Simulating HCI for Special Needs

Pradipta Biswas

Computer Laboratory, 15 JJ Thomson Avenue, Cambridge CB3 0FD

University of Cambridge, England

pb400@ cam.ac.uk

Abstract

Computers offer valuable assistance to people with physical disabilities. However designing human-computer interfaces for these users is complicated. The range of abilities is more diverse than for able-bodied users, which makes analytical modelling harder. Practical user trials are also difficult and time consuming. We are developing a simulator to help with the evaluation of assistive interfaces. It can predict the likely interaction patterns when undertaking a task using a variety of input devices, and estimate the time to complete the task in the presence of different disabilities and for different levels of skill.

Introduction

Computers offer valuable opportunities to physically challenged people as it help them to engage more fully with the world. However designing and evaluating human-computer interfaces for these users is more complicated than that for able-bodied persons, since the range of abilities is more diverse. Their patterns of interaction are also significantly different from those of able-bodied users. Therefore, existing HCI models are hardly applicable to assistive interfaces. Assistive interfaces are generally evaluated by analysing log files after a user trial. However it is often difficult to find participants with specific disabilities. Petrie et. al. [6] take the approach of remote evaluation but still need to find disabled participants. In this context, a modelling tool that can simulate HCI of users with disabilities relieves the designer from searching for disabled participants to run a conventional user trial. However, research on assistive interfaces and HCI modelling do not overlap. Very few of the existing HCI models have considered users with disability. Researchers on assistive interfaces have concentrated on designing assistive interfaces for a particular application (e.g. Web Browser, Augmentative and Alternative Communication aid etc.), developing new interaction techniques (e.g. different scanning techniques) or developing novel hardware interfaces (head mounted switches, eye-gaze trackers, brain-computer interfaces etc.). They have not looked at designing a systematic modelling tool for assistive interfaces. I am developing a simulator to model HCI of disabled users. It can predict the likely interaction patterns of users when undertaking a task using a variety of input devices, and estimate the time to complete a task in the presence of different disabilities and for different levels of skill. The simulator can be used to compare several existing assistive interfaces and to evaluate new alternatives. Besides disability, I shall also address the shortcomings of existing HCI models and hope to develop a system that will be easier to use than the existing models and support both able-bodied and disabled users.

Related works

The GOMS family of HCI models (e.g. KLM, CMN-GOMS, CPM-GOMS) is mainly suitable for modelling the optimal behaviour (skilled behaviour) of users [3]. On the other hand, models developed using cognitive architectures consider the uncertainty of human behaviour in detail but have not been widely adopted. For example, developing a sequence of production rules for Soar or a set of constraints for CORE [9] is difficult. Usability issues for cognitive architectures are also supported by the X-PRT system [9] for the CORE architecture. Additionally, Kieras has shown that a high fidelity model cannot always outperform a low fidelity one though it is expected to do so [5]. Researchers have already attempted to combine these two forms of model to develop more usable and accurate models. Salvucci and Lee [7] have developed the ACT-Simple model by translating basic GOMS operations into ACT-R production rules. The model works well to predict expert performance but does not work for novices. Blandford et. al. [2] implement the Programmable User Model (PUM) by using the Soar architecture. They developed a program, STILE (Soar Translation from Instruction Language made Easy), to convert the PUM Instruction Language into Soar productions. However, this approach also demands good knowledge of Soar from an interface designer. The second problem of existing modelling approaches comes from the issues with disability. There is not much reported work on systematic modelling of assistive interfaces. The AVANTI project [8] models an assistive interface for a web browser based on some static and dynamic characteristics of users. However, this model does not address the basic perceptual, cognitive and motor behaviour of users and so it is hard to generalize to other applications. My user model [1] breaks down the task of user modelling into several steps that includes clustering users based on their physical and cognitive ability, customizing interfaces based on user characteristics and logging user interactions to update the model itself. However the objective of this model is to design adaptable interfaces and not to simulate users' performance. Keates et. al. [4] measured the difference between able-bodied and motor-impaired users with respect to the Model Human Processor (MHP) and motor-impaired users were found to have a greater motor action time than their able-bodied counterparts. The finding is obviously important, but the KLM model itself is too primitive to use.

Objective

Based on the previous discussion, Figure 1 plots the existing general-purpose HCI models in a space defined by the skill and physical ability of users. To cover most of the blank spaces in the plot, we set our objectives as follows:

Developing a model that can

1. Simulate HCI of both able-bodied and disabled users.
2. Work for users with different levels of skill.
3. Be easy to use for an interface designer.

Present status

We are now developing a simulator that takes a task definition and locations of different objects in an interface as input. Then it predicts the cursor trace and completion time, for different input device configurations (e.g. mouse or single switch scanning) and undertaken by persons with different levels of skill and physical disabilities. The architecture of the simulator is shown in Figure 2 and it consists of the following three components:

The Application model models the task currently undertaken by the user by breaking it up into a set of simple atomic tasks.

The Interface Model decides the type of interfaces to be used by a particular user and sets parameters for an interface.

The User Model simulates the interaction patterns of users for undertaking a task analysed by the task model under the configuration set by the interface model. It uses the sequence of phases defined by *Model Human Processor*. The perception model takes a list of keyboard and mouse events and a sequence of bitmap images of an interface as input and produces a sequence of eye-movements and the visual search time as output. I am developing the cognitive model by using two interacting Markov processes following the concept of dual space model. The motor behaviour model predicts the completion time and possible interaction patterns for performing an action. It will be developed by statistical analysis of cursor traces of disabled users.

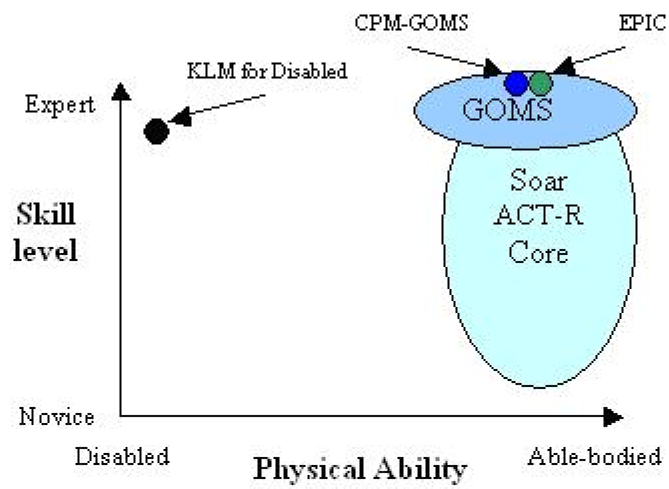

Figure 1. Existing HCI models w.r.t. skill and physical-ability of users

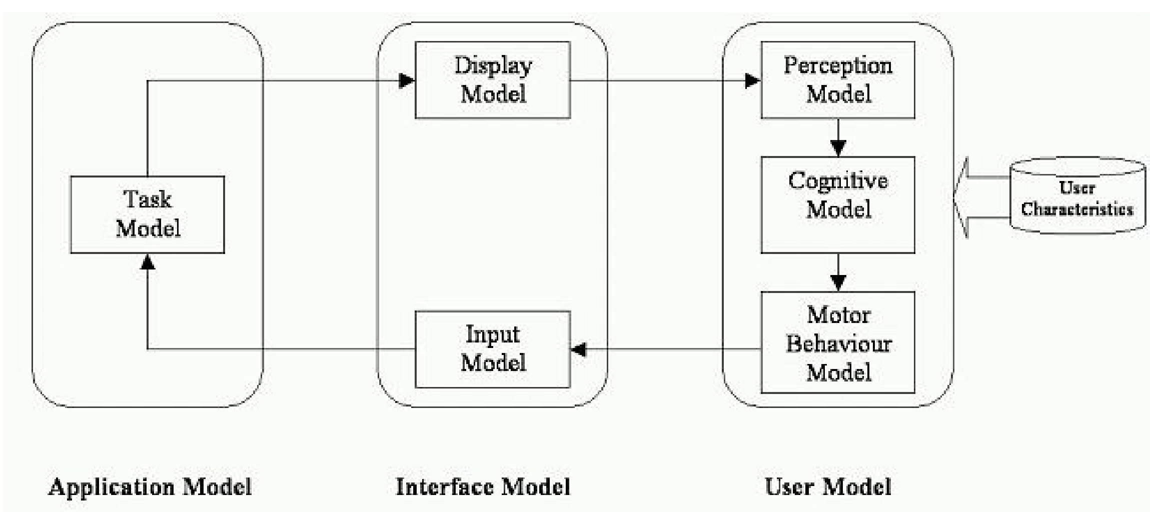

Figure 2. Architecture of the Simulator

We have confirmed the correctness of the model for novice users by an experiment with able-bodied persons. Our next step is to populate the remaining components of the models with more details and to validate them with an experiment with physically challenged people.

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About the author

Pradipta Biswas is a research student at the University of Cambridge Computer Laboratory under the supervision of Prof. Peter Robinson. His work concerns about modelling Human-Computer Interaction of physically-challenged people so as to simulate the performance of different interfaces and interaction techniques. He is a recipient of Gates-Cambridge scholarship. He has completed his M. Tech. in Information Technology in 2006 from Indian Institute of Technology, Kharagpur, India. Previously he was a student of University of Kalyani, India and completed his B. Tech. in Information Technology in 2004.