Simulation to Predict Performance of Assistive Interfaces

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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 have developed 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.

Categories and Subject Descriptors

D.2.2 [**Software Engineering**]: Design Tools and Techniques – *user interfaces;* K.4.2 [**Computers and Society**]: Social Issues – *assistive technologies for persons with disabilities*

General Terms

Algorithms, Experimentation, Human Factors, Measurement

Keywords

Human Computer Interaction, Assistive Technology, Usability Evaluation, Simulator, Scanning Interface.

1. INTRODUCTION

Usability evaluation is an important step for successful design of any product. Assistive interfaces are generally evaluated by analyzing log files after a user trial [5,7]. As an example of a different approach, Rizzo et al [9] evaluated the AVANTI project [10], by a technique combining cognitive walkthrough and Normans' seven-stage model. It is often difficult to find participants with specific disabilities to run a conventional user trial for evaluating assistive interfaces. Petrie et. al. [8] take the approach of remote evaluation but can not avoid the need to find disabled participants. In this paper we take a different approach for evaluating assistive interfaces. We present a simulator that can predict the time and possible interaction patterns for motor-impaired people undertaking a task. The simulator is used to compare several existing interfaces and to evaluate new alternatives.

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2. THE SIMULATOR

Our simulator 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 1 and it consists of the following three components:

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

The Interface Model: Several types of disability impede the use of a conventional mouse, keyboard and screen to interact with a computer. People with severe motor-impairment often access computer by one or two switches instead of keyboard and mouse. Visually impaired users cannot use a screen and they have to use a screen reader. The interface model decides the type of interfaces to be used by a particular user and sets parameters for it.

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. There is not much reported work on systematic modelling of assistive interfaces. McMillan [6] felt the need to use HCI models to unify different research streams in assistive technology, but his work aims to model the system rather than the user. The AVANTI project [10] models an assistive interface for a web browser based on some static and dynamic characteristics of users. The interface is initialised according to some static characteristics (e.g. age, expertise etc.) of the user. During interaction, it adapts itself depending on some dynamic characteristics (e.g. idle time, error rate etc.) of the user. 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] takes a more generalized approach than the AVANTI project. It breaks down the task of user modelling in 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)[10] and motor-impaired users were found to have a greater motor action time than their able-bodied counterparts. Our user model also uses the sequence of phases defined by Model Human Processor. It consists of perception, cognitive and motor-behaviour models. The perception model simulates the visual perception of interface objects. The cognitive model takes the output of the perception model and decides an action to accomplish the current task. The motor behaviour model then predicts the completion time and possible interaction patterns for performing that action.

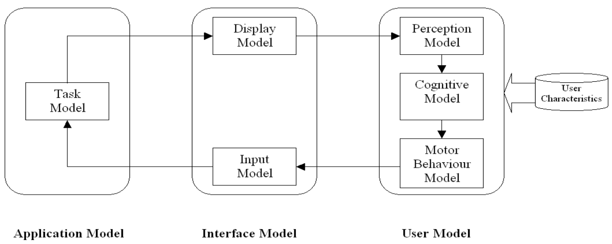

Figure 1. Architecture of the Simulator

3. A CASE STUDY

Many physically challenged users interact with computers through one or two switches with the help of a scanning technique. Scanning is an accessibility technique for successively highlighting items on a computer screen and pressing a switch when the desired item is highlighted. We have used our simulator to predict task completion times and interaction patterns for an eight-directional scanning system (a particular type of polar scanning that allows movement only in eight directions). We have developed a cognitive model by using the CPM-GOMS [3] model for optimal behaviour (expert performance) and a probabilistic rule-based system for the sub-optimal behaviour (non-skilled behaviour). We have assumed that our intended users have no cognitive impairment and so their cognitive model will be same as that of able-bodied users. So we validated the cognitive model through an experiment with eight able-bodied users. The actual and predicted task completion time is shown in fig. 2. It is found that, with two exceptions, the model can predict task completion time with an overall standard error less than 3% and without any significant difference between actual and predicted task completion time (t = 0.31 for a two-tailed paired t-test). The motor-behaviour model will be developed by an experiment with disabled users. We have also developed a new scanning technique based on clustering the screen objects, and have used our simulator to compare its performance with eight-directional and block scanning systems (a scanning system that iteratively segment the screen area is into equal sized sub-areas). We model only the scanning system, not the primary task done by it, so in this case we used cursor traces captured from interactions by able-bodied users as the input data. It has been found that the cluster scanning system can outperform other scanning systems. Further details about this study can be found in a separate paper [2].

4. CONCLUSIONS

In this paper, we have described a simulator that can predict the time and possible interaction patterns for disabled users undertaking a task. The simulator can predict the performance of users with different levels of skill and physical disabilities. In particular we have confirmed the accuracy of the simulator for novice users in eight-directional scanning system. We have also used the simulator to compare two other scanning systems. Our next step is to populate the remaining components of the models with more details and to validate them with some experiments with people with disabilities.

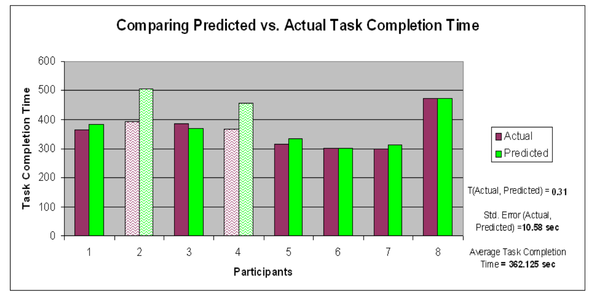

Figure 2. Actual and Predicted Task Completion Time

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