Appropriateness in the Design of Ubiquitous Computing Environments

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INTRODUCTION

The standards for ubiquitous computing technologies are much higher than those for traditional computing, since these technologies are always on and present.[8] These high standards are compounded when considering ubiquitous technologies embedded in the built environment.

In the recent past, the ubiquitous computing community has been highly focused on the technology and infrastructure to support novel applications, leaving largely unexplored the thinking about using embedded computation to humanize the built environment and enable it for interactions with information and other people.

Akin to Isaac Asimov's laws for robotics[2], Adam Greenfield's principles for ubiquitous computing establish a bill of rights for humanity in ubiquitous computing environments

Further to these principles, the designer must consider the appropriateness of the intended functions and interactions of an intelligent environment before proceeding with a design.

In his book *Digital Ground*, Malcolm McCullough says that above performance, appropriateness is the key success factor in ubiquitous computing projects. Applications must enhance, not undermine, our perceptions of grounding place. He further establishes a typology, "Situated Types," of spaces for work, play, home, and travel. [3]

This paper seeks to continue the thinking about the appropriateness of design for ubiquitous computing environments brought about through collaborations between interaction designers and architects. When considering the appropriateness of a new design for such environments within Situated Types of place, designers can break the study into four attributes:

Function – the degree to which the functions of the environment enhance or distract from its perceived purpose

Engagement – the cultural, physical, social, and content-related elements of the environment's interaction language

Calmness – ability of the interactive elements of the environment to dissolve into the periphery

Robustness – the environment's ability to handle user, input, and technical errors

In most cases the designer should strive for these attributes, but she may decide that a core characteristic of her design is to ignore one or more of these categories, aiming to provoke thought, further understanding, or make a statement. If this is the case, the decision should be a deliberate element of the design.

APPROPRIATE FUNCTION

Embedding technologies invisibly into a space enables as much an opportunity for a new art form as it does a new way of infusing the built environment

with new and enhanced function. The purpose of ubiquitous computing projects need not be entirely utilitarian; they can exist on a continuum between functional and thought-provoking/playful, as well as be moving, surprising, and fun.[4]

Formalists such as Philip Johnson insist that design need not be guided by the expected uses for a space and the goals of its users, because these uses can't always be predicted.[5] However, we must avoid embarking on frivolous technological augmentations of objects and spaces, confusing their purpose.[6]

New applications in the built environment need to be orthogonal and add enough value to be accepted. But situated technologies need not have a utilitarian purpose. A window that visualizes the activity of people outside doesn't fulfill any purpose other than making the occupants of the space feel connected with the goings-on outside.[7]

On the other hand, lack of forethought can result in frivolous functionality with arguably little utility, as in the case of an Internet browser embedded into a kitchen refrigerator. Cultural conventions and norms inform the expectations people may have of a given artifact or environment.[14] In the course of embedding technologies into existing objects and spaces, designers must consider whether the addition enhances or distracts from their expected purpose and use.[6]

Whichever choice the designer makes, it must be deliberate and considered carefully based on her expectation of users' willingness to learn a new interaction language or to use the intended functionality in the context of the space. In some cases, a designer may deliberately break with convention in order to promote reflection or to further the understanding of a given cultural practice.[14]

Designers must also consider the value the design offers (be it ornament, functionality, or both) and whether it justifies the real or perceived risks to the user for embarrassment, interruption, and compromise of privacy. Ubiquitous computing runs the risk of dehumanizing and embarrassing people, for example by unintentionally broadcasting personal information. People balance using these systems with the stigmatized risk of surveillance and other popularized nightmares with respect to smart environments, especially homes.[8]

Design for ubiquitous computing environments could be the practice that shows that a designer cannot ascribe to just functionalism or formalism. Especially with the new possibilities offered by these types of environments, it's difficult to predict all the uses an occupant may find for a given space, even if the design points to one or more clear functions. In fact, Dunne and Raby suggest that imposing the familiar onto a digital situation would hold back the possibilities for new culture.[7]

Ubiquitous computing environments need to be aesthetically pleasing enough to live and work with, but also provide enough value over and above the risks they introduce to justify their presence in a space.

APPROPRIATE ENGAGEMENT

Bruce Sterling describes a scenario in which an elderly woman at a hotel feels like she isn't "good enough" to be a guest there, because she struggles with its completely rethought interaction design language[9]. Regardless of whether the designer decides to emphasize the formal or functional, the designer must consider whether her design engages occupants appropriately.

Engagement in interaction design consists of the (1) cultural, (2) physical, (3) content-related, and (4) social elements of an experience.[14] Each of these elements can be studied with respect to appropriateness.

Cultural Appropriateness

The sum of the cultural conventions and norms an occupant brings to an environment informs her expectations of the activities and actions that may occur.[14] Invoked above with respect to appropriateness of function, the cultural appropriateness of an environment's interaction language is determined by how closely it matches these expected practices and conventions. A museum exhibit lends itself to an interaction in which visitors spend time and reflect at its various waypoints. But extending this expectation to a subway turnstile would result in a culturally inappropriate interaction language, resulting in a design that either goes largely ignored as people zip through, or causing human traffic jams at the entrance. On the other hand, a designer may see value in breaking with a cultural

norm to invite reflection, but this decision must be considered and deliberate.

Physical Appropriateness

Physical engagement consists of the physical manipulation, bodily movements, and the physical materials of an interaction language. It aids the occupant's ability to make sense of, reflect upon, analyze, and make plans for their actions with an environment.[14] The bodily movements expected of occupants in an environment should match those that they would normally perform (or could be expected to perform) in that context. In Bruce Sterling's example, the elderly woman could not intuit the novel, complex physical manipulation required to remove a drinking glass from its newly designed shelf. In having to rely on someone else for assistance with the task, she felt like she didn't belong as a guest in that hotel. One could say that the shelf's designer had created a physically inappropriate interaction language, because the manipulations required did not match those that would normally be performed in that context.

Content-Related Engagement

Relevant to designs whose focus is on interacting with information, such as those intended for learning and education, content-related engagement consists of recognizable structures and elements, including genres, archetypes, and narrative structures. While introducing conflicting elements prompts an inquisitive attitude toward a design[14], content-related appropriateness lies in the balance between these recognizable and perplexing elements. On the one hand straightforward information hierarchy can lead to a bland and uninteresting interaction, but on the other, too many twists and turns in a narrative, or a structure that presents too little information "payoff" for the perceived effort put into a given interaction, can lead to frustration.

Social Engagement

Dalsgaard, et. al. classify the forms of social engagement in a given interaction into *social* (between two or more people with no prior relationship), *group* (between friends and family), and *individual* interactions. Among these, the designer must consider users' willingness to engage with the environment in relation to other people.

While a detailed guide on interface design for ubiquitous computing is beyond the scope of this paper, we must consider whether the cultural, physical, content-related, and social elements of the design's interaction language are accessible to a typical user, and if the interaction language is suitable for the context.

Designers must consider, even if the interaction language is easy to grasp, an occupant would be willing to converse in that language in the given context. A hierarchical menu system for browsing information about wine may be suitable in an Internet browser, but it may not translate well when integrated into the surface of a wine bar. A language requiring patrons to spend time navigating the system would clash with the cultural norms associated with drinking wine together. A voice-driven method for interaction at a bank would be culturally and socially inappropriate in a place where users would want to keep the information in question (personal identification information, account balances) individually private.

APPROPRIATE CALMNESS

The possibilities for embedding technologies in the built environment can lead to information overload among users, clogging up their attention. If not designed carefully, technologies intended to make their lives easier could have the opposite effect, making them feel hurried, stressed, and disconnected.[10]

Calm technologies allow users to absorb information without feeling overwhelmed, while making them feel empowered and in control. Further, by putting users in touch with familiar details, these technologies make users feel at home[11]. Architects can help design intelligent information environments that appeal to the peripheral, allowing occupants to shift their attention to information when they wish, elegantly freeing up their attention for other goals and activities in the space, and invoking a feeling of familiarity among users, making it more likely that they will feel comfortable with the space.

The need for technologies to be calm is compounded in the built environment, where users may interact with a system without having decided to do so[8]. While developing the Ambient Room, researchers at the MIT Media Lab found that the continuous sound of rippling water was unpleasant to users over time, and instead replaced this information

display with the more subtle approach of reflecting light off of the surface of a water bowl.[12]

Calmness can also be used to connect spaces through "ambient presence"[7] as well as facilitating Dunne and Raby's concept of "spatial buffering." Users could choose to address communications requests by bringing them to the center or by simply ignoring them, keeping them in the periphery.

The current gamut of readily available information display technologies is primarily composed of LEDs, flat panels, and projectors, all of which transmit large amounts of light into a given space and are bulky. The prevalence of passive display technologies such as electronic paper[13] will make designing for the periphery easier for architects and interaction designers alike.

APPROPRIATE ROBUSTNESS

Ubiquitous computing systems are more present than traditional computing technologies. In fact, users may not even be aware that they are interacting with a system at all.[8] Hence, these environments need to be especially able to handle the various anomalies and exceptions that can occur while they are operating.

The types of errors that a ubiquitous system must be prepared to handle fall into three categories:

Input Capture – Miscalibrated finger touches and mistaken or unrecognized words in voice recognition

Technical Errors – System crashes, power failure, and disconnects

User Errors – Mistakes and omissions made by users

The consequences of errors multiply in the context of ubiquitous computing environments. One can turn off a frustrating traditional product, but someone who finds a given space frustrating will leave and avoid using it in the future. Further, a frustrating space can reflect on the reputation of the institutions that sponsor the work in the first place[3]. Although by current standards, the quality of technology is perceived to be high, they pale in the face of the rigorous requirements posed by ubiquitous computing.[8]

CONCLUSION

When designing a ubiquitous computing environment, the risk becomes great that the comprising embedded technologies will confuse the purpose of the space and make users feel a "lack of place"[3]. Appropriateness is key to preserving a sense of place within users. Remaining aware of appropriateness of purpose, engagement, calmness, and robustness will ensure that a given ubiquitous computing environment's design will be successful among its users. In developing such a system, the designer may choose to take one or more of these principles in the opposite direction, but the decision to do so should be deliberate.

ENDNOTES

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