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Performance Comparison of Manual and Touch Interface using Video-based Behavior Analysis

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ABSTRACT

The objective of this study is to quantitatively incorporate user observation into usability evaluation of mobile interfaces using monitoring techniques in first- and third-person points of view. In this study, an experiment was conducted to monitor and record users' behavior using Ergoneers Dikablis, a gaze tracking device. The experiment was done with 2 mobile phones each with a button keypad interface and a touchscreen interface for comparative analysis. The subjects included 20 people who have similar experiences and proficiency in using mobile devices. Data from video recordings were coded with Noldus Observer XT to find usage patterns and to gather quantitative data for analysis in terms of effectiveness, efficiency and satisfaction. Results showed that the button keypad interface was generally better than the touchcreen interface. The movements of the fingers and gaze were much simpler when performing given tasks on the button keypad interface. While previous studies have mostly evaluated usability with performance measures by only looking at task results, this study can be expected to contribute by suggesting a method in which the behavioral patterns of interaction is evaluated.

Keywords: User-observation, Usability, Mobile interface, Gaze-tracking

1. Introduction

User observation is a type of usability evaluation technique that looks into the process of interaction to identify behavioral characteristics, potential problems, and usage patterns (Oh and Lee, 2004; Lee et al., 2006). Since users' latent needs are not usually expressed clearly, user observation is integral in usability evaluation (Jang, 2008). For a more comprehensive evaluation of usability, this study employs user observation and behavior monitoring into usability evaluation of mobile interfaces.

Previous studies have mostly used third-person user observation only, where the interaction is recorded from outside the user. Park and Kim (2008) recorded their usability testing of touchscreen mobile phones to define errors. Kjelskov and Stage (2004) used video recording and think-aloud method together. Lee et al. (2006) collected data about mobile user interaction by video recording as well, and identified common navigation paths and critical incidents based to the results.

Usability evaluation based on first-person observation, where recording is done by the users, is relatively difficult. For effective first-person observation, gaze analysis has gained attention from previous studies since a user's spatial focus of attention has shown to be represented by the user's eye movements (Schroeder, 1998; Nakamachi et al., 2007; Sawahata et al., 2008). Goldberg and Kotval (1999) developed metrics for usability evaluation of computer interfaces based on information about gaze fixation and scanpath complexity.

Previous studies were limited in that they incorporated user observation at a level where only simple video recording was done for qualitative analyses. Also, gaze analysis has not been fully used despite its importance. This study proposes a method for usability evaluation of mobile

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interfaces with utilization of user observation techniques from both first- and third-person points of view. Eye gaze and finger movements were monitored closely and data were gathered by coding video recordings. Also, for quantitative evaluation, metrics were developed for factors of usability.

2. User observation tools

There are a variety of techniques for usability evaluation, including in-depth interview, think-aloud protocol, scenario building, cognitive walkthrough, heuristic evaluation, and surveys (González et al., 2008). However, in conventional methods such as usability testing and surveys, users often do not speak well or express fully. Thus, user observation is necessary for eliciting the detailed information needed.

Oh and Lee (2004) categorized user observation techniques into 2 types: first-person and third-person observations. Behavior is self-recorded in first-person observation while it is recorded from an outside position in third-person observation. Since first-person observation gives understanding in a user's point of view while third-person observation shows related environmental factors, both views need to be considered.

In this study, both first- and third-person observations were employed by using Ergoneers Dikablis, a gaze tracking device. To process the video recordings and to gather quantitative data, Noldus Observer XT, a video coding software, was used.

3. Development of metrics

Attributes and factors of usability have been defined in various ways by existing standards and models. However, most of them include common attributes for defining usability: effectiveness, efficiency and satisfaction. Definitions for the three factors are described in Table 1.

Studies have focused on developing methodologies and measurements for evaluating usability in terms of effectiveness, efficiency and satisfaction. Quantitative metrics are necessary in order to analyze data more objectively. This study developed metrics for each factor, while also adopting relevant measures. The metrics for effectiveness and efficiency as shown in Tables 2 and 3, respectively, were developed to produce results based on data from monitoring finger and eye movements. For satisfaction, relevant subjective criteria were organized for questionnaire

Table 1. Factors of usability (ISO 9241-11, 1998)

Factor	Definition
Effectiveness	The accuracy and completeness with which users achieve goals
Efficiency	The resources expended in relation to the accuracy and completeness with which users achieve goals
Satisfaction	The freedom from discomfort, and positive attitudes towards the user of the system

Table 2. Metrics for evaluation of effectiveness

Metric	Description
Task completion rate	Ratio of tasks correctly completed in allotted time
Error frequency	Total number or errors made in task completion
Spatial accuracy	Ratio of correct, on-target fixations to total

Table 3. Metrics for evaluation of efficiency

Metric	Description
Task completion time	Total time to task completion
Deviation from optimal	Number of extra actions taken
Number of fixations	Total number of fixations
Scanpath length	Total length of scanpath
Convex hull area	Area of convex hull circumscribing scanpath

Table 4. Criteria for evaluation of satisfaction

Criterion	Description
Preference	The degree in which users prefer over others
Ease of use	The degree in which users feel convenient
Perception of interaction	Rating of perceived process of interaction
Sense of control	User's sense of control towards interactivity
Intuitiveness	Perception on power of knowing or understanding without cognitive effort
Physical discomfort	Experience of physical discomfort in use
Enjoyableness	Feeling of entertainment and enjoyment

as shown in Table 4.

4. Experiment design

An experiment was conducted for usability evaluation of mobile interfaces based on user observation. Twenty people (15 males and 5 females) with similar experiences and proficiency with mobile devices and touchscreen interface participated. With an eye gaze tracking and recording system, video data were gathered as the subjects performed given tasks.

4.1 Devices and tools

Two mobile phones with different control interfaces were used for comparative evaluation. One had a button keypad (LG-KH8000), and the other had a touchscreen (SPH-W7700). The 2 mobile phones were similar in size, and their measures are displayed in Figure 1.

Figure 1. Devices used for the experimen

Dikablis eye gaze tracking device was used for video recording. The system has a headset that subjects can wear while performing tasks, with 2 small cameras: an eye camera and a field camera, as shown in Figure 2. The recordings from the 2 cameras were then integrated using Dikablis software. The movements of the pupil and the fingers were clearly seen on the connected computer screen as shown in Figure 3.

4.2 Process of experiment

All of the subjects performed the tasks in the same setting. They wore the Dikablis headset and held the mobile phone

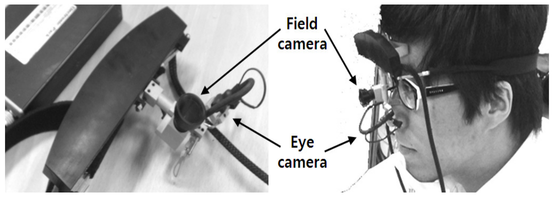

Figure 2. Components of Dikablis headset

Figure 3. Recording screen from Dikablis software

with both hands. A chin rest was given to eliminate noise caused by excessive head movements.

Two types of tasks - number entry and menu selection - were given to each subject to perform. For the number entry task, a 10-digit number was given. For the menu selection task, a sequence of items and menus were given verbally. Both tasks were performed on all 2 devices, so each subject performed 4 cycles of experiment. At the end of the experiment, subjects filled out a questionnaire to evaluate each interface in terms of satisfaction.

4.3 Gathering data

Video recordings were coded into quantitative data using Noldus Observer XT, a software for accurate analysis of observational data. Each subject's fingers and eye movements were then sequentially recorded along with a corresponding time dimension and description on behavioral characteristics, as shown in Figure 4.

5. Analysis and results

5.1 Description of behavioral characteristics

Based on the coded information, the scanpaths of the

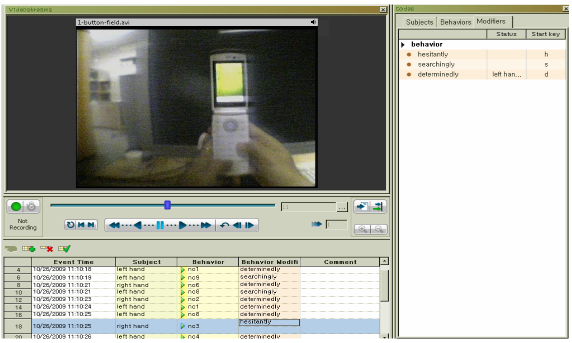

Figure 4. Coding video data using Observer XT

fingers and the eyes were drawn. The typical scanpaths are illustrated in Figures 5 and 6, which revealed differences between the 2 interfaces. Finger movements were much simpler on button keypad in both tasks. On the touchscreen, a larger number of unnecessary, inaccurate movements were made. In terms of gaze, the length was longer on the button keypad but the quantity was fewer.

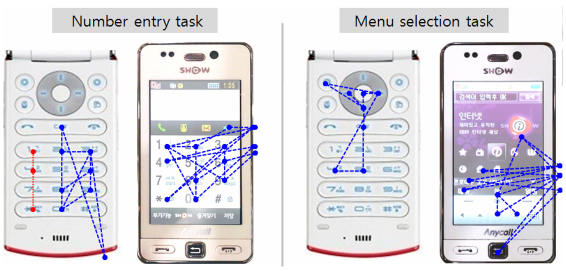

Figure 5. Summary of finger movements

Figure 6. Summary of eye movements

5.2 Results

Coded data were used to produce results with the metrics defined. Pairwise t-tests were done for comparison. Figures 7 and 8 summarize results from menu selection task. The same tendency was found in the number entry task. Figure 9 shows results from satisfaction evaluation. The dark gray bars show data for button keypad, and the light ones are for touchscreen evaluation results.

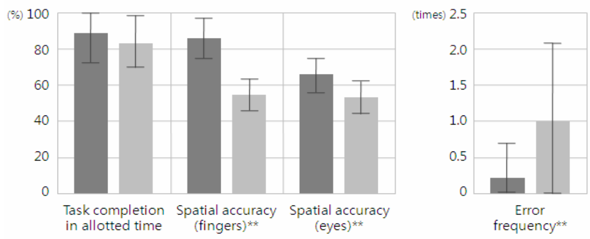

Figure 7. Result of effectiveness evaluation

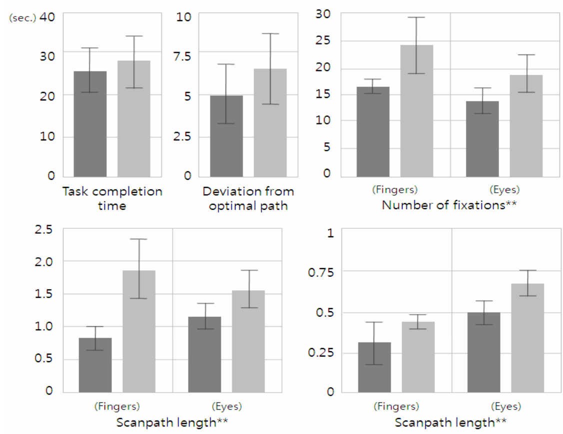

Figure 8. Result of efficiency evaluation

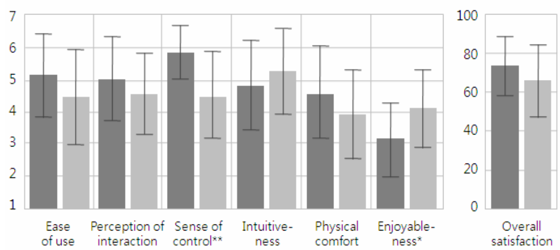

Figure 9. Result of satisfaction evaluation

A consistent result in which the button keypad is superior in terms of usability was found in all of the metrics except for intuitiveness and enjoyableness. With the button keypad, tasks were done faster with more accurate movements, fewer errors and less number of fixations. The touchscreen required users to make unnecessary and longer movements spanning a larger area. The results showed that the button keypad is generally better than the touchscreen in terms of usability.

6. Conclusion

In the experiment, user behavior was closely monitored by recording movements of the fingers and the eyes. By coding the video data, quantitative analysis was conducted to evaluate usability with metrics developed.

A comparative evaluation showed that the button keypad is generally more effective, efficient and satisfactory than the touchscreen. Also, observation of finger movements, eye gaze analysis and questionnaire all showed consistent results.

This study proposed a method for incorporating user observation into usability evaluation of mobile interfaces. It can be expected that the method of quantitative analysis based on user observation can contribute by suggesting a way for comprehensive evaluation of usability.

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