# Evaluation of Adaptive Interaction with Mobile Touch-Screen Devices

Kyle Montague, Vicki Hanson, Andy Cobley
School of Computing
University of Dundee
+44 (0) 1382 388237
{kylemontague,vlh, acobley}@computing.dundee.ac.uk

## ABSTRACT
Mobile touch-screen devices are becoming increasingly more popular across a diverse range of users. Whilst these smart phone devices offer users access to a wealth of information and utilities via their downloadable apps, there are still a large proportion of users who are unable to fully interact with the technology due to additional interaction needs. In this paper we present an evaluation on the use of shared user modeling (SUM) and adaptive interfaces to improve the accessibility of mobile touch screen technologies. Our studies involved 12 participants with various visual and mobility impairments.

## Categories and Subject Descriptors
H.5.2 [**Information Systems**]: Information Interfaces and Presentation - User-centered design.

## General Terms
Measurement, Design, Experimentation, Human Factors.

## Keywords
Human computer interaction, accessibility, shared user modelling, adaptive interfaces, mobile touch-screens.

## 1. INTRODUCTION
Touch-screen devices offer software designers a greater flexibility and freedom with their application interfaces. Interactions need not be limited by physical buttons and keypads, but instead can be built using onscreen targets of variable sizes, able to respond to a large array of interaction methods far beyond a simple button click. These attributes lend themselves well to the creation of multi-layer interfaces[1], making touch-screen devices the ideal candidate for user adaptive applications. User adaptive applications rely on detailed digital representations of users characteristics and abilities to make predictions and suggestions on a suitable interface for an individual. Shared user modeling (SUM)[2] allows otherwise independent applications the ability to share user data models, thus sharing the collection process and potential diversity of data. The aim of this research is to investigate whether shared user modelling with adaptive interfaces can improve the accessibility of mobile touch-screen devices. We hypothesized that users would incur fewer touch errors and give the applications a higher usability rating when using the SUM adapted interfaces.

## 2. METHODS
In order to evaluate whether shared user models could be used to improve the accessibility of touch-screen mobile devices, three loosely related applications were created. This allowed for comparisons to be made between the *Static* (non-adaptive) interfaces and the *Adaptive* interfaces sharing user model data between applications. Each application required the participant to use a single touch with onscreen controls to interact. Due to the physical characteristics our participants experience difficulties in two areas: interacting with the onscreen controls, and retrieving information from the device display.

The three applications created were: a Calibration tool, Indoor Navigation and a TV Guide. To allow the applications to share user models we deployed a series of web services, granting the apps access to read and modify shared user data. Questionnaires to collect background data such as mobile phone usage and user abilities were conducted before participants begin the SUM study. As well as the questionnaires, the simple usability scale (SUS)[4] was used immediately after each application evaluation.

Touch errors were evaluated based on the error rate results from the Calibration studies. The interface with the lowest error rate within the calibration app was the one with the least touch errors. Each participant rated the usability of the Indoor Navigation and TV Guide applications by filling out the SUS. The interface with the highest SUS score has the greater usability rating.

### 2.1 Procedure
The experiment was conducted on Apple iPod touches (2nd Generation) running the prototype applications. The devices supported multi-touch interactions, with up to 5 simultaneous touches. The applications however only required a single touch input. The output was displayed on the devices 3.5-inch (diagonal) screen, with a resolution of 320x480pixels (163ppi). Prototypes also made use of the audio output via the built in speakers or Sennheiser MM100 headphones with a 22-20,000Hz-frequency response. 2nd generation iPod touches are shipped with no accessibility support (VoiceOver, Zoom, Large Text and White on Black features were later added in the 3rd generation devices). Since VoiceOver was unavailable, applications were embedded with 3rd party text to speech (TTS) functionality. TTS was created by communicating with Google translate web service[5]. Requests were made over HTTP to the website and mp3 audio files were returned, and stored locally on the device. As a result of this decision the applications required frequent Internet access to provide a consistent interaction.

Each of the applications were designed and built to conform with the iOS interface guidelines [6] and all interface elements were given a minimum bounds of 10mm (60px on this device) identified in previous research [7] to be the optimal target size for daily users of these devices.

### 2.1.1 Calibration

During the calibration participants were seated in an armchair (otherwise their own wheelchair), and asked to sit in a relaxed position. The calibration tool generated 200 pairs of targets within the 320x480 screen. The targets were pseudorandom as constraints were applied to the position generator to ensure good distribution of the targets. The screen was divided into 3 sections vertically and 3 sections horizontally. 1:3:1 and 1:2:1. Our software tracks all touch interactions, and accelerometer movements made by the user, during the study the device was continually logging the timestamp, on screen target position and size, user touch location and duration. Similarly for the Indoor Navigation and TV Guide applications user interactions were collected and logged in relation to the interface elements. Within the Calibration study each participant was given both *Static* and *Adaptive* interfaces, however the ordering was randomised. Participants were then randomly assigned to be in either the *Static* or *Adaptive* group for future application interfaces.

### 2.1.2 Indoor Navigation

For the Indoor Navigation application participants were asked to complete a series of indoor way-finding tasks within the School of Computing building, using only the instructions provided by the indoor navigation app. Each participant attempted all routes within the indoor navigation study.

### 2.1.3 TV Guide

The TV Guide application provided users with fixed TV listings for 7 channels and 28 programmes. Users were asked to complete a series of tasks requiring them to browse through lists and grids of channels and programmes and retrieve information about the show times, descriptions and access formats of TV content.

### 2.1.4 Interface Adaptations

The interface adaptations were limited to the scaling of text sizes, targets sizes and restrictions on touch durations of *tapping* interaction. By default a *tap* is defined as any touch interaction with the screen regardless of duration, and the iOS devices use a system font size of 14px.

## 2.2 Participants

A mixture of 3 male and 9 female adults aging from 21-71 were recruited. Participants all possessed characteristics that would qualify them as low vision and or mobility impaired. Low vision was classified as requiring additional software or hardware assistance when using digital technologies such as screen magnification or text to speech. The mobility criteria included people that experience difficulties with moving in physical spaces, traveling up or down stairs. Mobility also included people that struggle with fine motor skills. All participants satisfied at least one of these conditions, with some meeting two or all three. All of the participants owned and used a mobile phone on a daily basis. Only three of the group owned touch-enabled smart phones, they were the only people to have used a touch-screen mobile device before.

# 3. RESULTS

## 3.1 Quantitative

Our hypotheses were the following:

H1 – *SUM Adaptive* interfaces will report lower touch error rates than the *Static (non-adaptive)* interfaces.

H2 – *SUM Adaptive* interfaces will report a higher usability rating than the *Static (non-adaptive)* interfaces.

Participants in the two interface conditions were able to complete all of the tasks with one exception in within the *Indoor Navigation* study. This was due to a technical disruption caused by a loss of Wi-Fi connectivity. As hypothesized, the SUM Adaptive interfaces produced lower touch error rates overall, this revealed a significant effect $t(173) = 1.980$, $p < .049$ (H1). As predicated (H2), participants rated the shared user model Adaptive interfaces as more usable than then Static interfaces, $t(228) = -2.095$, $p < .05$, one-tailed. The mean usability rating for the Adaptive interfaces was 3.33 (SD=0.84), compared with the mean usability rating of 3.07 (SD=0.94) for Static interfaces.

## 3.2 Qualitative

During the evaluations the researchers did observe user behaviors that the devices were unable to collect. Participant V4 *(Visual impairment, using the adaptive interface)* described their reluctance to use a mobile phone in public, as they would have to hold it an inch from their eyes to see the screen. However throughout the study the participant was able to use the device at a comfortable arms length. This same user did express difficulties identifying some icons, and read text with *"thin fonts",* these adaptations were not in the evaluation applications but are entirely possible with the current system.

# 4. CONCLUSIONS

Whilst our results show an improvement in touch error rate by adjusting onscreen elements to match the required target and font size for individual users, the participant comments highlight a number or issues with the technology yet to be addressed. Through the use of SUM and adaptive interfaces we aim to address the outstanding challenges within this research space and improve the accessibility of the technology. Further evaluations of the SUM applications with longer collection periods are required to provide more detailed representations of the users characteristics and interaction abilities.

# 5. ACKNOWLEDGEMENT

Support for this project was provided by RCUK Digital Economy Research Hub EP/G066019/1 - SIDE: Social Inclusion through the Digital Economy.

# 6. REFERENCES

[1] Shneiderman, B., Promoting universal usability with multi-layer interface design. Proceedings of the 2003 conference on Universal usability, 2003: p. 1-8.

[2] Bielikova, M. and J. Kuruc, Sharing user models for adaptive hypermedia applications. 5th International Conference on Intelligent Systems Design and Applications, Proceedings, 2005: p. 506-511, 572.

[3] Brooke, J., SUS: a "quick and dirty" usability

[4] scale. In Usability evaluation in industry, 1996.

[5] Google, Google translate. 2009. (30/06/10).

[6] Apple, iOS Human Interface Guidelines. 2009. (23/03/11).

[7] Lee, S., and Zhai, S. The performance of touch screen soft buttons. Proceedings of the 27th international conference on Human factors in computing, 2009