Social dimensions of wearable computers: an overview

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Abstract
Although the field of wearable computing is experiencing a great boost at the level of design and production, research on its social dimensions is still at an early phase and the literature on the subject is scant. This paper attempts to partially fill this gap by reviewing the current status of the field of wearable computing and the main issues that are starting to emerge from their usage. The first part defines wearable computers and assesses its technical and conceptual origins and developments. Examples of current wearable computing products are provided. The second part reviews some of its possible social implications, especially as they relate to the issue of control. It concludes by suggesting future research directions for the study of the social dimensions of wearable computing.

Technical origins

Wearable computers are, to a great extent, the product of two broad conceptual and technical developments: ubiquitous computing and embedded computing. Ubiquitous computing, a term coined in the late 1980s, refers to the presence of numerous 'invisible' networked computers located everywhere and nowhere (Weiser 1991; Weiser, Gold and Brown 1999; Ark and Selker 1999). A ubiquitous computing system is spread throughout the environment, thus enabling mobility; does not require conscious grasping of its mechanism, thus endorsing seamless interaction; and is networked, thereby facilitating communication among the various actors/elements/participants.

Embedded computing stems from a similar set of desires. Particularly, that of supplying all sorts of actors - human and non-human - with communication and computing capabilities, i.e. making them 'smart'.

The combination of ubiquitous and embedded computing gives rise to what nowadays is customarily called pervasive computing (Emigh 2002). For example, the Long Island Power Authority has set up a service that allows homeowners with central air conditioning to adjust the temperatures in their homes by visiting a page at the power companies site. But customers are not the only ones who can log in to change the temperature. During the summer the power authority can also adjust it (O'Connell 2001). Pervasive computing is seen by many technology developers as the-next-big-thing in computing enabling a change from the personal computer paradigm, to the personal computing paradigm where each individual shares, and is shared by, multiple computers. At last year's largest US computer fair 'Comdex Fall 2002', where the industry displays its visions for the future, Bill Gates announced a new Microsoft initiative called 'Small Personal Object Technology' (SPOT), that intends to endow personal objects with networking and computing abilities. For instance, the 'smart' alarm clock 'knows' exactly when to wake up its owner just in time for that 9 a.m. flight having previously checked the traffic conditions and if the flight is delayed. For more information on Microsoft's SPOT initiative read:

- http://www.nytimes.com/2002/11/18/technology/18GATE.html,
- http://news.bbc.co.uk/2/hi/business/2487787.stm or
- http://www.businessweek.com/technology/cnet/stories/966125.htm

Wearable computers translate these visions of connectedness and empowerment into the sphere of the human body. Not only is the surrounding environment responsive and communicative, but the individual's personal space is, itself, endowed with added capabilities. The philosophy of wearable computers is, on the surface, one of *personal* empowerment: wearable computers present the possibility of augmenting the human body's sensory and cognitive abilities (cf. Barfield and Caudell 2001; Mann 1998).

Definition of wearable computers

A wearable computer is defined as a 'fully functional, self-powered, self-contained computer that is worn on the body ... [and] provides access to information, and interaction with information, anywhere and at anytime' (Barfield and Caudell 2001: 6). To this set of qualities Steve Mann, acknowledged by many as the 'father' of wearable computers, adds the characteristic of its being controlled by the wearer (Mann 1998). However, Mann's emphasis on private ownership has not been embraced by the industry and, nowadays, most wearable computers are protected - both at the hardware and software levels - against reverse engineering.

Conceptual development

Over the last ten years the scientific field of wearable computers has acquired academic and commercial respectability (Baber, Haniff and Woolley 1999). This recognition, accompanied by a series of technical developments - such as miniaturization - has stimulated the expansion of the range of applications and promoted a shift in both its primary focus and scope.

Initially, wearable computers were considered *tools* that were designed to give wearers instantaneous and constant access to information. They were developed mainly for individuals who needed both hands free and fast access to, and distribution of, information. Thus, wearable computers were aimed particularly at the industry and military spheres.

Nowadays, the ultimate goal of wearable computer developers is to make them proactive, i.e. responsive, communicative and 'aware'. A wearable computer should be able to recognize its 'owner', its 'location' and the 'activity' being undertaken. Awareness is built-in through the development and incorporation of sensors, such as mechanical, acoustic, biological, optical and environmental sensors that can measure, for instance, the position, force, shape, displacement of a subject in space, his/her heart rate, body temperature, neural activity and voice pitch and also the surrounding conditions, such as temperature, humidity and light. These sensors generate information that can either be processed locally by the computer that is being worn to perform context-aware tasks such as navigation and communication, or remotely as when the information is transmitted and processed by a third party.

This shift implies much more than technical solutions, it signifies a shift in perceptions of the wearable computer's identity/value/use. Wearable computers stop being tools to become 'technological companions', 'extensions of the self' or a 'second skin', their wearers augmented, both physically and cognitively. Wearable computers thus provide new ways of connecting to our bodies and to the world.

By virtue of being aware, always on and always accessible, their potential is immense, and so are the dreams and desires of those who develop them. Wearable computers are now being prototyped for an array of new purposes, such as medical and lifestyle applications. At the lowest level of the spectrum are commercial enterprises such as that of Levi's and Philips, who have collaborated to create a hooded jacket, dubbed 'ICD+', that incorporates an MP3 player and a mobile phone. Using a conductive fabric, Philips created a keypad that can be placed on the cuff or pocket. The speakers are located in the hood, allowing wearers to take calls or listen to music, with the controls in the sleeves (Philips 2000).

At the higher end of the spectrum are ambitious initiatives such as the 'SmartShirt System' (previously called Wearable Motherboard(tm) Smart Shirt) being developed by Sensatex for health purposes, or the 'I-wear' clothing line prototyped by Startlab for leisure applications. The SmartShirt System is equipped with multiple sensory capabilities to monitor health indicators, e.g. heart rate and level of blood pressure. The shirt enables information exchanges within the garment, and wireless communication with receivers off the body. Possibility of feedback (re)action, e.g. injecting a certain drug when needed is being studied (Sensatex n.d.).

Starlab, a blue-sky research lab located in Belgium that fell victim to the dot-com crash, intended to develop a roadmap for an I-wear line (intelligent clothing) which would then include items such as the 'memory sweater'. The memory sweater would record biological, thermal and physical data enabling its wearer to 'save' an experience. For instance, while skiing down a mountain the skier's sweater could record the heart beat, the level of adrenaline, the temperature, the emotional state, the speed and the noise, among other data, obtaining a 'stamp' of the experience. This experience, no longer ephemeral, can later be relived or transferred to someone else (Viseu 2001a).

Social dimensions

Despite the major changes wearable computers are bound to introduce in social and cognitive dynamics, and how these will shape the development of the technology itself, little has been written about this issue. Human and sociological issues are often reduced to issues of productivity, i.e. 'Do the workers like it? Does it affect the quality and quantity of their work? Can the effects be measured?' (Barfield and Caudell 2001).

Wearable computer enthusiasts highlight the added cognitive and physical capabilities humans will be endowed with, citing for example, the advantages that will be derived from a system that helps the fallible human memory reach perfection, or the cost-saving benefits that derive from the implementation of real-time home care for an ageing population.

Critics, however, are quick to point out other possible outcomes and concerns. Among these the most often quoted are loss of autonomy (what happens when you depend on the wearable?); reliability issues (how can perfect reliability be assured?); safety (what are the long-term effects of wearing a computer?); security (how can you make the system unbreakable by intruders?); and finally, control (will wearable computers be used for control and surveillance purposes?) Here I will discuss in more detail the issue of control.

Wearables: control and surveillance

The issue of control soon forced itself upon the wearable computing debate. It comes disguised in privacy and surveillance vocabularies and is commonly cited, both by enthusiasts and critics, as the biggest stumbling block to the pervasiveness of wearable computers (cf. Gershenfeld 1999). A technological artefact that is always on has the potential to record all the wearer's actions, perhaps even thoughts and emotions. This poses grave concerns regarding control and the subsequent loss of privacy. Frequently critics paint an Orwellian picture of wearable computers, a panorama that seems to resonate with public fears, making it hard to sell the product to audiences (Viseu 2001b).

Like in most other contexts the solution to the problems of control and privacy loss is not a simple one. For instance, a wearable computer equipped with GPS can be of great help if an individual is injured and needs help, but it can also be the perfect tool for an employer to find out if the workers are spending too much time in the doughnut shop! The answer lies on a complex balance between comfort, security and ownership of personal data.

However, the picture looks grim since to date the most successful wearable applications are being designed for contexts in which wearers do not have a say in the decision process, such as the workplace or military environments. In these situations, the wearer is unable to control the data-flow of his/her wearable, be it because it belongs to someone else or due to the lack of understanding of its workings.

However, as wearable computers develop and become mainstream the possibility of privately owned wearables arises. If the wearer controls information contained in it, then he/she can decide when, where and why to disclose it. The wearer can, for example, select to exchange some personal information for a discount when entering a shop; or to encrypt it so that nothing is revealed. Here the wearable becomes part of the solution not part of the problem.

Conclusion

Wearable computers are still in a very early stage of development. Most products aimed at the general public are still at the prototype stage. Their final shape is still undecided, wearables may become valuable tools in enhancing social values and practices, such as the right to privacy, or they may create a major source of individual liberty threats. This means we still have time to try to shape them.

In order to fully assess the future implications of wearable computers it is necessary to abandon the notion that technologies are 'neutral', 'bad' or 'good' for this leads us to an approach where the technological artefact, its developers and users are seen as independent, autonomous actors. We must adopt a conceptual framework that enables us to recognize technological artefacts as (heterogeneous) networks that favour certain social dynamics, certain social patterns of organization and modes of experience.

An analysis of wearable computers should be grounded on the actions of all participants - from the visions and goals of developers, to the practices and needs of users. It is in the interplay between these actors that wearable technologies will be shaped, and it is also here where we can act in order to assure that individual rights and freedoms are preserved. Only by doing this will we achieve solutions that satisfy society as a whole.

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