Application of Inclusive User Modelling Web Service

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Abstract: This paper presents an application of a user modelling web service in personalizing interfaces for users with age-related and physical impairment. The user model stores user profile in standardized format independent of application and device. It allows users to carry the profile with them irrespective of device and application. The user modelling web service is used to adapt interfaces of a sensor network based geo-visualization system and an agriculture advisory system for UK and Indian rural population. A pilot study found that all users preferred the adapted interface and their performance was also improved with adaptation.

1. Introduction

User model can be defined as a machine-readable representation of user characteristics of a system. We have developed a user model that considers users with physical, age-related or contextual impairment and can be used to personalize electronic interfaces to facilitate human machine interaction. We have identified a set of human factors that can affect human computer interaction and formulated models [2, 3] to relate those factors to interface parameters. We have developed inclusive user model, which can adjust font size, font colour, inter-element spacing (like line spacing, button spacing and so on) based on age, gender, visual acuity, type of colour blindness, presence of hand tremor and spasm of users. The model is more detailed than GOMS model [6], easier to use than Cognitive Architecture based models [1,9], and covers a wider range of users than existing generic user models [8] for disabled users, a detailed literature survey can be found in a different paper [2] . The user profile is created using a web form and the profile is stored in cloud. The sign-up page can be accessed at www-edc.eng.cam.ac.uk/~pb400/CambUM/UMSignUp.htm Once created, this profile is accessible to the user irrespective of application and device. We have worked with different development teams to integrate this user model into their applications. So far, the inclusive user modelling system has found applications in a wide variety of systems including a digital TV framework for elderly users (EU GUIDE system), an electronic agricultural advisory system, weather monitoring system and an emergency warning system. In parallel we conducted user trials to validate the user model. Users preferred and performed better with the adaptive system than the non-adaptive version.

2. User Modelling Framework

We have developed the Inclusive User Model and used it to develop a user modelling web service that can automatically adjust font size, colour contrast, line and button spacing of interfaces based on visual acuity, type of colour blindness, grip strength, active range of motion of wrist and static tremor of users. The user modelling system

- follows a standardized user profile format specified by a EU cluster [7] and published by International Telecommunication Union [5].
- does not propose to change content of an interface rather specifies layout parameters, so it is easily integrated to different applications.
- can automatically convert interface parameters (like font size or button spacing) for multiple devices (e.g. TV, computer, laptop, mobile phone and so on) by assuming a viewing distance for different devices and taking the screen resolution as input parameter.
- has investigated details of visual, auditory and motor functions of humans and is developed through extensive user trials to relate human factors to interface parameters [3].

The personalization framework (Fig 1) takes input about users' functional parameters (like visual acuity, colour blindness, short term memory capacity, first language and dexterity level) and subjective requirements. It also takes input from a sensor network [10] in runtime to detect the context of application. The Wisekar (Wireless Sensor Knowledge Archive) system is an Internet of Things (IoT) based repository for archival of sensor-derived information.

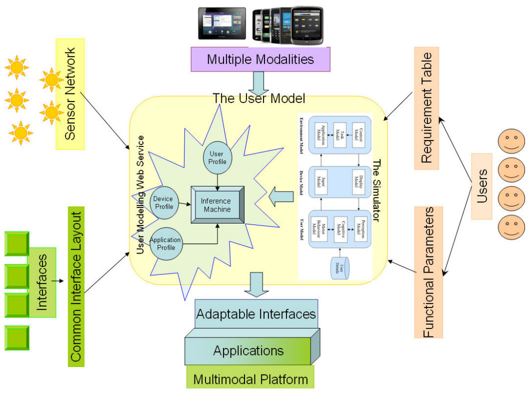


Figure 1. Personalization framework

These input parameters are fed into the Inclusive User Model that consists of perception, cognition and motor-behaviour models. The Inclusive User Model [2, 3] can predict how a person with visual acuity v and contrast sensitivity s will perceive an interface or a person with grip strength g and range of motion of wrist (ROMW) w will use a pointing device. Our user survey [4] generated a range of values of human factors for end users and we used this data in Monte Carlo simulation to predict a set of rules relating users' range of abilities with interface parameters. The rule based system along with the user, device and application profiles are stored in a cloud based server. The client application can access the web service using a plug-in.

The framework is integrated to applications using a simple Javascript program. The client application reads data from the user model and sensor network and changes the font size, font colour, line spacing, default zooming level and so on by either selecting an appropriate pre-defined stylesheet or changing parameters for each individual webpage or standalone application. A personalised weather monitoring system can be found at http://wisekar.iitd.ernet.in/wisekar_mm_full/index.php/main while a personalised electronic agriculture system can be found at http://e-vivasaya.rtbi.in/aas_cambridge/login.php . Different renderings can be generated with usernames user-1, user-2, user-3, user-4 and so on. In each case the password is same as the username.

3. User Trial

The following user trial reports a controlled experiment on the weather monitoring application. It compared users' objective performance and subjective preference for an adaptive and a non-adaptive version of the weather monitoring system. We purposefully used two different devices for signing up and using the application to highlight the notion of transporting user profile across multiple devices.

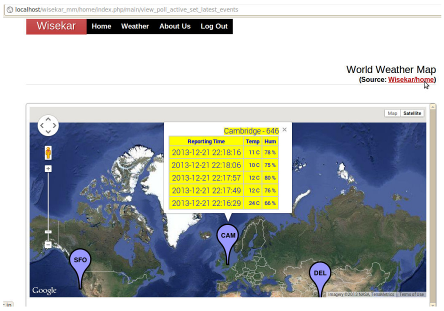
We collected data from 7 users (6 male, 1 female, average age 54.87 years) with moderate visual impairment, mainly age related short-sightedness and cataract.

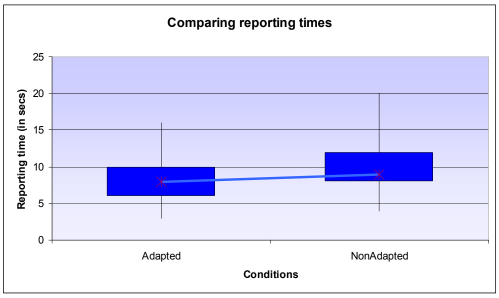
We have used a Windows 7 HP computer with 54 cm × 33 cm monitor having 1920 x 1080 pixels resolution to record users' performance with the weather monitoring system. We used a standard Logitech mouse for pointing. Users signed up using a HP Tx2 laptop with 30 cm × 20 cm screen and 1280 × 800 pixels resolution.

The participants were initially registered with the user modelling system using the Laptop. After that participants were briefed about the weather monitoring system. The task was to report temperature and humidity of cities on a specific date. Each participant was instructed to report temperature and humidity six times for each of adapted and non-adapted conditions. The order of adapted and non-adapted conditions was altered randomly to eliminate order effect.

During the sign up stage we found that different users preferred different font sizes ranging from 14 points to 18 points. We also noticed that one user was Protanomalous colour blind and he read 45 instead of 42 in the plate 16 of Ishihara colour blindness test. During use of the weather monitoring system, we measured the time interval between pressing the left mouse button on the bubble with the city name and reporting of the required temperature and humidity data. In total we analysed 84 tasks (42 for adapted and 42 for non-adapted). We found that users took significantly less time in adapted condition (average 8.25 secs, std dev 3.1 secs) than non-adapted condition (average 9.75 secs, std dev 3.63 secs). All participants were already familiar with mouse and also practiced the system before the actual trial. So we assumed that each pointing task was independent to each other. Under this assumption, the difference is significant in a two-tailed paired t-test with $p < 0.05$ and with an effect size (Cohen's d) of 0.44 (Fig 2). Without this assumption, the difference is also significant in Wilcoxon Signed-Rank test ($Z = -2.1$, $p < 0.05$). We conducted a subjective questionnaire to understand users' subjective preference. All users noticed bigger font and preferred it. One user was colour-blind and he preferred the change in colour contrast too.

The user study shows that users prefer different font sizes and colour contrast even for a simple system. The study also confirms that even for a simple text searching task users performed and preferred an adaptive system that can automatically adjusts font size, line spacing and colour contrast. The user modeling system successfully converted users' preference across two different devices having different screen resolutions. Future studies will collect data from more users and will use more complicated tasks than the present study.





a. Example of Adapted Wisekar   b. Comparing weather reporting times

Figure2. Application of Inclusive User Model

4. Conclusions

This paper presents an application of a user modeling system that is used to store a user profile online and uses it to adapt user interfaces across different applications running on different devices. The user model follows standardized format to store the profile so that it can be easily integrated to multiple applications developed by different development teams. Our user study confirms that systems adapted by the user modeling system are preferred by users and it also statistically significantly reduces task completion times.

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