SUMMARY
- Asserts that embedding computers in the world will alter information designs for two-dimensional on-screen spaces
- Argues for incorporation of commercial design, cognitive psychology, and architectural and civil design theories

Metaphorical Confusion and Spatial Mapping in an Age of Ubiquitous Computing

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As our culture steps into an era of ubiquitous computing, technical communicators face the challenge of creating useful content on devices that move through space, pick up information from the surroundings, react to the environment, metaphorically mimic the real world, and—if we do our jobs well—help people navigate in both virtual and physical spaces. Any analysis of our rhetorical situation now must encompass the idea of *embeddedness*—that our content will incorporate information derived from the world around it, and that whatever content we create will be enmeshed in a community of smart appliances, continuous connections, and interconnected communication activities. As a result, we need to cope with two additional rhetorical challenges: spatially mixed metaphors and multiple spatial maps.

People have learned to live with but not necessarily enjoy the conflicting overtones of interface metaphors derived from various disciplines and earlier media, assembled in a rough collage on desktop computer screens. Now we are about to add new components into this collage by pointing to and interacting with the physical world through personal digital assistants, digital phones, and personal locators. As communicators, we may find ourselves longing to impose order, to establish a consistently meaningful metaphorical interface for the information collages we create. Instead, we should probably accept a certain degree of confusion as more of what we design becomes an accretion of images harking back to physical objects like books, photographs, desks, and windows, while also adding images and organizational concepts that represent roads, buildings, appliances, and machines in the real world around the user.

Rhetorically, we must deal with an urban synthesis of metaphor, a Times Square of flashing associations, intermixed languages and cultures, and the ongoing fusion of the past with the present and the projected future. Rhetoric, then, must recognize that users will likely be working with—and thinking with—spatially mixed metaphors.

In addition, our idea of the paths users take through our content must expand in three dimensions, evolving into spatial maps—the conceptions people form of their environment as they move through it on both physical and virtual paths.

EMBEDDEDNESS

The computers that now sit on our desktops or on our laps are fairly self-contained objects, unaware of the information-rich environments around them. They may be connected to the Internet or a local network that requires them to be dimly cognizant of their place as part of a larger, interconnected computing system. But the machines most of us use on a daily basis do not care if they are used in the morning in an office in Chicago, in the afternoon in a café in Tokyo, or while the user wanders around, lost in a Paris alleyway at 2:00 in the morning. Our computers don't know if they are being used inside a building, under a tree, or on the open sea; they don't know if we are using them while in motion or while standing still.

The general assumption behind the software design that supports most stationary computers is that the actual physical location of the hardware doesn't matter. There-

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fore, we designers and writers have focused on creating online information systems that assume almost no interaction between our systems and the physical world that surrounds the computers, operating systems, applications, and content. Individual users may interact a great deal with the machine itself and the software it contains, but the machines tend to encounter the world only through the limited input they receive through the keyboard, the modem, or some kind of pointing device (mouse, trackpad, joystick). With the advent of personal digital assistants and other small-scale, integrated computing and communication devices, the way we think about, use, and design information systems is about to change.

In the age of fully ubiquitous computing, computers will become embedded in our everyday existence, becoming yet another part of the information environment that already surrounds us in most urban clusters (Norman 1999). When we shrink our computers down to the size of headsets and watches, and allow them to continually interact with the world through Global Positioning Systems, cell-phone connections, radio transmission, or temperature sensors, we are forced to re-think how we design information for these devices.

SPATIALLY MIXED METAPHORS

When we design text, video, sound, and images for highly mobile computing devices such as a PDA (personal digital assistant), organizing the interaction between the physical, spatial, graphical, and textual elements in the system will be essential in ensuring the system's usefulness. Until now, when dealing with a slightly three-dimensional user interface presented on a two-dimensional screen, an understanding of how we interpret space and then form our memories based on those interpretations has obviously been useful, but it has not been crucial to the success of the system (Hamilton, Life, and Narborough-Hall 1990). However if the same system is then ported to a handheld device that actively interacts with the environment surrounding the user, then our knowledge of the cognitive relationship between spatial data and the recall and use of various pieces of previously stored data (textual, visual, aural) must be incorporated into every aspect of the system (Joyce 2000).

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If the information systems we design do not ensure a cohesive link between the information in the system, the visual, textual, and aural components that comprise the interface of the system itself and the environment surrounding the system as it is used, then the user may not be able to find what she is looking for, and what we have designed is therefore no longer an information system but simply an annoyance—a very expensive piece of junk.

Annoyances with the design of online information devices will become even more pronounced when online environments mimic three-dimensional objects and systems, especially if we take those information devices with us into the world as we use them (Greenhalgh 1999). To design effectively for these embedded computing systems, we must aim at integrating our individual information systems into the information fabric that already surrounds our users. To do so, we need to think of our information systems more in terms of spatial relationships and in terms of interactive, experiential environments and less in terms of printed, essentially linear and abstract text (Schmalstieg, Gervautz, and Hildebrand 1999). One of the primary aspects of communication we therefore need to rethink is our use of metaphor.

When complex graphical user interfaces first came into widespread use, users were often confronted with a confusing jumble of mixed textual and visual metaphors, and ineffective or highly misleading information design (Adler and Winograd 1992). As with most new communication media, confusion in design was often the result of the attempt to copy design and interaction metaphors from various fields. For example, the concept of "window" as an access metaphor is wonderfully adaptive and simplifying as an architectural metaphor for the way someone looks into and searches through a complex data storage system. However, in many cases the "windows" we deal with in a standard Windows, Macintosh, or other graphical user interface may also contain pages we write on, and pages we can "scroll" through. In this case the metaphor shifts from glass-like windows we look through to paper-like pages we read.

With windows, pages, and scrolls as metaphorical referents, a graphical user interface combines a number of elements that in some cases actually do behave like their real-world equivalents. We do write on and edit pages of paper in the real-world, and we write on and edit our pages in word-processing programs. We do look through windows to see what is outside, or when standing outside, we use windows to look in. The metaphors lifted from established forms such as manuscript scrolls, pieces of paper, bound books, and typewriters also provide a comforting transition for users who don't need to know or don't want to know what is really going on inside their computers when they use them (Andersen, Holmqvist, and Jensen 1993; Apple Computer Inc. 1992).

But then again, as has been aptly pointed out in the last few years of interface design critique and study, many of the system metaphors used in operating systems and individual software programs have begun to reach the end of their usefulness as our online environments and computer uses have become more complicated and diverse (Bernold 1988; Fleming 1998). The limitation of many current computer interfaces becomes even more apparent when we consider the use of three-dimensional interface design elements and the spatial metaphors and relationships they call to mind. For example, if we use windows to "see" into our computers as we search for data, then where, exactly are we standing? Are we actually looking into the computer? Or are we looking out from the computer? Does the "construct" of our operating system interface surround us as we look even more deeply into another part of the system, or are we instead surrounded by our data, looking out to where even more data is stored? And if the background on which we draw these windows is a desktop, then are we instead looking through moveable holes in our desks, into a limitless plane across which we have scattered an endless collection of information? Or are we looking down through our desks into a pit of stored data, therefore peering more and more deeply in search of the items for which we are searching? When we look through our computer windows, are we looking straight out, straight in, up, or down, or around the corner? And is the trashcan really standing on our desktop? Is the printer standing on the desktop as well, and if so, is the printer really the same size as the trashcan?

The conflicting metaphors of many graphical user interfaces have become the basis for a number of serious critiques of current computing systems (Lunenfeld 1999) and have also become the basis for a number of good cartoons. If nothing else, these interface conflicts make us aware of how much of our online lives are influenced, complicated, and constrained by metaphor (Lakoff and Johnson 1980).

The conflicts between the metaphors we use to describe and work with our information systems also suggest that as computing becomes increasingly embedded into the environments around us, designers and writers must use electronic images, text, and video to represent the way users move through the real dimensions of height, length, depth, and time. Additionally, truly adaptive systems for ubiquitous computing systems will need to provide a continuous representation of a user's progression through space and time, while monitoring such external factors as immediate weather conditions, season, and time of day. A ubiquitous computing system might also track changes in congestion patterns on the streets or in the subways, report on sudden structural changes in the urban infrastructure (construction sites, accidents, fires, and other emergency situations), and then use all that incoming information to help a user navigate through and learn from the environment. These new sources of information and the three-dimensionality of the data force consideration of metaphors that have depth, allowing users to fly through them, walk around them, probe inside them.

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Making this kind of virtual environment consistent with inherited metaphors such as windows, pages, and scrolls will probably not be possible; in fact, as we have already seen with personal computers, users may not like the mixed metaphors although they will work with them. They will learn to live with the complexities of the environment. Particularly in these early years of ubiquitous computing, we will be dealing with a multitude of spatially mixed metaphors as the environment expands and develops. However, as the medium matures, the mixture of metaphors will likely become increasingly more comprehensible and distinctive, in the way a city develops an understandable character from its mixture of spatial, social, linguistic, and organizational representations—the longer you live there, the more you understand how the entire urban environment functions, and the more predictable and cohesive it appears.

SPATIAL MAPS

Until recently, most rhetorical analysis of online information systems and online texts has arisen directly from theories associated with the printed page or from theories associated with other visual formats such as painting, still photography, film, and television (Laurel 1991). However, this close association with individual, mostly two-dimensional and one-way media of transmission and presentation tends to confine the discussion of online work within theoretical constraints that fail to account for much of what actually happens to text when it moves to an online environment, and such analysis is even more limited when we begin to evaluate and make design recommendations for computing that will actively interact with the surrounding spatial environment—a situation in which text is only a small component of our interpretation and work in the world (Gillette 2000). In this situation, our design aesthetics and techniques must become more interdisciplinary and inclusive (Rehling 1999).

In reaching beyond standard design theory derived from print, film, and television to incorporate theories from the domains of commercial design, cognitive psychology, and architectural, urban, and landscape design, we need to begin assembling a framework to support a new aspect of online rhetorical analysis. A rhetoric of mobile use would begin with traditional ideas of persuasion, discourse, and structure derived from an examination and development of speech, two-dimensional textual presentation on the printed page, the artist's canvas, and the television and movie screen. But a more expansive, inclusive rhetoric could open its scope of inquiry to include the rhetoric of interaction derived from narrative inter-communication in live theater, social interaction in architecture and urban design, and usability and human factors study, particularly as applied in the field of commercial design.

Building the entire framework for this wider rhetoric is obviously well beyond the scope of this article and is in fact a blossoming field of inquiry that should keep rhetoricians, writers, and designers busy for a long time to come. In this article, I simply want to point to how a concept such as spatial mapping demonstrates a rhetoric of mobile use that would of necessity need to borrow from interface design, cognition studies, and perception research.

When finding our way through information-rich, complex environments in search of information to lead us toward a desired, final destination, we rely on memories of past, similar experiences and memories gained from past, similar environments (Reed 1996). We depend on being able to interact (consciously and unconsciously) with the elements of the environment to receive additional (and, one hopes, helpful) information about how to focus our search. In many ways, the more interconnected and complex the environment is, the more options we have to choose from when looking for help when lost (Boud, Keogh, and Walker 1985).

When we arrive in a new city and have to make our way from the airport to a meeting in a downtown office building, we may become conscious of our search for information and our interaction with the world around us. We may even become aware of the process of making a map in our minds to help us find our way. Such maps are composed of the objects and people around us, linked to the information related to those objects and individuals (Norman 1982). On the other hand, if we are in our home town, heading to an office that we have visited many times before, then we can simply go straight to the destination without stopping to think about all the environmental, information-driven interactions taking place as we travel forward, effortlessly navigating time and space. Of course, the goal of an effective ubiquitous computing system would be to aid in this process and make this assistance, this provision of informative content, similarly invisible—a part of the background. But current, self-contained systems present many difficulties and cause irritation in such situations precisely because they are separate from the environment itself. They provide no spatial map of the surrounding world.

When searching for information using a mature technology we are familiar with (such as a book, a videotape, a card catalog), we are often only dimly aware of all the affordances that help us map our search (Norman and University of California San Diego Department of Cognitive Science 1990). Only when we encounter new environments and new technologies do we realize how interconnected and difficult a search for information can be. If the technology or environment is poorly defined or poorly constructed, we quickly become very aware of the limitations or confusions inherent in a technology that places a barrier between us and the information we seek (Chen and Hernon 1982).

If we are going to design systems that rely so much on spatial interactions and interconnectivity, and if we are trying to design a rhetoric that connects the visual with the textual in a new spatially informed context, we need to consider how we construct what we see and how we then use that construction, that spatial map, to navigate through various information-rich environments.

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THE CONSTRUCTION OF SIGHT

Informally, if pressed to explain the physical process involved with vision, we might use technological metaphors to describe what is happening. We might, for instance, represent the eye as a type of camera with a lens and a plane of film to record images that are then sent to the brain for processing. However, as Arnheim's studies have shown, vision is much more interactive, involving thought during perception, and a give-and-take like that suggested by Plato (Arnheim 1969). In *Visual intelligence*, Donald Hoffman suggests that Plato, like many people of his time and for many years afterward, thought of sight as highly interactive, actively engaging with the world around us. From *Timaeus*, Hoffman highlights this discussion of the processes that lead to "sight."

> *For the pure fire within us is akin to this, and they caused it to flow through the eyes. . . . Accordingly, whenever there is daylight round about, the visual current issues forth, like to like, and coalesces with it [i.e., daylight] and is formed into a single homogeneous body in a direct line with the eyes, in whatever quarter the stream issuing form within strikes on any object it encounters outside. So the whole [homogeneous body] . . . passes on the motions of anything it comes in contact with or that comes into contact with it, throughout the whole body, to the soul, and thus causes the sensation we call seeing. (quoted in Hoffman 1998, p. 65)*

Even though spatial mapping is probably not what Plato had in mind in his discussions, his metaphorical description of the interaction between the forms around us and the forms inside of us, constituting the action of "sight," could also be a method of understanding the way spatial mapping works when we navigate through an information environment. Also, in this description of seeing, Plato includes a vital element in the creation of a useful spatial map—the fourth dimension of time that in turn is connected to movement (Hoffman 1998).

Contemporary research on the brain suggests that we create spatial maps as part of our investigation of the physical world. A spatial map is more than a simple image in our mind showing us where things are located in three-dimensional space (height, length, depth). There is still an ongoing discussion about what part of the brain is responsible for building these spatial maps (also referred to as cognitive maps), but to a large degree, we all use the right hippocampus, a boomerang-shaped network buried deep in the brain, to orient ourselves in space.

Damage to the hippocampus can leave people helpless when placed in a new environment or when a familiar environment undergoes some kind of subtle but transforming change (the addition of a new building to a street, the removal of trees along a drive). The hippocampus in turn interacts with the right parietal and right prefrontal cortex at the forefront of the brain, which deal with higher level aspects of vision and are vital in transmitting information about the outside world to the hippocampus for orientation. Women and men appear to use different portions of these parts of the brain to chart the world around them, so how these parts of the brain really interact to help guide our orientation is quite complex and individualized, and not clearly understood. However, when dealing with higher level exploration of an environment, a good deal of the entire brain is used (Bloomer 1990).

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When putting a spatial map to use, we rely on the left parietal lobe to dictate our voluntary, conscious movement through space and our interaction with objects we encounter along the way. We use most of the rhinal cortex and the lower inner surface of the temporal lobes (the essential parts of the brain connected to perceptual and procedural learning) to construct and put to use memories that are vital in adding texture and meaningful complexity to our spatial maps.

Through the use of our limbic system, we develop emotional states and then use the neo-cortex when thinking through emotional responses to a series of events and interactions, and these responses in turn become part of the overall spatial maps we continually create. And finally, our memories are scattered throughout many diverse parts of the brain, so when calling on and putting to use a complex series of spatial maps, we may be making use of nearly all portions of our brain at once (Logie 1995).

As is apparent, truly understanding the actual physical processes behind the construction of our spatial maps can be bedevilingly complex and may always require an elaborate use of metaphor to explain what is really occurring inside the brain in place of a precise cataloging of how the brain interlinks millions of different electrochemical processes. But when we design a virtual environment or a virtual information object, using a solid operational conceptual metaphor may be very helpful in guiding users toward the information they seek in our complex online environments, especially as those online environments become increasingly able to mirror more and more of the actual heights, lengths, depths, and time that surround us.

For some, spatial maps are based on the geometric relationships between objects, while others base spatial maps on the ordering of landmarks, nodes, and boundaries (Cavanagh 1989). When we enter a new environment, we quickly create new spatial maps (often based on old or similar ones) to help orient ourselves with our new surroundings, and update old spatial maps when an environment we've become accustomed to has changed in some fundamental way. Without these existing spatial maps or the ability to create them afresh based on new experiences, we would continually be at a loss when moving through, interacting with, or understanding our surroundings (Lee 1988).

We often combine spatial maps as we use something or interact with something or someone, creating an intertextual, interwoven collection of memories (signs, symbols, and categories) that help us organize and differentiate everything we work with and travel through minute by minute when awake, and sometimes even when dreaming (Attneave 1972). We continually sort, classify, organize, define, distinguish, categorize, update, name, number, quantify, alphabetize, rank, and evaluate the world that we see, touch, hear, taste, smell, and experience, and all this information gathering and categorization is connected to the spaces we inhabit (Cheng 1985).

We remember not only where things are but how we moved toward them in space and time (or how they moved toward us), and what we were doing and thinking. When we put our book down, we not only remember what page we were on (which we may have also identified with a physical spatial mapping device—a pencil-shaped bookmark), but also how far we had progressed through the book itself (indicated by the thickness of the pile of pages to our left and to our right while reading). Stored with our memory of what we were reading last is also the spatial data surrounding the text as we read, data such as what was arranged on the shelf with the book when we pulled it down or what was sitting next to the book on the nightstand when we picked it up (Anderson 1983).

We create such spatial maps for actual books and for online books. We map our searches in real libraries, and we map our searches in Internet libraries. The process is continual, an ongoing exchange of metaphor-based relationships between the actual and the virtual, the known and the unknown. In fact, we employ spatial maps every time we use something or even think about using something (Aleksandrov and Gorskii 1991).

When designing an information system for use on a PDA or another mobile computing device, we may therefore need to consider the many different environments into which that device could be put to use, because unlike a book, the actual contents of the system may change relative to the spaces surrounding the system at the time. For example, our information system may be part of an interactive technical manual that changes in adapting to a construction site where the device is used for testing different materials. A similar system may appear on a battlefield where the device is used to diagnose the problems and suggest solutions for a malfunctioning tank. Or such a system might serve as a hiker's guide that continually orients itself in time and space using a GPS system connected to the device (Bretz 2000). Each new situation demands that we present a new spatial map allowing users to navigate back and forth between the real world and the electronic representation, mediating between the virtual and the actual by building a mental model of space and time, based on our suggestions and the user's own investigation of the environment.

CONCLUSION

As we begin to articulate a rhetoric for assessing the success and failures of designing mobile content, we need to confront three interconnected concepts. First, we must deal with the challenge of embeddedness, the fact that the device carrying our content also continually receives content from its surroundings. Second, because we will continue to inherit our interfaces and content from earlier media formats, we need to learn to accept that interfaces sometimes dramatically mix clashing metaphors, particularly as they refer to spatial characteristics. Third, as users begin to interact with our information systems as an invisible part of their environment, we will need to understand how to efficiently provide useful spatial maps to speed user access to the information they seek.

In the days of print, we learned how to make the most of white space on the page and how to best organize the pages themselves using various binding and presentation methods. Now, as we enter the age of ubiquitous computing, technical communicators will become increasingly involved with the space that has risen from the words on the page, from between the book covers, and separated itself from the computer screen to become part of the world that surrounds us all. TC

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