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Situated Technologies

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Abstract

Architecture's privileged position as the technology of space-making is challenged by the current proliferation of a wide range of mobile, embedded, networked and distributed media, communication and information systems. Our interactions with (and through) these location-based, context-aware and otherwise "situated" technologies are beginning to alter the way we perceive, navigate and socialize within the built environment. Prompting a reconfiguration of material boundaries, organizational adjacencies, and public/private relations, these technologies (and the ways in which we engage them) have significant implications for how we conceive, design and experience space. In this paper, we identify three vectors for architectural research that explore the spatial opportunities presented by what we call Situated Technologies. Working across the overlapping boundaries of media, architecture and computing, this research attempts to articulate how architects might play a critical role in shaping evolving techno-social spaces increasingly governed by both material and immaterial processes. As *exploratory* research, it aims less to propose solutions to known problems than to arrive at precise questions that help us better identify and structure new problems for architecture presented by recent developments in ubiquitous/pervasive computing.

Introduction

Mark Weiser begins his seminal 1991 paper on ubiquitous computing titled, "The Computer for the 21st Century," by suggesting that "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). With respect to ubiquitous/pervasive computing, this is literally true. As computing leaves the desktop screen and spills out into the world around us, information processing capacity becomes physically embedded into everyday artifacts, materials and spaces. Perhaps more profoundly, Weiser imagines this "disappearance" as constituting an ever-present instrumentality available to us wherever we go, remaining at the periphery of our awareness. Drawing a comparison with a walk in the woods, he contends "There is more available at our fingertips during a walk in the woods than in any computer system, yet people find a walk among trees relaxing and computers frustrating. Machines that fit the human environment, instead of forcing humans to enter theirs, will make using a computer as refreshing as taking a walk in the woods." Through this simple analogy, Weiser projects a future where the computer and computing dissolve into the environment. What are the implications for architecture of computing becoming environmental? How will this transformation influence the way we conceive, design and construct space?

In the passages that follow, we outline three research vectors that arise when architecture engages the affordances of ubiquitous/pervasive computing. The first concerns the (re)contextualization of information as it moves from atoms to bits and back again, making possible new forms of agency for networked artifacts, materials and spaces. The next addresses the changing nature of computer assisted design with the shift from representational problems to performative ones. Here a preoccupation with modeling reality gives way to allowing reality to become a model of itself. Finally, we consider how "situating" these technologies in terms of action and activity opens architecture up to an expanded range of material and immaterial "events" that take place within it. Rather than considering material artifacts as the sole means for organizing space, architecture is enabled to engage other spatial "actants" (Latour, 1992) including people, networks and information flows in shaping the experience of the built environment.

From Atoms to Bits (and back again)

If atoms are the basic unit of the physical world, then bits are that of the infosphere. From the Chinese abacus, to Jacquard's loom, to Hollerith's tabulators, to the Turing machine, Vannevar Bush's "Memex", the pocket calculator and the modern PC, the history of computing can be read as a series of increasing levels of abstraction from the world of atoms to that of bits. From encoding weaving patterns in punch cards to the development of autonomous agents exhibiting properties of intelligent life-forms, information has increasingly lost its body (Hayles, 1999) and the physical world has become subject to forms of symbolic manipulation that afford ever greater degrees of automation.

With the dawning age of ubiquitous/pervasive computing upon us, however, we find a turn in the other direction. This linear progression from atoms to bits is reversed, with bits moving back into an "embodied" world of atoms through mobile and embedded computing. Dichotomies of analog/digital, actual/virtual, material/immaterial dissolve in favor of a dialogue between them. No longer content to remain in the realm of symbols, ubiquitous/pervasive computing involves sensing the world, deliberating about it, and subsequently responding to it through material and immaterial means.

This shift is primarily enabled by two technological developments: the continued miniaturization of microprocessors and the development of low-power wireless networking. These technologies contribute to the development of embedded sensor networks (Motes, EmNets) that are locationally aware, reconfigurable and adaptable to changing environmental conditions (CNSEC, 2001). The miniaturization of the integrated circuit has made it possible to embed information processing capacity into devices that would otherwise not be considered "computers": microwave ovens, cell phones, cars, clothing, as well as traditional components of architecture such as windows, doors, walls, floors, roofs, facades and so on. Along with this miniaturization, the computational performance of these circuits has increased while the cost of their production and power consumption has decreased.

Likewise communication technologies, both wireline and wireless, have improved considerably. Land line fiber optic cables provide greater signal capacity through a process called wavelength-division multiplexing in which different colors in the optical spectrum are used to multiply the communication channels. At the same time wireless technologies have had to grapple with the scarce resource of the radio frequency spectrum resulting in short range wireless systems like wireless Ethernet or WiFi (IEEE 802.11 standard) and Bluetooth, which replaces cables and allows devices to talk to each other at short range. By spatially sequestering such communication networks, robust communication can be maintained. However, their application within larger geographies requires their ability to scale. To address this, Multi-hop Wireless Mesh Networking has been introduced to enable network data packets to be routed through intermediate network nodes over greater distances. In turn, this enables the communication spectrum to be divided up so that computational devices can take turns using it. This allows multiple devices to communicate through different parts of the spectrum (from infrared to radio) while also sharing information through data aggregation collaboratively processed at intermediate nodes.

The implementation of these technologies suggest a different topology than that of existing electronic networks. On the Internet, spatial location is to a large extent inconsequential. With situated networks, proximity becomes critical. Their limited range not only requires them to search out proximate devices to relay information across the network but also enables them to operate under lower power conditions. This emerging topology of embedded networks reinserts the local into the global informational network, and enables networked “things” to perform relative to the specific conditions of their location and context. Artifacts, materials and spaces that autonomously access and share information become possible, making them not only producers but also consumers of that information.

Bruno Latour’s description of “actants” that perform chains of “competences and actions” in a specific setting is a useful way to think about these networked “things” (Latour, 1992). Responsibilities are delegated to them, as with more mundane objects like automatic door openers and speed bumps, for example. Yet when these “things” are capable of altering their programmatic configuration and developing others—both through interactions with each other and with their environment—new forms of agency emerge. The emergent “sociality” of such non-human actants has profound implications for the types of spaces that we can imagine. Architecture becomes capable of engaging material, human and informational activity, making it potentially more responsive to the changing context(s) of its use and the environment within which it is situated.

From Tools to Environments: Simulation vs Emulation

To date, architecture has predominately engaged the computer as a tool. Simple uses include drawing, modeling, rendering and animating design propositions. More advanced applications include the study of algorithmic form and complex systems. Drawing on evolutionary principles, today’s use of modeling applications has led to a renewed interest in genetic algorithms, enabling programs to ‘learn’ and adapt themselves to changing conditions. With embedded computing,

however, new opportunities emerge for the design of buildings and spaces capable of responding to evolving events and activity within them. Here, the computer becomes less a tool for simulating evolutionary design, and more a medium for enabling buildings and spaces to evolve in the built environment.

Computer aided design has been preoccupied with representational problems since its beginnings with Ivan Sutherland's Sketchpad system of 1963. The pursuit of drawing and manipulating geometries has since led to more sophisticated computing tools that provide increased control for representing, visualizing and simulating reality. In all of these cases the screen has remained the interface for interacting with information while the computer's memory has been the source and generator for all displays of the data. However, when computational technologies are distributed into the materials of the spaces we inhabit, their situatedness provides a more complex relationship with information. Not only does the nature of the interface change but perhaps more importantly the generative capability of information. This inspires alternative forms of interaction in response to the contingencies and provocations of the lived environment.

It is important to distinguish computing from more traditional tools in order to understand why representation has been their focus. Woolgar (1987) suggests that for prosthetic tools (hammers and their like) the "extensions" of humans is limited to the mechanical abilities of the body, whereas computing "emulates action and performance previously accredited to unique human intellectual abilities." Computing and more specifically artificial intelligence (AI) invokes an extension or mirroring of our thinking, reasoning and decision-making capabilities. In the early years of computing research this potential was the basis for contemplating an entirely different set of tools. Negroponte's formulation for an Architecture Machine (1970) is one of the most coherent attempts at bringing out the reasoning capabilities of the computer for design. The architecture machine would "converse" with the designer of whom it had a precise predictive model such that it could read his/her gestures and body language. It "would be so personal that you would not be able to use someone else's machine... The dialogue would be so intimate - even exclusive - that only mutual persuasion and compromise would bring about ideas, ideas unrealizable by either conversant alone. No doubt, in such a symbiosis it would not be solely the human designer who would decide when the machine is relevant." [Negroponte, 1970, p.13] Such a machine would not simply be a means to carry out the designer's will but potentially capable of exerting its own into the mix. While the prototype of Negroponte's machine remains elusive it nonetheless spurred a particular way of thinking about design and how computing could assist in the process. A key concept in this was that in order for computers to reason about the world they had to be able to represent it. It also suggested that these representations needed to be our representations.

Mitchell, writing in 1977 about computer-aided design, suggests ways in which computing can become a means for reasoning about representations:

"it is useful to regard architectural design as a special kind of problem-solving process and to

discuss design within the framework of a general theory of problem-solving... It assumes that we can construct some kind of a representation of the system that interests us, and that problem-solving can be characterized as a process of searching through alternate states of the representation in order to discover a state that meets certain specified criteria." (Mitchell, 1977, p.27)

The computer's "intellectual" contribution to design would be as a "generative system", able to present the designer with alternative solutions to problems of her/his definition. Here architectural problem-solving is understood as "problem worrying" (Anderson 1966) and designing as "puzzle-making" (Van der Ryn 1966, Archea 1987) such that the computer is a means to explore different heuristics. This is done by generating through combinatorial and parametric variations different designs which are then evaluated by the designer or the computer. Mitchell argues that representations built by the designer in the computer can give "special insights into a problem, and significantly aid the process of solution generation. For example, representation in terms of some particular mathematical formalism allows known theorems associated with the formalism to be exploited in the design process, while representation by means of orthographic projections facilitates understanding spatial relations" (p. 38). Fast forward to our contemporary condition and the basic premise remains the same. However, now more sophisticated "hi-resolution" representations allow for evaluative criteria like structure, lighting, acoustics and airflow to be tested. Performance is invoked to suggest that a variety of quantifiable and qualifiable measures can be assessed from these generated solutions. While provocative, it is noted that more variety including "low resolution" representations are required in order to provide "a 'self-reflexive' discourse in which graphics actively shape the designer's thinking process" (Kolarevic 2005, p. 200).

While not dismissing the potential for design offered by such tools, Situated Technologies provide a different paradigm for computing and design. This rests on a shift from representing environments to performing (in) environments. Rather than trying to simulate the world, Situated Technologies use the world itself as a model. Computational intelligence is not employed to develop and sustain representations but to facilitate the performance of computational artifacts in context. Rodney Brooks in "Intelligence without representation" takes up this position to argue against representations as a basis for designing AI systems:

"The fundamental decomposition of the intelligent system is not into independent information processing units which must interface with each other via representations. Instead, the intelligent system is decomposed into independent and parallel activity producers which all interface directly to the world through perception and action, rather than interface to each other particularly much. The notions of central and peripheral systems evaporate. Everything is both central and peripheral." (p.149)

Brooks rejects the idea of needing a shared representation from which to work. He points to the fact that it is people that construct representations in computers and to assume that the perceptual world (Merkwelt) we provide is anything like the one we actually internally use is not clear. In

fact it may be that our representations are more a means to communicate our perceptions with each other rather than how we actually perceive. For the machine to reason it must develop its own cognitions of the world which our computing systems are unable to because “the problems of recognition, spatial understanding, dealing with sensor noise, partial models etc. are all ignored. These problems are relegated to the realm of input black boxes. Psychophysical evidence suggests they are all intimately tied up with the representation of the world used by an intelligent system” (p.143). Shunning a centralized approach wherein a perception module delivers a representation of the world to a central intelligence which processes that information and then has an action module carry it out, Brooks suggests a decentralized system wherein activity becomes the means to divide up the intelligent system. Such a “behavior producing system individually connects sensing to action... The advantage of this approach is that it gives an incremental path from very simple systems to complex autonomous intelligent agents. At each step of the way it is only necessary to build one small piece and interface it to an existing, working, complete intelligence” (p. 146-7). In contrast, he argues that decomposing a centralized system requires “a long chain of modules to connect perception to action.” By doing away with representation altogether Brooks presents a model of intelligence that is contingent on the world that it interacts with and is emergent: “There are no rules which need to be selected through pattern matching. There are no choices to be made. To a large extent the state of the world determines the action of the Creature. [Herbert] Simon noted that the complexity of behavior of a system was not necessarily inherent in the complexity of the creature, but perhaps in the complexity of the environment” (p. 149).

Situated Technologies shift the locus of our attention from the capability of individual tools to the networked behavior of multiple systems in the environment. Computationally augmented objects, “emulators” as opposed to simulators, provide a glimpse into the possibilities that such technologies might have as they become pervasive.

Two contrasting examples are the in-flight simulator and the Re-performance®.

In-flight simulators are aircraft augmentation technologies that alter the actual flying characteristics of a plane. They are used as training environments that can make the augmented planes perform like another plane. One application is the “Upset Recovery Training” program:

“The simulation computers of the Learjet are programmed to produce responses that simulate actual aircraft upsets that have resulted in accidents. These upsets include wake turbulence, icing, trim run-aways, control jams, CG shifts, engine failures and hydraulic failures. Real aircraft accelerations and actual out-the-window visuals produce pilot stresses that are hypothesized to result in a level of training that ground-based simulators can not achieve.” (p. 11)

Similarly, Re-performance® is a registered trademark of Zenph Studios famous for their “re-performance” of Glenn Gould’s 1955 recording of Bach’s Goldberg Variations. Zenph produces software that contains “every detail of how every note in the composition was played, including pedal actions, volume, and articulations – all with millisecond timings. These re-performance files can then be played back on a real acoustic piano fitted with sophisticated computers and

hardware, letting the listener “sit in the room” as if he or she were there when the original recording was made. Most importantly, the re-performance can be recorded afresh, using the latest microphones and recording techniques, to modernize monophonic or poor-quality recordings of beloved performances.” (<http://zenph.com/reperformance.html>) In both cases the complexity of the environment isn’t modeled but engaged such that heightened emotional response and open interactions are made possible.

From Objects to Events: Typological vs. Topological Form

Typology in architecture is invested in the idealization of form, involving taxonomic classification of characteristics common to groups of buildings including shape, organization of parts, construction, symbolic meaning, and use. Topology, on the other hand, refers more to the metrical, geometrical constraints and variables of form that change from one instance to the next. A topological approach to form emphasizes not the shape of an object, but rather its transformational potential and the multiplicity of forces at play in its creation. This requires thinking about forms processually, as events rather than objects, contingent upon the dynamics of their performance. This implies a shift in focus from “totalizing representations of the material object” to the “diverse procedures in which forms take shape” (Galloway, 2004).

Bernard Tschumi’s statement that “there is no architecture without program, without action, without event” recognizes the significance of how a space is used—the movement of bodies within it and the duration of their experience – for architecture’s “social relevance and formal invention” (Tschumi, 1994). For Tschumi this offers a means to interrogate a static view of architecture that aligns with ideas of solidity, stillness, coherence and continuity. In contrast he proposes a program of disjunction and dissociations that “trigger dynamic forces that expand into the whole architectural system, exploding its limits while suggesting a new definition.”

Situated Technologies extend this idea of a dynamic space inflected by its inhabitants to include forces that are neither spatially consequent nor temporally concurrent. They are capable of constructing co-present spatial relations that intergate geographically dispersed locales and can draw on a history of transactions stored within memory that have transpired within a given space. This is quite different from the “animate” or “non-standard” morphological experiments popular within contemporary “digital architecture” research. Such investigations are primarily interested in form-finding techniques with the “design space” of parametric modeling tools that involves the generation of an array of possible topological variations from which a single instance is selected and subsequently rendered in built form. By contrast, research within Situated Technologies looks to *perform* such morphological variations *over time* in *lived* space by using the components of architecture to organize various networks of relations between material, human and informational actants. Architecture can be sensitized to respond to different actants as diverse as the will of a group of people, the pollen in the air, the stock market index or the fluttering of a butterfly.

One consequence of this approach is that space-making becomes "participatory." For example, consider how certain spatial practices involving the use of mobile phones or portable audio devices like the iPod have altered the social space of cities and evidence new ways in which space may be *enacted*. As Bull (2000) has shown, people use portable audio devices in a variety of ways to manage the contingencies of everyday life. On the one hand, the popularity of the iPod points toward a desire to personalize the experience of the contemporary city with one's own private soundtrack. On the bus, in the park at lunch, while shopping in the deli – the city becomes a film for which you compose the soundtrack. These devices also provide varying degrees of privacy within urban space, affording the speaker/listener certain exceptions to conventions for social interaction within the public domain, absolving them from some responsibility for what is happening around them. Talking on a mobile phone while walking down the sidewalk, text-messaging with a friend while on the bus, or listening to an iPod on the subway are everyday practices for organizing space, time and the boundaries around the body in public.

In Japan, the mobile phone (or keitai) has been described by Kenichi Fujimoto as a personal "territory machine" capable of transforming any space – a subway train seat, a grocery store aisle, a street corner – into one's own room and personal paradise (Fujimoto, 2005). Mobile phones there are used less often for voice communications than for asynchronic exchanges of text and images between close circles of friends or associates - exchanges which interject new forms of privacy within otherwise public domains. So while traditional notions of so-called "cyberspace" promised to unlock us from the limitations of offline relationships and geographic constraints, keitai space flows in and out of ordinary, everyday activities, constantly shifting between virtual and actual realms. Mobile phones in this case are less discrete material interfaces to networked information spaces than they are performances, in that they enact new relations between people and spaces. What's interesting is not that urban space itself is changed, more that new hybrid spaces are performed/enacted through habits of mobile phone use.

When buildings and spaces engage these techno-social practices as forces to which they can respond – whether in material ways through mechanically actuating building components or through immaterial ones by manipulating lighting, sound or information flows – the architectural "system" is expanded to include "variables" beyond the limits of its current definition. Architecture, in effect, becomes engaged in a "conversation" with its inhabitants and their actions (Pask, 1969), and its "design" constantly evolves over a lifetime of use.

Conclusion

This paper has attempted to outline a series of transformations in the way we might conceive, design and construct architecture in an age of ubiquitous/pervasive computing. We call this new area of research "Situated Technologies." A key aspect of this research looks at a shift from representational to performative strategies. Here, space is less a static image than a "performance" that is continually evolving through purposeful and random means. Here, Situated Technologies are not simply instrumentalities but also actants in the complex process of space-making, a process that evolves over the lifetime of a building.

As exploratory research, it aims less to propose solutions to known problems than to arrive at precise questions that help us better identify and structure new problems for architecture presented by recent developments in ubiquitous/pervasive computing. New questions and problems include: How might we rethink the design of traditional building components such as windows, doors, walls, floors, roofs, and facades when they are enabled to autonomously access and share information about their states, environmental conditions, or patterns of use and activity? How might thinking about the role of computers and computing in ways aimed not just at simulating the world but also emulating it offer new possibilities to the design process? How might Situated Technologies expand the "architectural system" to incorporate forces and variables beyond the limits of its current definition?

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