Socio-Technical Environments Supporting People with Cognitive Disabilities

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Abstract

The CLever ("**C**ognitive **Lever**s: Helping People Help Themselves") research project at the Center for Lifelong Learning and Design (L3D), University of Colorado (supported by the Coleman Institute) develops *socio-technical environments* to support caregivers and persons with cognitive disabilities and their caregivers. Our socio-technical environments are designed to allow people with disabilities to perform tasks that they would not be able to accomplish unaided. The objective is to make people more *independent* by assisting them to live by themselves, use transportation systems, interact with others, and perform a variety of domestic tasks. CLever's goal is to create more powerful media, technologies, and communities to support new levels of distributed intelligence.

My contribution to the workshop will focus on *distributed intelligence as a conceptual framework for the design and development of socio-technical environments*. It describes three specific environments that we have developed over the last six years, including: (1) human-centered public transportation systems; (2) end-user development environments for prompting systems needed in this environment; and (3) monitoring systems to integrate technical and human components to create safe and reliable environments. The technologies developed in the CLever project will be broadly available as dual-use

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technologies applicable to a broad variety of different application areas (specifically for aging populations).

Introduction

The CLever ("**C**ognitive **Lever**s: Helping People Help Themselves") research project at the Center for Lifelong Learning and Design (L3D), University of Colorado (supported by the Coleman Institute) develops *socio-technical environments* to support caregivers and persons with cognitive disabilities and their caregivers. Science for science's sake is not good enough for improving the life of people with disabilities. The central challenge for the CLever project is to provide knowledge and develop *socio-technical environments* [Mumford, 1987] that can be used to improve the human condition — particularly for people with cognitive disabilities. The mission of the CLever project (http://l3d.cs.colorado.edu/clever/) is to provide computationally enhanced environments to assist and empower people with a wide range of cognitive disabilities directly and through their support community.

Our approach is grounded in the basic argument that all humans have limitations and that the development of new media and technologies has been driven forward by serving as extensions to our biologically endowed capabilities (for example: reading and writing was invented to address the limitations of our short term memories).

Distributed Intelligence

In most traditional approaches, *human cognition* has been seen as existing solely "inside" a person's head, and studies on cognition have often disregarded the physical and social surroundings in which cognition takes place. *Distributed intelligence* [Salomon, 1993] provides an theoretical framework for understanding what humans can achieve and how artifacts, tools, and socio-technical environments can be designed and evaluated to *empower human beings* and to *change tasks*. Applying this framework to people with cognitive disabilities in *design-for-all approaches* creates new and unique challenges and opportunities, and in return it will create a deeper understanding of distributed intelligence.

Minds Are Improvable. Anatomy and cognitive abilities are not destiny [Carmien et al., 2005] — an important intellectual or philosophical grounding of the vision and mission of our CLever project is provided by Postman [Postman, 1985]: *"The invention of eyeglasses in the twelfth century not only made it possible to improve defective vision but suggested the idea that human beings need not accept as final either the endowments of nature nor the ravages of time. Eyeglasses refuted the belief that anatomy is destiny by putting forward the idea that our minds as well as our bodies are improvable!"*

The relationships between humans and their artifacts or tools can be seen as providing scaffolding and supporting learning to incrementally become independent of the tool (leading to "tools for learning"); and changing the task by distributing the activity between the human and the tool (leading to "tools for living").

Tools for Learning. Tools for learning support people in learning a new activity with the objective that they will eventually become independent of the tool. Tools for learning afford an internalization of what was (if it existed previously at all) an ability supported by external mechanism. Tools for learning often serve a scaffolding function; examples of such tools are: bicycles with training wheels or toddlers' walkers.

Tools for Living. Tools for living are artifacts that empower human beings to do things that they could not do by themselves. They support distributed intelligence. Examples of tools for living include eyeglasses, the telephone, screen readers for blind people, visualization tools, and adult tricycles. No matter how many times people use the phone to talk to friends across town, their native ability to converse over long distances unaided remains the same. Tools for living allow people with disabilities to perform tasks that they would not able to accomplish unaided, and therefore allows these people to live more independently.

The Importance of Use Context and User Objectives
Whether a tool is a tool for learning or a tool for living is in many cases not an attribute of the tool itself, but is determined by the use context and the objectives of the user. Wizards used in many computational environments, spelling correctors, and hand-held calculators can serve both purposes with different trade-offs. Learning to live and act without a tool will create an independence of the tool and may lead to a deeper understanding of the activity itself, but this will often come at a considerable costs for learning the activity and executing it in a more error-prone and time-consuming way compared to using the tool.

Socio-Technical Environments Supporting People with Cognitive Disabilities. Based on the "minds are improvable" perspective, the CLever research project has developed several socio-technical environments, including:

1. Mobility-for-All, a human-centered architecture for supporting mobile travelers;
2. Memory Aiding Prompting System (MAPS), an end-user development environment to create external scripts in support of weak internal scripts; and
3. LifeLine, an environment supporting independent travel by people with cognitive disabilities with unobtrusive supervision and assistance by caregivers.

Design Criteria and Challenges for Socio-Technical Environments

The three socio-technical environments presented in the previous section raise fundamental human computer interaction research issues in (1) mobile and environments with ubiquitous, context-aware computing architectures [Dey et al., 2001; Fischer & Konomi, 2005; Goto & Kambayashi, 2002; Krikke, 2005]; (2) personalization and user modeling techniques [Fischer, 2001]; and (3) the design of universally accessible interfaces for complex systems through participatory design processes. Some of the specific research findings and challenges derived from our research are:

- **No single perspective can yield a satisfactory solution.** The unique needs and abilities of our users must be juxtaposed with the complexity and constraints of modern public transportation systems and emerging technologies [Goto & Kambayashi, 2002], making collaborative, participatory partnerships essential. Such practices can not be reduced to afterthoughts, but need to serve as requirements to inform, enhance, and possibly existing practices of all participants.

▪ **Complex socio-technical environments cannot be designed and evaluated in the laboratory alone.** Problems such as people falling asleep or buses not running on time are only seen in the world, and not in the laboratory. Since a "proxy group" (the caregiver community) is articulating the needs of a non-verbal user community, new approaches must ultimately be tested, evaluated, and refined in the world with real users.

▪ **Personalization and user modeling techniques are critical**. As architectural components are refined and deployed, personalization and user modeling [Fischer, 2001] will increasingly become a challenging research area. Technologies must be developed that (1) permit support communities to easily configure mobile systems to suit the unique "universe of one" capabilities of each person and (2) allow systems to intelligently "adapt" to each users abilities and learning styles through use.

▪ **Context-aware, ubiquitous computational environments are necessary.** Because of communication and computational demands, the mobile user will not be able to carry a single device that has all information necessary to know where to go and what to do next. This provides an ideal research environment to study how personally relevant information can be extracted from distributed information spaces and how context-aware environments [Dey et al., 2001] and architectures should be designed to support distributed cognition.

▪ **Designing dual-use technologies is important to widespread adoption.** Early in our research, we identified that *"dual-use"* technologies were often widely adopted and less expensive because they served larger audiences. Just as curb cuts serve both persons in wheelchairs as well as parents with strollers, bicyclists, those on roller blades, etc., the technologies developed in the CLever project will be broadly available. One particular interesting and socially very important application area is to create socio-technical environments for aging populations [National-Research-Council, 2004].

▪ **Trade-Off Analysis between Tools for Living and Tools for Learning.** The reliance on tools for living is greatly enhanced by their universal availability through wireless and mobile technologies [Fischer & Konomi, 2005]. A deep understanding under which conditions tools for living create an over-reliance on tools, leading to deskilling and "learned helplessness" versus situations where they create independence is an important issue with broad implications.

Future Work

Our prototype systems provide "objects-to-think-with" on our path to design socio-technical environments for people with cognitive disabilities (with a focus in this article on human-centered public transportation systems). We are in the process to conduct more detailed assessment studies to understand:

▪ how people with cognitive disabilities perceive and use information in travel tasks on mobile handheld devices;

▪ how non-technical caregivers can make use of customization, personalization, and configuration environments; and

- how a caregiver can be supported and provide remote real-time traveler supervision.

An important aspect of our future research will be early and continuous participatory design and testing with real users in real-world settings and in our laboratories. Our assessment approach acknowledges that technology frequently transforms a task, and that a user adapts to technology, just as technology is adapted to the user thereby emphasizing co-adaptation processes. We will explore the strengths and weaknesses of different multi-modal interactions, the ability to contextualize information [Dey et al., 2001], and the usefulness and usability of our approaches to support end-user modifiability and personalization [Fischer et al., 2004].

To be maximally supportive, our environments need to “understand” users and their tasks in order to provide *“the 'right' information, at the 'right' time, in the 'right' place, in the 'right' way, to the 'right' person”*. A critical issue arising in this context is that this knowledge can be used to violate the *privacy* of people. The support environments developed in CLever require the capture and use of data about individuals. Once captured, this data might live indefinitely, be used in different contexts, and often allows for unique identification. Solutions need to be developed in which the privacy needs and rights of people are fully respected [Fischer & Konomi, 2005].

Our socio-technical environments must be designed to gracefully handle both *system and user failures* and *provide a safety net* when unexpected or unusual events occurs. This requires a level of reliability and robustness not normally seen in mobile devices and services. For the mobile phone user, dead batteries or “roaming out of the cellular network” may be an inconvenience. For the mobile traveler who is unsure where to go and unable to communicate, these situations may be considerably more serious and require immediate intervention. Rather than wait for an error to occur, our mobile systems must collect performance data and detect subtle anomalies that precede error states.

Conclusion

The ultimate goal of successful design is to improve the human condition. Our research ultimately will be judged by the opportunities for independence and societal inclusion it provides to those who would otherwise be left behind.

Information and communication technologies provide interesting opportunities to create “eye glasses for the mind” that will support all of us (but specifically people with cognitive disabilities) to live more interesting and more independent lives. To explore and understand these challenges requires innovative technologies embedded in social environments. We strongly belied that the results of our research will have broad implications for education, for meeting the challenges faced by aging populations, and by extending the possibilities and capabilities for all humans.

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