animated elements is another tool to suggest the malleability of the film space.
4.3.6 Locally applied principles

In this section, specific uses of toolbox principles within individual shots are highlighted.

In Pancakes, repetition of puppy forms creates visual rhythm, but the repeating pancake element sets the stage for the various 2D-3D spatial transitions. The same circular
element can become a spherical ball, a round flat pancake, or a single line segment, depending on the camera’s point of view (Figure 4.34). This animation takes advantage of the similarity of those forms to transition from one section of the story to the next.

![Discontinuous frames from Pancakes animatic, by Beth Albright](image)

Figure 4.34: Discontinuous frames from Pancakes animatic, by Beth Albright

In one scene, the puppies chase a bouncing ball through the empty space, and the ones that are further away from the camera are pictured higher up in the frame (Figure 4.35). This **vertical positioning**, as well the puppies’ **relative size**, communicates the depth of the scene. Throughout the film, the puppies are shown running across the screen from right to left, rather than the default left to right (Figure 4.35). Moving the puppies this way causes the viewer’s eye to follow the action left to right and back to left again, adding to the visual movement in the piece. This adds a playful and rambunctious feeling to the action of the puppies.
In one scene (Figure 4.36), the camera shifts to reveal the right-to-left line of puppies advancing towards the camera in a diagonal line, from the top right of the frame to the bottom left, before they blur into an edge of another pancake that becomes a trampoline in the next scene. This directional line of puppies deepens the scene space, extending it from a flat frame to a three-dimensional area.
The edge of the frame is an important element in the spatial design of this film. The action crosses the edge of the frame, but never crowds it (Figure 4.37). In combination with a lack of background detail, this wide open framing draws the observer into the action,
and obliges him or her to perceive the scene in a certain way, setting him or her up to be surprised by unexpected transitions between 2D and 3D space.

Figure 4.37: Frame from Pancakes animatic, by Beth Albright

Relative size is used to contribute to an ambiguous figure/ground relationship in Pancakes. Background elements are sparse, so when an object’s size changes it is not immediately apparent whether the object itself is growing or shrinking, or the camera is moving relative to it (Figure 4.38). A round shape that formerly appeared to be a pancake becomes a trampoline jumped on by standard-size puppies, but then once the puppies have
cleared the frame, a giant puppy steps in and picks up the “trampoline” in its mouth, and suddenly the scale is reset to the giant puppy, carrying another pancake. The relationship between figure and ground, or between positive and negative space, is exploited as a storytelling tool. Shots are designed to create ambiguity between figure and ground, so that they can be reversed to advance the story.

Figure 4.38: Frames from Pancakes animatic, by Beth Albright
Most scenes indicate no evidence of linear perspective, due to the lack of background information shown. However, the camera motion in Pancakes invokes linear perspective in one specific scene (Figure 4.39), to suggest that a few straight lines are marking the volume of a room. In this case it is used to visually deepen the film space.

Figure 4.39: Frame from Pancakes animatic, by Beth Albright

**Lens angle** is utilized as a tool to describe the space as flat, deep, or ambiguous. The frames in Figure 4.40 show three different lens angles, producing three different spatial effects. In the first frame, the camera is locked to a nearly orthographic front view, showing
the characters in profile and indicating a flat spatial area. In the second frame, the camera is much closer to the subject and the wider lens angle draws the viewer into the scene further, resulting in a deeper space. The third frame shows a group of puppies chasing a ball through a deep, ambiguous space.

![Figure 4.40: Frames from Pancakes animatic, by Beth Albright](image)

**4.3.7 Summary**

A Litter of Perfectly Healthy Puppies Raised on Fried Pancakes is one of six musical pieces composed by Peter Schickele, based on the drawings of James Thurber. ProMusica Chamber Orchestra will perform the six pieces in January 2009, accompanied by animation produced by ACCAD. The animation based on Pancakes serves as the second film produced as part of this thesis research.

Thurber’s original contour line drawings were the main visual influence for the project. In Goldilocks, the elaborately textured and layered film space was visually compressed through application of 2D principles. This project had the opposite spatial goal: to start with only the element of line, and apply toolbox principles to create an illusion of deep 3D space.
The toolbox was complete at the start of this film, and using it as a resource for spatial design choice was a goal of the production process.

The visual and spatial design of this piece affected all stages of the production pipeline. For example, modeling Thurber’s dogs in 3D presented several challenges. First, although the dogs in his drawings share a common character and style, they do not share similar proportions. He only drew them from certain angles, so a full set of reference drawings from all sides does not exist. The first task was building one dog model that combined all of the physical characteristics of a “Thurber dog.” Next, the rendering style had to be accommodated. To honor Thurber’s black and white hand-drawn style, Maya® toon lines were applied to the dog model. Since the toon lines and flat white surface shader remove all shading and flatten out the form, model revisions were required to achieve the “Thurber dog” look with the toon render style.

Inspired by Schickele’s composition, Thurber’s original Pancakes cartoon, and part of one of Thurber’s short stories, the film story follows a mob of playful puppies cavorting in repeating patterns. Based on this story idea, the following toolbox principles were selected for use (numbers below correspond to those used in Table 2.1):

2. Contrast and differentiation
3. Repetition, similarity and pattern
4. Vertical and horizontal position
5. Compositional angles and directional lines
6. Edge of the frame
8. Relative size
9. Linear perspective
14. Lens angle

Some were applied globally, like repetition, similarity, and pattern, and others were applied locally, like vertical and horizontal position and relative size. More information
about this and the other films that comprise the Thurber Project is available online at
http://thurberdogs.acad.ohio-state.edu/index.html.

Pancakes presents a view of the toolbox principles from the opposite site of the spatial design question as Goldilocks. Rather than applying tools to compress the film space of elaborately textured and layered elements, tools were applied to expand a flat line drawing into an illusion of deep 3D space. Selected toolset principles extend the space while preserving the character of the original 2D line drawings, and making it possible for those line drawings to be presented as 3D forms.
CHAPTER 5

CONCLUSIONS AND FUTURE WORK

5.1 Conclusions

Using a practice-based research methodology, this thesis organizes a set of spatial design principles from the disciplines of graphic design and cinematography and adapts them to digital animation production through applied examples. This toolset represents an organized resource for filmmakers, combining principles from multiple visual arts disciplines to provide a framework for planning, analyzing and communicating spatial design concepts. In order to establish this toolset, films that explore unique approaches to spatial design in animation are reviewed, and the principles relevant to spatial design distilled. These principles are combined to form a master list adapted for use in digital animation, referred to as a toolbox. The toolbox principles are applied to two short films and the results are evaluated for spatial effectiveness.

The toolbox principles are classified into two categories, designated “direct content tools” and “indirect composition results” (Table 2.1). Direct content tools, such as color, contrast, repetition, overlap, chiaroscuro, and depth of field are manipulated by the filmmaker to adjust the overall composition. Indirect composition results describe evaluative spatial design principles that are influenced and decided by the manipulation of direct
content tools. Examples of indirect composition results include **figure/ground relationship**, **visual hierarchy**, **unity**, and **balance**.

This toolbox provides a clear vocabulary with which to discuss spatial composition concepts amongst a diverse production crew. Because it is applied to two films for two differing purposes (one reducing three-dimensional space to an illusion of flat space using colors, textures, and patterns, and the other expanding a flat contour drawing into a deceptively deep space using only the element of line) the author is able to present analysis of application that substantiates the thoroughness of the toolset. Several of the principles were employed in service of different stylistic goals in the two films, providing a more comprehensive examination of their relevance. These two films were created using an iterative production process, so as the tools were applied, the resulting images were evaluated for effectiveness based on the stated stylistic objectives of the film, and then adjusted as necessary and re-evaluated.

The design process for the two films was different because of the continuing development of the toolbox, which began during **Goldilocks** film production. The principles were being recognized and used intuitively at the beginning, and then later the spatial analysis case study provided evidence of the effects of various principles, which could be referenced in decision-making. Defining the principles required making decisions as to how to interpret them in the digital animation environment. The inherent qualities of the medium dictated those interpretations, as well as the overall tool classifications. When production began on **Pancakes**, the toolbox existed as a resource, and spatial design decisions were made with an awareness of the tools and principles, and a desire to exploit them to improve the film’s spatial design.
When looking back at the end of a production, weak choices are much more evident than they were during the process. The two films produced during this research were no exception. For example, Goldilocks would be even more successful with more layers of scene texture. More background objects and props would create a deeper and richer visual space, and further illustrate the power of spatial design tools to affect the image. Added detail in environments and sets provides more contextual information, enhancing the sense of depth in the film space. In Pancakes, the single change that would most strengthen the film would be adding more three-dimensional camera motion, to take greater advantage of the depth of the film space. In several scenes, the camera angles are almost orthographic (a direct side or top view), maximizing focus on the repeating patterns of form and shape at the expense of flattening out the perspective. A more comprehensive use of 3D camera moves and dynamic framing would improve the spatial design of this film.

The toolbox withstood the scrutiny brought to bear on it by the production of these two films, but as it was applied throughout production, questions arose regarding the organization and classification of principles included therein. For example, light and shadow and chiaroscuro are combined, because they function the same way to affect spatial design. Since chiaroscuro is a specific treatment of light and shadow, it could be argued that including it in the tool is redundant. However, its specificity makes it a valuable descriptor, which is ultimately why it was included (although combined with the more general terms light and shadow). Transparency presents another question. Within this study, transparency was used to create overlap, so it was not included as a separate tool. However, since transparency is a common material attribute like color and texture, its exclusion might puzzle future toolset users. Another question comes from the organization
of the toolset: the division of the tools into two categories helped to clarify tools that describe an image quality (evaluative) from those that can be specifically adjusted (manipulative), but it raises the question of whether a category of “results” should be included in a set of “tools.” Perhaps only the direct content tools should make up the toolset, and the indirect composition results should be separate.

5.2 Future work

To address questions regarding the inclusion and classification of toolbox principles, future research could investigate each tool separately, listing the surface attributes or characteristics that influence each tool. For example, contrast and differentiation might include color, value, size, shape, and position, since those are all attributes that can show contrast between multiple elements in a composition. Through further categorization and analysis, connections between toolbox principles might be revealed that reinforce the current organizational scheme, or perhaps ones that suggest a revision to the toolset.

In this study, fourteen principles of spatial design are classified, nine of which were chosen for use in one film and eight of which were chosen for use in the other film. A few principles overlap both chosen subsets, and all fourteen principles are applied in one or both of the films. This raises the question of whether any of the principles are “always” used, regardless of film style. Further study of the toolbox principles could investigate whether certain principles must be used to create a flatter space, while others must be used to create a deeper space, or more generally whether or not the principles exist along a predictable spectrum of spatial depth.
Based in research of graphic design, cinematography, and animation, this study focuses on identifying 2D and 3D spatial design tools for use in 3D animation. Obviously, those disciplines can provide insight into other aspects of the 3D animated filmmaking process as well. Following the example set by this research, future studies could propose toolsets for color theory, lighting, motion or other specific aspects of making 3D animated films.

In another possible avenue of research, the toolbox principles defined here could be evaluated in the making of a stereoscopic 3D film (like 2007’s Beowulf). This thesis assumes that the final film frame is a flat two-dimensional image, but as the film industry races to add visual effects (such as stereoscopic projection) that the consumer cannot yet replicate on an at-home system, that assumption may be proven untrue. As technology advances and a three-dimensional appearance becomes commonplace, filmmaking tools must adapt to new visual possibilities.
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