Rethinking the Space of Intelligent Environments

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Abstract
Technologies are not mere exterior aids but interior changes of consciousness that shape the way the world is experienced. As we enter the age of ubiquitous computing, where computers are worn, carried or embedded into the environment, we must be careful that the ideology the technology embodies is not blindly incorporated into the environment as well. As disciplines, engineering and computer science make implicit assumptions about the world that conflict with traditional modes of cultural production. Space is commonly understood to be the void left behind when no objects are present. Unfortunately, once we see space in this way, we are unable to understand the role it plays in our everyday experience. In this paper, I argue that with the realization of the vision of ubiquitous computing, the fields of computer science and engineering reify the dominance of abstract space in real space. A new approach to the design of computing systems is necessary to re-embody space. The social nature of the interface allows us to situate it within Henrí Lefebvre's notions of space, providing new tools for thinking about how computing practice engages space as well as opening avenues to rematerialize the environment through embodied interaction.

1. Transforming consciousness

New technologies signal transformations of both individual and cultural consciousness. In the early days of computing, the belief that advancements in 'thinking machines' would unfold as quickly as other recent and ongoing technological achievements was widely held. The promise of intelligent machines lead to speculation among architects about the exciting prospects of designing intelligent environments. This enthusiasm dwindled as the potential of artificial intelligence proved overstated due to misconceptions about 1) what is possible to achieve with computers and 2) the nature of intelligence itself. Vestigial traces of these original visions can still be seen in places as diverse as ecological building design and ubiquitous/pervasive computing research, even if no longer connected to their forebears. Although the computing machinery now available is orders of magnitude more powerful than that of the initial dreams and experiments, current applications lack the magic inherent in those earliest proposals.

Why is this? I propose that despite a firm grasp of what computers can do, approaches to intelligent environments are still wrought with a misconception about the nature of intelligence. This underlying assumption about what computers should do hampers the potential of a fruitful marriage between architecture and computing. What is needed is a path that bridges concerns in both the design of computing systems and the design of space. Henrí Lefebvre's dissection and discussion of space provide a rich framework to contemplate the intersection and overlap of architectural and computer mediated spaces. Lefebvre believes that any attempt to understand the contemporary world that ignores spatial considerations are both partial and incomplete. The meanings that we attribute to space are inextricably bound with our understandings of the world in which we live. Our basic understanding of the world originates from the sensory spatial relationship between our body and the world. Conversely, the computer is a product of "a nineteenth and early twentieth century scientized approach to the world: that mind is separable from body; that it is possible to understand a system by reducing it to its components and studying these components in isolation (that the whole is no more than the sum of its parts); that the

behavior of complex systems can be predicted."[1] While useful, I would like to suggest, that this is not necessarily the world in which we would like to live. If we combine the field of computing with a different set of underlying assumptions, we may be able to create a world that is more rich.

Recent advances in science support philosophies of mind that employ a different relationship between body and thought, organism and environment. Our understanding of space is directly related to our understanding of the space of our body, which has long been sundered in Western culture by the Cartesian duality. If we do not accept this separation, what is the resultant space? This new understanding can change the ways in which we live and imagine the present–including how we can use computational media as a 'tool for thinking' in the precipitant space.

2. Towards the age of ubiquitous computing

Technologies are not mere exterior aids but interior changes of consciousness that shape the way the world is experienced.[2] We are currently in the midst of a collective change of consciousness – the age of the information machine. The computer arises from Western scientific ideology which is built upon the assumption that the mind is separated from the body. The influence of this assumption is present at all levels of the technology, from the architectural level in the hardware/software split to the reduced set of body senses/ movements engaged by its interface. This conflict between the abstract and the embodied is beginning to take the stage of the everyday as the digital/informatic realms, which have been inherently abstract, come directly into contact with cultural forms which have traditionally been inherently bodily processes. As we enter the age of ubiquitous computing, where many small computers will be worn, carried or embedded into our everyday environment (as computers 'disappear'), we must be careful that the values they embody are not blindly incorporated into the environment as well.

Early development in information technology followed the legacy of industrial interface design. In the early 20th century, as automation replaced humans in the workplace, its goal was to eliminate participation wherever possible. Consideration for the user has lagged behind the need to interact with computers. Computer science has a history of venturing blindly into disciplines, wielding the authority of the capital used to finance its research. For example, years of computer animation research were conducted before any computer scientists had any meaningful interaction with an animator. While research in human-computer interaction has been fruitful in certain areas, such as visual displays, it is not prepared to take on the design of physical spaces. In his book Digital Ground, Malcolm McCullough states, "Notions of what a computer is have not kept pace with realities of how digital systems are applied." The use of computers has evolved from its origins in mainframe computing and one computer for many users to the current age of desktop computing, with a one-to-one ratio of computers to users. Recent trends in computing have given rise to a third age of computing, where many, possibly thousands, of small computers are worn and/ or embedded into the environment. In this age of ubiquitous or pervasive computing, the human/computer ratio jumps from 1:1 to 1:1000s. In some ways, it can be argued that the age of ubiquitous computing is well on its way. The average American already owns twenty or more computers, although most are devices that someone would normally not refer to as

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[1] see Penny, S. *The Virtualisation of Art Practice: Body Knowledge and the Engineering World View.* CAA Art Journal 1997, 30-38.

[2] see Ong, W. *Orality and Literacy*, London: Routledge, 1982

a computer. Televisions, VCRs or DVD players, microwave ovens, cell phones, as well as many components of modern automobiles (anti-lock brakes, fuel injection and climate control for example) contain information processing components. Even today, these computers, often referred to as embedded systems, are being produced at much higher volume (billions/year) than desktop PCs (millions/year). At the current moment, the vast majority of these computers act in isolation. However, in the future, an increasing number of computers embedded in the environment will be networked and communication, sensing and information processing will disappear into the environment. As information technology becomes part of the social infrastructure, it demands design consideration from a broad range of disciplines. Appropriateness now surpasses performance in importance in technological design. "Appropriateness is almost always a matter of context. We understand our better contexts as places, and we understand better design for places as architecture."[3]

How does the computer participate in the world it represents? This question illustrates the design challenge that results from the conflict between the "(quintessential) product of engineering" and all of the "spaces" that it inhabits. Computation is a fundamentally representational medium, and as the ways in which we interact with computers expands, so does the importance of attention paid to the duality of representation and participation. [4] The focus of this attention, and the place where this conflict is potentially best solved is at the interface, the point or area in which the person and computer come into contact.

Somewhat appropriately, 'context' is a popular topic in current ubiquitous or pervasive computing research. Most early papers, and even some recent ones, make a point to say that context is more than just location[5]. What is included in context changes from researcher to researcher, but a couple of other typical variables are time, identity, identity of others, etc. Location is often an (x,y) or latitude, longitude if using GPS. Sometimes location is specified by building or room. The overwhelming majority of these research environments are for work settings and are focused on applications such as "How can we tell when a meeting is taking place?" so that presumably it can be recorded.

Although it is a step forward that computing has realized the importance of the social, and has begun in its own way and with the aid of interdisciplinary researchers to understand it in relation to computing, it is primarily focused on work environments. Social and spatial interactions as they relate to the production of capital are important, not the implications of technology on the everyday. However, computing has become part of the ambient, social, and local provisions for everyday life and as such it becomes important to look at the larger impact of computation on culture. Computing has revolutionized almost every discipline, and is continually increasing its presence in day to day life. However, it reifies an ideology which subordinates the body and physical experience.

3. A new sense of space for computing

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[3] see McCullough, M. *Digital Ground: Architecture, Pervasive Computing, and Environmental Knowing*. Cambridge, MA: MIT Press, 2004

[4] see Dourish, P. *Where the Action Is The Foundations of Embodied Interaction.* Cambridge, MA: MIT Press, 2001

[5] see Abowd, G. and Mynatt, E. *Charting past, present, and future research in ubiquitous computing.* ACM Transactions on Computer-Human Interaction. Volume 7, Issue 1 March 2000, pp. 29-58

Lefebvre confronts considerations of space that reside "comfortably enough within the terms of mental (and therefore neo-Kantian or neo-Cartesian) space." His central claim, that space is a social product, directly challenges the predominate "idea that empty space is prior to whatever ends up filling it."[6] Lefebvre's re-conceptualization of space is, at least partially, related to his conception of the body and its place in Western culture.

> "Western philosophy has betrayed the body; it has actively participated in the great process of metaphorization that has abandoned the body; and it has denied the body." [7]

Lefebvre describes the body, as he does many things, in the form of a triad: perceived–conceived–lived. Introducing a third term into the equation already destabilizes any notions of Cartesian duality. The body, as simultaneous subject and object, "cannot tolerate such conceptual division,"[8] and can be liberated through a production of space. This occurs, in part, through the distinction between physical, social and mental space. Lefebvre states:

> Social space will be revealed in its particularity to the extent that it ceases to be indistinguishable from mental space (as defined by philosophers and mathematicians) on the one hand, and physical space (as defined by practico-sensory activity and the perception of 'nature') on the other.[9]

All interactions with computer systems are at some level a social activity. Computation can be both a tool of and structuring force behind the relationships between people, institutions and practice. Even if one uses a computer in isolation, there is a social interaction present between the user of the system and the designer of the system. A user only knows how to use a computer system through a shared set of social expectations. Empty space thickens when mixed with information, making space itself an interface, and thus part of social space.

The unique properties of social space allow it to become the site for reconciliation between the physical and the mental, concrete and abstract. Going one step further, social space can be broken down into the triad spatial practice–representations of space–representational space. Lefebvre describes each as follows[10]:

> 1. Spatial practice, which embraces production and reproduction, and the particular locations and spatial sets characteristic of each social formation. Spatial practice ensures continuity and some degree of cohesion. In terms of social space, and of each member of a given society's relationship to that space, this cohesion implies a guaranteed level of competence and a specific level of performance.
> 2. Representations of space, which are tied to the relations of production and to the 'order' which those relations impose, and hence to knowledge, to signs, to codes, and to 'frontal' relations.

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[6] see Lefebvre, H. *The Production of Space*. Malden, MA: Blackwell Publishing, 1974, p. 15

[7] Ibid., p. 407

[8] Ibid.,

[9] Ibid., p. 27

[10] Ibid., p. 33

> 3. Representational spaces, embodying complex symbolisms, sometimes coded, sometimes not, linked to the clandestine or underground side of social life, as also to art (which may come eventually to be defined less as a code of space than as a code of representational spaces).

Spatial practice is closely related to perceived space. It is the space secreted by society, recursively reifying it. It falls between daily routine and the infrastructure that allows it–the actual routes and networks that organize the daily routine. Ultimately, it is in spatial practice where the effects of ubiquitous or pervasive computing design will be felt and internalized. Computing is part of the infrastructure that organizes daily life.

Representations of space refers to conceived space. It is the space of scientists, architects, urban planners and all who privilege the cognitive over the perceptual or lived. It is the dominant space in our society, and it is the space of contemporary visual and computing cultures. It is a mental space separated from physical space, or abstract space imposed on concrete space.

Representational space corresponds to lived space, it is where meaning resides. It is "directly lived through its associated images and symbols."[11] It is the passively experienced space, which overlays physical space, which the imagination is able to change and appropriate. Representational spaces "tend toward more or less coherent systems of non-verbal symbols and signs."[12] Embodied interaction moves the design of computing systems from representations of space to representational space, from conceived to lived space.

These spaces are not always clearly differentiable, they overlap and intermingle in varying intensities. Lefebvre states that in order to understand these three moments of social space, one can map it to the body. The spatial terms (spatial practice, representations of space, representational space) are analogous to the bodily triad of perceived–conceived–lived.[13]

Table 1. Lefebvre's spatial and body triads.

Physical	Mental	Social
Spatial Practice	Representations of Space	Representational Space
Perceived	Conceived	Lived

Lefebvre seems to imply that these triads are in some ways analogous although different. If social space reconciles the duality of the mental and the physical with a nature that is both abstract and concrete, one may also argue that representational space holds a similar position between spatial practice and representations of space just as the lived does between the perceived and conceived. If all interactions with computer systems are social, and the social is the space of embodiment, where physical and mental co-mingle, this is where we should begin to rethink design. The layered interfusion of spaces presented by Lefebvre provides a rich framework for thinking about the possibilities of designing

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[11] Ibid.

[12] Ibid., p. 38

[13] Ibid., p. 40

computationally mediated environments as they extends into everyday space while simultaneously reflecting a careful negotiation between technology and human beings.