An Evolvable Computer Interface for Elderly Users

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ABSTRACT
This research focuses on developing an intelligent, dynamically evolvable help facility which will offer appropriate assistance to the user while he/she is browsing the Internet.

Categories and Subject Descriptors
H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – g*raphical user interfaces (GUI), screen design (e.g., text, graphics, colour), user-centred design*

General Terms.
Design, Human Factors.

Keywords
Elderly, Internet, human-computer interaction, interaction patterns, intelligent techniques.

1. INTRODUCTION
Elderly people encompass a large and increasing section of the population. In the UK, the Office for National Statistics, General Register Office for Scotland and Northern Ireland Statistics and Research Agency (2006) report that, over the last 30 years, the proportion of the population aged 65 and over has increased while the proportion below the age of 16 has decreased [20]. Within the population aged 65 and over, the proportion of people aged 85 and over has increased from 7% in mid-1971 to 12% in mid-2004. However, it is estimated that the number of elderly people is projected to exceed the number of children from 2023 onwards [21]. A study carried out in Ireland by the National Council on Ageing and Older People (2002), has shown that the Internet offers elderly people the potential to participate in the new economy, gain access to information relevant to them, share experiences and overcome geographic isolation [1]. Compared to younger people, however, elderly people are less comfortable with computers and perceive less efficacy and control in computer use [6]. Elderly people can experience computer anxiety which generally increases in line with less experience [9]. One of the key obstacles that prevent elderly people from using computers is the ageing process itself [2]. Despite these difficulties there is a need for elderly users to integrate computer usage into their everyday lives in order to be able to participate fully in society [15]. Computer technologies are a promising method of increasing the quality of life of elderly people providing that the systems designed accommodate the specific needs of these users [5]. Recent research has shown that although elderly people experience more difficulties with technology than younger people, their performance is improved if the system design is changed to meet their requirements [5].

Research in the area of evolvable interfaces focuses on user initiated changes, where the user must specify any required changes, i.e. the changes are not dynamic. Although there is much ongoing research on evolvable interfaces, there is very little published research on measuring and adapting dynamically to change in people's behaviour in usage of computing applications. This is the central challenge of the work proposed in this research. Our aim is to develop an intelligent, evolvable help facility specifically for the Internet, where the system can log and monitor user activities continually over time, recognise when assistance is required and dynamically offer assistance to the user to suit current needs. The core of the evolvable help facility will use intelligent techniques to learn user specific interaction patterns and subsequently identify changes in these patterns thereby triggering the appropriate level of assistance to be offered to the user. As a user interacts with the Internet, his or her behaviour can be logged and analysed [4; 17].

2. THE AGEING PROCESS
It is impossible to put together a simple profile or to identify a single stereotypical elderly PC user because there is a great deal of diversity within the user group. Each elderly individual is unique and therefore requires different specifications for different applications and interfaces. A person's ability can vary widely through time depending on factors like fatigue and illness [10]. Dickinson et al. (2005) suggests that poorly designed interfaces are a fundamental obstacle to digital inclusion and that elderly adults find it more difficult than their younger counterparts to use standard interfaces [8]. By designing technology to include the elderly, they can remain living in their own homes longer, keeping in contact with the outside world through, for example, Internet banking, shopping and email, and thus increase their sense of well-being and security. Browne [3] reports that short-term memory does not decline much with age, but working

Supporting Human Memory with Interactve Systems, workshop at the HCI 2007 (British HCI conference 2007), September 4th, 2007, Lancaster, UK

memory (the ability to make use of items in short term memory), does show impairment with increasing age [13]. Zajicek (2001) has reported that exploratory learning is vital for building conceptual models of the operation of a PC interface where the user must remember a sequence of actions and reason about them [23]. However, Age Associated Memory Impairment (AAMI) in elderly people has a detrimental effect on exploratory learning where their ability to create a mental model of the operation of an interface is reduced [23]. Attention span, hearing, vision, memory and reasoning capability are also shown to degrade naturally with age [23]. Other research has shown that elderly people have difficulty remembering and navigating routes and particularly struggle to select the correct order of landmarks on a route [22]. According to Zajicek (2001), the navigational structure of information on the Internet is quite similar to the way in which landmarks and special features of a physical route are organised [23]. Hence, elderly people encounter the same navigational difficulties while using the Internet due to their deficiency in remembering routes [23]. Haimov (2006) reports on studies which have shown that the foremost impairment which affects the cognitive performance of an elderly person is deterioration in memory [11].

3. EVOLVABLE INTERFACES

An evolvable interface is any interface which changes over time to suit the needs of users. Research has been carried out on evolvable interfaces for the Internet, but has tended to focus on user-initiated changes.

3.1 Internet Interfaces

IBM have developed Web Adaptation Technology as part of the accessibilityWorks project which adapts webpages to suit the preferences of the user, such as magnifying pages or adapting mouse and keyboard settings [12]. In September 2006, the European Union agreed to fund the €3million DIADEM (Delivering Inclusive Access for Disabled and Elderly Members of the community) Project, coordinated by Brunel University, London [7]. This three year project aims to develop an expert system that will monitor user activities, evaluate user interactions with online forms and then develop a system that will adapt the computer interface to suit the needs of the individual user [16]. Gregor et al. (2002) have reviewed a talking web browser, BrookesTalk, developed at Oxford Brookes University [10]. The talking web browser was designed to enable visually impaired users to easily access the Internet. It was developed using standard user centred design and its review highlighted the weakness of this approach and suggested that a user sensitive inclusive design methodology would have produced a more successful outcome where designers are encouraged to seek out diversity among the intended users of a system in order to design a more appropriate system. This view is also shared by Newell and Dickinson (2006) who report on a prototype email, web search and navigation system for users over 60 years who had no experience in using computers and who had never used the Internet [19].

Current help facilities on webpages are not dynamic and do not offer help to the user unless the user specifies that he/she needs assistance. In order to provide dynamic help to a user while browsing the Internet, this research will develop an intelligent help facility which will offer assistance to a user as they need it – without the user having to ask for it. The system will be aware of which user is currently using the system and will recognise when a user needs help to complete a specific task by referring to previous instances where the user successfully completed the task.

4. PROPOSED RESEARCH AND PRELIMINARY WORK

This research focuses on elderly users that have a reasonable proficiency in the use of computers. Our aim is to implement an intelligent help facility to dynamically offer assistance when it is recognised that a user may be experiencing difficulties. To do this, the authors have carried out some preliminary work to demonstrate that monitoring browser interaction patterns can be effectively achieved and that Artificial Neural Networks (ANNs) can be utilised to identify interaction patterns for individual users.

4.1 Using Intelligent Techniques

Initial experiments by the authors have established the usefulness of an ANN to categorise users' browsing tasks [14]. Data was gathered from 20 volunteers. Each participant was asked to complete two web browsing tasks, Task A and Task B. Each task consisted of five small subtasks where the subject was asked to find a specific piece of information by using the links on the webpage specified. The aim was to identify which task a user completed. An event logger (free software created by the Mozilla project) was utilised to log participants' activity as each task was conducted [18] including the title and URL of the current webpage, the time taken to complete the task and whether the left or right key had been pressed on the mouse. A log was created in the form of an XML document. A parser program was used to extract the relevant data from the XML file. The information from each logged event was stored in an Access database where the data was analysed. After the data was gathered and analysed, half of the data (seen data) was used to train the ANN. The experiment was repeated ten times and after each repetition the classification accuracy (CA) of the output was examined to calculate the performance of the network. This was done by analysing the number of correct classifications over the two tasks. Once the accuracy of each training procedure had been established the average was calculated and the overall CA determined. This was repeated for different network architectures and once the optimum network architecture (number of neurons in the hidden layer) had been determined, the accuracy of the trained network was tested by applying the remaining half of the data (unseen data) to the network. Again, the process was repeated ten times, the average obtained and the overall CA calculated. The overall CA obtained was 96% when the ANN was tested using unseen data. This preliminary work shows that ANNs can be successfully utilised to monitor users' browsing interaction patterns and thus identify which task the user completed.

4.2 Monitoring Interaction Patterns

The initial step towards developing an evolvable interface is the accurate identification of users' browsing interaction patterns. Initial studies have been carried out with users aged between 54 and 86 to establish typical interaction patterns when using the

Internet. Data was gathered from a controlled study group of elderly computer users and care was taken to select elderly people with similar computer experience and age. Before the data gathering process, the elderly participants were asked to complete a questionnaire about their computer experience and the study group was chosen based on the results obtained. Results from the questionnaire established that the most common sites used by the age group are shopping, hobby and email sites which help them to keep in contact with the outside world. Common tasks carried out on these types of websites were identified. Each task consisted of a number of subtasks which required participants to navigate through the website specified and therefore enabled the interaction patterns of older users carrying out these tasks to be collected. These preliminary experiments logged factors such as time taken and the navigation pathways. The University of the Third Age (U3A) has facilitated access to a wide population of older people who are familiar with computers but who still require assistance when accessing the Internet. The data gathered from the study group will be interpreted to offer a level of assistance that will suit individual needs. In addition, the elderly participants were asked about any difficulties they encountered while using the Internet. The most prominent answer was that they had difficulty remembering how they had completed certain tasks, such as opening emails, on previous occasions. The elderly participants found that they could remember how to complete a task when they were given individual assistance with small prompts to jog their memory and help them to complete the task.

4.3 The Proposed System

The system proposed in this research is outlined in Figure 1. It is envisaged that the intelligent system will be a hybrid of a number of intelligent techniques since it requires learning, classifying and reasoning capabilities that can detect if the user is having difficulties completing a specific task. It will do this by referencing the original pathways (the sequence of user actions required to achieve a task) and actions the user employed to complete a specific browsing task. At this stage of the research the intelligent techniques which are likely to be utilised during the research include Rule-Based Reasoning (RBR), Case-Based Reasoning (CBR) and Artificial Neural Networks (ANNs).

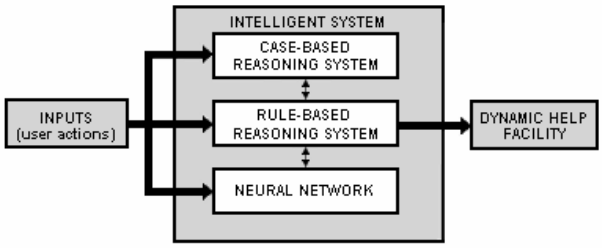

Figure 1: Overview of System Architecture

It is envisaged that the intelligent system will consist of three components which interact as follows. The RBS will continually monitor user activities and make a decision on whether the intelligent system intervenes to provide help. For example, if the user has not interacted with the computer for a specified period of time, then the system may initiate help through a rule of the form:

IF interaction = 0 **AND** time >T **THEN** output help from the help facility

The RBS may communicate with the CBR system to ascertain if there was a previous occasion where the same situation occurred and if so what was the outcome, i.e. what assistance was given to the user and did the user successfully complete the task. The RBS will then make the decision on whether to offer the user the same assistance or to adapt the level of help to the current situation. The ANN will identify user patterns to provide more detail regarding user interaction which will provide useful information for the RBS. By utilising all the information from the CBR system and the ANN, the RBS can make a decision on the appropriate (initial) level of help to offer the user.

It is proposed that the output from the help facility will be in the form of a pop-up window where the user will have the choice of a number of possible options. These options will be tailored to the specific user depending on how they have been categorised by the system, for example, experienced or novice users. By choosing the appropriate option the user will assist the dynamic help facility in determining the level of help required. The help facility will then provide the steps the user requires to complete the task, where the detail contained in the steps will be relevant to the level of help the user requires. Once the user has chosen an option, the RBS then makes further decisions using this additional information. For example, a user may indicate that he/she cannot remember the next step needed to complete a task. Therefore, the dynamic help facility might offer navigational help to the user in the form of a tutorial detailing the steps involved. In addition, if the user wishes to refuse the help they can simply choose to close the help facility. The interaction between the user and the RBS will be an interactive process and the outcome will be a solution to the problem that satisfies user needs. This problem/solution case will be stored in the CBR system to be retrieved later when similar problems are experienced by the user. The intelligent system will be trained on the data gathered from the elderly (see section 4.2). The rule base and problem/solution cases will be initialised using this data.

4.4 Evaluating the System

It is expected that some of the people in the study group will experience more problems than others when using computers and therefore allow the system to be fully evaluated. The development of the system will be an iterative process and therefore the system will be subject to frequent testing and evaluation by the target user group. After the initial prototype of the system has been developed a full evaluation of system will take place. During this evaluation the elderly people will be asked to assess the system on the appropriateness of the help and the suitability of the level of help that was offered to them. They will be asked about the aesthetics of the pop-up screens, i.e. could they read the instructions easily, was the text too small or too large, was the language used easy to understand, was the colour scheme suitable? They will be asked for suggestions on how to improve the system and these will be incorporated into the system design and subsequently evaluated again after the suggested changes have been made. The results of the evaluation sessions will be analysed and subsequently modifications will be implemented in the system. This process ensures that the final prototype will be capable of offering the user the appropriate level of help, should they require it. Further work needs to be carried out with the target user group in order to ascertain the most acceptable and

useful methods of presenting help to the user. During the design process suggestions made by the user group will be incorporated into the prototype design which will be tested and evaluated by target users.

5. CONCLUSIONS

This paper presents a review of evolvable interfaces and factors which hinder elderly people's ability to use a computer interface effectively. Currently, research on evolvable interfaces concentrates mainly on user-initiated changes where the user must specify any required changes to the interface. This paper has presented initial work in the development of an intelligent evolvable help facility that will dynamically offer individualised assistance to elderly users while accessing the Internet.

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