A Distributed Cognition and HCI Perspective on Design for Software-Intensive Systems

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There is currently a shift in cognitive science away from the notion of cognition as a property of isolated individuals and toward a view of cognition as a property of larger social and technical systems [9, 2, 8]. This extends the reach of cognition to encompass interactions between people as well as interactions with resources in the environment. As a consequence, the human body and the material world take on central rather than peripheral roles. As Andy Clark put it, "To thus take the body and world seriously is to invite an emergentist perspective on many key phenomena - to see adaptive success as inhering as much in the complex interactions among body, world, and brain as in the inner processes bounded by the skin and skull." [2]

This new perspective on cognition is emerging from the fields of distributed cognition [9, 6] and embodied interaction [2, 13, 5]. It has fundamental implications for the design of software-intensive systems and should be represented in a workshop such as is being proposed.

There are many new challenges that make this a most propitious time to convene a workshop about design. A central one is that the miniaturization and commoditization of computing components, the unbundeling of the monolithic computer into fragmentary pieces (e.g., laptops, cellphones, PDAs, etc.), and the explosion of wireless connectivity is enabling a world in which computing is ubiquitous and in which new work and living practices are rapidly evolving. Advances in design of software systems will increasingly require that we better understand the emerging dynamic of interaction in which the focus task is no longer confined to the desktop but reaches into a complex networked world of people, information, computer-mediated interactions, and computationally-augmented environments.

The history of computing hardware can be summarized as a progression from a focus on low-level components towards integration on larger and larger scales, from vacuum tubes and transistors to LSI, VLSI, chipsets, personal computers, LANs, WANs, and now the global internet. But this machine-oriented view is far too narrow, because progression on the human side has been at least as dramatic and important, from isolated single users, to timesharing, to groupware and support for community activities, to the frontier where ubiquitous, wireless, context-aware multimodal mobile computing enables currently unknown social possibilities. There are certainly exciting implications for myriad areas; on the other hand, the landscape is littered with failed schemes, from the ambitions of early AI to the recent dot.com meltdown. Better understanding of cognition and social interaction is absolutely key to unlocking the mysteries surrounding these enormous opportunities and avoiding the myriad dangers.

Claims are often made that better engineering will solve design problems, or better management, or progress in basic technical areas such as distributed algorithms or user interface design. No doubt all this will help, but until we extend our view of cognition to encompass interactions between people as well as with material resources in the environment, progress will be heavily interleaved with failure, and will continue be very expensive when it does occur.

To improve design practice and ensure that applications evolve to effectively support users requires a data-driven iterative process. Although user-centered design is increasingly a component of software development, it too often involves only brief periods of application testing, in artificial settings, and rarely examines the wider community context. Although it is well documented [10, 12] that user-informed design improves usability, unless we understand the overall context of real use and make detailed data collection and analysis a part of design we are unlikely to develop the scientific foundation needed to support principled design.

There are numerous important issues that this workshop should address. In addition to a host of issues such as whether research should be approached in small-science or big-science ways, how open source development bears on design, three I think are particularly essential to address are:

1. The Cultural Chasm Between Design Disciplines

   There is a cultural chasm to be bridged between design disciplines; not just one of terminology, but one of what questions each discipline holds as essential. There is a crucial need to begin to develop a shared research agenda.

2. A Central Role for Cognitive Ethnography in Design

   An examination of cognition situated in interactions with the social and material world narrows the gap between thought and action. Doing is a kind of

thinking and thinking is doing. Perception and action turn out to be more closely related than had previously been thought [3]. The examination of real-world activity can reveal the nature of this linkage [7]. These considerations create a demand for ethnographic studies that focus on cognitive processes as they are enacted in naturally situated activity. A methodology of cognitive ethnography closely integrated with design activities is essential to scientific progress. In addition, digital media have now reached a level of maturity and availability that make it possible to develop powerful tools to support all aspects of the ethnographic enterprise. Digital representations of activity can be combined and transformed in ways that make visible many otherwise invisible phenomena. In the history of science, changes in the means of creating and manipulating representations have often led to changes in theory. The ability to record, view, and re-view the fine detail of action in meaningful settings has made it possible to *see* the phenomena at the core of embodied, situated, and distributed cognition. New recognition algorithms promise to extend this view by adding automatic recognition, tracking, and summarization of meaningful components of video and audio data.

3. New Interdisciplinary Education and Training Programs for Design

   A number of large corporations (e.g., Xerox, Microsoft, Intel, Kodak) have attempted to bring ethnographic methods into their design cycle, but as yet, the techniques lack maturity. While there is growing appreciation for the importance of ethnography for system and interface design [1, 5, 8], there is a lack of graduate programs capable of providing the training necessary for effective and efficient ethnographically-driven design.

Author Background

After completing a Ph.D. in cognitive psychology at the University of Florida and a postdoctoral fellowship in artificial intelligence at Stanford University, I was on the faculty at the University of California, San Diego for a decade. Along with Ed Hutchins and Don Norman, I led the Intelligent Systems Group in the Institute for Cognitive Science at UCSD and the Future Technologies Group at NPRDC. I left UCSD to become Director of the MCC Human Interface Laboratory and subsequently established the Computer Graphics and Interactive Media Research Group at Bellcore. In 1993, I moved to the University of New Mexico as Chair of the Computer Science Department. In 1997, I returned to UCSD as Professor of Cognitive Science. In collaboration with Ed Hutchins, I direct the Distributed Cognition and Human-Computer Interaction Lab.

My research explores the cognitive consequences of computationally-based media. It is motivated by a belief that we are at the beginning of what may be a paradigm shift in thinking about information, one that starts to view information as being more dynamic and reactive to the nature of our tasks, activities, and even relationships with others. The research goal is to understand dynamic interactive representations, their cognitive and computational characteristics, and how they can change the structuring of tasks and mediate performance.

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REFERENCES

[1] Beyer, H., and Holtzblatt, K. *Contextual Design*. Morgan Kaufman, 1998.

[2] Clark, A. *Being There: Putting Brain, Body and World Together Again*. MIT Press, 1997.

[3] Clark, A. *Mindware*. Oxford University Press, 2001.

[4] Cole, M., Hood, L., and McDermott, R. Concepts of ecological validity: Their differing implications for comparative cognitive research. In *Mind, Culture, and Activity* (1997), M. Cole, Y. Engestrom, and O. Vasquez, Eds., Cambridge University Press.

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

[6] Goodwin, C. Gesture, aphasia, and interaction. In *Language and Gesture* (2000), D. McNeill, Ed., Cambridge University Press.

[7] Goodwin, C., and Goodwin, M. Emotion within situated activity. In *Linguistic Anthropology: A Reader* (2001), A. Duranti, Ed., Blackwell, pp. 239–257.

[8] Hollan, J., Hutchins, E., and Kirsh, D. Distributed cognition: Toward a new theoretical foundation for human-computer interaction research. *ACM Transactions on Human-Computer Interaction* (2000), 174–196.

[9] Hutchins, E. *Cognition in the Wild*. MIT Press, Cambridge, 1995.

[10] Myers, B., Hollan, J., and Cruz, I. Strategic directions in human computer interaction. *ACM Computing Surveys 28*, 4 (1996), 794–809.

[11] Neisser, U. Memory: What are the important questions? In *Memory Observed* (1982), U. Neisser, Ed., pp. 3–20.

[12] Nielsen, J. *Usability Engineering*. Academic Press, 1993.

[13] Nunez, R. Could the future taste purple? reclaiming mind, body and cognition. *Journal of Consciousness Studies 6* (1999), 41–60.