I, John Meyer, hereby submit this original work as part of the requirements for the degree of Master of Architecture in Architecture.

It is entitled:
Technological Proximity: Ambient Digital Interaction in Architecture

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Technological Proximity: ambient digital interaction in architecture

A thesis submitted to the Graduate School of the University of Cincinnati in partial fulfillment of the requirements for the degree of Master of Architecture in the School of Architecture and Interior Design of the College of Design, Architecture, Art, and Planning by

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The future of digital technology is breaking past the limits of the device. Space and architecture are an integral part of the future of digital technology where wayfinding and interaction are rapidly adjusting to our new expectations of technology in space. The roles of performance, security, display, and personalization become an architectural interaction for users, and the growing trend of gestural and aural interface affect spaces and order differently than the device age. This thesis examines the evolution of digital technology into the nascent field of ambient computing, with architectural responses of interactivity, navigation, and spatial constructions for a new digital interactive age.
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preface
the technological generation

Technology. Devices. The Internet. Connectedness. All of these are vital elements that have shaped the way I have grown. They have shaped the way I interact with people. And three years ago, I deactivated my social media for 15 months. This experience taught me a valuable lesson that has affected the thesis proposed here. The cluetrain manifesto notes, the value of the social network is its connectedness.¹, but as architects, we are tasked with bringing value to a physical world. Combining complex machinations of interactions, and the digital fluidity that has given license to control, personalize, and organize the functions of our lives; technology increasingly creates the complexity of our environments by shaping our interactions and communications. All the while, our devices act as a lifeline to this digital landscape. The greatest infrastructure we use today is our digital one. However, as we interact with that infrastructure, we are limited to frames and frames of content: I propose that architecture meets the digital future with an ambient gestural digital interface that transcends the limits of a device based digital network and creates navigational, interactive value for its users.

Technology is rapidly evolving to change the frames with which we view content: from VR headsets to aural voice inputs like Amazon’s Echo ecosystem. Combining digital connection with the interactions of others creates a crossroads of innovation as exhibited by the rise of the social networks, and through continued interest in computing, performance, and interaction, the path of architecture leads to the future of digital

gestural interaction and ambient computing. With an acute interest in the personalization movement, and the nascent “internet of things”, this thesis questions the digital interaction of spaces as they contribute to the world and environment around us. Spaces that force us to interact, elevators that are now breeding grounds for wishful email reception, and public spaces that are now hotspots for Internet and digital content consumption. These traditional spaces have been turned on their heads in recent years, and the acceleration of technological innovation between the connected world may very well pull apart urban fabric, weave it more densely, or layer digital veils over physical structures that are digitally unseen in the current age. This digital technological layer adds complexity to our attention, with increasingly short attention spans and instant information accessibility changing our expectations through our devices. Add the promise of artificial intelligence that streamlines processes and the physical world must respond in a way to combat digital overload, reshape the periphery, and provide filtering of informatics that is appropriate, useful, and conscientious to its users.

Combining the fourth industrial revolution, millennial generation habits, and my curiosity of its eventual usefulness this thesis has led me down a path of the digital forest that leads to a future of ambient informatics and responsive environments. Hidden to the human eye, we are constantly surrounded in waves, bytes, bits, and communications that help decide our daily actions, help inform us towards our goals, and drive innovation faster and faster, but ambient interactions with technology are still in the development phases. Ambient interaction proposes changing our digital interactions from devices to spaces. Our current digital networks are only glimpsed by small frames of glass in our pockets, at our desks, and in our hands, but they influence our subconscious surroundings with little interface. This relationship of a massive service only glimpsed shows the focus and the periphery of our digital world, with ambient and gestural interface as a way to overcome the spatial barriers to digital integration within spaces.

Currently, we interact with our handheld devices in a haze of focus. In the near future, our digital world will break the frames of the devices we use. Ambient informatics is on the rise, and as architecture adds another layer to its function; this new interface has the opportunity to hold the long term value as the newest infrastructure of our age. However, the ability of architecture to filter and provide structure and guide interactive data is an important factor for success in the future of buildings and spaces.
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As technology advances, the role of the frame takes a greater role in the ways that we interact with the digital world. Currently, devices are advancing to smaller form factors, wearables, and embedded technology. Computational advancement is on a path towards an integrated and ambient computing with our physical world, and along with it a new economy that blurs the biological, technological and physical. Advancements in ambient informatics have dedicated research teams, and increasing usage in electronic arts. As ambient computing and interactive data bring new spatial factors to digital computing, the role of the interstitial, the felt, and the perceived increase. Art pieces such as installations at LAX Tom Bradley international terminal bridge architecture, video art, and interaction. The inputs to digital technology are breaking from the screen as wearables, aural devices like Amazon Echo and camera based technology provide alternate human computer interaction on a daily basis.

The current generation faces major hurdles in the applications and filters of information superabundance. The increased inputs and availability to digital computation have given rise to big data. Context-aware data, annotations, and metadata tags are emergent metrics of successful data filtering for a digital world. IBM notes in 2016 that “every day, we create 2.5 quintillion bytes of data — so much that 90% of the data in the world today has been created in the last two years alone.” This overwhelming volume of data must also be addressed in the physical spaces we inhabit. A biological form in an increasingly digital world. The rise of connected devices and the burgeoning distractions of smartphones, phones, and tablets all point to a limit of representation for media on screens, in the two dimensional. The limits of our attention and embodiment require rest, a need that architecture has provided through the ages through views, surfaces, and furniture. The new model of ambient technology can require architecture to also filter and digital information or digital feedback as our expectation of feedback and instant information extends to our spaces. The limits of our humanity are filtered or guided in an ambient digital future, and the explosion of information accessibility and new interactivity can inform architecture’s role as containers and spaces for people.

**Filters and Distraction**

How can architecture effectively filter interactive digital cues into the spaces in which we interact? Since the advent of the digital handheld telephone, types of information accessibility have began to shape human computer interaction as the user has left the confines of the desk and evolved in a new mode of embodiment in physical space. The new model of ambient technology can require architecture to also filter and digital information or digital feedback as our expectation of feedback and instant information extends to our spaces. The limits of our humanity are filtered or guided in an ambient digital future, and the explosion of information accessibility and new interactivity can inform architecture’s role as containers and spaces for people.

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**Figure 01: Evolution of Technology and Interface**


The digital ambient is exhibited in new constructs of interactive plane and the interstitial behind to create a depth of digital surface.
Ambient Technology

As the name implies, ambient informatics questions the framing of our technology as it moves from large server rooms, our desks, and eventually our hands. Along these lines, the evolution of human-computer interaction is changing the spatial interactions of people, and architecture begins to be affected by the changes in interaction design. Now framed by consumer handheld devices we use daily, the evolution to ambient informatics and ubiquitous computing will redefine a small, pocketed frame into a sensing atmosphere that responds to many interactions.  

Digitally integrated architecture has evolved out of the desire for information accessibility as the communication networks humans use have burgeoned and have shifted from wiring to waves. Currently, information technology is a layer added to existing forms of spatial constraints. However, our devices, data, and information have already affected the way we navigate through our daily lives. From instant communication to timely wayfinding, we are directed by algorithms and instant feedback. Delivery on demand, peak demand cost increases, and the sensory reactions of buildings are beginning this digital revolution, with the exception of the building itself. Walls, Floors, and Ceilings remain static, yet the wires that once carried information through said surfaces is soon abandoning its traditional conduit. From wire to radio, the technological world is rapidly dissolving its physical presence, but is rapidly manipulating the services and interactions we have as users of spaces. By integrating the concepts of the new digital urbanism, this thesis applies interaction design strategy to reconstruct the spatial requirements of a digital performance through video art, musical performance, and theater. As a result, this digital influence will allow for greater personalization, control, and flexibility for the coming generations as the digital overlays the physical.

The ubiquity of information availability and inputs has skyrocketed and the latest incarnation of the technological intervention is the social medias. The sharing-ness of this infrastructure is overlaid onto many physical systems from transportation to housing. The overlay allows for

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large computational systems to shift and contribute to many overtaxed infrastructures, and personalization of previously abstract and unseen networks.

As environments take on characteristics of a digital world, the interaction between human and computers comes to the forefront of our experience. Currently, the systems are relegated to a set of devices that are windows into the digital world. As our devices advance, the systems behind the windows advance as well. The focus that we carry with these small devices into the world is a radical redefinition of personal space. Being engrossed in our devices changes our sociological interactions as well as our sense of space. A pair of headphones has a strong impact on our sense of boundary and privacy in an environment. Taking away these focused interactions as a future space interacts directly with the user through ambient informatics drastically changes our interpersonal interactions. This relationship is illustrated in Kissing Architecture as a study of video art installation in MoMa shows the effect that surfaces and immersive surroundings have on the patrons of a museum or exhibition.2

The city and the urban environment are a historical melting pot for the confluence of the greatest in technology as space's premium necessitates creative ways to overcome physical limitations. Cities were the first breeding grounds for wireless networks as wires became costly to run: the city's cellular towers are the densest and the microcell organization speaks to the density of the area.3 As the digital form navigates into the physical, the vast majority of the digital conversation is about the insights of the interactions between users. Thus, the constraints of physical place take a backseat to the importance of programming and informatics.


Literature

An understanding of the future of the interactive digital starts with an understanding of the city and the big data that drives urbanism in the contemporary age. Patrick Geddes, in his Cities in Evolution tells of the importance of the city's history: of where the human condition interacts at its highest evolution. The urban environment is a key convergence of people, services, and infrastructural density.4

As the next iteration of the city continues, the technological influence can reshape the way in which spaces are used and interacted with. This evolution shows the continuation of the lineage of the city. Similarly, the importance of the history of the city is crucial to understand the impacts of these technologies on our daily lives. Knowing where these improvements have been made allow for true usefulness of architecture to influence and support the future. For example, fire codes in New York have adapted to new fire fighting techniques and technology, and similarly, the wireless revolution has changed the way we distribute information.

The role of science fiction plays an important role in how we view the importance and future of technology as well. From Star Trek to Mirror Worlds, our picture of the future can be influenced by the imagery of these imaginations. In Mirror Worlds, Gelernter tells of the devices that allow persons to predict futures5. The device based interface and the role of the decision making process foretells the big data and input based thinking we employ today. The social implications are disparate from the city but are illustrative of the role of decision making in the modernity.


Our relationships to objects and surfaces has been greatly affected by our fixity on devices.
As the forward thinking improvements to technology bridge the gap of the old and the new, the technological evolution affects the process of daily life: the sensing, the social, and the sharing are all components that coalesce in the city as the human condition becomes more and more dense. Physical constraints open doors to the other dimensions of creativity, sharing, and new technology.

Apicella, Marlowe, and Fowler bring these ideas in the fold of a historical view of hunter-gatherers as the first social networks. This cooperative model allowed for innovation and spurred ties to modernity and technology, regardless of place. As the relationships between humans became more and more complex so did the relationships to surroundings, habitation, and harvesting. The resource chain in the historical sense has been important mostly in cities due to the interdependencies of the population’s density. As this continues, the digital interface ascends the hierarchy of needs into entertainment. What once was seen as utilitarian: a telephone, transformed itself into a multi-modal form of communication, and most recently entertainment. The mobile device has skyrocketed to the most popular platform to consume images and video, but has also become an indispensable tool for a majority of the population leading to the fear of missing out, issues of connectedness, and interpersonal interaction.

**Precedent**

Sensing Spaces, an installation in the Royal Academy of Arts, London, was an opportunity for the social and emotional aspects of architecture to be isolated in the gallery and a commentary on digital sensationalism. The alterations of space and the visual only point to one aspect of the architecture, however, the politics and the reaction to user was a lacking element. The exhibit elicited various reactions from critics and was influential in showing the manipulations of the senses: light, elevation, and placement in space. All are important distinctions as the user reacts and becomes informed of his sense of place.

> “The exhibition is all about the power of architecture to shape – even dictate – our emotions. My mood changed radically from one room to the next… However, the exhibition does not seek to provoke you in a sadistic or cynical way. Rather than dread and angst, on leaving I felt something more like peace.”

The importance of the spatial relationships in the exhibit is a reactionary response to the sense of location. Manipulating ground planes, apertures, and materials in the framework of the museum challenge locality and typical arrangements of space. Similar to the urban environment, the adjacencies create new relationships that challenge the senses. This example serves to exhibit how the manipulation of the senses can drive an architectural response to a user and surroundings in a place based environment. The static response is inherently architectural in its solidity, but the variability lies in the user which is its greatest success albeit some critics citing it as its greatest downfall. The importance of sense in the project is an elevated sense of being, similar to OMA’s Kunsthal where the experience is the sense of the whole and the sense of abstractions and manipulations to simple planes that we trust as normal: floors, walls, and ceilings.

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34th Street Ferry Terminal in New York contrasts the emotional aspects of the museum installation with the directionality of transit. New York City is immediately adjacent to two rivers, and the importance of the ferry itself is a waterborne mode of transportation. The ferry terminal, designed by KVA, takes data from the tides, water levels, and amounts of passengers to influence the canopy above the waiting area for the ferry. This intervention of the information influencing lighting is a direct application of data in environment, but not necessarily interaction. It gives reason to the influences on the senses and the surroundings of the area. The limit of this influence, however, is directional and non-specific. It merely displays data as an abstraction, without a purposeful informing of its users.

This response is contrary to the experienced senses but is influential in its digital connectedness. The sense of sight and light is the direct communicator for the architecture of the terminal. The passenger flow, the reasoning of the space is the generator for the canopy, and this relationship to the physical shows the influence of time and the locations of the structure in the city.

A performance space, similarly by KVA breaks down the traditional notions of stage and display. The Symphony Orchestra Pavilion in Birmingham Alabama exhibits the new places that traditional performance is creating. Moving away from the traditional music hall and into the community in new ways, performance is rapidly redefining itself to stay relevant in the digital age.

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Imogeian Heap is a musical performance artist that has challenged the spatial confines of the stage and audience. Her collaboration with CodaSign produces musical interventions that combine the spatial qualities of ambient informatics with the performance onstage. Using several cameras, a sophisticated set of gloves, digital processing, and current media generation software, Heap’s performance encompasses the gestural inputs of a new age of performance. Using the stage area, Heap performs in ‘sound worlds’ where the interaction of her gloves and location change the timbre and manipulations available to her. These sound worlds are a representation of new digital proximity to space that creates inputs to a generative digital output: the music of the performance.

Microsoft’s project RoomAlive brings gestural input and augmented reality to a traditional living room setting for the goals of promoting a gaming environment that extends past the television. Utilizing 3-dimensional sensors, cameras, and multiple projectors, the game and surroundings are projected onto the surfaces within the space. By projecting over an existing area, the system must align itself to various surfaces. Coupled with gestural manipulation, the projected games add depth and interaction to the existing surfaces. In the gaming environment, peripheral feedback such as shockwaves and flashes can be added to scenarios. Microsoft is experimenting with the gestural input in the gaming environment, but these principles can be applied to other areas.
ALISSA+NIENKE Design Studio, Netherlands, project, LivingSurface exhibits biofeedback through a surface shape shifting display. The project takes input from heartbeat and breathing patterns of viewers, interprets the data through a processing program, and controls fans and actuator assemblies in surfaces mounted to walls.1 The researchers note shape, color, temperature, and humidity as variable addressed in similar architectural wall like interactive installations. The movement quality of the biofeedback in LivingSurface correlates to specific pulse information from sensors that the viewer attaches to a finger. LivingSurface approaches biofeedback, but does not address the aural input factors that free an interactive wall installation from the setup time required from a viewer.

Background Summary

Architecture is rapidly implicated in gestural technologies. Surface and digital inputs are advancing to allow for gestural digital communication in Microsoft’s RoomAlive, and LivingSurface provides frameworks for interpreting biological data into representative planar manipulation. These gestural and aural inputs for digital computation are the beginning of an evolution of digital interface that architecture can use to engage occupants.

Privacy

"Facebook’s Privacy Trainwreck, by Danah Boyd, follows the implication of Facebook’s Newsfeed feature in 2006, the backlash after its implication, and the sociological responses of users as social media changes the exposure and invasion principles of the interactions of users online. The cost of social convergence is the factor that the author relates the sense of privacy to through the actions of exposure and invasion.

The background of the paper is the feature of Facebook being implemented in 2006. The subsequent backlash was similar to that of DejaNews in the mid 1990’s as the searchability of newsgroups changed the dynamic of interaction. Suddenly, the accessibility of information changed the way the users felt about the information that they were sharing. This change in the status quo of accessibility pointed to two factors: exposure and invasion.

Boyd’s findings in the paper are of the importance of social medias to influence the social convergence. More and more, the social networks drive social convergence further, even though users can be uncomfortable with the changes. Constant notification of social activity on the surface level can break down the protections afforded by the ease of accessibility of data. Previously, before Facebook’s News Feed, data was still public, but less accessible. This afforded privacy to the users that was seemingly revoked with the introduction of the feed. The feed gave exposure to the...
data, changing the participation level of others in the comings and goings of others online. “participants had to shift their default expectation that each action would most likely be unnoticed to an expectation that every move would be announced” (Boyd, 14). The findings for of the paper also point to the limit of humans to maintain social networks in terms of weak and strong ties. The detail of information shared affords trust in the relationships between humans, however, as the social network expands, the ties become weaker, thus the level of detailed information slowly erodes. Similarly, celebrity gossip can have a similar effect: the gosipee knows very little of the gossiper, and thus the sense of invasion occurs.

“The Taste for Privacy”, a paper by three Harvard researchers focuses on the quantification of social networks’ profile privacy as it relates to the social and personal influences within each user’s network. The finding assesses four aspects of a social profile online, and enumerates two methodologies for the privatization of an online profile. First, the privatization of a profile is related to the peers of the subject, as more peers have a private setting, so too will the user. The other variable is the activity level of the user, where the more the user is active, the greater the percentage of the profile is private. These settings show a sociable trend amongst well connected individuals to create a similarly closed environment that becomes curated, multi-layered, and increasingly elaborate. Secondly, four hypotheses found that the more privatized their network, the greater chance the user is private; the more active the user, the more private; women have more private profiles; and users with private profiles are subject to a set of cultural similarities that are different from those with public profiles.

The first three hypotheses were supported by the data collected in 2006-2007 from a private university with a high social network usage. However, the fourth hypothesis, involving cultural similarities was more difficult to measure through the data gathered. These was an immediate differentiation of the data, so the hypothesis is true. However, taste and the portrayal of taste is difficult. Taste’s relationship to perception of public or private is reliant on a quantifiable social capital that has divergent importance. Culturally speaking, the ability for humans to effectively blend medias, as well as respectfully curate medias are both seen as positive. I.E, interest in classical music is positive, as well as properly curating heavy metal bands. This dual nature, however, means that the data is not easily supportive of a specific outcome, as some curation is increasingly blended.

The findings of the paper were highly indicative of how architects see culture. Buildings are longstanding, permanent structures, that are non adaptive to rapidly evolving arts, such as music and video, and thusly, the architectural manifestations of these archetypes is in question in many current markets and discourses. Creative programming to adapt to organizational change is a new challenge. Designers seek to optimize the places created for users through various privacy solutions: various types of spaces, public to private, that are similar to Goffman’s social “performances”. This “presentation of self”, however, is the greatest challenge of identity, and is a continually evolving discourse within larger, more rigid frameworks, such as a building public space, a constructed social network, and daily interactions. The challenge, therefore, is finding the most applicable metrics in these systems to apply in conjunction with privacy and creativity, to form the identity with which we operate in these systems. The hierarchy of these culturally significant indicators in theory, can inform the reactions of people within a set of spaces.
Contextual Annotations and Artificial Intelligence

“Autotagging Facebook”, a paper by two Harvard researchers and a third from UC Berkeley focuses on the improvement of tagging photos by utilizing contextual information in social network connections to improve AI understanding and automatic image processing.

The background of the paper is rooted in facial recognition of photos that are also uploaded by an author. Tagging and annotating these photos using facial recognition is an important usability feature that provides a competitive edge. Photos with other data such as geolocation, date, and time, with many of these data points such as geolocations and times correlating with ‘friends’ within the author’s network are the basis for the contextual information that can be used to cross-reference facial recognition accuracy. The database of billions of photos uploaded to Facebook allow for a large body of image annotations previously manually inputted as well as the social networks providing contextual information about the user’s interactions to facilitate AI learning. Although this data exists, very little is known about the interaction between facial recognition and this parallel contextual information. The authors attempt to show the gains of utilizing additional information to aid in automatic facial recognition and image tagging processing by comparing the aggregated data to facial recognition in an unconstrained environment. Their work is based loosely on geolocation correlation in tagging photos that provides a short list of possible candidates. The researchers here specially look at a community of connections to improve the network of photos of everyone in the community.

The paper found that about 74% of persons in the dataset were tagged at least once, with 97% having a compatible frontal face in frame. The authors developed a framework to combine social data into recognition by using a conditional random field (CRF). Notably, the pairwise potentials for cross referencing geolocation in previous events was applicable in creating events, where the set of photos that are closely related allow the system to add additional links between the tags and data in multiple sets of photos, thus joining faces from the same event. Through the study, the authors found that the miniature social clusters surrounding the photographers and uploaders of photos increased performance the most.

The authors iterate the social importance of tagging to promote the connectedness of the user to their community online. This coupled with the increasing accuracy of additional data gathered by mobile devices such as geolocation, time, and scheduled commitments, will only enhance the data that can improve auto tagging performance. The authors note the possibility of creating additional clustering around social structures such as churches, schools, and workplaces, as many of these arenas create time-based interactions.

In architecture, understanding the importance of archetypical interactions and the spatial relativity of the framing of a photograph with the role of identification in social situations can help improve spatial adjacencies. From a digital and online perspective, the ability for AI to accurately tag and annotate a photograph provides immense value to the digital overlay and annotation of the photograph in allowing users within a social network to create a social sphere of connectedness automatically. Placing these interactions in situ gives immediate recognition for humans, but computers have a separate set of inputs to understanding. Utilizing
the AI variables, such as geolocation, past tag correlation, and multiple appearances in event gives greater clarity to the invisible social network in the photograph, similarly a space can have consistent variables that tie one aspect to another for a spatial experience for a user.

Human Computer Interaction

“The Challenges and Opportunities of Social Media”, a paper by Andreas Kaplan and Michael Haenlein from the Kelly School of Business focuses on the challenges of integrating the various types of social platforms for the new business world. They provide a categorization of social medias by their unique characteristics, and then integrate ten pieces of advice for the reader.

The background of the paper is in the growing trend of Facebook and other social medias to share and disseminate information that was previously controlled by its authors and publishers: i.e. the companies and public relations managers. The paper comments on the evolution of the internet from a “giant Bulletin Board System” as the basis of sharing via the Internet. This basis is still the core of the evolution of sharing networks we use today, under the umbrella of social media, that as technical advances continue, to evolve into “virtual content sharing that is fundamentally different from, and more powerful than the BBS if the late 1970s”. The authors begin by providing background and definitions of social medias by their historic origins, the technical hurdles, and the differences as compared to web 2.0 and User Generated Content.

The authors section the social sphere into six types: collaborative projects, blogs, content communities, social networking sites, virtual game worlds, and virtual social worlds. In the evolution of the Internet, accessibility drove much of the growth along with the creation and accessibility of tools, such as the smartphone, the connected camera, and touchscreen. In combination with a new generation of “digital natives”, the social evolution of Web 2.0 and User Generated Content allowed for the current climate of social medias. The authors look at the various types and classify them by a sociological principle: their self presentation/ self disclosure. This, in combination with the aforementioned advances in tools allowed for advances in the theory of content creation, including social presence and media richness theories. In the work, the authors show the six types of social medias in the relationship of self presentation and media richness in a matrix. This allows the authors to analyze the types, and their opportunities and successes. The authors then note various precedents of the six types, their histories, and their shortcomings. The major findings of the paper conclude in five points for the use of media, and five points about being social. The five points of using media note the importance of media quality, integration, and voicing of the media, notably: “one goal of communication is the resolution of ambiguity and reduction of uncertainty,” which thus reinforces the importance of online message, brand, and self-presentation. The five points of being social respond again to the issue of authenticity, through honesty, “unprofessionalism”, humility, and quirkiness.

This paper quantifies some of the most important fundamentals that the “digital natives” consistently use to express themselves and their “brand” on the internet. The foundation of the sociological principles and the media richness theories are the basic ingredients for our interactions.
Many of these social networks are so successful because of the ways that they integrate the way we interact. Through photos, videos, text, and audio, the six archetypes of the social world are recreating much of human interaction. Similarly, as a building is a framework for interaction: take for example, the Roman Forum, the internet is quickly becoming a universal version that breaks down communication barriers, such as time and differing languages. In architecture integrating the strengths of the digital, such as the instantaneous communication is an important goal of the buildings of the future on an urban scale.

**Literature Review:**

**Geolocation and Social Connectedness**

The importance of the review to my work is the ability of the social networks to respond to the human elements of space; the existing applications, shortcomings, and the future of the topic; and the ambient technologies’ shift that drive the digital into spaces.

Geospatial relationships are a key metric of integrated network design, as volunteer geolocation becomes a prevalent feature of many social networks. Furthermore, the ability of social networks, AI systems, and algorithms to identify geographic indicators from datasets without direct input is allowing a mapping of the human-digital social networks in increasing detail. This advancement in inference and application is allowing developers, businesses, and institutions to drive further into analysis of social network adjacency that in turn provides deeper insights into forces surrounding them. As Tufecki notes, the idealization of social network privacy as rights and violations keeps the isolationism of the digital network architecture constrained and neat. However, the physical and geospatial implications of a social network can further advance the architecture of a space in terms of delineators: as privacy drives many ‘architectural’ features: the wall, the door and the lock. This opportunity to provide privacy in a cross-indexed, searchable world has further reaching effects than privacy controls. In these instances, the content is not limited by the privacy concerns, but rather is bounded by controls of visibility in the online sphere.

Utilizing interaction patterns from data in social networks provides immense insight into the changing relationships we exhibit.

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2 Tufekci, “Can You See Me Now? Audience and Disclosure Regulation in Online Social Network Sites.”

3 Stefanidis, Crooks, and Radzikowski, “Harvesting Ambient Geospatial Information from Social Media Feeds.”
As Cho notes, these changing relationships show the geolocation of friendships, with a majority of close relationships still affected by close physical proximity, but the influence of long distance travel being relative to less strong ties. This explicit example of travel requirement shows the breakdown of distance as a barrier to communication, but reinforces the necessity of physical meeting to reinforce social ties.

As architecture addresses the influence of the digital world in the everyday habitations and patterns of living, the constant feedback loop of inference, analysis, and prediction must be able to adequately affect the spaces and places we inhabit. This literature review has provided a high-level overview of the conditions and opportunities of geospatial locations in online social networks which will provide the framework to create a new hierarchy of spaces that respond to the digital. The ascension of the digital beyond the frame of the device provides the opportunity to break the geospatial barriers, as the ability to combine social ties in the realm of the physical ever increases.

4 Benevenuto et al., “Characterizing User Navigation and Interactions in Online Social Networks.”

5 Cho, Myers, and Leskovic, “Friendship and Mobility: User Movement in Location-Based Social Networks.”

This paper follows the trends of social relationships as they communicate with geography. The authors note the importance of social relationships and the precision of quantification of geography using social data. The authors directly observe the relationship between geography and friendship: thus in turn effectively creating an algorithm to predict location that exceeds IP-based locations.

Albrechtslund argues for the surveillance practices that drive online social networking. He challenges the conventions of control and power, where social networks use surveillance as empowering, coining the term, participatory surveillance.


The authors examine the frequency and length of connections of users to social networks, as well as usage patterns to determine interaction patterns. The analysis given by the authors gives quantification to browsing activity for close and extended networks. The authors work shows the opportunities for better interface design based on usage patterns and a framework for richer studies of social interactions.


The authors address the proliferation of GeoSNs or geo-social networks,
that base their interactions on “check-ins”, photo sharing and friend tracking. The authors note the privacy threats with this type of interaction, the location privacy, the absence privacy, the co-location privacy, and the identity privacy of an individual. Lastly, the authors note the importance of historical data, and the management of past check-ins’ uses to adequately provide the privacy for users.


This paper addresses the opportunities of gossip to improve advantages in node mobility, thus capitalizing on the mobile device. The mobility of the nodes improves the routing and spatial connections of the network’s structure. The key takeaway of the paper is the importance of time in the forgetting of the past to adequately respond to current conditions in the network to remain agile.


This paper analyzes the structural patterns of geographic and social movement through cellphone data. The authors take human dynamics and motion as constraints that drive mobility, and correlate jumps in space to friendship ties. They found short range travel not indicative of network ties, but long distance travel to be related to social network ties. The find social relationships explain 10-30% of human movement, while the remainder is dominated by scheduled, periodic behavior. The model reliably predicts locations and improves current models of human movement.


The authors of this paper introduce concepts to rank spaces as indicators of friendship online. They rank spaces on new factors such as visitor diversity, and overall visitor frequency, which in turn allows for greater accuracy in predicting online friendship over standard models of colocaiton.


Ellison’s research focuses on the usage of social networks, specifically Facebook in a university community. She notes the misalignment of perceptions and actuality in the audience of a user’s network. The study focuses on cases where the intention and the actuality are aligned, and the spatial qualities of the resulting connections, and how those differ from networks where the intention and the actual audience are misaligned.


Expert and his colleagues acknowledge the role pervasive computing has initialized networks into the digital age, wit the geo-locating networks filling databases that allow for projections from patterns, however, the spatial influence of a network topology is not limited to the dataset. Therefore a space’s connectivity is affected by the space’s other properties, thus leading to different structures based on these configurations.


In times of disaster, the usage of social networks and cloud services spaces, with mobile usage as a driver for data access and dissemination. The social data includes important geographical data which can be interpreted to
improve disaster response.


With geolocation data being implemented in social media, the overall usage of privacy settings is a low-penetration method of retaining privacy online. This paper studied networks, including the strangers that have access to the social data of a set of college students, with low privacy setting penetration.


This paper builds upon the notion that social networks are derivatives of their physical counterparts: networks of people communicating. This research infers location data from content rather than direct geolocation data, with allows for geolocation data to be filled in by inference without specific geolocation tagging. This mimics the natural networks that we use that are not automatically embedded with geolocation data, but intrinsically exhibit a concept of place.


This research works on the principle of graded connections based on the way you are socially connected to them. Socially aware applications can give a spatial quality through interaction by filtering the level of access or adjacency that a user has to another. Similar, to allowing a visitor to have a key, or access card, the connection level between users can be related to the type of social connection.


This paper observes the spatial properties of social networks, noting that 40% of links are below 100km, and the notable relationships between spatial ties and social networks. This paper is relevant as it notes the representation value of social networks in the digital collections of geolocation and the standards that can be inferred from a dataset.

A Salvatore Scellato et al., “Distance Matters: Geo-Social Metrics for Online Social Networks,” n.d.

This research focuses similar to the previous work, on the importance of short distance links, and the close geographic relationships of a social network, with the clustering supporting location-advertising within the social network. News and communication based networks show a longer average distance between nodes, and the examples given by the authors provide spatial opportunities of connecting the clusters of data into a meaningful implementation.


The authors of this research infer geolocation on information without explicit location data by using known locations of social ties. The researchers present a more effective method by using a classification method for geolocating a user.

The authors in this paper focus on mapping and the evolving human landscape, as a dissemination from social media leads to insight on information flow and society. They argue the geospatial data provides ambient information that can represent fleeting social hotspots, and can be indicative of larger social implications. They argue for the evolution of geospatial data availability from ambient social analysis as the child of volunteer geographic data.


This research shows the privacy concerns addressed in online social networks as analogous to spatial mechanisms of privacy: locks, walls, and doors, and shows little adaptation to the online features of search-ability, cross-indexing, and persistence. The author promotes internet privacy as rights and violations being indicative of the Internet as an isolated social realm, but the reality of integration within a physical social realm complicates the relationships and geospatial qualities of the network. Lastly, the gender and racial differences are significant to create various communities that treat privacy differently.
Hypothesis

As the movement into the technological age and fourth industrial revolution continues to influence the building medium, the blend of digital and spatial is at a crossroads. On one hand, virtual reality negates the need for space, instead replacing it with complete representation. On the other, ambient technology relies on the embodiment of the user for directionality, attention, and interaction. The ambient information evolution has great potential to positively affect the spaces we use. However, digital technology evolves at an astounding rate, with unknown applications and outcomes in quantum computing, artificial intelligence, and data analytics. For example, the translation of language between computers and persons is increasingly fluid. Spaces similarly are now beginning to address the additional realm of the ambient digital world, and the technological movement shows the prospects of sharing and social content, not just computational evolution. Through tactility, personalization, and reflection of the world surrounding it, architecture is progressing into a responsive environment that can be driven by ambient and gestural interface. The challenge for architecture is the stark contrast in evolutionary time as it integrates digital technology. Architecture must provide meaningful spaces to convey data, contextual information, and effective filtering to prevent information overload, exhaustion, and digital burnout for the newest generation, while still maintaining its firmness, utility, and delight. Thus, architecture can effectively convey

1 Oft cirtted as the classic architectural principles, firmness, utility, and delight are valuable successes of architecture to provide for basic human habitation. M Vitruvius, On
additional digital interaction through filtered interactions of surface, and
digital respite through tranquil surfaces and the spatial orientation and
arrangement of space.

Proposition

Complementary data, geolocation, and gesture can be communicated
spatially through digital interaction. This allows users to consciously
or subconsciously interact with and sense new elements of place, art,
and personalization. The architectural precedents above are various
approaches to the discourse of ambient and the discourse of the digital
technology in space. A strong divergence in simplicity as tranquility and
in-sharing as filtering allows modern users to curate a digital lifestyle that
may or may not correspond with their physical lifestyle. The new economy
has led to ‘Liveness’ and embodiment in space as a strong discourse of
affecting the peripheral experience of technology within a building.
This thesis maintains that as the interactions begin to form value, the
interactions take on additional architectural value as designed experiences
and services are reliant on an ambient or gestural digital interaction in
space. This thesis proposes a wall construction that integrates the lighting
systems and digital interaction systems to guide a series of interactions
in the buffer of space adjacent to the boundary of a space as a method
of allowing the periphery of a space to add digital interactivity to guide
users.

Understanding the flow of services, communication, and trends will serve
to inform the architectural impacts of the surrounding context. The
dichotomy between the focus and the periphery in the device age leads

Figure 13, Digital Focus Battle, Author

today, we interact with architecture in a shifting battle between
mobile device focus, and architectural periphery
tomorrow, ambient computing exists in the periphery; affecting navigation, wayfinding, and information attainment with architecture as filter or serenity.
embodies a universality of digital technology, and thus lacks façade and shell. Rather, the architecture remains contained to explore the limits of ambient integration at the human scale. The space’s ability to drive decision-making and influence senses of the inhabitants will be an important factor, specifically approaching the tactile and visual senses at the wall and object. Aspects of sensing digital technology: optimization, personalization, spatial reconstruction, integration, and reconfiguration and flexibility are important to the digital overlay on the physical. Isolating the spatial construct from place removes the architectural bias of place as a filter. Thus, as the architecture affects the user’s perception of the ambient informatics, the application of digital technology may further define a new architectural typology, similar to how the open office has reacted to portable devices.

Architecturally, the space provides a spatial edge or limit to an inhabitable space. The architectural limit defines the number of users, the flow of way finding, and the types of gathering that occurs in space. A minimum opportunity for motion or is introduced, through programmatic action: the pavilion exhibits the characteristics of interactive design in a theater like projection, motion animation, and stationary gestural communication. The project manifests itself as a pavilion or showroom program to exhibit the various surfaces that can affect communication and navigation in a space. The exploration of ambient gestural interface through camera and 3 dimensional perceptive inputs that are digitally manipulated and re-outputted to the interactive surfaces serve to test the architectural filter for digital technology.

Reflections and Lessons Learned

Architectural design with the ambient use of camera based input shows two challenges to spatial design. The first challenge is the definition
of input variables. Sensorial inputs based on data disconnected from the actual events of the spatial construct proved difficult to attain and filter for an individual user without graphical input, logins, or a specific device. Requiring a login, graphic, or text input negated the aural ability of the ambient interaction to disavow itself of tactile input. This is an opportunity of artificial intelligence and facial recognition to advance ambient interactions. The second challenge is the sensorial limits of a camera’s range. The ability of the human eye to focus and move based on the peripheral sense is substantially different than the fixed field of a digital camera. The lack of additional perception outside the direct view is a unique ability of our biological form that has no digital equivalent.

The goals of integrating the digital interactivity and ambient informatics on siteless architecture serves to integrate needs and changing responses to technology without the constraints of place. Bringing communication value and architectural proximity together allows for a new framework of digital communication and can provide space to a program with complex infrastructural requirements in an increasingly digital age. Noting the crossover of complex requirements and informatics allows for a new opportunities of multipurpose spaces besides meeting rooms, or a response to increased anxiety in the multiuse living space as the digital converges on a less digitally tranquil livelihood. The project tests whether architecture and surface can provide filtered, relevant digital information to a user through ambient technologies in space, or if the relevant feedback to the user merely overwhelms the user and continues to perpetuate information overload and burnout. The project tests whether abstaining from digital informatics is more effective than filtered informatics through architectural construct.

Future Work

This work examines the opportunity for the digital technology of buildings and architecture to appropriately provide new data to users of a building or space: evolving the office and working atmosphere, or the living conditions of a digital native. Architecture of the periphery can act as a relief for the overloaded digital focus in our future, whether that be through effective filtering or tranquility. The understanding of the technological implication in filtering and tranquility can serve in the future to judge a space’s ability to overload or calm a user in an increasingly digitally focused world.

With the principles examined in this thesis, I aim to develop integrated digital experiences for a building that allows dynamic ambient interactions and positions architects to address advances in ambient technology. Future work will continue to explore the ambient interactive as a form of digital communication in spaces that can affect program and navigation. Designing with digital interactivity as a continuous dialogue through spatial progression will be a goal of future work. The result of this thesis work is to fundamentally understand the human conditions and basic principles of an ambient interactive interaction. The findings of this thesis are applicable across many other industries as technology provides additional communication and spatial value; such as optimization of healthcare through tele-care and integration of artificial intelligence based medical diagnosis. As architects, spatial designers, video designers, and graphic artists improve interactions in space, the principles of filtering and abstaining from technology can positively affect spaces for users. The future of architecture may instead be viewed as four principles: the firmness, utility, delight, and interactivity of an architecture.
Carom interprets the input of the hand as a gestural interface for an LED light surface construction. Utilizing 3D camera technology, software interprets the active points of a user in 3D space, combines that input with proximity data, barometric pressure, and temperature to output color on the surface proximate to the user’s hand and body.

The application of this surface material along the wall based edges of a pavilion space allows users to experience the spatial feedback of the space in three configurations: a display wall, a theater like setting, and a vista. The spatial combinations of the system and the movement in the space allows for Carom to denote wayfinding through feedback along the surface.
spatial study

The initial spatial study of a siteless architecture led to the distinctions of four interactive positions. This dialogue between the user and the ambient space informed the future development of the project, as the limits of the biological form were questioned. The architectural values of light and tactility were lacking in this original study, with the simplistic forms of the space lacking a level of detail. The addition to the surface's forms allowed for a scale: the scale of the hand, to humanize the system.

The three forms investigated in this study were the platform, the wall, and the stair. The success of the wall as a surface for interaction and a location for wayfinding led to the development of the vertical plane in the project.
The evolution of the surface took into account the proximity of the user to the surface. This variable is an attainable measure that can be interpreted by three dimensional cameras. This, along with a push to advance the lighting techniques of the space past traditional lumieres, led to a surface that is driven by a camera based input that drives an LED lighting system in the surface assembly.
information interpretation

Figure 24. Information Interpretation, Author
The surface is comprised of 4 main parts: the angular panels, support frame, the led lighting and related controls, and backing. Atop the construction is a 3-dimensional camera that tracks users major points of contact: the feet, hands, head, and an interpolated skeleton. These points are then related to the surface and the LED lighting behind through a series of controllers and power supplies that provide lighting feedback to the user based on their proximity to the system.

The distances and variables that control the system are based on the proximity of the user to the system. Variables like motion, z axis distance, and temperature control the intensity and values of the LED systems, a lighting response to felt ambient variables.
Carom, the project of the architectural thesis, distills the ambient and gestural digital interface into an augmented surface construction, that affects the buffer zone at the boundary of a pavilion space, creating a peripheral interactive zone for participants. The pavilion design incorporates the digital surface and architectural tranquility through its surfaces and spaces, and the construction of the surface at scale exhibits the challenges of creating an architectural response to the data inputs of an ambient space. This thesis investigates how the architectural value of the physical space correlates to the application of digital technologies through placeless architectural space, finding advancements in spatial feedback and surface constructions that add digital participation to the space along an architectural boundary. The project shows a feedback in lighting and surface, but the project’s failure to explicitly affect the user is a consequence of its lack of specific programming in the pavilion. The next step to advance this thesis and the digital space is to integrate this concept beyond the pavilion by applying the digital feedback model to a new program: an office space, a circulation space, or a living space. By setting itself to a single programmatic goal, the digital environment will influence the interactions of its environment and change a space’s use for participants and the future.


Scellato, Salvatore, Renaud Lambiotte, and Cecilia Mascolo. “Socio-Spatial Properties of Online Location-Based Social Networks,” 2010.

Scellato, Salvatore, Cecilia Mascolo, Vito Latora, and Dipartimento Fisica. “Distance Matters: Geo-Social Metrics for Online Social Networks,” n.d.


MIT SENSEable City Lab, “MIT SENSEable City Lab”. http://senseable.mit.edu.