

AUGMENTED REALITY AND THE DISAPPEARING COMPUTER

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ABSTRACT

In this paper, I argue for returning to the real world as the starting point for designing future information and collaboration environments and an integration of real and virtual worlds. This is based on the opinion that we have to emphasize again the importance of the rich affordances of the physical, architectural environment. This approach results in augmenting everyday places and objects with information processing capabilities but in a new and unobtrusive way. In the resulting hybrid worlds, the computer as a device will disappear, will be invisible, respectively be in the background, while the functionality will be available in a ubiquitous fashion. I will distinguish between “mental” and “physical” disappearance and discuss a number of resulting design issues and the role of affordances for designing smart artefacts and their user-interfaces. Examples are taken from our work on developing so called “Roomware”-components for the i-LAND environment - an interactive landscape for creativity and innovation - and from a recently launched project “Ambient Agoras: Dynamic Information Clouds in a Hybrid World”.

1. INTRODUCTION

The advent of information technology has caused a significant shift: away from real objects in the physical environment as the sources of information towards monitors of desktop computers as *the* interfaces to information. As a consequence, many people consider desktop computers in combination with virtual communities and chat rooms as the future environments for information and communication activities. In contrast to this, I will present an approach that goes beyond the now already more or less traditional desktop computer setting. Instead of Virtual Reality, we argue for Augmented Reality and an integrated design of real and virtual worlds. The resulting hybrid environments provide and require new forms for interacting with information and for cooperation between people. Our application area is the support of collaborative activities in the Workspaces of the Future as fundamental constituents of so called *Cooperative Buildings* (Streitz et al., 1998) where “the world around us is the interface” for people’s activities. The idea of going back to reality as the starting point for designing usable work environment, especially also for groups of people, is rooted in our opinion that we have to emphasize again the importance of the rich *affordances* of the physical, architectural environment. Of course, we do not intend to go back to reality as it used to be. Instead, we will be augmenting everyday places and objects with information processing capabilities but in a new and unobtrusive way.

When augmenting the physical environment with computer-based devices providing new functionality, that does not imply to put lots of computers in a demonstrative way all over the place. On the contrary, we want the computer as a device to disappear, respectively be in the background, while the functionality will be available in a ubiquitous fashion (=> ubiquitous computing). This is in line with the earlier proposals of Mark Weiser. In this context, my favorite quote from him is “The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.” (Weiser, 1991) And I like to add “... and facilitate a coherent and social experience when interacting and cooperating within the environment by providing appropriate affordances.” I take this view and interpret it as the design goal of a two-way augmentation and smooth

transition between real and virtual worlds. Combining real and virtual worlds in a computer-augmented environment resulting in hybrid worlds allows to design enabling “interfaces” that build on the *affordances* of everyday reality and virtuality seeking to use the best aspects of both worlds. I will give some examples later on.

My approach is to transform and transcend human-*computer* interaction resulting in rather direct *human-information* interaction and *human-human cooperation* based on *human-artefact* interaction, at the same time making the technology device character of computers disappear.

2. THE DISAPPEARING COMPUTER

In this approach, I distinguish between two types of disappearance of computer devices.

- *physical disappearance* of computer devices is achieved by making the computer-based parts very small so that they can fit in the hand, be interwoven with clothing, be attached to the body or even implanted in the body. In most cases, the computer is integrated in a “shell” of a compound artefact of small dimensions where the features usually associated with a computer are not visible anymore.
- *mental disappearance* (and I will distinguish further between *cognitive* and *emotional* disappearance) of computers is achieved by becoming “invisible” to the “mental eyes” of the users. This can, for example, happen when computer devices are stripped of their usual casing and are embedded in the architectural environment (e.g., walls, doors) or furniture (e.g., tables, desks, chairs) around us, somehow appearing in a new camouflage. The important aspect here is that they are not perceived as computer devices anymore but as embedded elements of augmented artefacts in the environment. Examples are the roomware components we developed (Streitz et al., 1999, 2001).

I distinguish between “cognitive” and “emotional” disappearance in the following way. In the *cognitive disappearance* case, the appearance of the devices is transformed so that they are not perceived as computers anymore but as information appliances for communicative and cooperative situations. The resulting artefacts can be even quite large, as in the example of an interactive wall (our DynaWall – see below - measures 4.40 m wide and 1.10 m high) or an interactive table with a horizontal surface (e.g., our InteracTable - see below) although it is smaller than the wall but still larger than a standard desktop computer display. People perceive more visual stimuli and associations that remind them of available everyday objects than of computer displays and boxes. In these cases, people move the „computer device“ character in the background and the functionality in the foreground.

In the *emotional disappearance* case, users are “drawn in” by a high emotional load of the artefact. Take the example of a stone-like artefact (similar to a “Handschmeichler” in German) with a very smooth surface and a round or oval shape that fits the shape of the palm of your hand very nicely. You like to touch and move it in your hand, to play with it, to carry it around in your pocket, etc. Another example would be a game with a very intriguing functionality and easy to handle interaction that guarantees full control over the game. It provides so much fun and excitement that after some time you even forget about the standard desktop display you are using as an output device. In this case, the functionality available, e.g., via a very realistic animation is important for creating this type of disappearance.

3. AFFORDANCES FOR DISAPPEARANCE AND COHERENT EXPERIENCES

Causing computers to disappear is not really our final goal and not only because you might wonder about the answer to the question “how do I interact with an invisible computer?” I like to argue that the notion of disappearance is an important objective on the way to achieve the goal of what we call “coherent experiences” in human-information interaction and human-human cooperation. This becomes obvious when we realize that the visual appearance of the integrated artefact is only one aspect of making

computers disappear. It is one design dimension of the affordances of disappearance. The other very important dimension is the type of interaction available. Useful disappearance and finally coherent experience is the result of the combination of macro affordances (physical shape and form factor) and certain micro affordances (e.g., tactile characteristics of the artefact's surface) in combination with the software providing appropriate interaction affordances. In many cases, their design is based on metaphors taken from real world objects and actions in order to be intuitive and thus minimizing the learning effort. In the following, I will present some examples of the Roomware[®] components we developed at GMD-IPSI as part of the i-LAND environment (Streitz et al, 1998, 1999) in our AMBIENTE-Lab in Darmstadt, Germany. Roomware[®] results from the integration of information technology into room elements as, e.g., walls, doors and furniture. Roomware components are interactive and networked; some of them are mobile due to independent power supply and wireless networks, and are provided with sensing technology.

3.1 The Roomware[®] Components DynaWall[®] and InteracTable[®]

The DynaWall[®] in our AMBIENTE-Lab is a large interactive wall covering one side of the room completely. The size of 4.50 m (15 ') width and 1.10 m (3' 7") height and the very smooth integration of this very large display (realized by a back projection which is hidden to the user) into the architectural structure creates the impression that you are really writing and interacting with a wall or wallpaper, depending on which metaphor is conveyed, respectively people adopt for themselves. The surface is touch-sensitive so that you can write and interact on it with your bare fingers or with a normal pen (no electronics needed). Several people can write/ interact in parallel in (currently three) different areas of the DynaWall. Beyond these physical affordances, our BEACH software enables very intuitive interaction based on gestures that are reflecting actions with physical objects in the real world (e.g., "take and put", "throw", "shuffle", ...). When throwing objects (with different accelerations), the speed and thus the flying distance is dependent on the initial momentum provided by the user. People can interact this way immediately after having seen it once.

A similar combination of affordances is provided by the InteracTable[®], another roomware component we developed. It has a display size of 65 cm x 115 cm and a diameter of 130 cm (50 "). Beyond the type of interactions available at the DynaWall, it provides additional forms of interaction required by horizontal and round or oval-shaped displays. To this end, we developed in BEACH special gestures for shuffling and rotating individual information objects or groups of objects across the surface so that they orient themselves automatically. This accommodates easy viewing from all perspectives. Furthermore, one can create a second view of an object, shuffle this to the other side so that the opposite team member has the correct view at the same time. Now, everybody can view the same object with the correct perspective in parallel, edit and annotate it.

It is important to note that although the physical appearance of a wall and a table is different the visual appearance of the information objects and the design of interacting with them is done in such a way that it provides a coherent experience. Other examples are the ConnecTables[®] where moving them together in physical space results in creating a shared workspace between them in the virtual world. More details for interacting with different roomware components are given in (Streitz et al, 2001).

3.2 The Passage mechanism

Passage is a mechanism for establishing relations between physical objects and virtual information structures, thus bridging the border between the real world and the digital, virtual world. So-called *Passengers* (Passage-Objects) enable people to have quick and direct access to a large amount of information and to "carry them around" from one location to another via physical representatives that are acting as physical "bookmarks" into the virtual world. It is no longer necessary to open windows, browse

hierarchies of folders, worry about mounted drives, etc. Passage is a concept for ephemeral binding of content to an object. It provides an intuitive way for the “transportation” of information between roomware components, e.g., between offices or to and from meeting rooms.

A Passenger does not have to be a special physical object. Any uniquely detectable physical object may become a Passenger. Since the information structures are not stored on the Passenger itself but only linked to it, people can turn any object into a Passenger: a watch, a ring, a pen, glasses, a wooden block, or other arbitrary objects. The only restriction Passengers have is that they can be identified by the *Bridge* and that they are unique. Passengers are placed on so-called *Bridges*, making their virtual counter parts accessible. With simple gestures the digital information can be assigned to or retrieved from the passenger via the virtual part of the Bridge. The Bridges are integrated in the environment to guarantee ubiquitous and intuitive access to data and information at every location in a building (=> Cooperative Building). For example, a Bridge can be integrated into the table top of an interactive electronic table (=> InteracTable[®]) in the cafeteria or mounted in front of an interactive electronic wall (=> DynaWall[®]) in a meeting room. More details can be found in (Konomi et al, 1999).

The preceding examples provide first steps of moving away from human-*computer* interaction and via human-*artefact* interaction towards human-*information* interaction and human-*human* cooperation. But we have also to be aware of the fact that this approach will be only one (important) part of a more comprehensive story. It remains to be seen if taking only metaphors from the real world is the best way for the design of disappearing computers. Similar to the breakdown of the “desktop” metaphor based on icons for folders and trash cans showing us the limitations of that approach, we will witness that a unidimensional approach will cause a lot of problems again. This and other open issues will provide the topics of our new activities described below.

4. CONCLUSIONS AND FUTURE WORK

While the guiding vision for the development of our roomware components was already provided by the framework of *Cooperative Buildings*, the actual development was somehow limited to application scenarios addressing primarily the support of collaborative work in meeting rooms. This limitation was a major motivation for us to extend the scope of the problem space and place more emphasis than before on more comprehensive architectural environments, collections of artefacts and a wide range of activity patterns when interacting with those artefacts and moving in these spaces.

At the beginning of 2001, we started a new project called “Ambient Agoras: Dynamic Information Clouds in a Hybrid World” (www.Ambient-Agoras.org). It is funded by the European Union as part of its proactive initiative “The Disappearing Computer” (www.disappearing-computer.net). The project “Ambient Agoras” aims at providing situated services, place-relevant information, and feeling of the place (‘genius loci’) to the users, so that they feel at home in the office, by using information technology in an innovative way, e.g., mobile and embedded in the environment. *Ambient Agoras* adds a layer of information-based services to the place, enabling the user to communicate for help, guidance, work, or fun. It integrates information into architecture through smart artefacts, and will especially focus on providing the environment with memory, which will be accessible to users. *Ambient Agoras* will augment reality by providing better affordances to existing places. It aims at turning every place into a social marketplace (= *agora* in Greek) of ideas and information - an *Information Market Place* - where one can interact and cooperate with people. As the title implies, *Ambient Agoras* is a project that brings together technology and people in a particular context. The context and metaphor we will pursue is that of the *Greek Agora*, a place in the center of economic and social activity where information and ideas are exchanged. I will complement my presentation at the conference in August with some results from this project.

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REFERENCES

- Konomi, S., Müller-Tomfelde, C., Streitz, N. (1999). Passage: Physical Transportation of Digital Information in Cooperative Buildings. In: Streitz, N., Siegel, J., Hartkopf, V., Konomi, S. (Eds.), *Cooperative Buildings - Integrating Information, Organization, and Architecture. Proceedings of CoBuild'99*. LNCS 1670. Heidelberg: Springer, pp. 45 - 54.
- Streitz, N., Geißler, J., Holmer, T. (1998). Roomware for Cooperative Buildings: Integrated Design of Architectural Spaces and Information Spaces. In: Streitz, N., Konomi, S., Burkhardt, H. (Eds.), *Cooperative Buildings - Integrating Information, Organization, and Architecture. Proceedings of CoBuild '98*, Darmstadt, Germany, LNCS Vol. 1370, Heidelberg, Germany, Springer, 1998. pp. 4-21.
- Streitz, N., Geißler, J., Holmer, T., Konomi, S., Müller-Tomfelde, C., Reischl, W. Rexroth, P., Seitz, P. Steinmetz, R. (1999). i-LAND: an interactive landscape for creativity and innovation. In *Proceedings of CHI'99* (Pittsburgh, May 15-20, 1999) ACM Press. New York, pp. 120-127.
- Streitz, N., Tandler, P., Müller-Tomfelde, C., Konomi, S. (2001). Roomware: Towards the Next Generation of Human-Computer Interaction based on an Integrated Design of Real and Virtual Worlds. In: J. A. Carroll (Ed.), *Human-Computer Interaction in the New Millennium*. Addison-Wesley. (to appear in May).
- Weiser, M. (1991). The Computer for the 21st Century. *Scientific American*, 1991, 265 (3), pp. 94-104.