Interfacing Architecture | Collapsing the Distance Between Design & Experience

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INTRODUCTION

Over the past two decades, computers have woven their way into every aspect of human life, transforming mankind's interaction with the world. Computer interfaces offer power and efficiency, enabling a single user to understand complex patterns in vast amounts of information. Considering the complex nature of buildings, it is no surprise that architectural design has become a popular application for computing as a way for architects to interface with the building design through three-dimensional modeling programs. However, the current trend is to implement these modeling programs in support of the traditional model of design, which distances the architect from the spatial qualities of experience and generates designs that do not respond to the human scale of inhabitation. This paper will provide a brief overview of related research in Augmented Reality and Human-Computer Interaction, where some researchers have turned to phenomenology in order to solve similar problems that exist within computer science. Extending this research into the practice of architecture, we will examine three established interfaces within the history of design methodology. Finally, we will propose a new interface that focuses on a restriction of information, embodied interaction and the ability to alter the design in real-time. The proposed interface, *ArchInSite*, connects the user, the design and the site through a hybrid process of three-dimensional modeling and sensory diagramming in an effort to collapse the distance between design and experience.

AUGMENTED REALITY RESEARCH

Augmented Reality, which was pioneered in the early 1990s by Boeing employee, Thomas Caudell, weaves computer-generated graphics, labels and environments into the physical world. Caudell's research focused on the application of heads-up displays in the manual manufacturing process [2]. In contrast to Virtual Reality, which completely removes the user from his or her surroundings, Augmented Reality attempts to strengthen the relationship between the user and a physical location by virtually overlaying information onto the physical environment. Since Caudell's research in the latter part of the twentieth century, Augmented Reality has undergone extensive transformations in both application and technique. In addition to the head-mounted display systems that Caudell references, digital projectors, hand-held computers, and smartphones have also been used to explore the possibilities of Augmented Reality in a variety of fields, such as tourism, advertising, navigation and surgery.

Ongoing work being conducted by Amir Behzadan and Vineet Kamat at the University of Michigan combines video compositing, a data stream from a Global Positioning System (GPS), and a head-mounted display in order to create an interface that virtually places proposed construction projects into the physical world [1]. The mobility of this interface allows the user to operate the system on site in order to create visualizations of the project prior to construction. Another research group at the German National Research Center for Information Technology created the Mobile Augmented Reality Visual Navigation System (MARVINS) as a mobile, multimedia museum guide that uses a similar head-mounted display technology. The user would be able to check out the system at the museum's front desk and then be physically and virtually guided through various exhibits in the museum [7]. However, these head-mounted display systems have been known to create registration problems in Augmented Reality applications.

Some researchers are exploring other technologies in Augmented Reality systems, such as digital projection. These projection-based systems fall under a subcategory referred to as Spatial Augmented Reality. The use of digital projectors eliminates the registration problems, but, in doing so, restricts the environment in which the technology can be applied. This lack of mobility separates the user from the technology and limits the effectiveness of the interface. More recently, Augmented Reality research has focused on smartphones, such as Apple's iPhone. These smartphones are promising avenues for exploration in Augmented Reality because they allow the user to retain total mobility and have become widely available to the public.

HUMAN-COMPUTER INTERACTION

While Augmented Reality capitalizes on the relationship between the virtual world and reality, another branch of computing, known as Human-Computer Interaction (HCI), focuses on the relationship between the user and the virtual world. For the description of this particular branch of computer science, this paper will employ Paul Dourish's *Where the Action Is* as its predominant source. In the book, Dourish summarizes two established research areas within the field of HCI before proposing a third computing model of his own creation that draws inspiration from philosophical writings on phenomenology.

The first research area that Dourish examines, which he refers to as tangible computing, strives to transform the physical nature of interaction between the user and the interface. Tangible computing integrates multiple external devices that provide a more diverse level of input than the typical x and y coordinates supplied by a point-and-click mouse. These external devices include cameras, Radio-Frequency Identification (RFID) tags, and even everyday objects that have been made into active entities in order to respond to the user or environment. One application of tangible computing that Dourish references is a project called *metaDESK*, which was created by the Tangible Bits research group, at MIT's Media Lab. The *metaDESK* consists of a horizontal desk surface that displays a geographical map via rear-projection technology. In addition to the desk surface, there is a flat-panel display that provides three-dimensional visualizations of an area of the map that is specified through a transparent, moveable 'passive lens.' Lastly, more information can be input by physically placing a variety of objects, such as building models, onto the map surface. Like other tangible computing interfaces, this project has no single point of user interaction and, therefore, questions the established sequential organization of computing [3].

The second research area, which Dourish refers to as social computing, explores the intersection of computers and their social context. These interfaces are often implemented for practical reasons in business environments in order to improve human interaction, such as video conferencing or collaborative computing systems in air traffic controlling. Recently, however, computers have facilitated human interaction in more leisurely settings. Many restaurants and other entertainment venues have incorporated table computers, such as the Microsoft *Surface* and Northrup Grumann's *TouchTable*, as a way for users to interact with the menu and other users.

After examining the research being conducted in these two areas, Dourish proposes a method that combines aspects from tangible and social computing, which he labels *Embodied Interaction*. Dourish argues that the primary advantage of tangible computing is the integration of physical objects that the user interacts with on a daily basis, such as the chair that the user sits in or the pen that the user holds. Tangible computing also responds to the physical forces that constantly affect those objects, such as gravity, inertia, and friction. The motivating idea is that these types of interfaces allow the user to capitalize on a wide-range of physical coordination skills that are already embedded in the user's brain, making the interface inherently more efficient than point and click interfaces. However, Dourish points out that our experience as human beings is not merely physical, but it is social as well. With this mindset, Dourish establishes the foundations of *Embodied Interaction* as a practical application of philosophical theories on embodiment within a new model for computer interaction that is both tangible and social [3].

Dourish acknowledges that the idea of embodiment has been extensively explored within phenomenology, a branch of philosophy that focuses on human experience. Edmund Husserl is credited as the founder of phenomenology as a way to study the role of perception within the acquisition of human knowledge. Phenomenology distinguishes itself from other philosophical views by studying the world directly as opposed to studying the world through abstract reasoning and introspection. Other philosophers have built upon Husserl's research, including Martin Heidegger, Maurice Merleau-Ponty, and Alfred Schutz, who extended the study of phenomenology into social contexts. Dourish argues that phenomenology provides the opportunity for computer interfaces to capitalize on the user's ability to seamlessly interact with the surrounding world [3]. This paper will return to these ideas of embodiment, and propose an interface that situates itself within Dourish's model of *Embodied Interaction*.

ARCHITECTURAL INTERFACES

Although the term 'interface' is of recent origin, it is reasonable to apply the term *ex post facto* to architectural representation, modeling and construction. The current meaning of interface, focused on computing applications, refers to an abstraction that is used to mediate between the user and a set of information. These interfaces are abstractions of information in the same way that architectural drawings, models and other instruments are abstractions that guide the design and construction of buildings. Therefore, this paper will examine three examples of architectural interfaces as precedents of architectural process before introducing a new type of interface that integrates elements from Augmented Reality and *Embodied Interaction*.

"Grosse Einheit"

In "The Secrets of the Medieval Masons," Paul Frankl carefully reconstructs the procedure and representations of medieval masonry, centering on the controversy surrounding the design of the Milan Cathedral. His mission is to provide precision and context to the general adoration of the Gothic style brought on by the Gothic revival, which led to the arbitrary inscription of geometric figures onto plans and sections without any understanding of their meaning. Frankl discusses the obstacles that medieval masons faced in a time when no standard of measure or construction was available. He demonstrates how the use of a single measuring stick, called a *grosse Einheit*, formed the basis for the layout of the construction. The subdivision of figures by means of simple geometric inscription directly on the stonework allowed for the development of details from this measure [4]. This process is what is referred to as the secret in the title of the essay. It is possible to label the use of the *grosse*

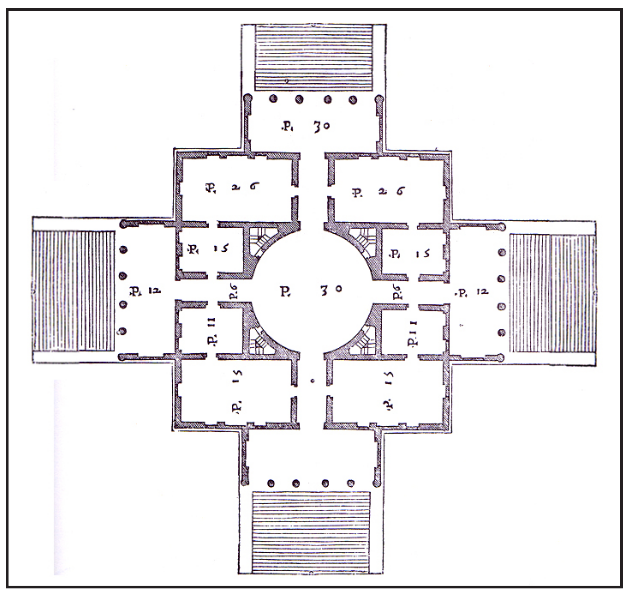

Figure 1: Plan Drawing from Palladios's Quatro Libri dell-Architettura

Einheit as an early form of an architectural interface that mediates between the mason and the complexities of the constructed building.

Architectural Drawings

Five centuries later, Palladio's work in Italy in the 16th century became best known through the publication of *Quatro Libri dell'Architettura* (The Four Books of Architecture), a set of carefully drawn and notated plans and elevations from his own work (Figure 1). These drawings were widely known throughout Europe. In fact, his fame in France and particularly in England was more widespread than in his native country, almost exclusively from *Quatro Libri dell'Architettura*. For Palladio, these drawings acted as an interface between the design and the constructed building. However, the drawings depict Palladio's own 'perfected' versions of the buildings, wherein the proportions of the rooms are drawn as they should be rather than as they were actually built. As Frankl has noted in his discussion about Gothic architecture, these later measurements of the rooms are not based on methods of construction, but rather on numbers selected by the architect as representing an ideal order. The buildings were subsequently constructed with the help of standardized systems of abstract measure that were developed to facilitate trade during the Renaissance. What we are left with, then, is an idealized abstraction of the buildings, drained of materiality and color. Architectural drawings, such as these, have been the predominant means for architects to interface with building designs for hundreds of years. Given the fact that these drawings fall short of representing the building's spatial qualities, one can see the seeds of a troubling disconnect between architectural design and architectural experience.

Computer Generated Modeling

Over the last fifteen years, a number of architects, including Frank Gehry, Zaha Hadid, and Greg Lynn, have shifted the focus of their explorations from drawings to computer based modeling software. Much of this software was originally based either on Computer-Generated Imagery (CGI) software developed for motion picture and gaming markets or on avionic design software adapted to an architectural setting. And, while the three-dimensionality of these programs provides some opportunities for experience-guided design, these models are generally not explored with this focus in mind. Instead, the models transform the building design from a set of spatial conditions into a sculptural object, without any sense of scale. As in architectural drawings, the implementation of three-dimensional models as an interface abstracts the architecture and distances the user from the building's spatial experience.

Embodied Representation

There are some architectural firms, however, that are concerned with representing the spatial experience of their designs. These firms employ perspectival drawings, animated fly-throughs of three-dimensional models, and Quick-Time Virtual Reality panoramic renderings as presentation interfaces. And, while these interfaces, upon first glance, appear to bridge the gap between design and experience, they ultimately fall short because they do not allow for meaningful user interaction. That is to say, a perspective drawing does not provide a true representation of the lived experience, because it depicts only one, predetermined view of the space. Similarly, an animated fly-through depicts only the views from one, predetermined path through the design. And, while a Quick-Time Virtual Reality panoramic rendering allows the user to spin around and see many sides of one space, the user's position in the space remains locked, thus limiting its effectiveness in simulating architectural experience as a sequence of first-person perspectives throughout the building. However, the larger problem with these interfaces is not their limitations in representing the architectural experience, but their inability to be used as interactive design tools. In fact, many of these forms of representation are not employed until after a design has been finalized through traditional methods, such as architectural drawings and models.

ARCHINSITE

The gap between design and spatial experience within the practice of architecture led to the creation of a new interface for design. While Augmented Reality has provided the basis for this project's conception, most Augmented Reality systems remain closed and do not allow the user to alter the environment in real-time. In order to be useful as a design tool, an interface must allow for user input. The formal integration of GPS, real-time video compositing and three-dimensional modeling brings

Figure 2: The ArchInSite Prototype, which utilizes a Sony UX Micro PC, GPS Receiver, and Maya Modeling Software

forth a new method by which architects can perceive and design within the building's proposed site.

The ArchInSite Prototype

We have developed a prototype that consists of a Sony UX Micro PC running Maya modeling software, a GPS data parser, and video capture software (Figure 2). The system utilizes a Maya Embedded Language (MEL) script that enables the built in camera and the data streaming from the GPS to reorient the model in virtual space based upon the position of the user.

Hardware

The *ArchInSite* prototype utilizes several hardware components to form an interactive design interface :

- A Sony UX Micro PC allows the user to implement the interface on the physical site.
- An on board camera allows for the real-time compositing of site imagery.
- A GPS chipset allows the interface to interpret the user's location relative to the building, and provide the appropriate perspectival representation.

Software

Several pieces of software are implemented in the *ArchinSite* prototype in order to integrate the hardware components:

- Autodesk's Maya 3D Modeling and Visual Effects serves as the central piece of software that contains the model of the design and runs a script that retrieves the input from the other software.
- AGGSoftware's NMEA Data Logger interprets the GPS data stream and logs the user's coordinates in a text file that can be retrieved by the script running in Maya 3D Modeling and Visual Effects.
- Capturix's Video Capturix utilizes the Sony UX Micro PC's built-in front camera and takes a photograph every second and saves it to a file that can be retrieved by the script.

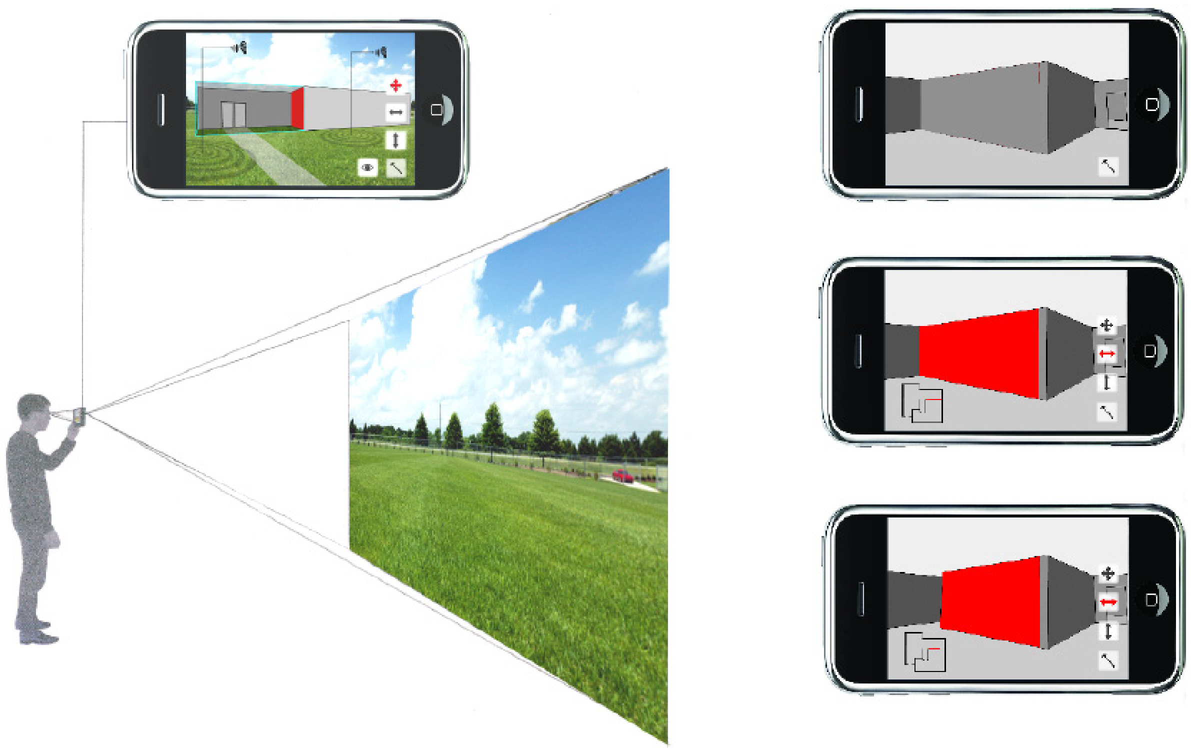

Figure 3: Renderings of the Proposed ArchInSite Interface on Apple's iPhone

Interface

Once on site, a button within the interface allows the user to establish the location of the proposed building via the GPS data stream. After the location has been established, the user is able to input his or her location relative to the building by simply walking around the site with the GPS receiver in hand. *ArchInSite* interprets the user's position and generates the appropriate view of the model composited into the physical context via a video feed from the handheld computer's built-in camera.

ArchInSite on the Iphone

While the *ArchInSite* prototype acts as a proof of concept, our eventual plan is to develop this interface for smartphones, such as Apple's *iPhone*, which comes equipped with all of the necessary hardware components including an onboard camera and GPS (Figure 3). The *iPhone* also has a built-in accelerometer that addresses many of the registration problems, angle recalibrations, and orientation issues that are often prevalent in Augmented Reality interfaces.

The decision to move towards a standalone application for the *iPhone* allows us the opportunity to specify the parameters of the interface:

- The model is rendered in a simple, grayscale hidden line in order to distinguish it from the surrounding context.
- In addition to the perspectival visualization capabilities, the interface will also allow the user to input sensory experiences from the site via the iPhone's built-in microphone and video camera.
- Two icons in the lower right-hand corner contain two separate tools sets. The first allows the user to alter the model and the second allows the user to input the sensory experience.

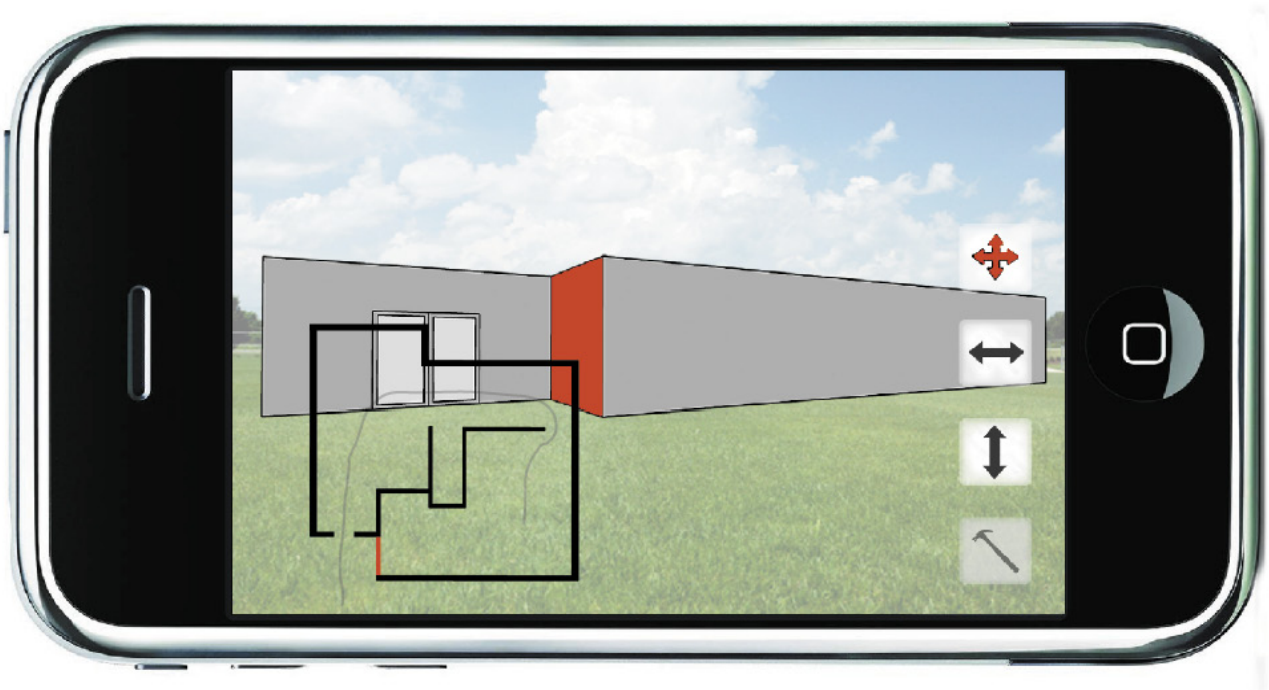

Figure 4: Rendering of the Proposed ArchInSite Interface on Apple's iPhone with Planometric View Overlay

- When the user selects the tool set for altering the model, an overlay of the design in a planometric view appears in the lower left-hand corner. The building element that the user selects to alter will appear red in both the perspective view and planometric overlay. The planometric view also includes a graphic representation of the user's current position and previous path of movement inside of the design (Figure 4).

DISCUSSION

ArchInSite has three major characteristics that carry significant implications within the practice of architecture and interface design, more generally, as interfaces become more and more embedded in a physical context: Restriction of Information, Embodied Interaction, and Ability to Alter the Design.

Restriction of Information

Throughout the implementation of *ArchInSite*, the proposed design is never shown from any perspective that would not be experienced by an inhabitant. That is to say, the information provided to the user is restricted in order to produce an experience that is consistent with reality. This restriction of information is in contrast with traditional methods of architectural design, wherein the architect employs planometric and section drawings, which make no direct reference to architectural experience. In *ArchInSite*, the user must 'live' with the architecture through a sequence of first-person perspectives in order to form an understanding of its spatial qualities. However, the interface's graphic representation of the design is intentionally diagrammatic, and is not meant to simulate materiality. The model is rendered as simply as possible in order to avoid excessive graphic interest that may distract the user. This diagrammatic representation shifts the user's focus from the graphic capacities of the modeling program back to the experience of the design.

Embodied Interaction

The smartphone's GPS and digital compass allows for embodied input of the user's location in relation to the proposed design. By operating the system on the proposed site, the user will also experience the peripheral sensory data such as temperature, wind direction, sound and smell, creating a new model for immersive environments. These qualities of *ArchInSite* situate the work within Paul Dourish's model of Embodied Interaction. However, *ArchInSite* goes beyond facilitating this passive experience of the sensory environment by allowing the user to actively collect and overlay the sensory information inside of the interface. When the user reaches a point on the site where the noise of a busy highway is distracting, a set of sensory-mapping tools allows the user to input this information into the system in order to form a continuously updating diagram that ties the design to the site conditions. The smartphone's onboard microphone and video camera also allow the user to directly record this data, transforming the process of diagramming from the abstraction of past experiences or ideas into the graphic organization of data collected from the site. *ArchInSite*'s ability to connect the user, the design, and the site through a hybrid process of three-dimensional modeling and data-collection diagramming distinguishes the interface from traditional methods of design and provides a richer representation of site.

Ability to Alter the Design

Perhaps the most significant aspect of this proposed interface is the user's ability to alter a design in real-time and watch the effects unfold on the site. By lowering the height of the roof or changing the positioning of a wall or window to reveal views of the surrounding site, the user is able to experience the architecture that results from the design change. The introduction of the planometric view of the design in the lower left hand corner during the process of altering the model responds to the user's layered understand of architectural experience. In his book, Intertwining, Steven Holl describes the interrelation of these two types of design considerations, which he refers to as *ideas* and *phenomena*. An *Idea* refers to the overall, organizational structure of a building that determines the placement of the various programmatic pieces. *Phenomena* refer to the embodied experience of the space and its sensory characteristics [6]. Clifford Geertz makes a similar distinction in the field of anthropology in his book, *Local Knowledge*. He refers to experience-near and experience-far as two types of understandings that are necessary compliments for anthropological fieldwork [5]. The main focus of the ArchInSite interface is to visualize and diagram the design's *phenomena* (or experience-near). However, when the user selects the tool set for altering the model, the planometric view appears, responding to the *idea* of design (experience-far).

Furthermore, the graphic representation of the user's path through the design (generated by GPS tracking software) incorporates the user's personal narrative into the model. This integration of experiential and abstract information presents a richer method for architectural design that is grounded in the user's immediate experience and mental organization of past events. The embodied diagram that results from the interface becomes significant because it allows for reflection and critique that are informed in the same manner in which the building will ultimately be experienced by its inhabitants, thus, collapsing the distance between experience and design.

CONCLUSION

Although the integration of computing systems into the field of architecture has changed the architect's tool palette, the fundamental problem of architectural design persists. Architects continue to isolate the design process from the phenomenal nature of experience. In this paper, we present a new interface for architectural design that integrates the physical site and sensory experience into a three-dimensional modeling program. However, we do not propose *ArchInSite* as a closed system for design in and of itself. Instead, *ArchInSite* is being developed as a form of diagramming that capitalizes on the advances in smartphone technology. An interface such as *ArchInSite* is suitable for diagrams that precede design as well as a method for evaluating the successfulness of a project on site throughout the course of the design. Architectural interfaces form a particularly interesting area in which to study how rational and experiential data interact in an interface.

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