The *Animated Work Environment*: A Design-Research Exemplar Supporting Social and Virtual Collaboration in an Increasingly Digital Society

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Abstract

While single-user computing via the Internet has established a powerful global link between people, it offers little to individuals working intensively and collaboratively with an array of tools, documents and materials in one physical space. This shortcoming in the everyday employment of Information Technology (IT) has prompted the architect-author to assemble a team of researchers to develop a physical, programmable work environment supporting both social and virtual collaboration in an increasingly digital society. The transdisciplinary team – architect, robotics engineer, human factors psychologist, and sociologist – envision the work environment less as a design product and more as the locus of interaction between people, software, information, machines, furniture, and other physical surroundings – a complex manifestation demanding the expertise of all four disciplines. The *Animated Work Environment* (AWE) project involves the designing, prototyping, demonstrating and evaluating of an articulated, programmable robot-environment with embedded IT. The development of AWE follows a careful design science research methodology involving early prototyping, scenario-generation, and three kinds of ethnographic investigation performed iteratively throughout the design process. This paper presents the developing full-scale, working AWE prototype and its programmable configurations. Such a design-research investigation redefines research in all four participating disciplines, here meeting to realize a complex, responsive, physical environment aimed at facilitating productivity, connectedness and innovation across fluid assemblages of people working in a variety of locations and settings.

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Introduction

Developments in computer and information technology continue to revolutionize many aspects of human existence, particularly with respect to the working life of many people. However, while more information is becoming available in increasingly smaller packages in ever more locations, the physical environments within which humans use the information for their work have remained largely static. Complex tasks, like those requiring non-trivial combinations of digital and printed matter, peer-to-peer collaboration within the computing environment, and tasks distributed across space and time, continue to be difficult to accomplish and a source of frustration for workers (Streitz 1997).

In this paper we present our efforts towards an alternative vision for working life in a digital society: what we call the "Animated Work Environment" or simply "AWE." AWE is envisioned as an intelligent, programmable physical space adjustable along a continuum, controlled by a user-friendly interface and embedded with IT (Information Technology). AWE takes advantage of recent advances in IT to integrate, within a programmable environment, multiple technologies such as flexible screens, input devices, and proximity sensors. AWE is viewed as part of a growing tendency within IT research which is concerned with various aspects of working life, including the use of multiple displays (Raskar et al. 1998; Wigdor et al. 2006), managing mixed-media (Luff et al. 2006), and managing healthcare records (Washington Medial Center, Microsoft Research 2004). AWE seeks to improve the quality of work, both "at work" and "at home," by intelligently adapting to work and leisure activities which employ digital technologies.

In particular, AWE builds on prior research in intelligent environments such as the *Interactive Workspaces Project* (Johanseon et al. 2002) and *Roomware* (Steitz et al. 2001). However, unlike these precedents which focus their concerns on the manipulation of information on computer screens of various kinds, AWE sits technologically at the interface between computer technology, architectural design and robotics, where the physical environment is also subject to manipulation. The AWE concept is inspired in part by William Mitchell's vision offered in "e-topia" (Mitchell 2000). Mitchell believes that "the building of the near future will function more and more like large computers" and that "our buildings will become…robots for living in" (Mitchell 2000).

The robotic dimension of the AWE project is enabled, in part, by recent progress in continuum robotics ([AUTHORS] 2006). Continuum robots (figure 1) feature continuous backbones, similar to elephant's trunks, as opposed to traditional rigid-link robots, similar to human arms. Continuum robots, which are readily scalable, offer the possibility of incorporating programmable smooth components into physical spaces. The concept of exploring continuum "links" to create active spaces has been explored by the group of Kas Oosterhuis at the Technical University of Delft, which has constructed programmable flexible spaces framed by continuum structures (Oosterhuis 2003). The AWE prototype presented here is, however, more complex, featuring in-concept continuum surfaces (figure 1) and focused on supporting and enhancing working life in an increasingly digital society. A further elaboration of the motivations for and ambitions of the AWE Project has previously been articulated in publications by the authors ([AUTHORS] 2006).

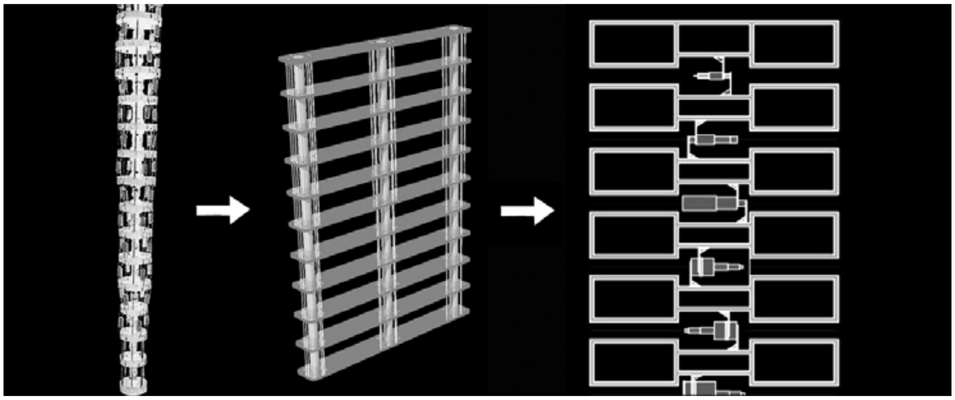

Figure 1. A translation of "invertebrate-like" continuum robot technology in the AWE project as considered in this paper: *left, a trunk-like form previously developed and extensively tested by the investigators; center, a planar surface as initially conceived for AWE; and right, a hybrid of these two at a different scale in the current AWE prototype.*

The AWE research project very much follows a design science research methodology, involving early prototyping and social science research of three kinds which inform iterative design developments. More specifically, the team's sociologists, early in the research cycle, performed phone and internet surveys of workers wants and practices, while the psychologists performed task analyses of workers representing a cross-section of working life. The outcomes of these two early ethnographic activities provided design parameters for developing the AWE prototypes. The psychologists have since performed usability testing, iteratively, in the developmental process of designing, analyzing and redesigning the AWE prototype.

A Physical AWE Prototype and its Six Programmable, Fine-Tunable Configurations

Our current prototype of AWE (figures 2 and 3) employs two key components: a vertical "spine" of eight stacked panels framed in aluminum, each 5-feet-wide and linked together by eight motors; and a horizontal work surface on wheels, of roughly a boomerang shape. On the vertical spine, mounted on the lowest frame, is an array of computer displays oriented in a concave, "wrap-around" configuration determined by the team to be most satisfying to users of multiple displays. The next-lowest panel has capacity for one or more such displays.

The six panels above these two lowest panels – all six having the same dimensions – contain smaller computer displays, tablets, magnetic white boards, audio and lighting and a large-format projection screen. We envision digital and analog tools as mounted to lightweight, plastic-metal-hybrid panels sized to match the dimensions of each of the six identical frames, and that these panelized tools are interchangeable. This construction would afford users the ability to plug-and-play the individual panelized tools into any of the six uppermost frames, as working tasks and leisure activities demand.


Figure 2. **The new AWE prototype.** [LEFT] *Eight aluminum frames and eight motors create the programmable "spine" of AWE. Larger computer displays occupy the lowest two frames; interchangeable panelized "tools" are "plug-and-played" into the upper six frames.*
Figure 3. **The new AWE prototype.** [RIGHT] *Under construction, showing 5 of its 8 panels.*

The advantage of the new prototype is that its programmable spine can be organized in several standard modes to create spatial configurations much more supportive of working and playing in a hybrid, digital-analog collaborative work environment. Six standard spatial configurations (see figure 4) are selected by the user from a touch screen mounted on the horizontal work surface. Once AWE assumes the selected spatial configuration, the user(s) can "fine-tune" the configuration to individual specifications by depressing AWE's touch sensors and saving the modified configuration under a new name (e.g. "COMPOSING – Laura and Steve"). As well, the horizontal work surface – structurally independent from the vertical spine assembly and equipped with casters (in our soon finalized physical rendition) – can be repositioned and rotated to create a physical environment more suited to, say, a presentation activity (figure 7, "5"). To continue to evaluate the efficacy of AWE, the human factors investigators iteratively submit the developing AWE prototype to usability testing as research milestones are reached.

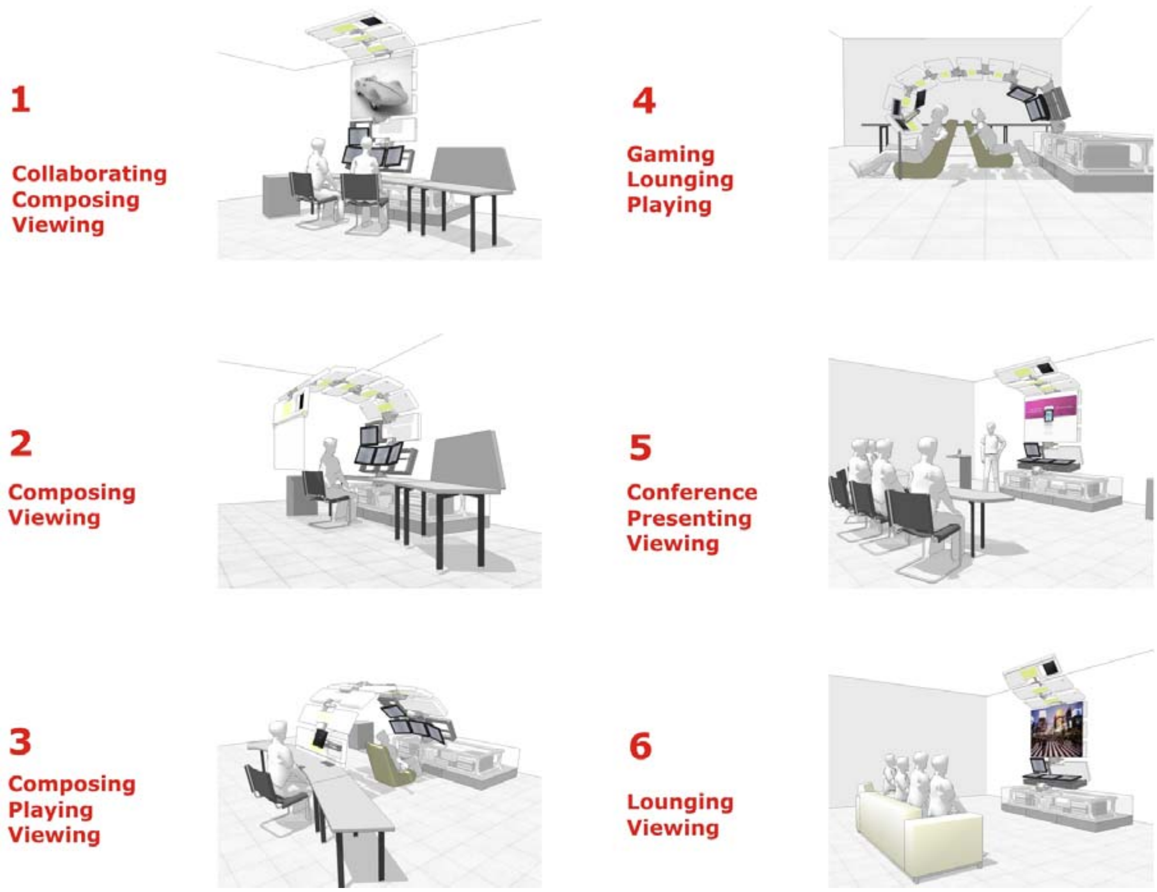

Figure 4. AWE. *The six standard configurations which can be fine-tuned by users.*

AWE as Exemplar of Design Science Research within the Discipline of Architecture

While it might be said that architects typically consider how users will engage works of their design, there is a fundamental difference in the case of this robot-architecture: the investigators are dealing with a responsive system actively engaged by, and interacting with the user, rather than a building engaged, wrote Walter Benjamin, "much less through rapt attention than by noticing the object in incidental fashion" (BENJAMIN, 1992). Unlike a conventional building, a robot-architecture and its users are bound together in a performance "by design." This makes a robot-architecture much more like a cell phone or an automobile than a building: a tool that enables the productive and dynamic interaction between people and things in the world.

A robot-architecture must reach beyond simplistic formal ambitions; it must instead explore ways for improving life, for developing existing living spaces, and for enhancing human interaction. This is not the utopian dream of the early twentieth century in which technology and architecture were expected to transform, absolutely, everyday reality. Instead, architecture and technology and, here particularly, a robot-architecture-hybrid must support human activity, respond naturally, and perform according to our necessities.

Responses to life problems and opportunities must not come from a computational or robotic or architectural solution itself, but rather through the way IT technologies, embedded in architecture, help forward the interaction across people and their surroundings to create places of social and psychological significance. For philosopher Andrew Feenberg, "technology is not simply a means but has become an environment, a way of life" (FEENBERG, 2002). Clearly, a robot-architecture is more than an aesthetic search, a stylistic possibility, or a technological quest; it is, instead, a way to develop new spatial patterns in support of human activities.

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