

A Research Agenda for Highly Effective Human-Computer Interaction: Useful, Usable, and Universal

****Interim Report****

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Foreword: The ACM SIGCHI (Association for Computing Machinery Special Interest Group in Computer Human Interaction) community conducted a deliberative process involving a high-visibility committee, a day-long workshop at CHI99 (Pittsburgh, PA, May 15, 1999) and a collaborative authoring process. This interim report is offered to produce further discussion and input leading to endorsement by the SIGCHI Executive Committee and then other professional societies. The scope of this research agenda included advanced information and communications technology research that could yield benefits over the next two to five years.

The participants included representatives from several countries, but this draft needs refinement to satisfy the unique situations of each nation and each situation.

Introduction

Research in information and communications technologies has produced advanced networking, high performance hardware, and powerful software environments. However, too often we lose the benefits of these technologies because the user interfaces are poor. A comprehensive plan of research in Human-Computer Interaction (HCI) will ensure that users and organizations derive the full benefits of advanced information and communications technologies.

A major research program in Highly Effective Human-Computer Interaction will make the next generation of user interfaces dramatically more useful, usable, and universal. More

useful systems will contribute to societal goals of providing quality services, improving education, and fostering a strong economic climate. More usable systems will result in safer, more reliable and more satisfying systems to use, as well as systems that require less maintenance. Universal interfaces will enable increased participation and success by for all citizens: novices and experts, young and old, men and women, rich and poor.

The top priority applications for an HCI research focus are medicine, transportation, electronic commerce, education and training, and national security. In each of these domains, HCI research is needed to develop improved design methods and metrics, improved tools for building usable, consistent, and reliable user interfaces, software architectures for the next generation of user interfaces, and improved methods of delivering online assistance. Usable interfaces must be provided to everyone: diverse users with differing cognitive, perceptual, learning and physical abilities, on a wide-range of hardware/software platforms, with varying network capacities.

We propose HCI research that focuses on expanding proven strategies that will have profound impacts on national priorities of economic development improved well-being of citizens, and national security. Exploratory development of novel devices and strategies is also important, but our focus is on high-payoff research in science, design, and engineering. We recommend substantial increases in scientific, design, and engineering research for pervasive highly effective human-computer interaction that support diverse users, working alone and within groups, and located at work, at home, or while traveling.

Useful Interaction

Computers and computation play an ever-increasing role in our work and personal lives. Cheaper, smaller, and faster hardware is yielding a wide range of new products that fundamentally changes our perceptions of what a computer is and what it can be used for.

Computing no longer only sits on the desktop but is becoming pervasive in society. Advances in microelectronics, networking, and wireless communications give us the opportunity to access our information at anytime from anyplace. As a result, information technology is an increasingly essential part of the fabric and activity of our lives at all levels, dramatically altering the world we inhabit, what we can do in it, and the quality of the lives we live. Yet as this happens, we see the promise of the technology but suffer the limitations of current low levels of effectiveness of interaction with the technology.

This shortfall between technical promise and effective interaction arises because the capability to design and build a system does not ensure its usefulness. Too many technologists use a "let's build it and see" approach. Research funding for this type of activity is currently available. But this approach is not replicable, and it provides poor guidance to sustain future development of interactive technologies. Accordingly, the equally important but more difficult research into the fundamental characteristics of useful interaction should be funded, too.

To address this problem, support is needed for research to study, analyze, and reflect on the use of technology, and to incorporate these findings into principles for design and evaluation. This interdisciplinary research should have these goals:

- Understand the factors that make technology useful. An important challenge in this area involves identifying factors of demand-pull from those of technology-push. What are the characteristics of interactive systems that can be linked to measurable improvements in people's lives?
- Understand the role of pervasive information technology. An important challenge in this area is to understand the role that such technology plays in society, the ways this can be improved, and the ways in which it should be guided. How can decision makers develop policies that encourage fullest use of developing technologies while not unduly complicating life? What should be the core functions of the new interactivity?
- Produce methodologies and metrics. These methodologies and metrics should measure and predict the utility of new forms of work and information access. An important challenge in this area is to create and disseminate proven, broadly applicable tools and tests on which developers can rely.

Usable Interaction

Those who seek to make human-computer interfaces usable face four core problems, each of which makes human-computer interaction less effective than it could be. These core problems of usability should be addressed by a research agenda that focuses on HCI engineering, techniques for information understanding, HCI models and metrics, and cross-platform engineering.

Good interfaces are hard to build. Even the best interfaces still have some problems of usability, and most interfaces have significant problems. The impact of poor usability includes the waste of innumerable person-hours, high levels of frustration, and significant under-use of potentially useful systems.

To address this problem, research support should (1) develop engineering methodologies for integrating design, development, and usability evaluation methodologies into the software engineering process, encompassing the range of development activities from needs assessment through to use; and (2) develop user-interface architectures that better support the building of good interfaces.

Users tend to be overloaded with information. Within a single application, levels of information can often be high enough to be unintelligible; with the growth of (1) networked information infrastructure such as the World-Wide Web and (2) enormous new stockpiles of information, users can easily be at a loss to use these resources effectively. The impact of this problem is the ironic situation in which users find themselves so overloaded with information that they end up with nothing they can use.

To address this problem, research support is needed on techniques for aiding users to understand information, such as the use of information visualization, information management including summarization, multilingual interfaces, and translational information retrieval.

Usability is hard to predict. Developers must rely on incremental empirical methods to find and resolve usability problems because reliable models for interface usability are not available. Without reliable predictive models, developers are often forced to rely on their own intuition; when this intuition fails, the cost to developers and to the economy as a whole may be astronomical. The impact of this problem includes lost time and effort during software development, the deployment of interfaces that still contain bugs, and longer development times.

To address this problem, research is needed for metrics, models of interaction, and simulation. This includes (1) fundamental research into better models of human-computer interaction and collaboration, (2) more applied research into building simulation tools for designers that incorporate our expanding understanding of HCI, and (3) establishing criti-

cal parameters, reference tasks, and better evaluation methodologies.

Users require software to run on a variety of software platforms and hardware devices. This problem is amplified by the trend toward mobile and highly distributed computing, where users might want to access the same application on a variety of platforms ranging from networked desk-top computers, to palm-top or mobile telephones. Providing different interfaces specially crafted for each type of device and modality combination will be extremely costly and could result in users having many different versions of interfaces on different devices. The impact of this problem includes massive under-use of interfaces' potential and excessive development costs.

To address this problem, research is needed into how to design and implement user interfaces that withstand variations of interaction devices, from wristwatches to large computers, while preserving usability.

Universal Interaction

Researchers and developers in HCI have made important advances in access and effectiveness for certain categories of workers and citizens. However, there are important gaps or digital divides between these people and other members of society, who have not received the full benefits of these achievements. Currently, the gaps tend to repeat or worsen existing inequities that have adverse impact on people with disabilities, and, to a lesser extent, people who are using computers in non-traditional, non-workplace settings. The issue of universal interfaces focuses on removing these gaps, to permit and encourage full participation and contribution by all members of society. In this section, we describe research challenges relating to important barriers to universality of human-computer interaction.

Universality applies at two levels in society: individuals and constituencies. At both levels, universality involves access to full and effective participation in areas of employment, civic and governmental endeavors, commercial activities, cultural events (both experiencing and producing), and recreation. Full and equitable access must ensure that individuals and constituencies can be equally effective in their participation. Universal access begins with computing resources that are usable and useful for all users. To achieve this vision, we must have computing systems that support universal access for citizens as individuals and as members of multiple communities and constituencies. Research is urgently needed to reduce the gaps and digital divides through (1) accommodation of diverse abilities and (2) support for mobility and disabling circumstances.

Accommodation of diverse abilities. Accommodating people of widely varying abilities (and disabilities), age, education, literacy, and culture poses significant technology and design challenges. In the workplace, employers and retailers are reluctant to add to their costs by modifying purchased hardware and software. In government, there are continued debates about how much accommodation is "enough" in the

provision of information and services to citizens. Similarly, people may be excluded from economic or civic opportunities by systems that are not designed for diverse levels of education and literacy. Moreover, the needs of communities and constituencies are poorly understood, and the relationships among identity, communities, and access are also poorly understood.

To address this problem, interdisciplinary research is needed into:

- Technologies and design practices that can be easily and/or rapidly adapted to meet the needs of diverse users and user populations.
- Educational strategies, technologies, and design practices that can be adapted to accommodate these diverse groups.
- Ways of integrating disability access into existing product life-cycle models, so that universality becomes an integral part of conventional computer development activities.
- Technologies that can support swift and accurate translation of human interfaces from one education level to another, from one literacy level to another, or from one language to another.
- The social science and technology of access and the implications for designing and developing shared electronic spaces for individuals and communities.
- New forms of community empowerment, so that members and representatives of these groups can become co-analysts, co-designers, and co-evaluators of the new technologies and services.

Mobility and Disabling Circumstances. Additional barriers involve mobile workers or people who are using computers under disabling circumstances. A mobile worker typically has reduced access to resources - smaller, less capable devices, reduced connectivity, and slower data communications. Workers who must control a computer-based device while keeping their hands and eyes on a task (e.g., operating heavy machinery, flying an aircraft) cannot use a conventional workstation. A thorough understanding of the issues faced by mobile users will also benefit users with permanent disabilities.

To address this problem, interdisciplinary research is needed into:

- The potential for new interaction devices to accommodate the needs of people with disabilities and people using computers under disabling circumstances. An important challenge in this area is to preserve consistency in the interface and the operations between conventional and novel interaction technologies. Consistency is necessary to maintain

effective, efficient, and accurate performance, to preserve the value of users' training, and to ensure high-quality interactive experiences that contribute positively to the quality of work life or the quality of interactions with services and recreation.

- The difficult problems of connecting diverse devices with varying bandwidths, with very different assumptions about the extent, duration, and quality of connectivity. Complex protocols that provide rich services over high-bandwidth networks will have to be redesigned and re-architected to support similar services over the slower and more error-prone connections of mobile computing. Reliability of transmission and assurance of delivery of critical messages will require social, design, and technology advances to meet crucial commercial and governmental requirements.
- The provision of consistent services and functions across the diverse platforms of mobile computing. An important challenge in this area is to develop designs and technologies to achieve graceful degradation of performance and of data attributes, so that the same content can be viewed and edited on both high-quality, rich-media platforms and also lower-quality, reduced-fidelity platforms.