Exploiting Inclusive User Model for an Electronic Agriculture System

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Abstract. 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. This paper presents a case study of exploiting this Inclusive User Model to personalize an electronic agriculture application. The e-agriculture system aims to help farmers in reporting crop diseases electronically and getting help from experts. We have integrated the user model with this application so that it can be used by users with a wide range of perceptual, cognitive and motor impairment. Once users signed up to the user modeling system, their profile is carried with them regardless of the type of device they are using. The paper presents brief detail of both the user model and the e-Agriculture system along with description of a user study conducted on the system.

1 Introduction

This paper presents an inclusive design technique through user modelling. We have described an electronic agriculture system to help farmers in rural India and UK. The system will be used by both agricultural experts and farmers through a variety of devices ranging from low-end mobile phones to high end computers. The range of abilities of users and contexts of use will also be different considering the vast geographic stretch and cultural differences of India and UK. Tackling such diversity demands a new type of inclusive design where interfaces can be customized based on user and context profiles.

Precision agriculture is an innovation strategy that has been proposed to cope with the problem of environment sustainability. It centres on the use of technology to increase the agricultural efficiency through urgent forecasting and early warning system. The e-Agriculatue system supports early warning and disease identification through two applications

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The Pest-Disease Image Upload (PDIU) application will be used by farmers to upload images of infested crops, while they are in the field. The uploaded images will automatically be sent to remotely located experts, who will advise farmers about remedy. The application will run on low-end mobile phones or smart phones. It not only makes it easy for farmers who have difficulty in operating a keypad but also accommodates those suffering from poor vision or cognitive impairments.

A web-based Dashboard system that runs on a personal computer and used by experts to advice farmers. Experts can be across all age levels and it is therefore important to design a user interface that takes into account impairments of different kinds that an expert might possibly be dealing with.

Any information regarding modern agricultural trends and practices being delivered to farmers should be aligned with their actual needs and their existing experience and knowledge base. In other words, the information has to be as personalized and interactive as much as possible. Our user modelling system [3] first developed a simulator to predict perceptual, cognitive and motor abilities of users with a wide range of abilities. The simulator embodies both internal state of an application and machine learning models for visual and auditory perception systems, cognitive module and motor action system. We used the simulator along with a user survey on Indian population to develop a user modelling web-service and an adaptation algorithm to personalize user interfaces for the eAgriculture system. Figure 1 and 2 demonstrate different rendering of the eAgriculture system for different user profiles.

The user modelling system is itself application agnostic. A demonstration version of the simulator can be downloaded from

http://www-edc.eng.cam.ac.uk/~pb400/CambridgeSimulator.zip

A demonstration version of user modelling web services can be found at the following links.User Sign Up: This application creates a user profile,

http://www-edc.eng.cam.ac.uk/~pb400/CambUM/UMSignUp.htm

User Log In: This application predicts interface parameters and modality preference based on the user profile,

http://www-edc.eng.cam.ac.uk/~pb400/CambUM/UMLogIn.htm

Adaptation Example: This application renders a single webpage differently based on user profiles.

http://www-edc.eng.cam.ac.uk/~pb400/CambUM/UMStyleSelect.htm

Video demonstration: http://youtu.be/MiYp-d6rSXM

A couple of similar approaches are the Global Public Inclusive Infrastructure (http://gpii.net/) and the EU Cloud4All project [4]. However these projects do not have a user performance simulation and works mainly based on users' explicitly stated preferences. The use of the performance simulation with sufficient validation will help to cover a wider range of users than existing systems and reduce the development time for any new interface as designers can run initial validation without conducting long user trials. Additionally, our system considers wider range of applications and users than existing system with respect to ethnicity and socio-economic context of use.

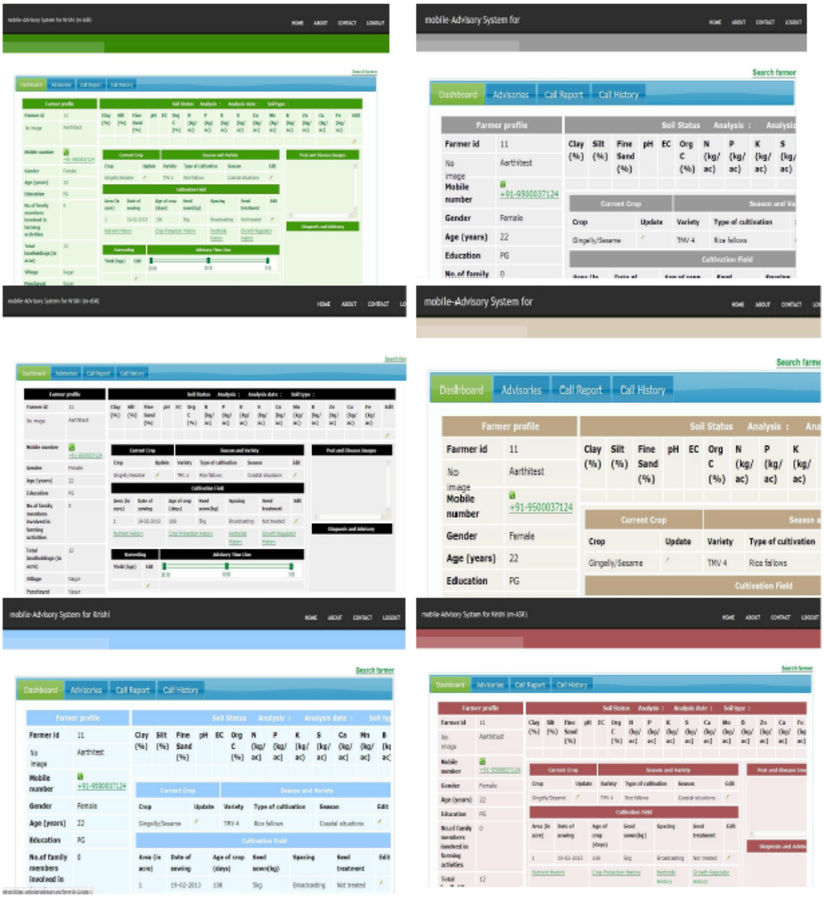

Fig. 1. Different renderings of the Dashboard application

Fig. 2. Different renderings of the PDIU application

User Studies

We have conducted a series of user trials to validate the adaptive interfaces generated through the user model. The first study [1] conducted an icon searching task involving users with age-related and physical impairment. The study was conducted on a desktop PC and a Tablet computer using different organizations of icons in a screen and with and without integrating the user model. It was found that users could select icons quicker and with less error when the screen was adapted following the prediction of user model.

The second user study [2] evaluated the prediction of the user model for situational impairment using a text searching task on a tablet computer while users were walking in a field. The study used same texts and dimensions of screen elements of the PDIU application. Again it was found that a screen adapted through the user model was quicker to user and produced fewer errors.

The third study aimed to improve the PDIU interfaces by recording interaction patterns and then analysing task completion times and wrong key presses by users. Based on the analysis we recommend a few changes in the interface and application logic to facilitate users' interaction. The study is not a comparison between adaptive and non-adaptive interface, rather it is an overall external validity test of the adaptive PDIU system. This last study is described in the following sub-sections.

1.1 Participants

We collected data from 5 young users (age range 24 to 40 years) and 5 elderly users (age range 56 to 65 years) from Mandi. They were all male, related to farming profession and use low-end mobile phones. Young users were educated above matriculation level. One of the young users needed big font size and one had Protanopia colour blindness. Elderly users' education levels vary from high school to Matriculation. All elderly users preferred biggest text size and two had colour blindness. They can all read English words used in the PDIU interfaces.

1.2 Material

The study was conducted on a Nokia 301 mobile phone.

1.3 Procedure

The task involved taking photographs of three leaves arranged on a desk using the PDIU application. At first they were registered to the application. The system then asked their preferred font size and conducted the Ishihara Colour Blindness Test [5] using the plate number 16. Based on their response, the application adapted itself and users were asked if they found the screen legible. Then they were demonstrated the task of taking photographs and after they understood it, they were requested to do the same. The experimenter recorded a video of the interaction. During the task, users needed to go through the screenshots shown in figure 1 below. The sequence of actions were as follows

Select PDIU from PDIU home screen (figure 1a)
Scroll down to Open Camera under Image 1 (figure 1b)
Select OpenCamera and take a photograph
Scroll down to Open Camera under Image 2 (figure 1b)

Select OpenCamera and take a photograph
Scroll down to Open Camera under Image 3 (figure 1c)
Select OpenCamera and take a photograph
Press Menu (figure 1c)
Scroll Down to Save option (figure 1c)
Select Save (figure 1c)

After they completed the task, we conducted a general unstructured interview about their farming experience and utility of the system.

a. PDIU Home Screen b. Open Camera Screen c. Menu Screen

Fig. 3. PDIU interfaces used in the study

2 Results

The following graphs (figures 2 and 3) plot the task completion times for the operations involving taking three pictures and saving them. In these figures, C1 to C5 stands for young participants while P1 to P5 stands for their elderly counterpart. An one factor ANOVA found a significant effect of type of tasks among all 10 participants [$F(3, 36) = 4.05$, $p < 0.05$]. Users took only 21.9 seconds on average to record the first image while they took 51.2 seconds on average to record the second image, 48.4 seconds on average to record the third image and 50.7 seconds on average to go to the Menu and press Save button.

We also analysed all instances of wrong key presses and Table 1 lists them with respect to each participant. In Table 1, C1 to C5 stands for young participants while P1 to P5 stands for their elderly counterpart.

During the open structured interview it emerged that they belonged to different sections of the society. They were farmers, land lords, part-time farmers of their ancestral agrarian land pursuing another profession like bus driving. They mostly harvested crops like corn, maize, bajra, wheat and so on. One of their major problems was the quality of grains. One of them reported problem with harvesting corn, which often suffered from disease resulting white ends and less grains than usual. Another one complained about wheat, which suffered from a disease causing dried stalks. They face massive problems on farming, as they do not get enough modern equipment for harvesting good quality crops. One of them reported about a help centre in their capital town, but it was nearly a hundred kilometres away from their farming place with no good public transportation available. So they hardly could get help from them.

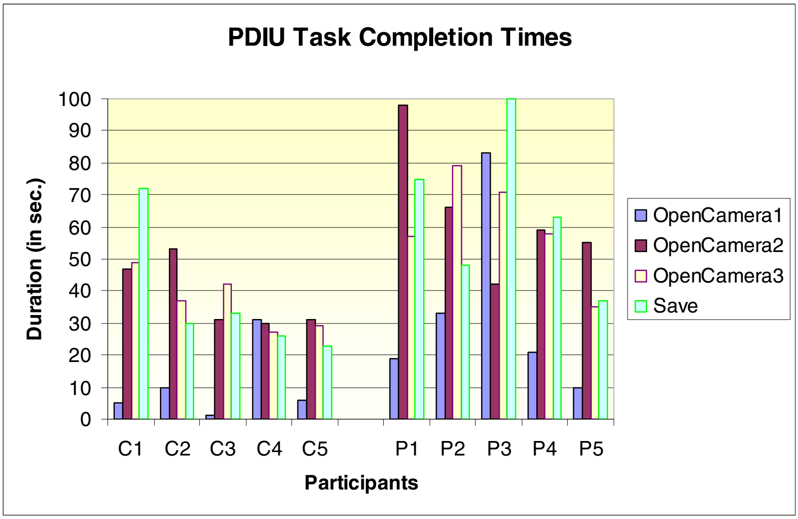

Fig. 4. Task completion times for participants

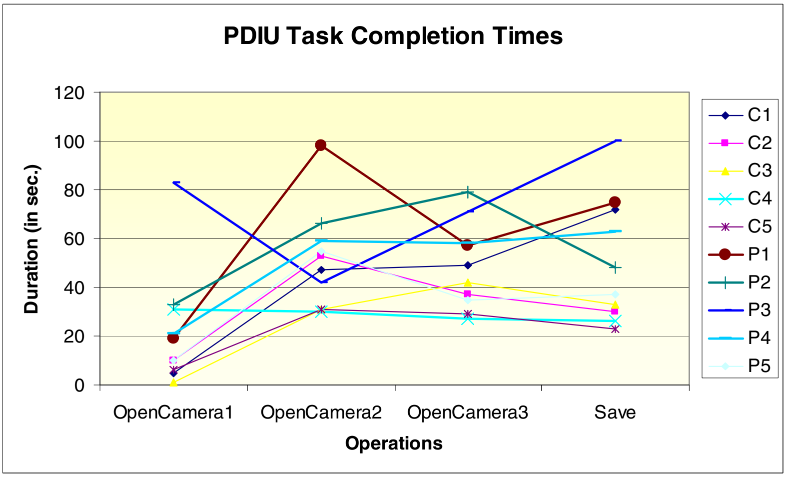

Fig. 5. Task Completion Times for each operation

Table 1. Lists of wrong Selection

Participants	Wrong Key Presses
C1	Went back from OpenCamera2 to OpenCamera1, scrolled up instead of down, recovered himself Cancelled Save option, was confused but then recovered and finished successfully
C2	Pressed middle button to select the PDIU in home screen Selected OpenCamera1 second time instead of scrolling to OpenCamera2
C3	No wrong key press
C4	Scrolling up instead of scrolling down before reaching OpenCamera buttons
C5	Pressed Submit instead of selecting Save, had trouble between selection and scroll down buttons
P1	Scrolling up instead of scrolling down before reaching OpenCamera buttons Pressed Back button instead of Selecting OpenCamera2 Pressed Back button again in the PDIU home screen Pressed Back button again instead of Selecting OpenCamera2 Could not scroll down to Save button in Menu items
P2	Pressed middle button of Scroll Button instead of selecting Capture in OpenCamera2 Pressed Menu instead of going to OpenCamera3
P3	Pressed Back button in PDIU Home Screen Presesed Back Button from the OpenCamera Screen Presesed Back Button again from the OpenCamera Screen Pressed Left button instead of Middle button in one system message screen Pressed OpenCamera1 second time instead of scrolling down to OpenCamera2 button Pressed Back button instead of Capturing image in OpenCamera3 Scrolled up to OpenCamera2 from OpenCamera3

Table 1. (*continued*)

	Scrolled down from Save button but then get back to Save button
P4	**Pressed middle button instead of Capture button in OpenCamera2**
P5	**No wrong key press**

3 Discussion

The farmers found the system useful and the interfaces were legible and comprehensible to them. However some of them especially the elderly ones faced problem in scrolling and recovering from error. It seemed to us a simpler interface will be more useful to the elderly users. Based on the study and list of errors we propose the following recommendations.

Initial focus on OpenCamera Screen
This initial focus can alleviate a few scrolling errors as users will understand that they need to scroll down to select the open Camera buttons.

Only one OpenCamera button with automatic Save option
The ANOVA shows that users were significantly slower in taking the second or third photograph and saving them. If there is only one OpenCamera button which automatically saves or submits the picture, a lot of scrolling errors can be avoided and the overall task completion time will also reduce significantly.

Confirmation of Back action in middle of interaction
We found users were often confused if they pressed the back button. It may be useful to add a confirmation dialog if they press the back button in the middle of taking a photograph or saving it.

Overridden buttons while capturing images
Users pressed the middle button to capture image which is a common feature in most mobile phones with a camera. It will be a good idea to let users do so making the system more intuitive.

4 Conclusions

This paper presents of a case study of personalizing an application using user model. The user model helps to render an interface differently for different users based on user profiles. Users do not need to manually change settings of browser, mobile phone or download applications. Once signed up to the user modeling web service, their profile is carried with them regardless of the type of device they are using. However our user trial also points out that the user model can not alone optimize interaction; rather a set of guidelines or recommendation about application logic is complementary to user model.

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