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11 *Bodyarchitecture*: the Evolution of Interface towards Ambient Intelligence

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Abstract. *Bodyarchitecture* is a research platform for investigating different forms of natural, multimodal human-computer interaction. It involves the research and development of computer vision, speech and gesture recognition systems that connect media and physical spaces to what its inhabitants are, and do and say. Following the Ambient Intelligence paradigm, it was conceived to be invisible to the user, so that you can communicate and interact with it in a natural way.

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11.1 Introduction

Virtual worlds are collections of computer-generated binary information. They are accessible through technological interfaces that, in the current dominant user interface paradigm, produce a perceptive effect of making users believe they are typing on virtual paper in a flat rectangular screen.

The *Xerox Star* (1981) followed by the *Apple Macintosh* (1984) were the first commercial systems with a Graphical User Interface (GUI), which used the 'desktop metaphor' to manage user interaction with a computer. From the perspective of design and usage, both *Star* and *Macintosh* represented, when introduced, tremendous progress in human-computer interfaces. A single touch of a finger on a mouse, a keyboard or a light pen could activate icons and windows, thus allowing non specialized users to accomplish complex computational work.

Despite a myriad of technological innovations, progress in the conceptual design of human-computer interfaces has been insignificant since 1981. Millions of personal computers have been sold over the past few decades –thanks mainly to the persuasive power of *Microsoft Windows*— but the computer remains largely a hard to use box sitting on a desk or a laptop. We can only fully interact with it through the articulation of complex language, an exercise that, in most cases, has nothing to do with the tasks we want it to perform.

Aside from the human-computer interface problem, another important issue is that the actual configuration, bound to computers with flat rectangular screens, windows, keyboards and a mouse, do not seem to embrace the real power of information technology.

According to Randall Davis (MIT), the state of the art of that technology suffers from an historical accident: someone had a brilliant idea to connect a typewriter to a computer – and, since then, we have been typing. This is nonsense. We do not type to talk with others.

Why do we have to type to communicate with a computer?

11.2 Bits everywhere

The search to overcome the *desktop* model has put many researchers (artists and scientists) to work. If we look at the new trends of man-machine interfaces, one solution that has become very popular, is to immerse the user completely within a virtual world –in a similar way to what happened to the actor Jeff Bridges, who was sucked into a computational domain in the movie *Trom: An Electronic Odyssey*. In these systems –of which virtual reality is the best example– the main effort is dedicated to creating human-centered devices that allow the users to immerse and interact (sometimes almost effectively) within the simulated world.

In virtual reality research the *locus* of interfaces alternates mainly in two directions: *wearables* and immersive environments. In the first, the idea is to ‘pack’ the entire surface of your body with a matrix of small tactile sensors and vibrators –hundreds of them by cm2. For example, the Italian engineer, Danilo de Rossi, at the University of Pisa, is developing a prototype of such a tactile bodysuit. In addition to your skin, your ears, eyes, nose and other body parts can already be interfaced, i.e., extended to receive and transmit computational data. In the most exotic scenario, a part of your body is transformed into 'hardware' (which, from a technical perspective, means to implant silicon chips right in your flesh; for example, in the central nervous system) so as to link your mind with a computer. The first successfully realized human brain interface was implanted in Johnny Ray's brain in 1998. The technique was developed by the neuroscientists, Philip Kennedy, Roy Bakay and their team, affiliated with the Emory University in Atlanta, Georgia.

Although the technique is still very rudimental, according to the report of the scientists, the patient, Ray, who became totally immobilized after a cerebral stroke, via electrical patterns that correspond to move an arm, was able to move a cursor on a computer screen [1].

Another less invasive option is to immerge in a hardware controlled *CAVE*, the walls of which consist of huge projection screens. *CAVEs* (CAVE Automatic Virtual Environment) are cubical rooms of variable dimensions with walls formed by panoramic projection screens. Over the screens, computer synchronized video projectors create a single projection field that wraps the interactors with images and 3D sounds. In this system, you are asked to wear a kind of stereoscopic glass with a track device that helps to generate a 3D personal perspective of the scene. Another position track interface, being developed at the University of North Carolina, is a bodysuit covered with optical sensors that are interpreted by a set of diodes spread about the room. With such a device, when you walk or move in the *CAVE*, your movements are mapped informing the computer of the orientation and position of your body.

CAVEs technology (which name refers to the "Myth of the Cave" in Plato's *Republic*) was developed in the Electronic Visualization Laboratory of Illinois University, Chicago, by Thomas DeFanti, Daniel Sandin and Carolina Cruz-Neira, in 1992 (date of the first public demonstration at SIGGRAPH'92 computer conference). It is worth mentioning, however, that the concept of an interactive mediatic room is not new. In the fictional *The Veldt* (1950), Ray Bradbury describes an environment that by reading children's minds is capable of generating hyperealistic simulations to the point of transforming those fantasies into experiences.

From the user's perspective, these systems produce a common effect: it only takes to 'switch on a plug' and your perceptions of the technology as a separate tool will disappear.

You will have the impression of immerging in another world.

While virtual reality systems try to create a 'world' within a computer –by means of a tremendous apparatus that simulates the physical world— another 'opposed' technological approach bets on the overlay of virtual space, including a cyberspace domain, to the world that is already there. According to this trend, one of the problems with virtual reality systems is that the 'external world' ceases to exist to the interactor. We cannot see things or relate to people who are not linked to the system. The missing liaison between the physical environment and the data world –between atoms and bits- oblige us to interact in parallel, i.e., in one or the other space.

In this case, following the Ambient Intelligence paradigm, the main challenge is to build practically 'invisible' interfaces (i.e. interfaces built in a human centered manner) that are capable of overlaying virtual data to the physical world, instead of recreating it inside a computer.

The idea of overlaying virtual space to the world that is already there was first suggested by Mark Weiser (XEROX PARC) in the article "The Computer For the 21st Century", published by *Scientific American*, in 1991 [2]. Coined *ubiquitous computing*, this proposal focused on the research and development of technologies that would bring the virtuality of the computational data out to the physical world. According to Weiser, one way of thinking *ubiquitous computing* is to imagine a totally new design for computers (nothing to do with Steve Jobs' *Sunflower*, of course). Designed out of their plastic boxes, ‘ubiquitous’ computers are projected to cause the sensation of living in an extended world filled with invisible engines. In such a world, users would be surrounded by thousands of network interconnected systems designed to satisfy their needs for information, communication, services and entertainment.

Examples of ubiquitous computers are *tabs*, *pads* and *boards*. *Tabs* are clip-on computers with small screens and track sensors that help to identify themselves to receivers placed troughout a building . This attachment permits people or objects to be localized. *Pads* were conceived to function as scrap paper. Spread out like sheets of paper over a table, this device has no individual use –anyone can take one and use it anywhere.

The prototype, designed by Robert Krivacic (Xerox PARC), is something like a cross between a conventional laptop and a sheet of paper. It has two microprocessors, one display, a multibutton pen and a radio *network* that supports several devices per user per room. *Boards* are similar to 40 x 60 inch blackboards. They can be used for several tasks: such as video screens, bulletin boards or digital bookcases containing texts that can be *downloaded* to tabs and pads. Interaction with boards occurs via wireless electronic chalk.

In 1999, the Advisory Group to the European Community's Information Society Technology Programme (ISTAG) issued a proposal for a new paradigm–the Ambient Intelligence (AmI). The AmI approach intends to tie together ubiquitous computing, ubiquitous communication and intelligent human-centered interfaces.

In four scenarios, this program showcases ideas on how information technology might be deployed and experienced in 2010 [3]. In those futuristic visions, humans will be surrounded by lots of physical devices that are interconnected by seamlessly mobile and fixed communication infrastructure. That is, instead of sitting in front of a machine, the machine will be all around us. Moreover, interactions between you and such a system will be through natural feeling human interfaces, which recognize, respond and learn our presence and preferences.

Other research projects that pursue to achieve similar goals are *tangible bits* and *augmented reality*.

In *tangible bits*, the challenge is to transform everyday objects such as doors, tables, books, lights or even the flux of air and water into computational interfaces. According to the director of Tangible Media Group at the MIT Media Lab, Hiroshi Ishii, these interfaces would enable you to access and manipulate digital data (videos, graphics and 3D models) using nothing more than the innate knowledge you have acquired dealing with physical objects of the real world: “If you can pick up a mothball, you can run Ishii's computer” [4].

The ‘computer’ developed by Hiroshi Ishii and his team is a small room, augmented with lights, sound, air and water flow that are all controlled by a computational system. In this space, patterns of light projected from the surface of moving water reflect on the lab’s ceiling to communicate the activities of a hamster (the lab’s pet). Other light and sound signs (e.g. bird songs and thunder) signal incoming e-mails. And other *Net* traffic and past activity can be retrieved by turning back the hands of a physical clock.

In *augmented reality*, the hybridization of physical and virtual spaces is accomplished through devices designed to overlay graphics, texts and other computational data to the interactor’s perception of the environment. Most of the research focuses on developing head worn ‘see-through’ displays that track the 3D position and orientation of the user’s head (six degrees of freedom: three degrees of position and three degrees of rotation).

Based on the tracker’s input, the system can overlay digital data (visual and audio information) aligned with the user’s point of view of physical surrounding. For example, graphics and text overlaid on the surrounding environment could indicate how to operate, maintain, or repair a broken piece of equipment, without requiring the user to refer to a separate paper manual [5].

11.3 Bodyarchitecture

Inspired by those ideas, I am developing an artistic prototype, which I have named *Bodyarchitecture*.

Bodyarchitecture is a research platform for investigating different forms of natural, multimodal human-computer interaction. It involves the research and development of computer vision, speech and gesture recognition systems that connect media and physical spaces to what its inhabitants are, and do and say. Following, the Ambient Intelligence paradigm, it was conceived to be invisible to the user, so that you can communicate and interact with it in a natural way.

A sample interaction with this system would be:

- You walk into a room. It is three meters across by three meters long and three meters high
- The walls are blank and two-dimensional. As you walk in, the thump of your feet alters the balance of the inert space until you reach the center
- Now, your body activities are transcribed to the walls, i.e. the walls begin to move (it seems) in a three dimension, fluid manner
- Add to that, a hidden audio stereo system that 'pulls' your body sounds – the beating of your heart, the pace of your breathing, the frequency of your voice- and you will get the picture of the kind of architectonic impact the increasing complexity of changes may cause.

This system also supports spoken language interaction, which means that with voice commands, you cannot only reshape the surroundings but also control, command, explore, record and all the other forms that are used to manipulate, process and analyze data that the system produces. For example, you may command the walls to disappear and the system will provide timely external information. In this application, scenes from the surrounding world are captured and converted to digital video signals using as input devices video mixing technology, similar to the one developed for TV special effects.

The projected physical installation of *Bodyarchitecture* is a 3x3m empty room furnished with six LCD projectors (four covering the walls, one the floor and one the ceiling), ten video cameras (four used by computer vision systems and six to display external information), an audio stereo system and an array of computer controlled devices – temperature and pressure sensors and motion detectors (see Figure 11.1). The workstations that perform the room's computation –the system's brains— are placed in an outside area. This is how the *Bodyarchitecture* prototype has been taking shape in my head.

11.3.1 Putting it together

The project formally started in 2001 as a research project. The early stages of design of *Bodyarchitecture* were directed toward research on vision and speech recognition systems [6].

The second phase was directed toward building an infrastructure. In November, 2003, I was invited by the architect and space artist, José Wagner Garcia, to put up a portable, immersive and interactive system. Because *Bodyarchitecture* project partially fitted the mold (and money is essential for the evolution of a new project), I decided to use that opportunity as a proof-of-concept test bed.

It is at the very early stages but, for now, the architecture of this prototype uses: (1) a PC cluster technology; (2) custom software; (3) a 3D bird tracking devices and cameras for real time interaction and (4) a portable four wall projection 3x3x3 m.

The next phase will be directed toward developing camera and microphone arrays to track the users position and movements and connecting the various components of the room (e.g., tracking and speech recognition systems) to each other and to internal and external stores of information (an interactor, cameras and internet data). To accomplish this objective a software architecture that allow the room to run in real-time, will have to be developed.

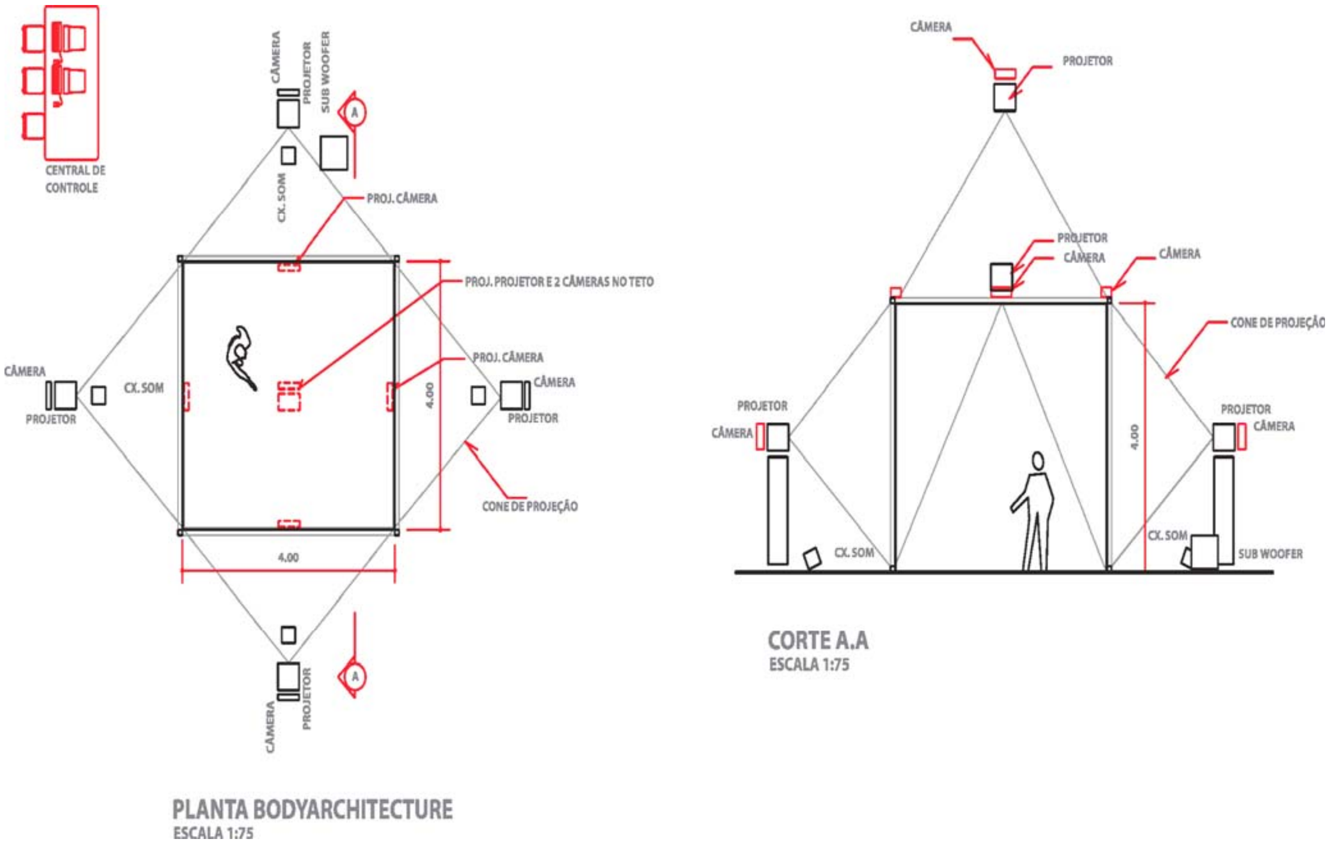

Figure 11.1 Projected physical installation

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