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Overview

My research area is the intersection of human computer interaction (HCI) and ubiquitous computing. More specifically I create and evaluate *assistive systems* and *performance support systems*. Assistive systems pair human computer interaction techniques and technology to enhance the quality of life for people with various special needs. Performance support systems assist people improve their performance conducting a task by providing information or performing calculations with computer applications. Evaluating these systems is challenging because they are used by varied populations in the natural operating environments.

The goal of ubiquitous computing is to enable seamless interaction between users and computing technology that is integrated into the environment [9]. An example of ubiquitous computing is the modern home. If one asks people how many computers are in their home, people typically say they have anywhere from two to four computers. However, they do not count the computer in their coffee pot, DVD player, cell phone, microwave, etc. because they interact with these computers seamlessly. Research in ubiquitous computing pushes the envelope to integrate technology into more areas of our everyday lives.

The end goals of ubiquitous computing can only be realized through research and development in HCI. We must create technology with intuitive interfaces so people can seamlessly interact with computers. HCI researchers design, implement, and evaluate interactive computer systems with the user perspective in mind [1]. Researchers in the intersection of these two fields must identify specific problems that can be solved with technology, look at what kinds of technology populations can use, create dynamic, robust interfaces with limited system resources, and evaluate the application in the natural environment.

My research objective is to develop methods for evaluating usability and user acceptance of assistive and performance support systems in natural, non-traditional environments. Traditionally, user studies are conducted in usability laboratories or in situ but with highly controlled conditions. In contrast, non-traditional environments change rapidly without forewarning, are difficult or impossible to control, and have environmental and operational constraints. Examples of non-traditional environments include, but are not limited to, health care facilities, emergency response sites, urban regions, and military areas. My research area is important because current traditional field study evaluation techniques do not account for the limited space, testing equipment, privacy concerns, safety, stress, and the uncontrolled nature of non-traditional environments. In order to create usable technology in these environments, we must test in the environments.

To this end, I have designed and developed assistive [2, 4] and performance support systems [2, 6] for dialysis patients, nurse researchers, and soldiers. I also researched whether people can effectively use PDA technology [8] and complex interfaces [7]. Additionally, I have collaborated with researchers from Georgia Tech and Carleton University to develop a framework for usability testing in non-traditional environments [3, 5].

Assistive and Performance Support Systems

For my dissertation work, I am designing, developing, and deploying a dietary intake monitoring application (DIMA) for dialysis patients to monitor their fluid and sodium consumption. Computerizing fluid and sodium intake for dialysis patients has many benefits. Traditional food diary methods for monitoring intakes fail in 80% of patients. Furthermore, patients who do not comply with their dietary restrictions run the risk of serious health complications and death. An additional complication is that my user group has varying literacy levels and computer skills. Simplifying the interaction between the device and patient will ensure that most, if not all, patients will be able to self monitor themselves. I am studying how patients use the application and adopt it into their lives. Our interdisciplinary group's higher level goal is to study how real time feedback about consumption information will affect dialysis patients' self efficacy and overall health [4].

I have also collaborated with nurse researchers at Indiana University Purdue University - Indianapolis to create a PDA application that calculates the depth a feeding tube should be inserted for pre-term infants and children under three years of age [6]. The calculations nurses needed to perform were complex and sometimes miscalculated because of time constraints and mathematical errors. The application ensured accurate calculations and an easier way to save data for later review. Nurse researchers are studying whether nurses using performance support systems calculate more accurate measurements for food tube placement.

My colleagues and I designed and implemented a health monitoring sensor system at Sandia National Laboratories for soldiers that could also be applied to health monitoring in extended care facilities for the elderly [2]. The system provided military leaders information about the troops in order to make decisions based on the data. The monitoring system provided troops with information about personal health and environmental concerns (e.g. air quality).

Some future research directions that I would like to pursue in assistive and performance support systems are:

- Applications to empower patients through self education and/or communication between patients and care givers.
- Performance support systems for health care workers to assist in data analysis, reference material searches, and real time patient information gathering.
- Support systems for emergency response teams to gather information and obtain real time data pertinent to emergency situations.

Interdisciplinary Research

I have collaborated with nurse researchers, nephrologists, nutritionists, biostaticians, and dialysis patients in hospital settings. I made connections with nurse researchers by presenting technology and health care possibilities at Indiana University Hospital during their annual nurse researcher retreat. In the beginning of the meeting, nurse researchers did not realize the potential of computing technology and suggested some basic ideas for applying technology to health care. For example, the researchers wanted to transfer a manual to a web site and create a PDA application to do some calculations. These ideas are perfect projects to build a trusting relationship between the interdisciplinary researchers. In addition, these projects are excellent opportunities for undergraduates to get research experience and learn how to communicate with researchers in different areas.

After the meeting we were able to broaden the nurse researchers' view of technology and discuss larger projects in health care. In the future, I would like to continue interdisciplinary projects with researchers in health care, emergency response, and defense. Interdisciplinary research allows me to identify problems that can be addressed with ubiquitous technology and create usable solutions.

Technology Usability

Once problems are identified, researchers must look at what kind of technology can be used to solve the problem and if the user population can use the technology or solution system. For my dissertation research, I compared how healthy people and dialysis patients in various age groups physically interacted with PDAs. Participants completed tasks such as pressing buttons, viewing icons, voice recording, and scanning barcodes. My study used quantitative (e.g. number of errors) and qualitative (e.g. NASA Task Load Index) metrics to measure usability. I found that there were no major differences in performance among these user groups for most tasks. However, the preferred icon size was much larger than the icon size currently available on PDA interfaces [8].

I developed low fidelity, paper prototypes of the dietary intake monitoring system for dialysis patients to learn how dialysis patients mentally organize food and interpret consumption-level icons. My study found that patients are eager to show us how much they knew, but their preferences were not always in line with the design they could accurately read. In the study, participants took pride in learning new concepts and terms. We think we can utilize their willingness to learn when introducing the dietary monitoring application [7].

In the future, I would like to:

- Develop interface design guidelines for populations (e.g. elderly) who do not ordinarily use ubiquitous and mobile computing technology (e.g. physical and cognitive interactions).
- Develop models for introducing technology to populations who do not ordinarily use ubiquitous and mobile computing technology.
- Develop user acceptance models for populations who do not ordinarily use ubiquitous or mobile computing technology.

Evaluating Usability in Non-Traditional Environments

Once we have identified a problem, determined which technologies are appropriate for a population, and developed a system to address the problem, we must ensure that the system works in natural environments. All of the studies for my dissertation take place in a dialysis ward during patient treatment because this is the only viable location and time to meet with patients. There is very little existing literature on conducting usability studies in non-traditional environments, so new methods must be developed.

As part of my work with dialysis patients, I have begun to formulate methods and guidelines for usability studies in health care facilities. For example, researchers must take into account the safety of all people involved - participants and test givers. For my paper prototyping study, all paper prototypes were laminated and cleaned between studies. Researchers must also be aware of patients' sensitivities. For example, my user group has varying literacy levels, thus I must avoid situations that may embarrass them by exposing their literacy levels. Researchers must know the

rules and regulations of the facility and adapt the study appropriately. For example, video and audio recording equipment is prohibited by the Health Insurance Portability and Accountability Act (HIPAA). Alternative recording mechanisms, such as shorthand, had to be utilized. Researchers must be aware of patients' comfort. For example, since dialysis patients experience cramping after two hours of treatment, I had to be aware of patients' unspoken signs that patients were not feeling well enough to participate. Researchers must design adaptable studies. For example, participants may need immediate medical treatment during the study. My studies are modular and have short sub-tasks so that we can stop and restart a study with little review and time loss.

I am collaborating with researchers from Georgia Tech and Carleton University to bring this new area of user studies in non-traditional environments to the attention of the HCI community [3, 5]. We are developing a framework for conducting field studies in non-traditional environments by identifying themes in case studies.

The field of user studies in non-traditional environments has plenty of further research avenues, such as:

- Identifying key themes and differences between various non-traditional environments.
- Refining the developing framework for user studies in non-traditional environments.
- Developing additional, improved methods for user studies in non-traditional environments.

References

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