Intuitive & Light-Weight Driving Direction on Mobile Phone

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***Abstract*—**As car navigation becomes practical and more affordable, it is increasingly popular particularly for travelers and commuters who are neither acquainted with the routes nor aware of the new roads and the condition of traffic congestion. However, most navigation system requires a large capacity storage to store detail map interface which can be considered overly complicated to users. This paper presents an inventive and easy-to-use navigation system on mobile phone, namely Mobile Driving Director (MDD). Open source tools and platform-independent technologies, such as J2ME, are used in implementing the system to ensure its light-weight, minimal cost, and wide range of compatible device. Administrative backbends and interface frontends are enabled through advanced database design and the three-tier application architecture. This MDD system, though presented and demonstrated by using Bangkok's routes and locations, is a general navigation system that can be applied to any area. The usability evaluation on the system was conducted to extensively scrutinize on the user interface and other usage issues.

***Index Terms*—** car navigation, mobile application, mobile navigation system, usability evaluation

I. Introduction

Bangkok is one of the most congested traffic cities in the world. The number of vehicle registration In Thailand increased 3% from 24,807,297 in 2006 to 25,618,447 in 2007 [14] while the number of vehicles on the Thailand's expressway increased 3% from 12,587,868 per day in 2006 to 12,965,652 per day in 2007 [4]. Traveling from one place to another on the complex road network of Bangkok can get worst if the travelers do not plan the route well. Running into traffic jam can incur significant loss in productivity and cost to environments. A simple tool that helps commuters to choose appropriate routes and directions to save time, energy, and emotion stress is needed.

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Nowadays, car navigation systems produced by big companies have a limitation in that they are expensive and designed as an extra unit attaching to the car. The cost of this device is about US $300-$1,000 (10,000 – 40,000 baht) [9] while the average monthly income of Thai residents is approximately US $616 (18,500 baht).
Moreover, Thais are not accustomed to the detailed map navigation. Thus, we proposed a navigation system that is less complicated and more appropriate to Thai users, who are more familiar with the landmark-based navigation.

The proposed system is portable and can be operate on any J2ME-enable mobile phones. There are more than 30 million registered mobile phones in Thailand [13]. Thus, user-friendly navigation on mobile phone can reach a large number of populations, especially in metropolitan area where appropriate driving direction to save time is needed the most. The usability of navigation system was evaluated against five perspectives, i.e., learnability, efficiency, effectiveness, satisfaction, and reliability, to ensure the ease of use and its accuracy of the functionalities. The results will be used as a guideline in developing user-friendly navigation on mobile phone in the future.

This paper is organized as follows. In Section II, we describe related works concerning various kinds of navigation systems and their usability. Architecture of the proposed system is presented in Section III. In Section IV, we discuss the usability evaluation. Section V gives the conclusion and future works.

II. Related Works

In this section, we give an overview on two main areas contributing to our MDD, development and evaluations. Related navigation systems are illustrated and followed by usability guideline reviews.
Researchers have been conducting the research on navigation through mobile phone. For example, "Pharos" [1] is a location-based services and talking map navigation system on mobile phone which utilized GPS and GSM network. 2D-SNA [16] system which could display the results in 2D and 3D format, in which 3D mode could be "Bird's Eyes View" or "Drawer View" mode. Project m-LOMA [2] is map navigation on mobile phone which could display the city in virtual reality through PDA's and smart phones without any additional 3D components. Navigation system does not only have map navigation but it can also provide users with Mobile AR-Navigation Systems(Augmented Reality Navigation System). INSTAR (Information and Navigation Systems Through Augmented Reality) [17] which displays routes captured from real places recorded by video camera

Constantine & Lockwood (1999)	ISO 9241-11 (1998)	Schneiderman (1992)	Nielsen(1993)	Preece et al. (1994)	Shackel (1991)
Efficiency in use	Efficiency	Speed of performance	Efficiency of use	Throughput	Effectiveness (Speed)
Learnability		Time to learn	Learnability (Ease of learning)	Learnability (Ease of learning)	Learnability (Time to learn)
Rememberability		Retention over time	Memorability		Learnability (Retention)
Reliability in use		Rate of errors by users	Errors/safety	Throughput	Effectiveness (Errors)
User satisfaction	Satisfaction (Comfort and acceptability of use)	Subjective satisfaction	Satisfaction	Attitude	Attitude

TABLE I: Usability attributes of various standards or models [3].

installed inside the cars. Mostly, researchers aimed at providing more detailed navigation system. Our system is distinctive in that it is aimed at reducing the details of the navigation. The proper interface design has to be evaluated, which we utilize the systematic approach of the usability testing. The comprehensive review of the usability guidelines is elaborated in the following paragraphs.

Usability plays an important role in testing the program. Usability test is a part of usability engineering process [10] which could be compared to the measure of the quality that the users experience when interacting with the user interface [8].

Many researchers have defined usability as shown in Table 1 such as (1) Shackel proposes to measure usability on 5 dimensions, which are effectiveness (speed), learnability (time to learn), learnability (retention), effectiveness and attitude. (2) Nielsen defines usability to consist of 5 kinds of attributes, which are efficiency of use, learnability (ease of learning), memorability, errors/safety, satisfaction. (3) ISO 9241-11(1998) defines usability to consist of 2 kinds of attributes, which are efficiency and satisfaction (comfort and acceptability of use) [3]. We further explore the usability focusing on the mobile application and select a set of elements to assess to improve the system.

For mobile application usability, there is a research work about usability testing for mobile phone between the tests in the laboratory and in the field in order to find out whether they are different. It yielded differences [10]. Even the test was done in the same laboratory; the results could be different according to the body motion [12]. User interface is also a factor affecting usability. Ketola and Röykkee divided user interface into the 7 following pats: input, display, audio and voices, ergonomics, detachable parts, communication method, and applications [7]. Besides, the size of screen [7] [6] [5] and limitations of buttons [6] [5] also affect usability. To fully assess all the interface and functionality issues, we decided to explore all elements of the usability guidelines by grouping the similar items in all guidelines into 4 elements in the terms of efficiency, effectiveness, satisfaction and learnability. Moreover, extra concerns on mobile application usability are aware during the study. We planned the usability testing tasks based on the derived framework. The detailed methodology is elaborated in the section IV. The tests were applied on the implemented MDD system that presented and demonstrated in the next section.

III. Architecture

MDD is the system in which users look for unknown or unfamiliar routes in a short time. MDD could be used with any mobile phone with Symbian operating system. In this paper, the development and the system evaluation were done with the Nokia N72 mobile phone.

A. System Components

This system was developed using Java 2 Micro Edition (J2ME), which is an edition of JAVA, intended for small gadgets such as mobile phones and PDAs [11]. The system utilizes General Packet Radio Service (GPRS) to transfer driving direction information between the mobile phone and the server. This system was tested by use the Nokia N72 phone.

Nokia N72 is a mobile phone with Symbian Series 60 Version 2. Symbian is a popular operating system designed specifically for smart mobile devices such as PDAs and cellular phones. Currently, there are 202 models with Symbian operating system and 165 million Symbian phones were shipped since 1998 [15]. Nokia N72 provides a handful of functionalities such as GPRS, Bluetooth, SMS, MMS and WAP. This Nokia N72 was equipped with a 2.1-inche display with the resolution of 176 x 208 pixels. Our system can be widely adopted by a large number of mobile phone users since the plenty of Symbian-compatible phone in use.

B. System Flow

MDD is a service that provides step-by-step information for travelling from one place to another. First, users select the starting point on their mobile phone and then select the destination. The data concerning the starting point and the destination will be sent to the server through GPRS/EDGE of cellular networks. The frontend interface utilizes J2ME application platform interfacing with the mobile phone GPRS accessories. Once the server receives the request, it will look for the data concerning the starting point and the destination. The server composes the step-by-step driving instructions from the beginning till the end of the journey then the server sends back the route data to the users' mobile phone (see Fig. 1). The users will be provided the driving direction in three formats which are text, simple graphics, and driving animation (see Fig. 4).

MDD also allow the users to browse for the recent routes and it is equipped with help menu that provides user manual. The main functionality details are provided as follow.

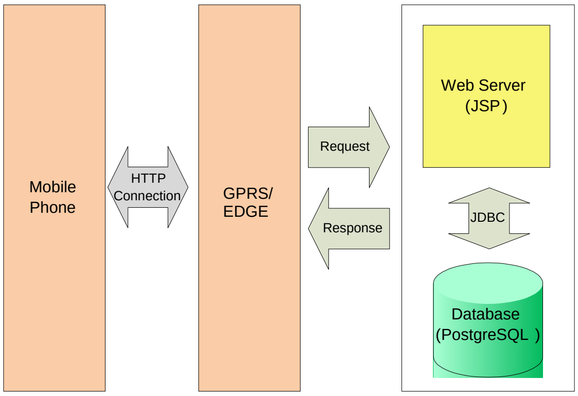

Figure 1: General System.

Navigation

This function is used to select the routes which users would like to make driving direction inquiries. First, users select a starting point from provided locations which are classified into 6 categories, i.e., school, garden, organization, port, hospital and hotel as see in Figure 3. Next, users select a destination locations provided in the same manner as they select the starting point. After that, the system will show driving direction information.

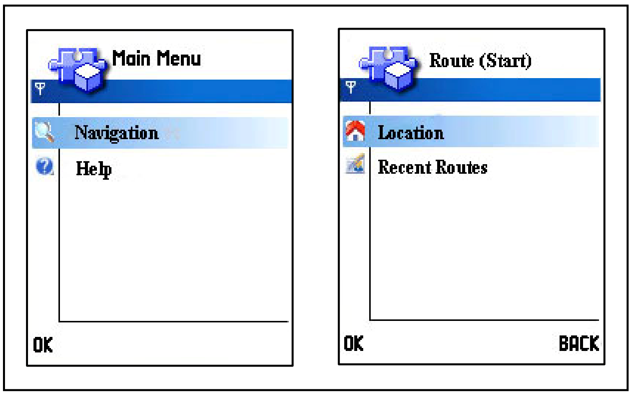

Figure 2: A main menu and Navigation.

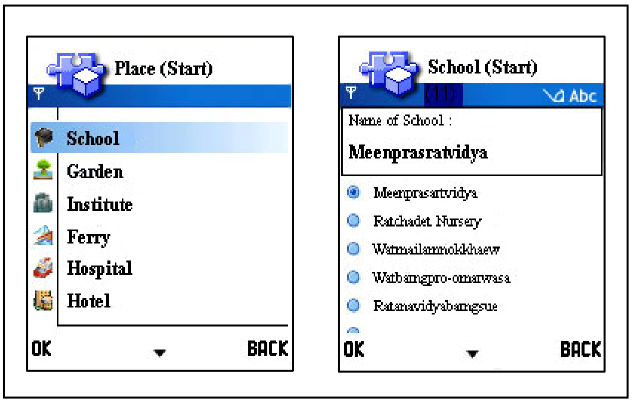

Figure 3: A main menu of place-selecting style and a main menu of a start place.

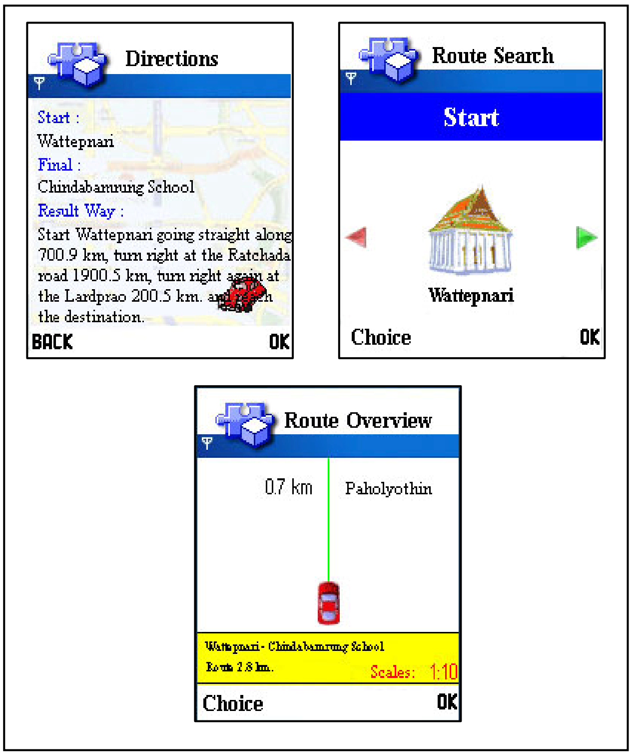

Figure 4: A display of a result in various ways (Text, Simple Graphics, and Driving Animation).

Navigation (Recent Routes)

The users can browse for the routes they have recently looked for. The system will store the data so that users could retrieve it instantly.

Help

This function is used to explain clearly how to use the program in each single step. Help menu is composed of different chapters according to the usage.

IV. Usability Testing

We inspected our MDD on its usability. The results will be used to develop more user-friendly system with easy-to-use features so that users will be most satisfied. The usability and related research methodology items are described as follow.

A. Subject Background Information

The system was tested with 30 users in Bangkok metropolitan area. The sampling group is in the age of between 19-25 years. 26.7% were male and 73.3% were female. 90% were studying at undergraduate level. 100% were students. According to the survey, most of them were familiar with computer and mobile phone. 60% drove a car and 30% traveled by taxi. 66.7% had driven for less than 1 year. On the average, they drove a car for 1-2 hours a day. Their distance was 11-20 kilometers a day, on the average.

B. Tasks

The users were asked to use the system as instructed in three main funtionality ares as follow: Navigation (Location), Navigation (Recent Routes), and Help menu.

C. Subjective Inventories

After user was tested program, the users completed the questionnaire concerning usage in every step. The questionnaire contributes of 5 parts: 1) personal data, 2) computer and mobile phone experience, 3) road usage behavior, 4) suggestions, and 5) usage attitudes.

D. Procedure

In the first step, the users would be given overall details about the program so that they would be familiar with the system. The users then tested every function according to the designed scenarios. Afterwards, the users completed the questionnaire to evaluate the usability of the system in terms of efficiency, effectiveness, satisfaction and learnability by the questions design for each element. The questions are 5-scale opinion rating questions. The scale ranges from 1 to 5, which aligned with "strongly disagree" to "strongly agree" to the questions. During their experience with the program, we observed the behaviors of users in terms of how well they could use and what were their difficulties. Afterwards, the users would be interviewed about opinions and suggestions on using the navigation in every step along with advantages and disadvantages of the program. The users also suggest how to improve the program and what should be added.

Standard of Test Assessment	
Strongly Agree	4.51-5.00
Agree	3.51-4.50
Neutral	2.51-3.50
Disagree	1.51-2.50
Strongly Disagree	0.00-1.50

TABLE II: Standard of Test Assessment

V. RESULTS AND DISCUSSION

We developed a practical intuitive mobile phone navigation system, MDD, and conducted the usability testing. The results on the usability were described in the objective findings section and the users' open-end opinions were highlighted in the subjective finding section.

A. Objective Findings

1) Evaluation on Efficiency

In order to evaluate the users' opinions towards the efficiency of the program, we outlined nine usability investigation questions to cover the efficiency aspect as follow: 1) the program can be easily installed; 2) the locations are grouped into categories appropriately; 3) for the origin and the destination can be set conveniently; 4) the information of locations is up-to-date; 5) the duration for route inquiry is suitable; 6) the number of inquiry steps is suitable; 7) route inquiry steps are in accordance; 8) "Help" is clear and informative; 9) "Recent Routes" function is useful.

From the results (see Fig. 5), most users rated positively towards the MDD' efficiency experience. The overall efficiency rating was 3.74 (see Fig. 7). Eight out of nine major efficiency factors were rated in the "Agree" range. Moreover, the time used to process the driving direction inquiries, which we considered the core efficiency factor was rated highest, 4.00. In general the system worked well; however, there were rooms to improve the system to achieve higher users' efficiency satisfactory. The major issues needed to be improved is the installation process, which got the lowest opinion's score, however, it is still in the neutral rage.

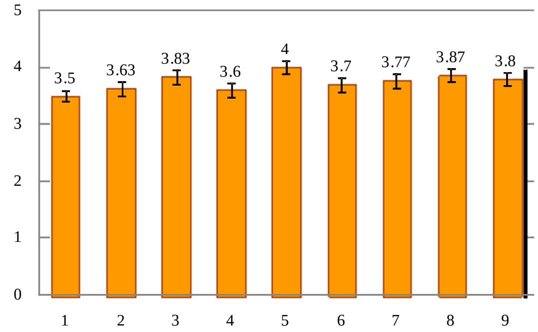

Figure 5: Evaluation on Efficiency.

2) Evaluation on Effectiveness

The effectiveness of the system was measured on the route inquiry success and its accuracy. The user rated this in the "agree" range (mean = 3.67, S.D = 0.61). This means that the users believe that the system provide a clear and accurate instruction to the destination. This confirmed our main objective that the intuitive interface could also provide the instruction to navigate the route effectively.

3) Evaluation on Satisfaction

The satisfaction of the users was measured mainly on the interface experiences. Ten questions that were used to assess the users' satisfactory were given as follow: 1) the driving directions given in form of the "Text" format is easy to read and understand; 2) the driving direction given in the form of "Simple Graphics" format is easy to read and understand; 3) the driving direction given in the form of "Driving Animation" format is easy to read and understand; 4) the pre-defined shortcuts are suitable; 5) the program is beautiful and attractive; 6) the size of the text on the screen is suitable; 7) the system uses easy to understand language; 8) the system uses appropriate color; 9) the button and text layouts are suitable; 10) the screen looks clean and neat.

All areas we assess for the users' satisfaction on the interface got positive ratings. The overall rating was also laid in the "agree" range (Mean = 3.78, S.D = 0.80). The users particularly liked the clean and neat interface of the program that we assessed in item no. 10. The driving direction given in the "Simple Graphics," assessed with the question no.2, format should be improved to make it easier to understand. Users suggested that the driving directions should be added with some landmarks, (see Fig. 6).

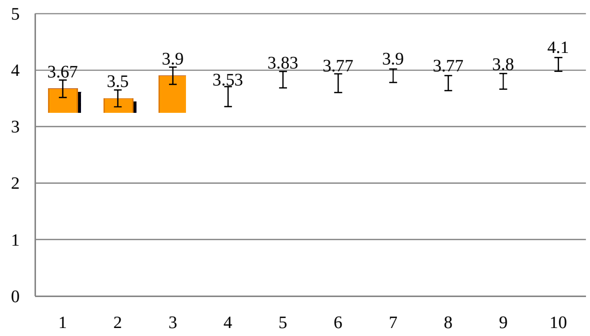

Figure 6: Evaluation on Satisfaction.

4) Evaluation on Learnability

The user found out that, in general, the program was easy to use with the rating of 3.97 (S.D = 0.81). This was another main area we would like to assess since the system should be very easy to use. Additional suggestions that could make the system more intuitive were given in the subjective findings.

To sum up the overall usability evaluation, Fig. 7 depicts the overall users' usability rating in each major category. Users "agreed" that the system was efficient, effective, and easy to use. They were also satisfied by the using experiences.

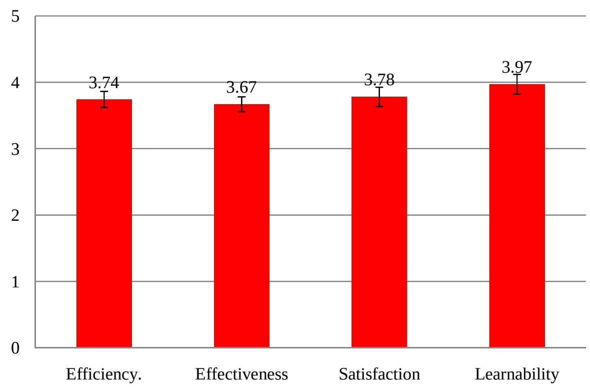

Figure 7: Evaluation on Results of Usability Testing.

B. Subjective Findings

We highlight interesting opinions of the users from the interviews and the observation here:

Efficiency: There should be more categories of the location available for the users to select.

Effectiveness: Operation in overall was agree.

Satisfaction: There were useful comments to improve each driving direction instructions and visualization. Directions in the "Text" format were easy to understand but difficult to remember. Directions in the "Simple Graphics" mode were easy to understand. Directions in the "Driving Animation" mode were easy to understand but the landmarks should be added so that it was easier to navigate. We might be able to present "Mix" mode to combine the advantages and disadvantages of each mode.

Learnability: Mostly found out that the driving directions system was easy to use while can provide detailed enough directions to reach the destination.

VI. Conclusion And Future Work

In this research, we aimed to develop a simple light-weight navigation system on mobile phone. The usability evaluation was conducted extensively to ensure the balance between the usability and the functionalities of the system. The results revealed that evaluation on usability for navigation on mobile phone were positive (3.51-4.5 out of 5) in most aspects. The users find that the program is easy to use, has attractive layout, and responsive. Users suggested that there are 4 aspects which can be improved. First, additional categories of location should be added such as parking lots, universities, department stores, convention centers, and recreation parks. Second, additional locations, landmarks, and points of interest should be added. Third, the step-by-step instructions is preferable to the current all at once instruction since it is more convenient, easier to understand, and requires less cognitive loads. Finally, the important landmarks should be added and showed in the "Driving Animation" mode. Once, we have included the additional features to improve the functionality and usability. We intend to distribute navigation on mobile phone to the general public to facilitate their journey and make driving experience more enjoyable.

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