Interactive Architecture in Domestic Spaces

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Abstract. Research in the field of smart home environments is still very much technology driven. While technical aspects like system reliability, performance or data security are undeniable important design factors, potential end users desire more than pure technical functionality favoring systems with high social and hedonic value. So far, the integration of digital information layers into the architectural environment and their consequences for human perception are still largely unexplored. In this paper we present three examples of interactive architecture for increased quality of life in domestic spaces: *myGreenSpace*, *meetingMyEating* and *ubiGUI*.

Keywords: Ambient Intelligence, Large Domestic Screens, Smart Spaces, Aesthetics, Design, Architecture.

1 Introduction

Large displays are a common sight in most urban landscapes. With the rapid advances in display technology in terms of size and cost, large displays are gaining increased presence in all areas of our everyday life. Less than ten years ago, for example, any public viewing of a sport event would have taken place inside pubs on standard television sets. Today, we gather in public spaces and watch such happenings live on display walls [10]. Information screens in airports or train stations are not located exclusively in the waiting hall anymore, but large, medium, and small sized displays are distributed across those places to provide helpful information for travelers.

However, it is not only visible information that alters the way we see space and move through it. Who hasn't ever changed his location within a room for no other motive than seeking better wireless network reception? Like people looking for metal on the beach with metal detectors, we are holding our wireless devices into all corners of the room in search for the best or any signal. By doing this, we get aware of the spatial boundaries of the signal. Wireless network coverage (whether GSM, UMTS or IEEE 802.11) forms one part of what we call Ambient Intelligence and is one invisible information layer whose limits and layout many of us are conscious of [1].

Thus, it may be the lack of information that stands out. What is a hotel lobby or a lounge at a conference if it doesn't provide wireless network access? In some cities, the same holds true for cafés. In architecture or in an urban context, one might think about using such an invisible yet ever-present phenomenon for implicit zoning. Technology can add to traditional architectonical parameters and can help to form places where people gather and feel at ease.

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The idea of wireless network coverage as a three-dimensional form that overlays our physical space brings the concept of ambient technology close to concrete boundaries. On the other hand, an example that does quite the opposite are navigation systems. Integrated into the car and, more recently, omnipresent in our smart phones, they can be considered as ambient information. Using a navigation system detaches the user from physical space, especially when driving in a car. Even if the point of destination is clearly visible as a landmark on one side, the system might suggest turning to the other side. The digital map and the point that shows the car's current location potentially receive more attention than the physical environment surrounding the user. These are just some examples illustrating how digital technology changes physical spaces. In the remainder of this paper we will focus on interactive architecture and in particular large interactive screens in domestic settings.

2 The Importance of Aesthetics in System Development

Research in the field of smart home environments is still very much technology driven and potential users are rarely integrated in the design process of future systems [3][6][17]. While technical aspects like system reliability, performance or data security are undeniable important design factors, potential end users desire more than pure functionality. A variety of authors, including Hassenzahl [1] or Heidrich et al. [8] showed that users wish for more than the pure technical functionality and prefer devices with a high social and hedonic value. And as future ICT devices will be increasingly used within home environments, these aspects are likely to gain additional importance in the future.

Today, large-scale visual displays usually provide explicit information, which require a comparably high cognitive effort to decode and process. What is often overlooked by system designers is the fact that many users consider a permanent confrontation with audiovisual impressions as unpleasant and distracting [15]. A variety of studies (see, e.g., [2]) showed that users often wish to avoid needless distractions by dynamic information displays, favoring quiet and elegant peripheral interfaces. Some authors, like Fogarty et al. [4] even come to the conclusion that peripheral displays are primarily chosen and installed because of their aesthetic properties. Consequently, designing calm and unobtrusive interfaces is especially important in living spaces, which are traditionally used for recreational purposes and personal well-being.

A variety of authors addressed this challenge by developing so-called ambient displays, which combine the paradigms of ubiquitous computing and calm technology in an aesthetically pleasing way. Ambient displays present information within the user's environment through subtle changes in light, sound and movement, which can be processed in the background of awareness [16]. The term 'display' in this context means any construction, which makes information visible. Hence, an ambient display must not necessarily be a traditional display like a computer monitor, but it may also be a dynamic light installation, a water fountain or any other artefact, which is able to display information [12]. In most cases, information is not visualized directly. Instead, different degrees of abstraction are used to display data, which requires less attention and makes the interpretation of the information content easier [11]. Prominent examples of ambient displays using large-sized screens or projections include *Kandinsky System* [4], *Weather Composition* [9] or *InfoRiver* [14]. These systems successfully demonstrate the potential of peripheral information presentation in technology-enhanced environments. Through their abstract, aesthetic and non-disruptive nature, most existing prototypes effectively reside in the user's periphery of attention. Nevertheless, they are still distinct objects in the physical surrounding instead of being seamlessly integrated into the user's existing environment. So far, the integration of digital information layers into the architectural environment and their consequences for human perception are still largely unexplored. In the following section, we show some examples of interactive architecture for domestic spaces.

3 Interactive Walls for Increased Quality of Life in Domestic Spaces

Rather than following the concept of most existing ubiquitous computing applications, in which devices are spatially scattered or are worn on ones body, we aimed to integrate computational intelligence into the environment. By doing this, we are leaving the desktop metaphor and are using architectural elements like walls as interfaces to computers. To illustrate our approach, we developed the following three sample applications, which will be further elaborated in the remainder of this section:

- ***myGreenSpace*** extends a space virtually by using a display wall to render a forest scene that adjusts the perspective to the position of the viewer.
- ***meetingMeEating*** enables two persons, both sitting alone in front of a large screen, to dine together - over a distance.
- ***ubiGUI*** is an interface for medical health care applications that allows multiple input methods and is optimized for large screens.

3.1 myGreenSpace

MyGreenSpace can be described as a virtual three-dimensional wallpaper. A forest scene is shown on an entire wall of the living room and, by tracking the head position of the user, the perspective of the forest adjusts according to the view of the user. Linking head position and displayed image content creates an immediate, yet indirect way of interaction between a user and the ambient display. When a user is sitting or standing in the room, the perspective will only show minor changes, similar to the view out of a window. However, when the person is moving within the room, the perspective will reveal new views, again following the window metaphor. Thereby, the display only draws attention to it when the user is walking, but does not distract when he is still.

Fig. 1. Section through the system setup (left), screenshot of myGreenSpace (center), and person sitting in front of the display wall showing myGreenSpace (right)

The system is following the concept of a spatial extension [1] and creates the perception of a larger room. Metaphorically, the display becomes a transparent pane that separates the physical room from virtual space. With current technology, the illusion works only for a single user. The image on the screen is two-dimensional, spatiality is created by movement of the user's head, as described by Overbeeke et al. [17]. But future technology could enable multiple users to view *myGreenSpace* without using 3D-glasses. Exhibited during *CEATEC 2011*, *NICT* and *JVC* Kenwood presented a 200 inch display that supports multiple viewing angles.

Additional to displaying calm and relaxing scenery, *myGreenSpace* transports ambient information by showing distinct objects in the forest. In our demo setup, forest ghosts appearing in the scene can notify the user about events or can represent information. The user can select what they stand for - they can be a reminder to take medication, but they could also represent the number of friends online in a social network. In cases like the medicine notification, the user might wish not to be stigmatized by medical technology and the abstraction of information can provide privacy.

3.2 meetingMeEating

MeetingMeEating allows two persons at separate locations to dine together. Here, we combined a video conferencing system and the concept of the spatial extension. Two users at different locations sit on tables that are placed in front of display walls. The display walls show the video streams of the dining partner and a part of the partner's table.

Similar to *myGreenSpace*, the display wall becomes a part of the room, again extending the users space. But rather than showing a purely virtual space, the representation of a real space is shown, partly connecting two distant physical spaces into one visual contiguity. *MeetingMeEating* is using head tracking to adjust the perspective and uses background segmentation to overlay the video content with virtual three-dimensional content.

Fig. 2. System concept (left), person sitting in front of display wall, which is showing the video stream of the dining partner (center), and integration into virtual scene (right)

Students at our lab have conducted several user studies to prototype a social network around this application. The studies proposed a website where user profiles can be stored in order to find possible matches for a pleasant dinner. While today, social networking is mostly text and photo based, we envision that in the future, social networking could include real social interaction and that it could integrate into our domestic space instead of being only available on desktop computers and mobile devices.

3.3 ubiGUI

UbiGUI is a graphical user interface, specifically designed for large, wall-sized displays. It is an ongoing research project that introduces new functionalities to rooms by connecting users and system using the wall as the interface. We developed and used it to control and visualize different healthcare devices. However, *ubiGUI* also serves as an interface for other applications like smart home controls, presentations and games.

Large screens present a variety of specific issues, which we want to address by creating a user interface that is optimized for this type of scale. Input modalities are one central issue. Users need to be able to interact with the screen from different locations: sitting on a sofa, walking freely in the room or standing right next to the wall. While on the sofa, a mouse or track pad might still be an adequate input method, gestures might be more suitable when standing. When the wall is within reach for the user, touching the wall could be the best way to interact. There cannot be a sole input method for a large screen, which is why *ubiGUI* combines different input methods such as mouse input, gestures (pointing, using marker-less motion tracking) and multi-touch input.

Variable scale can also be important when dealing with larger screen sizes. From a distance, the entire screen is visible to the user. However, when approaching it, the level of perceivable content decreases with the narrowing field of view. At the same time, the user will be able to see finer detail. Displayed content will have to have different scales and levels of abstraction, depending on the user's location.

Another issue that we addressed is privacy. A large screen is an exposed element within a room and attracts attention. The size and also the fixed position and spatial orientation make it less suited to display private content. In a domestic environment, and especially in rooms that are usually shielded from the outside, the system should adjust private content, depending on whether or not other users are present.

4 Conclusion

As illustrated above, research in the field of smart home environments is still very much technology driven. While technical aspects like system reliability, performance or data security are undeniable important design factors, potential end users desire more than pure technical functionality favoring systems with high social and hedonic value. So far, the integration of digital information layers into the architectural environment and their consequences for human perception are still largely unexplored. In this paper we presented three examples of interactive architecture for increased quality of life in domestic spaces: *myGreenSpace*, *meetingMyEating* and *ubiGUI*.

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