Adaptive Interfaces: A Little Learning is a Dangerous Thing…

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Abstract. In this paper we present a possible approach to improve accessibility and usability of software applications through shared user models. Previous work in adaptive user interfaces has relied on local and domain specific user models, which lack in scope and detail. Shared user models can increase the accuracy and depth of data used to adapt the interfaces and user interactions. This research focuses on the accessibility of touch screen mobile devices for users with low vision and mobility impairments.

Keywords: adaptive interfaces, mobile computing, low vision, physical disability.

1 Introduction

Personalised applications and websites are becoming increasingly popular, and many computer users interact with some form of user-adaptive system on a daily basis. Contemporary adaptive educational systems (AES) tend to be driven by two factors- the user's domain knowledge and the user's interests of the session [1]. Currently domain knowledge is more dominant within the user model. Whilst non-educational systems apply a more equal weight to the user's interests, both the user's domain knowledge and interests rely on local user models. In this case, a little knowledge may be a dangerous thing [2]. These adaptive systems store a local user model of data collected within the scope of the application. The current research investigates shared user modelling as a possible technique to improve the accuracy and detail of user data to create more effective mobile device interactions, concentrating on improving the accessibility of the technology for users with low vision and mobility needs.

It is vital that computer technologies and software are usable by people with very diverse skills and needs. Guidelines exist to give a generalised view of accessibility issues and techniques to reduce these issues, promoting developers to design accessible, usable, flexible, and intuitive solutions. Whilst this has encouraged the designers to take a more user centred approach, the final products may not be fully accessible. Technology users are unique, with individual needs and requirements of software tools, and may not necessarily fit designers' generalised abstract group

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representations. Adaptive Systems [3] attempt to bridge the gaps between design and user needs by providing personalised designs. They do this by personalising content based on domain specific user models, which provides a valuable structure for educational systems intended to develop and progress users' domain knowledge. The adaptive systems often use a multi-layer interface design [4], with a spectrum of diverse complexity and functionality layers for users of different skill set. Adaptive systems allow content to be presented and tailored to meet the needs and interests of individual users. Therefore, the more realistic the user model the higher accuracy of the personalisation and accessibility of applications. This research will be focusing on the use of shared user models with touch capable mobile devices.

2 User Models

User models are structured data sources for representing user characteristics such as interests, preferences and domain knowledge. All the data is recorded in context of the system it was stored for, and self-contained within the application. Shared user modelling expands the range of variables being recorded, and allows multiple applications to make use of the same data. Such models already exists in technology, with the Facebook Open Source Graph protocol (OSG)[5] being one such example.

Shared user models need to accommodate a wide and diverse range of systems, requiring them to contain additional data to allow the abstract shared data to be put into context for individual applications or uses. We, therefore, break the model into the following architecture: User, Application, Device and Environment. Within the User section we look at interests and user preferences or attributes. Application records data on the users' domain knowledge and goals within the current application. Any data about the hardware preferences and capabilities is recorded in the Device section, and attributes of the users surroundings during system use are logged in the Environment section.

2.1 Web Services

With shared models, applications must all obtain and update information stored within the user model. This is why the User Model Web Service (UMoWS) [3] structure was selected. The user models are contained within the database accessed only by the UMoWS. Any application wishing to make use of the shared user models must communicate via the web service methods of the UMoWS using unique authentication credentials. Applications can request and update information on a selected user as long as they have permissions to do so. Connected to the UMoWS is a User Management control panel, allowing users to view and edit their model information and access permissions for this content. The diagram in Figure 1 shows the overall structure and how applications can make use of the shared user models.

As can be seen from Figure 1, the only way to access the user models is via the UMoWS. To ensure the security of users information all access to the web services requires authentication, this means applications will be required to register for an API key to gain access. Before that application can retrieve or store any user data the user must first grant access to do so. Access permissions can only be granted by the user, using their login credentials via the User Management control panel. The control panel will allow the user to modify and remove any granted permissions or information being stored. Once an application has the appropriate permissions it can then use the permitted web services to access the shared user model. Web services included will be the standard operations for retrieving a users model with specific fields, adding new information and adding new fields to be recorded (useful for domain specific data). Simple Object Access Protocol (SOAP) will ensure that any application wishing to access the web services can do so using a standard format.

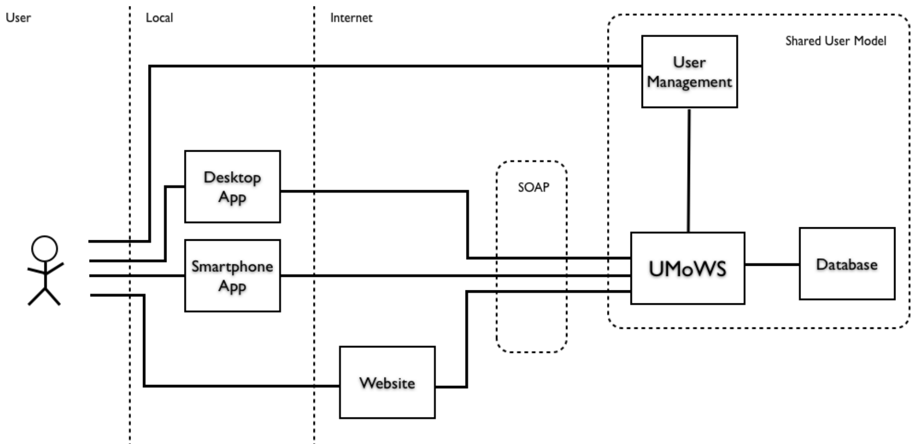

Fig. 1. UMoWS structure showing how applications access the shared user model data via SOAP requests

2.2 Data Acquisition

Applications will have their own techniques for collecting data on the user's domain knowledge, however it is important that the shared user model also contains information about the application itself. This allows domain specific data to be put in context and helps build relationships between the concepts within the user model. All applications will be registered with details outlining the scope of the system and the goals of the application, allowing comparisons and connections to be identified between different applications and their domain activity. The device and environment information should also be logged in the user model with each session the user has. This includes details on the device capabilities both hardware and software, showing possible interactions that can be carried out on the device, and environmental details on noise, light levels, mobile or stationary to help identify relevant interactions for the current session.

3 Adaptive Interfaces

The goal of adaptive interfaces is to improve the interactions a user has with the software based on knowledge of the user and their experience within the application

[6]. Adaptive interfaces tend to retain the same overall layout and interaction style for each user, whilst personalising the content being presented. Multi-Layer interface design works differently [4]. With these, users are presented with an interface layer that matches their application skill level. As users progress and become more skilled new features are opened up and added to the interface. Multi-Layer Adaptive Interfaces combine the user modelling and domain knowledge monitoring techniques of Adaptive Systems, with custom interface layers for different characteristics or situations. The diagram in Figure 2 shows how a single application created with a multi-layer interface design could provide individual users with tailored interfaces and interaction methods. Adaptive interfaces allow applications to cater for a wider range of users with distinct characteristics and needs, rather than the popular one size fits all solutions we see all to often in software today.

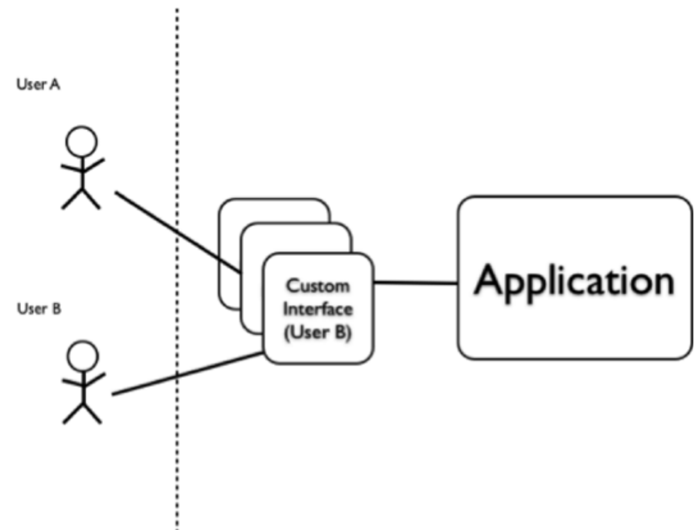

Fig. 2. Structure showing multi-layer interfaces being used to personalise an application for individual users

4 Touch Screen Mobile Devices

Although touch screen capabilities are becoming more common in desktop computers and laptops, there has been a shift in the balance of technologies used to access news, information and the Internet in general. In recent years we have seen an increase in the uptake in both new types of devices and styles of interaction. In the UK, for example, the overall up-take of communication devices and services have all increased in the last 3 years [5,6].

With technologies such as digital television and personal video recorders (PVR) there comes a higher level of functionality and menu complexity than their predecessors. This requires a greater understanding and knowledge from the user. Whilst the new input devices have a similar form to the older devices, the methods of use and cognitive load have increased to incorporate the new functionality of the systems. Reports [5, 6] also show that the number of people with access to broadband has increased, suggesting also an increased use of web services and exposure to web browser applications.

Looking at the top 10 smartphones in 2009, two of which were touch screen devices; by 2010, 8 of the top ten were touch screen devices [7]. Seven of these use multi-touch displays. Touch screen interfaces allow for very flexible interfaces and interaction methods. However most lack the tactile feedback that a physical button provides, creating new complications when informing the user of a successful button press. Some manufacturers have elected to substitute the feedback created by a physical button with device vibrations and or notification sounds. However no standard technique has been formed, causing inconsistencies between devices, and even between applications within the same mobile phone.

Touch screen devices also allow for greater flexibility when creating user interfaces, there a fewer restrictions on the type of layouts and controls possible compared with non-touch input devices. Currently work is being carried out investigating techniques to make touch screen devices more accessible for users with physical impairment that make touch screens difficult. That research has focussed on the target sizes, positioning of buttons and the use of gestures [8].

5 Mobile Indoor Navigation Tool

Our initial prototype for the shared user modelling is a tool for users with low vision and mobility needs to assist with indoor navigation [11]. By loading in the shared user model, the tool is able to customise the route taken from a start point to destination, based on data that might affect a user's way-finding capabilities and interaction needs. The interface is individually tailored to meet the needs of the users, providing the instructions in the format that best suites their characteristics and preferences, as shown in Figure 3.

A pilot study was run with a small number of older adults (4 in total) aged between 60 and 86. None of the participants had any prior experience with touch screen mobile smartphones. Most, however, picked up the interaction method of pressing the buttons they could see on screen relatively quick. One participant did encounter a number of issues when using the navigation tool. Originally the researcher believed this to be a fault with the application communicating with the web services retrieving the navigation instructions. The tool was reset and the route restarted. This time the researcher observed the way-finding task and identified that the user was touching the onscreen button multiple times within a short space of time due to a slight hand tremor.

The false positives from this participant's touches caused this technology to be very challenging. The researcher was able to explain the problem to the participant before the final task was performed. Shown in Figure 4 are the logs from both the route prior and post explanation of the issue. The logs from the first route show that the participant was skipping ahead instructions then having to select the "previous"

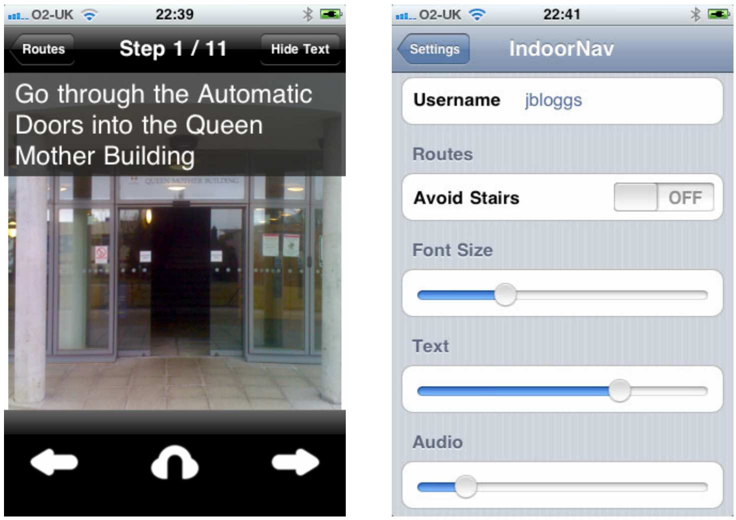

Fig. 3. Screen shot of the navigation tool instruction interface (left) the corresponding user profile showing interaction preferences (right)

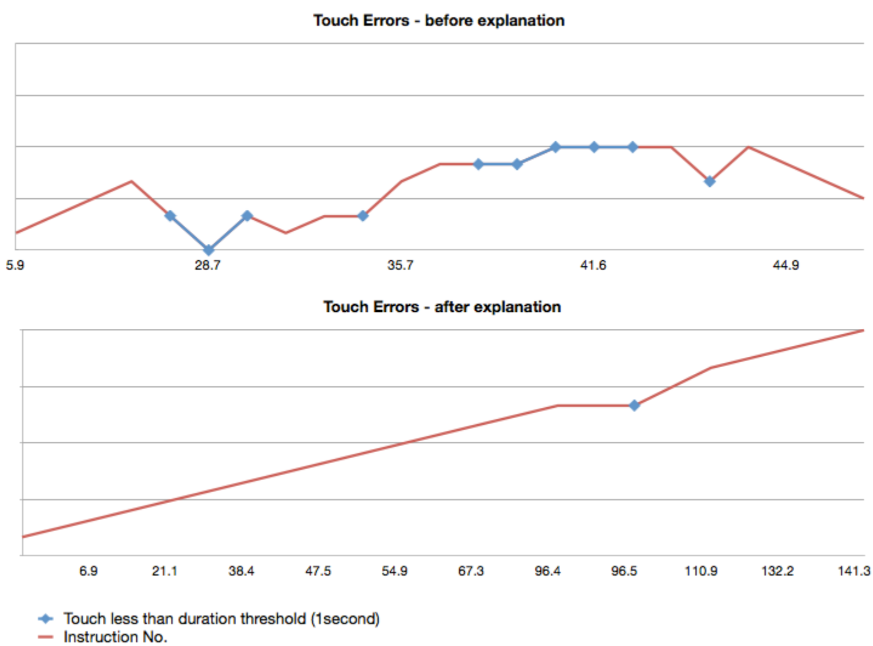

Fig. 4. Graphs of touch interaction logs from indoor navigation user study

button to get the correct one. By default the touch screen Smartphone does not threshold the duration between touches. The graph shows all the points where the duration between touches was less than 1 second. The 2nd graph shows the logs after the situation with the application was explained to the user. The 2nd log is more like the result we would hope to see from the application, with just one error where the "next" button was double tapped resulting in the user skipping from step 8 to 10 within the way-finding sequence.

The prototype was later modified to include catches for this type of interaction problem. Further work is being carried out to personalise the threshold durations for what is an intended touch or not.

6 Mobile TV Guide

To evaluate the effectiveness of shared user modelling at a method of improving the accessibility of the touch screen devices, there must be at least two applications. Therefore, a second prototype mobile app is being developed to assist users with browsing electronic programming guides (EPG) for digital television (DTV). Ofcom reports [5, 6] define accessibility of content targets for DTV public sector channels. For subtitling, they state minimum percentage as 90%; for audio descriptions10%; for

Fig. 5. Screen shot of TV guide prototype showing shortlisted content based on shared user model (left), low vision optimised version of the interface (right)

signing 5%. With such a low percentage of programmes available in AD and digital signing format, users could face great difficulty searching for a programme they would like to watch in the format they need. With regards to the additional (non public sector) channels they may never find a programme they can access fully. The mobile TV guide app combines the rich user profile data from the shared user model with the EPG information to assist the user in finding shows both in a format that's accessible and of interest to them. The prototype will shortlist content based on the individual's access needs and present the information back to the user in a format that best suits their characteristics. Screen shots of the app and an adapted version for a low vision user are shown in Figure 5. Interface customisations will include scaling and hue shifting of all text, images and buttons.

The Mobile TV guide and Indoor Navigation app are two very distinct systems, however they share a great deal of overlap in terms of interaction with the mobile device. The 2^{nd} prototype will allow this overlap and the effectiveness of shared user modeling to be properly evaluated as a potential technique for improving the accessibility of touch screen mobile devices for users with low vision and mixed levels of mobility.

7 Conclusion

Touch devices afford the flexibility to create interesting methods of user interaction. Due to the lack of consistency between interfaces there are a number of usability and accessibility issues created. Designers cannot rely on the one-size-fits-all approach to touch screen interface design and existing adaptive systems are unable to always make the correct adaptions due to lack of accuracy and scope in the local user model. Detailed shared user models would allow developers to build applications that could be customised at runtime to suit individuals needs, helping to ensure that applications are accessible and usable by all, regardless of individual user differences, devices and environments. Full studies to the indoor navigation tool and mobile TV guide with visually and physically impaired participants are currently being conducted. The prototype has been extended to include more detailed interaction data, capturing not just the order and timestamps of button presses, but also the duration of a single touch (press & release) and touch position within target element. This new data will allow further refinement to the threshold filtering of intentional interactions and optimisation of target sizes of elements on an individual basis. These studies should allow for a detailed comparison between the one-size-fits-all, local model and shared user model adaptive systems.

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