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EXPERIENTIAL MEDIA SYSTEMS

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Definition: *Experiential media systems refer to new, complementary model of media computing, which allows us to develop a rich contextual understanding of human activity, at different scales of time and space, as well as affect human activity in a radically new way.*

Our civilization is currently undergoing major changes. Traditionally, human beings acquired knowledge through experiential interactions with the physical world. That knowledge allowed them to better adapt to their reality and evolve. Today our interactions with almost every element of our lives (health, weather, economic and social policy, communication) involve computation and mediated information. However, we still lack effective ways of connecting our computational approaches with our physical experience. To achieve knowledge of our new world and significantly improve our condition we need unified experiences of the physical and computational forces that are shaping our reality.

Experiential media systems refer to new, complementary model of media computing. In the traditional multimedia computing model (e.g. the creation / consumption of a video), capture, analysis, and media consumption are not co-located, synchronous or integrated. We are, however, witnessing a rapid decline in cost of sensing, storage [10], computing and display. Thus, sensors (audio, video, pressure, tangible), computing, ambient visual and sound displays and other feedback devices (vibration, light, heat) can now be co-located in the same physical environment, creating a real-time feedback loop. This allows us to develop a rich contextual understanding of human activity, at different scales of time and space, as well as affect human activity in a radically new way. The goal is to achieve enhanced, user-oriented, unified physical-digital experiences. These media systems will give rise to a new set of multimedia applications grounded in human activity in the physical world.

Experiential media applications

We now briefly discuss on three application areas of societal significance – health, education and everyday living as the driving force for the development of these new media systems. In the health domain these systems can reveal new frameworks for successful interactive biofeedback for rehabilitation. In education, examples include hybrid physical digital environments that enable children to acquire complex concepts in science through natural interfaces and social interaction. In social communication and everyday living, experiential media can summarize human activity and present it as part of the physical environment to reveal the situated context in which it has occurred. We have been working on developing initial prototypes of experiential media systems [14,17]. Our efforts in our application areas include (see Figure 1):

- Biofeedback: We have been working on developing an experiential media system that integrates task dependent physical therapy and cognitive stimuli within an interactive, multimodal environment. The environment provides a purposeful, engaging, visual and auditory scene in which patients can practice functional therapeutic reaching tasks, while receiving different types of simultaneous feedback indicating measures of both performance and results.

- Systems for Everyday Living: We are investigating novel forms of media interaction frameworks (incorporating gestures, tangible interfaces), that use media from everyday user activities [3]. In our current work, we have built a real-time, mediated environment that uses tangible interfaces for facilitating social communication [17].

- Experiential education: We are currently investigating the creation of experiential frameworks for pattern awareness in movement and in shape, for children. In our current work, fused vision and audio sensing is coupled to a system modeling gravity. This helps drive a generative model for audio-visual immersion that is cognitively consistent with the underlying physics concepts.

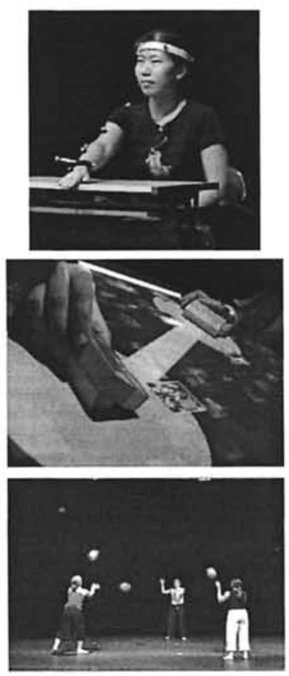

Figure 1. Top: biofeedback, Middle: tangible interfaces, Bottom: experiential education.

We note that these applications are example starting points for research in experiential media. In due course a number of new and exciting applications will emerge within these areas. They include novel interfaces for real time monitoring of patient performance by clinicians and therapists, interactive multimedia for math and teacher education, assisted home living for the elderly, and robotic assistance in navigation. Research and education activities will result in generic frameworks that can also be applied to other problem areas such as intuitive navigation of large scale data sets and new classes of interfaces for fast solutions to complex science problems (i.e. electromagnetic interference in integrated circuits). Figure 2 illustrates tangible interfaces for shared media browsing.

Figure 2. Tangible interfaces for shared media browsing.

Motivating ideas

Experiential media analysis has been motivated by research in artificial intelligence, distributed cognition, human computer interaction / ubiquitous computing as they relate to the physical world.

Artificial Intelligence

There are two research areas in AI that are particularly relevant – robotics [4,5] and bounded rationality [21]. Rodney Brooks' robots essentially contained a set of loosely interacting behaviors (move left leg, avoid obstacles etc.), that were implemented in hardware with short paths from sensors to actuators. The behaviors were all simultaneously active, but there was a hardwired arbitration amongst them. They had no centralized reasoning unit or stored abstract representation of the world. The resulting robots seemed to be "intelligent" to human observers and were capable of complex behavior in the real world spaces. There are three crucial ideas here – situatedness, embodiment and intelligence. Situatedness is the idea that rather using an abstract stored representation of the world, "the world is its own best model" [5] – the current state of the world is responded to by the robot (via the behaviors). Embodiment is the idea that physical grounding is crucial to intelligence and finally the last idea is that intelligence emerges though the dynamics of interaction with the world. Reactivity is another important idea [5] – the ability of the robot to be able to respond to the world in a timely manner is an important aspect of intelligence. Russell's work on bounded rationality [21] deals with finding programs that maximize the expected utility given the machine and the environment – i.e. the ability to generate maximally successful behavior given available information and computing resources. However, Russell's work deals with abstract dis-embodied agents.

Distributed Cognition

There are three important ideas here [11,13] – (a) cognition may be distributed across members of a social network, (b) cognition results as a consequence of coordination between external and internal structures (c) processes may be distributed over time to affect later events. Hutchins [13] provides the example of a ship navigation to illustrate that different sailors have very specialized tasks that must be carefully coordinated for the ship to navigate safely. An example of how cognition is distributed in space (external) as well as internally – we will often rearrange objects on our desk until an arrangement solves a task like a search – indeed our "messy" work environments are often best suited to finding our belongings. In general, we will *adapt the environment* to solve the cognitive task, rather than solve it entirely in our heads [20].

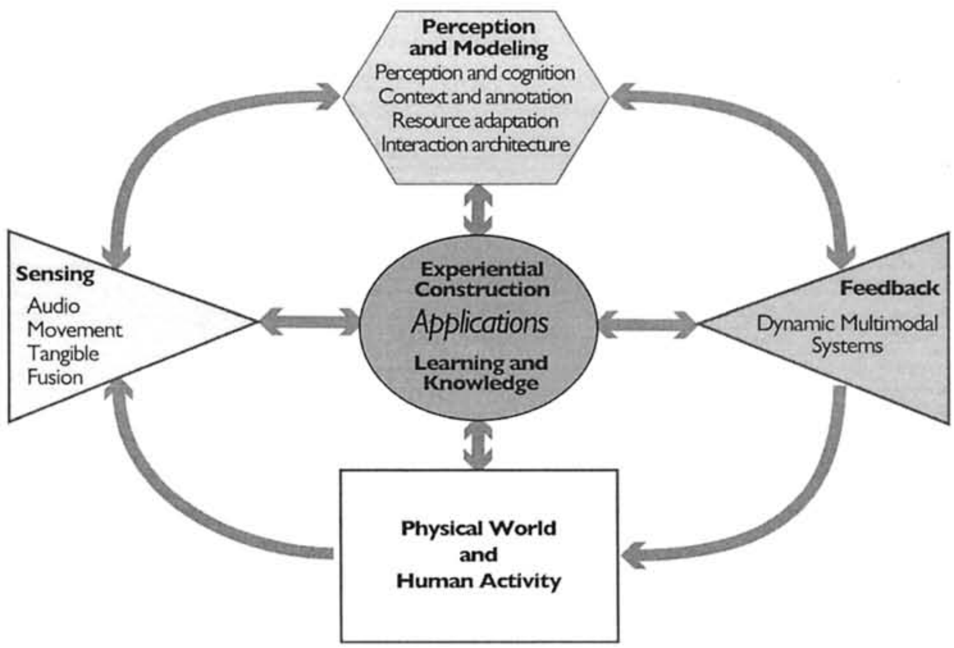

Figure 3. The functional description of an experiential media system.

Human Computer Interaction

Tangible interfaces [15] are an emerging area of interest in the HCI community. They deal with using physical artifacts for both representation and control of media. These interfaces allow us to leverage our extant understanding of the physical world (ability to pick up objects, move objects etc.) to manipulate media. Dourish [9] suggests that in an embodied system – meaning and action are tightly bound together – meaning is an emergent process and achieved through action. Lucy Suchman's work [22] showed that everyday human activities did not have the detailed level of planning found in AI based approaches – indeed they revealed that while human beings may have long term goals such as "I'm going to work" etc. the details of the action are highly improvisatory in nature. For example, you decide to walk to work instead of using the car, then stop by at the coffee shop to pick up some coffee, and then stop to chat with a colleague before heading off to your physical office. She concluded situational resources rather than detailed plans, play an important role in determining human action.

Ubiquitous computing

Marc Weiser's vision [2,23,24] has resulted is many parallel research efforts primarily centered around paradigms of human computer interaction in moving computing away from the desktop [12,19] and context awareness [6,7,8] (limited to location and activity). Importantly, ubiquitous computing has not dealt with research issues concerned with multi-sensory analysis to help us understand the semantics of the interaction.

Summary

A central idea that emerges from these different disciplines is that human activity in the physical world is highly contextualized on the current situational resources. Embodiment allows us to distribute cognitive loads to the environment and also manipulate it to simplify tasks. Meaning can be distributed within a social network, and emerges through dynamic interaction with the environment. Finally, interactions with the environment must be reactive – they must occur in real-time.

The creation of experiential media; challenges and proposed solutions

The development of experiential media systems requires highly integrated research across five areas (see Figure 3).

1. Sensing: multiple types of electronic sensors must be used for sensing and recording the physical world and most importantly human activity. Movement and audio sensing through sensor arrays, pressure and tangible sensors/control devices and multisensory integration and sensor fusion constitute the focal points of our work in this area.

2. Perception and Modeling: The computational modeling of human functioning and sensing allows cognitive and perceptual principles to be incorporated into the design and analysis of control and feedback systems. A clear understanding of cognitive and perceptual capabilities and tendencies, as well as limitations and biases, will be achieved through mathematical modeling and validity testing in the design of new hybrid multimedia systems and interfaces. This will be coupled with research on context representation, annotation, resource adaptation, interaction architectures and computational modeling to optimize the ecological coupling between users and systems. The impact will be to facilitate a cognitively consistent real-time coupling between human action and media perception.

3. Feedback: Appropriate devices and modes of communication must be developed for optimally connecting user(s) into the experiential media environment. The development of dynamic, multimodal feedback systems will allow for content and choice of devices that can adapt and change continuously in congruence with information derived from sensing and modeling areas and the evolving human activity.

4. Experiential construction: The work of the above three areas must be integrally combined with the physical world to produce an enhanced, user-oriented,

physical-digital experience that naturally couples human activity and that can produce new horizons of knowledge and human experience.

5. Learning and knowledge: The knowledge produced by the resulting physical-digital experience must be evaluated. Weaknesses per component or in the integration of the components must be identified and solutions for improvement and optimization must be developed collaborative with all members of the team creating the system. Avenues for further evolution of the system and its functioning and learning potential must be identified and tested.

What is the Expertise Needed? The knowledge required to create experiential media systems is fragmented across disciplines. Technological sensing and modeling expertise traditionally lies primarily within engineering. Media communication and experiential construction and design expertise traditionally lies within the arts. Perception, cognition, and learning modeling expertise traditionally lies within psychology and education. Therefore experts from these disciplines will comprise the core of a large interconnected network of experts necessary for experiential media research. Other disciplinary experts are vital to the development of specific applications and thus the network needs to embrace a range of additional specialty members on those projects. For example, in biofeedback for rehabilitation medical doctors, and physical therapists are included as integral contributors.

Current Media Development: The traditional media computing model has led to the development of tools and content within disciplinary silos. Media tools are mostly created by engineers who focus on data and information processing often without considering user behavior and meaningful communication. Perceptual and cognitive optimization modeling often remains theoretical and incorporation and real-world usability testing of developed principles varies widely. Much of the media content is created by artists and designers with limited training in computation, perception and learning. Psychologists and educators are increasingly using media in their work but their relationship to media development is often one of a client rather than a contributor. Marc Weiser's vision [2,23] addressed many parallel research efforts primarily centered around paradigms of HCI / computing away from the desktop [12] and context awareness [8] (limited to location and activity). While there are wonderful examples of interaction design [15,16], we do not have a principled research framework that integrates knowledge from across disciplines to create experiential media systems.

Interdisciplinary efforts have played a significant role in media development. There have been a number of significant efforts in the past 30 years to bring engineering, arts and sciences together for the creation of new media tools and content. Among them are the MIT Media Lab, the CMU Entertainment Technologies Lab, IRCAM at Centre Pompidou and the CCRMA at Stanford. Projects produced there by a collaboration of traditional artists with traditional engineers resulted only in re-working of existing knowledge. Importantly however, there are a small number of researchers with interdisciplinary engineering-science-arts training, from these institutions, who spearheaded collaborations with a major impact. Miller Puckette, a Professor of Music and Computer Science (UCSD), is a scientist also trained in music who lead the development of the

MAX/MSP [1] software tools for interactive audio/visual creation and manipulation while at IRCAM. Psychologist Steven McAdams, who headed many successful collaborative psychology-engineering-arts projects at IRCAM [18], has a PhD in psychology with specialization in music cognition and has working knowledge of digital signal processing and electronic music composition. The "Beyond Productivity" report of the NRC committee on information technology and creativity suggests that hybrid training across engineering, science and art can produce important innovations in information technology.

The development of experiential media systems must be achieved through the training of a new generation of hybrid media engineers-scientists-artists who approach the issue of media development as an integrated multidisciplinary process. These new media scientists need to: (a) combine discipline specific training in one of the key contributing research areas (sensing, perception, modeling, feedback, experiential construction, learning), with broad understanding of the other research areas; (b) have working knowledge of the connections that exist between the constituting areas; and (c) be able to apply their knowledge to the collaborative creation of physical-digital media systems. The proposed training and development requires a large interdisciplinary network of faculty and students covering all areas of necessary expertise as well as a common integrative research and education agenda for this network. The Arts, Media and Engineering Program at Arizona State University has a research and educational mission that integrates the required expertise for development of experiential media.

Experiential media can provide a space for imagination and reflection in new and insightful ways. They will allow us to better understand, express and communicate our current experiences and gradually develop into skillful mediated communicators and storytellers. The dynamic, customizable nature of experiential media will increase diversity in expression and communication and encourage personalized active learning. Experiential media in medical rehabilitation will allow for easier, faster, customizable, substantial training of patients and for increased recapturing of lost functions. Enhanced individual expressive and communication abilities will improve psychotherapy and social work. Mediated art forms will be able to holistically investigate and represent today's experiences rather than those of the past. Experiential media can greatly facilitate communication, increase knowledge in all facets of our lives and improve understanding across our global communities.

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EXTENSIBLE STYLESHEET LANGUAGE

Definition: *The Extensible Stylesheet Language or XSL is a W3C recommendation used for formatting Extensible Markup Language (XML) documents for displaying or reformatting the XML, perhaps using a different schema.*

Since XML is gaining wide acceptance for data interchange, in particular on the Internet, XSL is of great value for translating documents from one XML dialect to another. Highly optimized XSL transformation (XSLT) engines are available on a wide range of platforms (e.g. Java, .Net, Perl) for this purpose.

The XSL syntax is itself XML compliant, and many development tools are available for authoring and debugging XSL transformations. The language is template based as opposed to procedural, and relies heavily on XPATH to select relevant segments of XML documents upon which to perform operations. The resulting output format for XSL can be XML, HTML, or plain text with a range of character encoding and formatting options (see Figure 1.)

For any application that uses XML for data input and output, XSL is the most efficient and platform-independent tool available to enable interoperability with other such applications. The other main benefit of XSL is to separate content from presentation. The source XML data can be transformed through one of several styles to create suitable renderings or user interfaces for a wide range of devices.

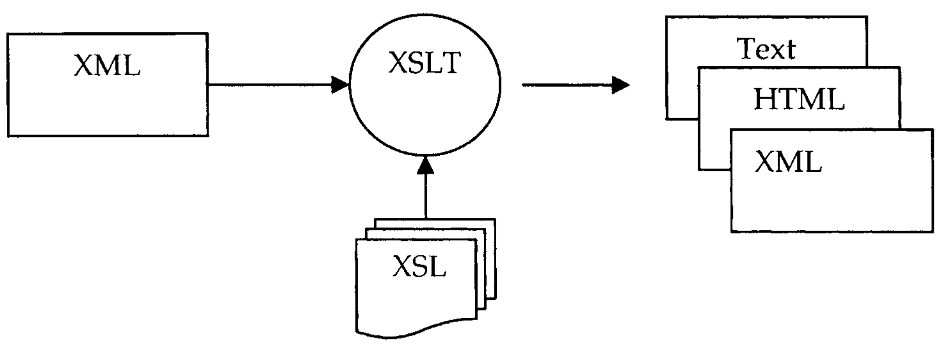

Figure 1. Transforming an XML document using XSL to create alternative representations.

See: Multimedia Content Adaptation

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