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Interface Design of Location-Based Services

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1. Introduction

Recently, mobile networks have been widely deployed in global mobile markets and returns from telephony services had proven to be significant to specific mobile operators (Varshney, 2003). According to reports from market research studies (Canalys, 2005), the shipments of converged smart mobile devices, namely Smartphone and wireless handhelds, rose by 170% year-on-year in Europe and Middle East in the first part of 2005. Reed (2001) stated that "telecommunication companies are making huge investments and they know that Location-Based Service (LBS) technology is a key application from which they can generate revenue". For example, NTT DoCoMo reports that the number of I-mode subscribers in Japan now exceeds 38 million, which is nearly half of all cellular phone subscribers in Japan (NTT DoCoMo, 2003). Furthermore, a market overview shows that the global LBS market is already noticeable and continues to grow rapidly.

A wide range of services that rely on users' location information have been conceived although the markets are not completely mature. In the future, while mobile users access the Value Added Service (VAS), they always suffer some possible problems induced by the small physical size of the screen. In fact, the screen of Smartphone is too small to display dynamic content such as PoI (Point of Interest) of LBS information which included graphics, icons, and multimedia on the map. The display of PoI information on the map should be tailored to the needs of users, meaning display of information should be simple way to avoid overly complex information. Hence, previous research presents two different ways to display information on handhelds, both List View Display (LVD) and Map View Display (MVD) (Dunlop et al., 2004). Unfortunately, very little has been published on the evaluation of LBS on Smartphone users, and the main focus of the few available papers is not on the rigorous experimental evaluations demanded by research of mobile Human-Computer Interaction (HCI). Thus this study not only concerns issues of mobile HCI, but also of user interface (UI), that concerns cognitive and psychological aspects in process of development. This aim of the study discusses an empirical study which is undertaken to extend the original interface and compare MVD and LVD of diversity visualization of PoI information developed for Smartphone. Two objectives of the study are the following:

1. To develop a diverse prototype of LBS interface, which displays dynamic PoI information on the map in an intuitive and clear way base on the design principles of mobile HCI.
2. To evaluate and extract the more adaptable element of visualization of display through rigid experimental evaluations, and give specific post-questionnaire for investigating and analyzing users' subjective opinions.

2. Literature Review

2.1 Local based service (LBS)

Mobile location-based commerce refers to the provision of location-based information on mobile devices as a result of a user request (Varshney, 2003). It aims to provide specific targeted information to users based on each specific user's location at any time (Benson, 2001). OGC (2003) stated that LBS is defined as a wireless-IP service that uses geographic information to serve a mobile user, or as any application service that takes advantage of the position of a mobile device.

The LBS applications include emergency and safety-related services, entertainment, navigation, directory and city guides, traffic updates, and location-specific advertising and promotion in addition to site-based purchasing with e-wallet enabled wireless devices. These services can answer questions such as, "Where can I find a Chinese restaurant," or "Where are my nearest friends?". For example, NTT DoCoMo expresses a "friend finder" service on its iMode system (Levijoki, 2000). Users can predefine which friends are allowed to know their location. Integrating the map database with the PoI database can create detailed, available digital representation of the road network and business services. To cover simple city maps, routings, business finder, etc., these services are usually combined with a digital map associated to the user location. Reichenbacher (2001) shows that LBS applications typically use information from several content databases:

- Road network (digital maps).
- Business and landmark information often referred to as Yellow Pages or PoI information.
- Dynamic data such as traffic and weather reports.

The POI information can vary from maps to maps, as the icons of how the information is presented in the map view. Colourful bitmap icons are used to represent interesting objects on the map (Dunlop et al., 2004). Neudeck (2001) also presents the first practical guidelines for screen map graphics that can be embedded in the design of mobile maps. These guidelines suggest that mobile maps should be simple and highly generalized, should be based on cartographic principles, rendered fast, graphically concise, attractive, crisp, and legible.

In addition, their content should be flexible and should be dynamically updated and linked to other information. These services must be capable of displaying PoI and landmarks, the geo-location of people, objects, and events, routes, and search results (i.e. people, objects, events). The basic functionality of solutions for mobile geographic information visualization is provided by city maps with searchable PoI like the Digital City Kyoto Guide (Ishida et al., 1999). Apart from research projects, industry solutions offer a view on the commercial state of the art in mobile geographic information visualization. These solutions are strongly influenced by solutions of navigation systems. Dunlop et al., (2004) present two types of views providing both map and list-index information access:

1. Map View Display (MVD) (Left of Fig. 1.): The main part of the MVD shows a map of a city centre with an overlay set of attractions represented by squares. Users can browse a selected set of attractions by pointing and tapping on symbols of attractions in a selected area.
2. List View Display (LVD) (Right of Fig. 1.): LVD shows a list displaying the names of attractions in a sorted order in a manner similar to an index at the end of a guidebook.

An electronic method of presentation has an advantage over paper editions in providing different sorting criteria.



Figure 1. MVD and LVD

As mentioned above a core functionality of the Taeneb City Guide user interface (Dunlop et al., 2004) is incorporating dynamic query filters for searching and finding tourist attractions. Query filters are predefined for different types of attractions and are designed for rapid selection either as pop-up lists for single choice, or a separate view with a checklist for multiple choice selections (see Fig. 2). For example, for restaurants there is a multi-choice filter with a food type (Fig. 2) and a single choice filter with a price range (Fig. 2(b)). The results of a query are displayed as a subset of data either as a list using LVD or as a scattered plot of matching attraction-icons on a map display using MVD.

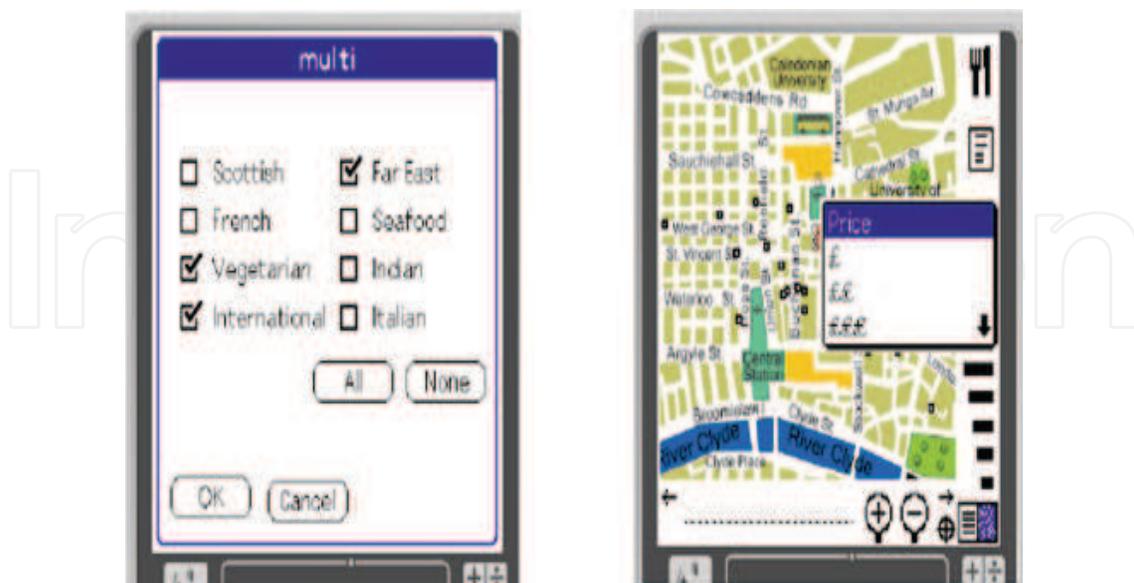


Figure 2. Restaurant query filters

2.2 Mobile human-computer interaction (M-HCI)

The mobile environment has its own characteristics. Mobile users have little patience for learning how to operate new services. The mobile users have less "mental bandwidth" capacity for absorbing and processing content than a stationary user in front of a PC (Rischplater, 2000) as the interaction with the mobile phone is often reduced to a secondary task that must not interfere with their primary task. Interactivity is a more intuitive way of working with a computer. This intuitive approach in HCI has the objective to make the use of a computer easier, faster to learn and more transparent to the user.

Interactivity is mostly used to compensate for the small displays, and not for enhancing the user experience. Thus, while small displays can interface design processes, consideration of user aspect is indispensable. Meanwhile, it is important to separate the physical or technical interactions from symbolic interactions, i.e. the surface and deep structure of interaction. Hitting a button or moving the mouse is a surface, physical or explicit interaction, while a symbolic or implicit interaction is for instance the selection of a menu option. A menu is a set of options displayed on the screen where the selection and execution of one (or more) of the options results in a change in the state of the interface (Paap and Roske-Hofstrand, 1988). In the past, one of the problems with using menus is that they take up a lot of space on the screen. A solution to this is the use of a pull-down or pop-up menu (Preece, 1995). Also, most windowing systems provide a system of menus consisting of implicit or explicit pop-up menus (Marcus, 1992).

Empirical studies prove that systems requiring too much attention or too many interactions are either not used efficiently or are not used at all. One reason for this is "information overload" from complicated interfaces. While some problems are affiliated with cognitive abilities, the main reason is that mobility increases the load of cognitive processing. The objective should be to simplify visualization to such an extent that the user is not required to think unnecessarily. For web site design, Krug (2000) coined the term "Don't Make Me Think!" Visual comprehension can be summarized as "what you see depends on what you look at and what you know". Multimedia designers can influence what users look at by controlling attention with display techniques such as using movement, highlighting, and salient icons.

However, designers should be aware that the information people assimilate from an image also depends on their internal motivation, what they want to find, and how well they know the domain (Treisman, 1988). So far, many existing location-aware systems use some kind of metaphor, very often taken from the real world, in order to illustrate their concept of interaction with location-aware information. Our mental representations of spatial knowledge include information on spatial relationships and how to navigate within our environment. (Medin, Ross, and Markman, 2001). One of these may be an interpretation of how well the user knows the map symbols and how familiar he is with using the mobile device and the map on it. It has been stated that "mobile devices are not aesthetically pleasing enough, navigation is troublesome and services are hard to use" (Olsson and Svanteson, 2001). Before further investigating this statement, it is important to explore the principles of usability and why it is so important.

Nielsen (1993) separates five attributes for usability - represented in the usability branch below:

- Learnability: The system should be easy to learn so that the user can rapidly start getting some work done with the system.

- **Efficiency:** The system should be efficient to use, so that once the user has learned the system, a high level of productivity is possible.
- **Memorability:** The system should be easy to remember, so that the casual user is able to return to the system after some period of not having used it, without having to learn everything all over again.
- **Errors:** The system should have a low error rate, so that users make few errors during the use of the system, and if they do make errors, they can easily recover from them.
- **Satisfaction:** The system should be pleasant to use so that users are subjectively satisfied when using it.

A major portion of usability engineering and thus usability testing is the Human-Computer Interaction (HCI) "the study of how people interact with computer technology and how this interaction can be made more effective" (Battleson, 2001). Usability Engineering by Faulkner (2000) has a couple of pictures in the whole book showing a user interface that discusses several methods for collecting usability data which include observation, thinking aloud, questionnaires, interviews, focus groups, logging actual use, heuristic evaluation and user feedback. Usability testing can be done either in a laboratory environment or in an authentic real-world environment. In this research, the effectiveness of maps for mobile devices was tested in the laboratory environment due to constraint of research time involved in conducting real-world testing. The laboratory environment is not a real-world situation which is a disadvantage. Karat, Campbell and Fiegel (1992) stated that usability testing was compared with individual and team walkthroughs in order to identify usability problems in two graphical user interfaces.

2.3 Mobile interface visualization

Most of the research projects described above use maps to communicate geographic information on mobile devices. There have been few studies that have dealt with map displays on mobile devices. Reichenbacher (2001) has studied the process of adaptive and dynamic generation of map visualization for mobile users. Jern (2001) states that dynamic user interfaces play a major role in enabling the user to take on a more active role in the process of visualizing and investigating data.

Compared to the PC world, mobile access is still quite restricted, especially with respect to the display of graphical representations such as images, drawings, diagrams, maps and logos. Reichenbacher (2004) expresses graphical means to put a visual emphasis or focus on several features. These graphical means are:

- highlighting the object using a signal color, e.g. pink or yellow.
- emphasizing the outline of the object.
- enhancing the contrast between the object and the background.
- focusing on the object of interest while blurring other surrounding objects (crispness).
- enhancing the LoD (Level of Detail) of the object of interest against that of other objects.
- animating the object (blinking, shaking, rotating, increasing/decreasing size).
- clicking on a graphics object to display more detailed information about that object (Jern, 2000).

By the way, in recent years the visualization of information has evolved to an important and innovative area in computer graphics. Graphical user interfaces (GUI) are on their way to becoming the most pervasive interfaces for mobile systems, at least in part because of conventional wisdom about their ease of use (Marcus et al., 1998). The GUI technologies have

tended to focus heavily on the user-input aspects of human-computer interaction, with little integration of data output and display technologies (or data visualization technologies). This will change very quickly, and a variety of "output widgets" will become as commonplace in GUIs as input widgets are today. Popular GUI such as Windows, Macintosh, Motif and OpenLook are basically more similar to each other than dissimilar. A design innovation targeted specifically at improving the mobile interface is the use of icon-based input techniques (Rohr and Keppel, 1984). A previous study has evolved a highly standardized set of metaphors for interaction with the computer based on a series of user friendly on-screen input techniques such as icons and pull-down menus. The GUIs that present information to the user in the form of icons, images representing objects, actions, and commands can typically be directly manipulated by the user (Benbasat and Todd, 1993; William Horton, 1994). Furthermore, because of the limited space on the display, the graphical indicators cannot all be displayed simultaneously. Therefore they have been prioritized so that only the most important indicators for each situation and task are displayed at a time.

Besides, in a symbolic presentation of GUI, the main rule is to ensure that the symbols are easy to recognize and understand. Hence maps use different symbols to represent the reality, and each symbol must be clearly distinguishable from other. The symbols should be based on the signs usually seen on the street and in other places and should be presented in a way familiar to people. People should easily recognize these symbols from the map on the handheld devices without much effort. Keeping this in mind, pictorial symbols are usually selected to represent points of interest; for example, a representation of a bus is used for bus stands, an icon of a person for friend finder, a fork and knife for restaurants or a stethoscope and needle for hospitals. A list of these symbols is shown in Table 1.

Feature	Symbol
Bus Stand	
Friends Finder	
Hotel	
Petrol Pumps	
Restaurant	
Hospital	

Table 1. Pictorial PoI symbols

These kinds of symbols are very familiar to most people and will ease the map reading process significantly. Thus the size of the symbols should be optimally selected. These sizes are determined using legibility principles and are then tested for effectiveness by the user. The legibility of symbols is increased through the use of the tool tip option shown in Fig. 3 (Reichenbacher, 2002), which displays a description in text form as soon as the user places his/her stylus on the object.

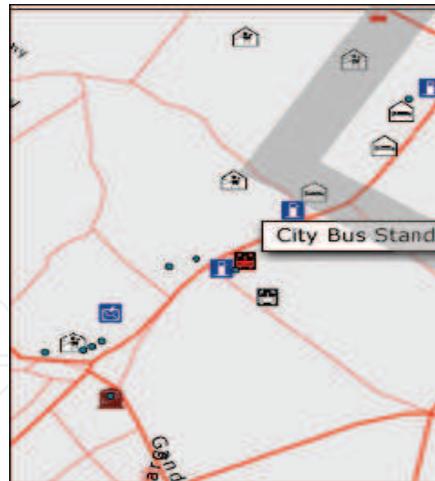


Figure 3. Text description using tool tip (Reichenbacher, 2002)

To find the proper symbol for a map, one has to execute a cartographic data analysis process. The core of this analysis process is to access the characteristics of the data to find out how it can be visualized. The data that has to be visualized will always refer to objects or phenomena in reality. The characteristics of the data are size, value, texture (grain), colour, orientation, and form (Kraak, 2001). These characteristics lead to the use of simple, easily recognizable symbols that are familiar to the users, with much of conventional map symbol association such as blue for water, green for forest, etc. To make the symbols understandable, certain possibilities used in case of web maps can be employed, for example mouse-over (shown in Fig. 4), tool tips, etc., which trigger the information in text form describing the object. One more possibility to increase the legibility of the symbol can be to increase the size of the object when the user moves his/her pointer on it, and to provide further information when it is clicked (Rajinder, 2004).

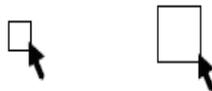


Figure 4. Mouse-over effect



Figure 5. Map with further information for identified feature

Clickable icons can be used to access additional information on specific points or areas on the map, information that is not shown all the time to help reduce the overloading of the map presentation (Gartner & Uhlerz, 2001). The example in Fig. 5 shows the use of a popup information box that gives further details about the identity of a selected geospatial object. Such informative 'boxes' compensate for the reduced information density of the map.

3. Methodology

This research methodology can be separated into three parts. The first part is the introduction of the current LBS application architecture and platform in the mobile commerce environment. The second part is undertaken to compare LVD and MVD visualizations of LBS information, and to develop a prototype interface for Smartphones based on small-screen design principles from previous research. The interface of this prototype is called LBSI. The final part is to conduct an experiment to verify the performance of LBSI for intuition and usability. After the experiment, the sampling users are given questionnaires which evaluate variations on a multiple rating scale. This scale is the five-point Likert scale, which is used to response their opinions.

3.1 Framework of current LBS system

LBS apart from the already described technology require specific infrastructure for positioning the mobile terminal. The systems offering positioning for mobile terminals in LBS are divided into three main classes: satellite positioning, network-based positioning, and local positioning (Paikannussanasto, 2002). Fig. 6 shows the conceptual model of the Smartphone solution from this study. While the Smartphone can play many roles in different domains, this study aims only at LBS. There are many related fields involved, which have been discussed in the literature review above.

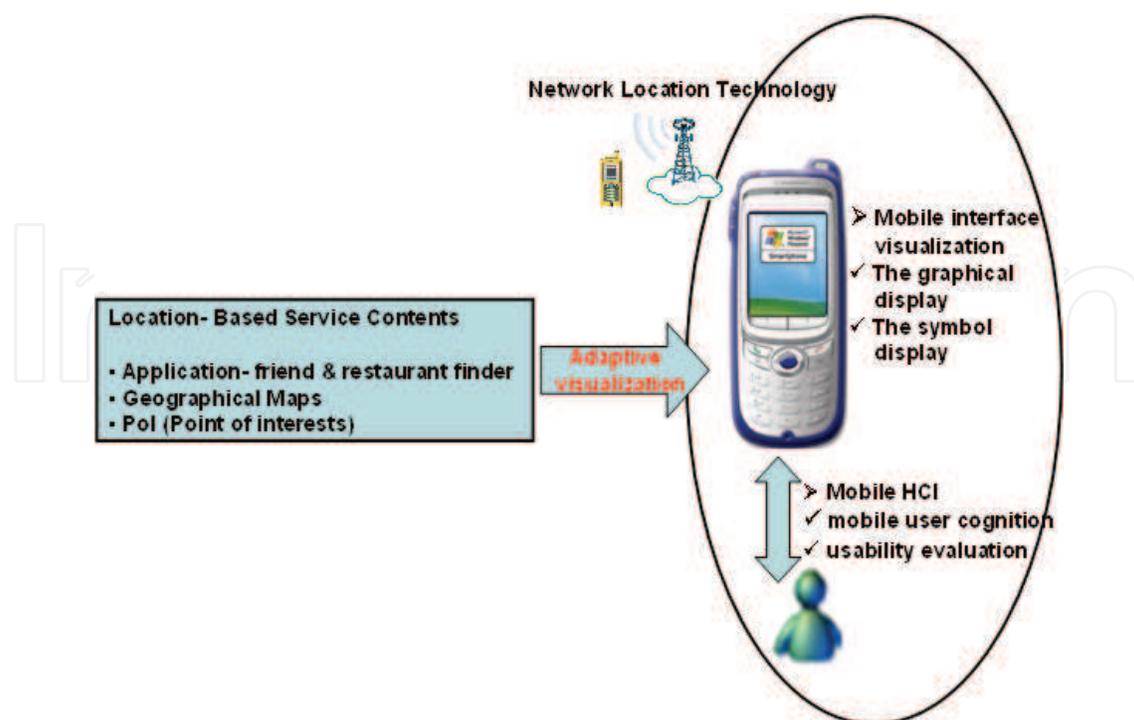


Figure 6. Conceptual model of the Smartphone solution

3.2 LBSI - A prototype of a MVD/LVD mobile visualization

As the aim of this experiment was to compare two different visualizations of LBS interfaces (LBSI) rather than its entire usability in real-life settings, it was decided that the experiment could be conducted reasonably well using a Smartphone emulator embedded in a desktop computer instead of using a much more expensive Smartphone. The participants interacted with the LBS interface using a mobile phone capable of running the Microsoft Windows Mobile™ 2003-based Smartphone Emulator, which emulator screen size was set at 6cm×5cm to simulate the users holding the device approximately 25cm from their face. The procedure of development uses the Microsoft Visual Basic.Net program to establish a prototype of interfaces.

The inspiration for the development of LBSI is not only based on several ideas of design paradigms from NTT DoCoMo's I-mode (I-area) and refer to some web pages (<http://www.phonedaily.com/>, <http://www.olemap.com/>), but also extended by concepts of papers that have been reviewed to consider usability for the mobile domain.

3.2.1 Task of navigating LBS

There are several applications for LBS. Based on LBS usage analysis, previous studies reveal that the most popular services are tracking friends and finding restaurants (Assarf and Taly, 2003). Hence the development of interfaces in this study adopts both applications - friend finder and restaurant finder. Thus the experiment assigned tasks were based on two fictional navigational routes. Each user was exposed to two typical navigation tasks:

- Task 1: First the user adds selected friends to his friend finder list simply by adding some friends (e.g. Yuchang, Alice, Steven, Breind, Wow) in the friend list. He then uses the powerful LBS functionality (Friend Finder application) to find a randomly assigned friend who is visible on the screen of the Smartphone. Then he needs to contact the assigned person with a message.
- Task 2: How should a traveler choose a restaurant for lunch in unknown city? To assign the user to find one of several types of restaurants and a particular price level randomly. He then operates either MVD or LVD of LBSI on the Smartphone emulator and selects a restaurant in an assigned area (e.g. Shihlin, Taipei).

3.2.2 LVD / MVD - friends finder / restaurant finder scenarios

Let us assume that the Smartphone is able to use the embedded LBS function. Related persons will be located on the map (Taipei Shihlin 7(a)) as shown in Fig. 7(g). For friend finder information, the LBSI generally provides a LVD as the preferred type of view. Fig. 7 shows several sample pages accessed via LBSI. As can be seen from Fig. 7, LVD in LBSI allows the users to do the step by step from 7(a) to 7(i).

The LVD as shown procedure step by step in Fig. 7 and 8 below, they provides a rapid way to seek information of restaurant and friend by method of query filters which are predefined for different types of attractions as lists for choice. The MVD as shown procedure step by step in Fig. 9 and 10 below like LVD.

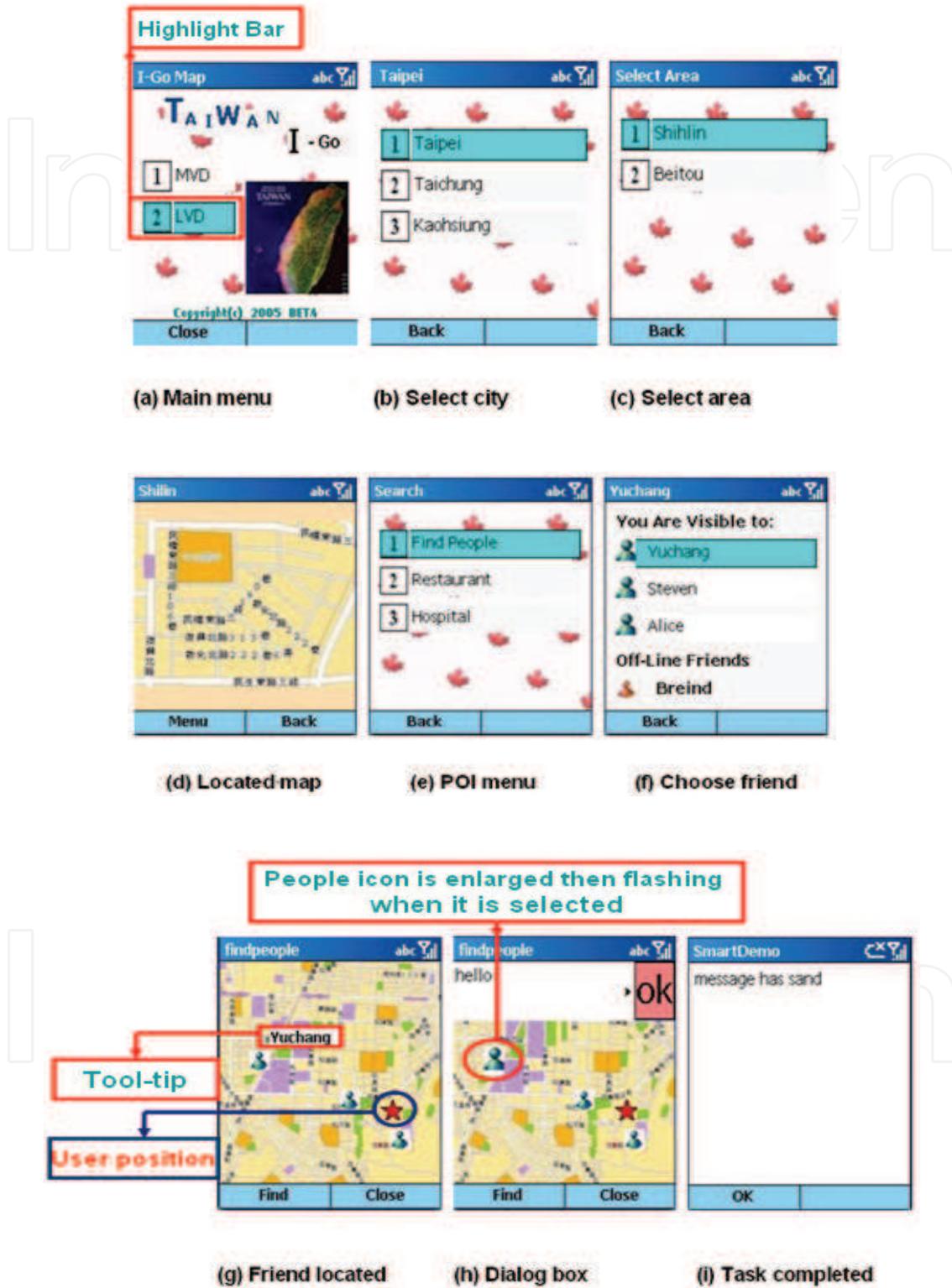


Figure 7. Interface flow of an application of friend finder (LVD)



(a) Main menu

(b) Select city

(c) Select area



(d) POI menu

(e) Select Types of food

(f) Select price level

Restaurant icon is enlarged then blinking when it is select



(g) POI search results in detail

Figure 8. Interface flow of a generic restaurant finder application (LVD)

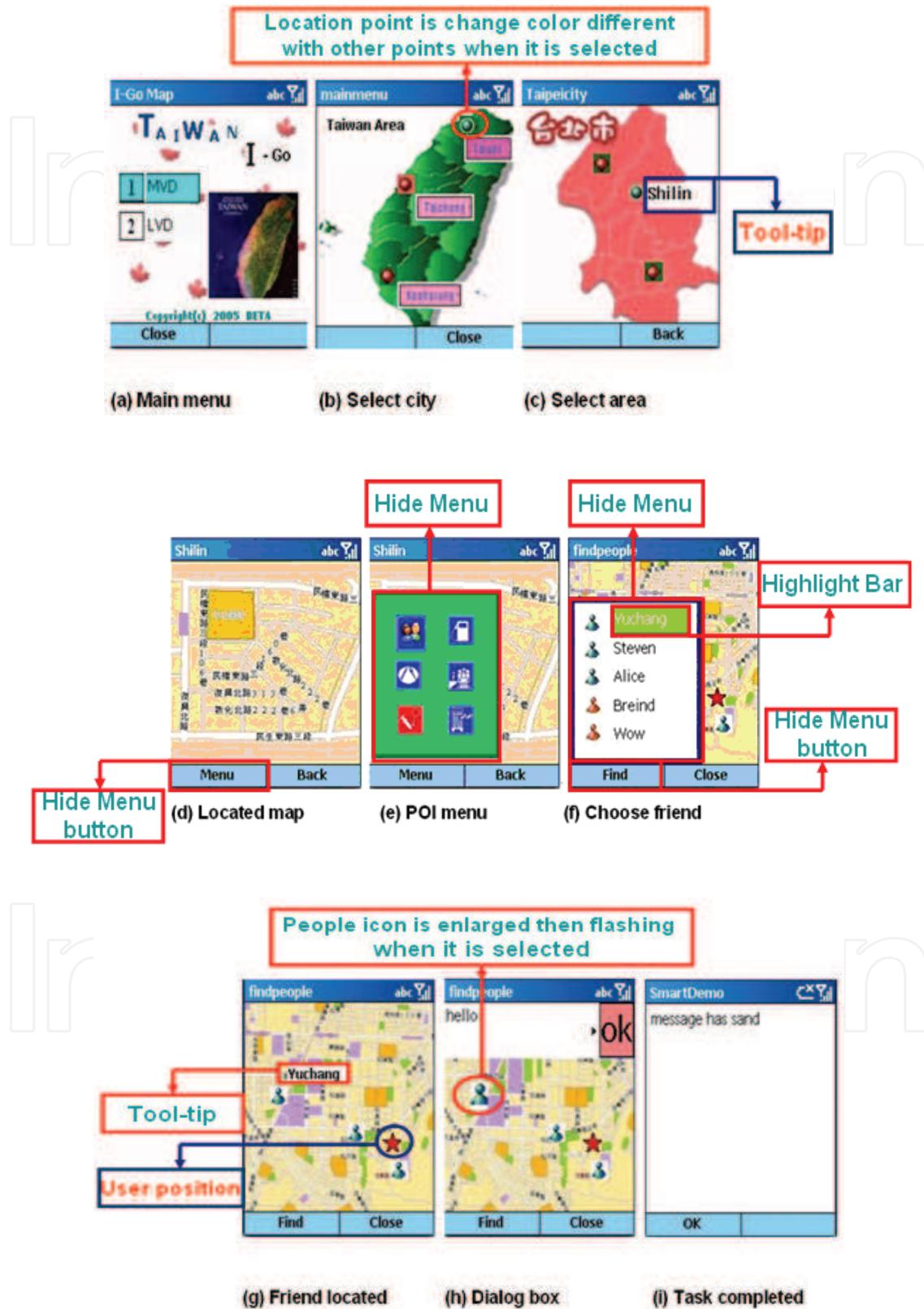


Figure 9. Interface flow of a generic friend finder application (MVD)

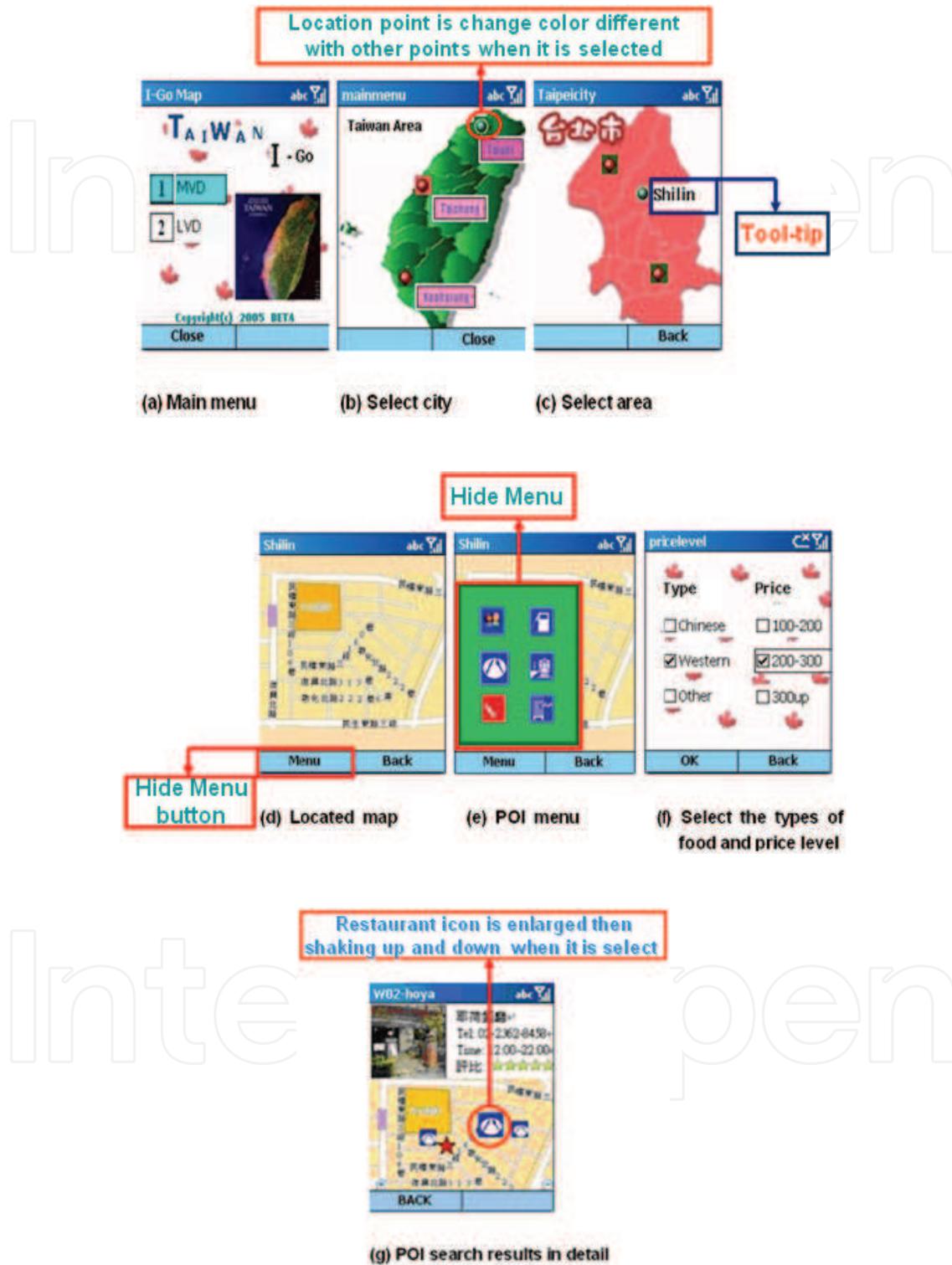


Figure 10. Interface flow of a generic restaurant finder application (MVD)

These designs of the interfaces are based on principles of small screen design and mobile HCI (Masoodian and Lane, 2003; Kraak, 2001; Nivala, 2004; Rohr and Keppel, 1984; Jern,

2000; Reichenbacher, 2004; Holmquist, 1999; Gartner and Uhlerz, 2001; Krug, 2000; Marcus, 1992; Dunlop et al., 2004). It is summarized as follows:

- Query filters are predefined for different types of attractions and designed for rapid selection as either pop-up lists for single choice, or a separate view with a checklist for multi choice selections as shown in Fig. 10(f).
- The object is highlighted using a signal color and its outline is emphasized. Graphics and icons can help support the function of the table of contents during this process. In addition to the many new tools available to highlight their functionality, they can be even more effective as guides through and around a product as shown in Fig. 7(a)-(f), Fig. 8(a)-(f) and Fig. 9(c).
- Clickable icons can be used to access additional information on specific points or areas on the map, information that is not shown all the time to help reduce the overloading of the map presentation as shown in Fig. 7(h) and Fig. 9(h).
- The symbols should be based on signs usually seen in the street and other places and should be presented in a way familiar to people. People should easily recognize these symbols from the map on the handheld devices without much effort as shown in Fig. 9(e) and Fig. 10(e).
- Multimedia designers can influence what users look at by controlling attention through display techniques such as using movement, highlighting, and salient icons as shown in Fig. 7(a)-(f), Fig. 8(a)-(f) and Fig. 9(c).
- One more possibility to increase the legibility of the symbol to increase the size of the object when the user moves his/her pointer on it, and to provide further information when it is clicked, as shown in Fig. 7(h), Fig. 8(g), Fig. 9(h) and Fig. 10(g).
- A previous study has evolved a highly standardized set of metaphors for interaction with the computer based on a series of user-friendly on-screen input techniques such as icons and pull-down menus. A design innovation targeted specifically at improving the mobile interface is the use of icon-based input techniques as shown in Fig. 9(d)(e)(f) and Fig. 10(d)(e).
- Most windowing systems provide a system of menus consisting of implicit or explicit pop-up menus as shown in Fig. 9(e)(f) and Fig. 10(e).
- The object can be animated (blinked, shaken, rotated, increased/decreased in size) as shown in Fig. 7(h), Fig. 8(g), Fig. 9(h) and Fig. 10(g).
- To increase the legibility of symbols, the tool tip option is used to display the description in the form of text as shown in Fig. 7(g), Fig. 8(b)(c)(g) and Fig. 9(b)(c).

3.3 Experiment

3.3.1 Environment and apparatus of experiment

All displays of LSBI are developed by Visual Basic.Net to simulate a scenario for the environment of a city guide. These participants used mouse buttons to navigate forward or backward through each step of LBS functions.

3.3.2 Subjects

There are twelve undergraduate students participated in the experiment and assumed that the variance of different groups were equal. Each participant was randomly assigned into one of two groups, the control group or experiment group. The control group used a LVD

interface and the experimental group used a MVD interface on a Smartphone emulator to fulfill their assignment of task. None of the subjects had LBS experience from before, and while they had used mobile phones in the past, few had used Smartphone. Table 2 gives a summary of the profile of the subjects.

Average Age	22 Years	
Gender	Male (50%)	Female (50%)
Smartphone Experience	Yes (50%)	No (50%)
LBS Experience	Yes (0%)	No (100%)

Table 2. Profile of the subject

3.3.3 Experimental variables

This study used a 'within-subject' design where each participant responded to a different task within each environment. Participants were parted in two groups, with six subjects in each group. One was named group1, the other was named group2. Each group focused on two guiding tasks of PoI (restaurant, friend) directions successfully. These sets of tasks, referred to as task 1 and 2, were randomized across the two environments (see Table 3). Each ordering of the tasks and environments were replicated 6 times, requiring 12 participants in total.

Task \ Display	LVD	MVD
Task 1	Group1	Group2
Task 2	Group2	Group1

Table 3. Profile of the task

Two independent variables are involved in the study below:

- The type of display interface, i.e. MVD or LVD, and
- The type of task, i.e. friend finder and restaurant finder for accessing PoI information.

Besides, user-dependent variables were measured to characterize user efficiency and usability:

- Operating Time: time of operation for the tasks of finding their PoI (Friends or Restaurants).
- Clicks: times of clicks of assigned task performance in all procedure.
- Error of Clicks: error times of clicks of assigned task performance in all procedures (other clicks without correct route which include backward).

3.4 Experimental procedure and hypothesis proposing

Each user was first asked to familiarize themselves with the LBSI for approximately 5minutes. No LBSI manual was at hand. The experimenter stressed that it was a prototype service and that automatic location of the user's present location was not implemented. The user was asked to accomplish each task while "talking aloud". Since clarifications regarding

an opinion were regarded as important, only the accuracy was considered and completion times were measured. If difficulties occurred, the user was first given a hint by the experimenter, and if this information did not suffice, the user was guided through the task before starting with the next.

Participants parted in two groups were required to fill out a background questionnaire at the end of the session. General background information such as age and gender was recorded along with users' previous travel and mobile device experience. The recorded data was categorized as:

- Objective: time taken to complete the individual questions, the number of clicks needed to be followed to complete a task (referred to here as clicks).
- Subjective: degree of user satisfaction, user comments and suggestions.

The hypotheses were tested in the SPSS V12.0 software using the repeated measurement General Linear Model (GLM). The significance level was set to 5% and the level of multiple comparisons was an independent T-test. Our hypotheses for the experiment were:

- By operating time, usability of LVD was more effective than MVD.
- By clicking times, usability of LVD was more effective than MVD.
- By clicking times of error, usability of LVD was more effective than MVD.

4 Results and discussion

4.1 Experimental results

In this chapter, the performance of all participants was evaluated by three indicators: Operating time, Clicks, Error of clicks and post-questionnaire.

Dependent Variable	Operating Time	
Independent Variable	LVD	MVD
Mean	42.58	77.05
Standard Deviation	35.76	35.51
Sample Size	12	12
Degree of Freedom	22	
T-value	-2.369	
P-value	0.027*	

Table 4. T-Test for average operating time of independent populations ($\alpha=0.05$)

4.1.1 Operating Time

As shown in Table 4 the operating time when using LVD is significantly different from that of MVD ($p<.05$). From the sample means for the two groups, one can see the group using LVD spent significantly less training time than the MVD group.

4.1.2 Clicking times

As shown in Table 5 the click time when using LVD is significantly different from that of MVD ($p < .05$). From the sample means for the two groups, one can see the using group LVD spent significantly less clicking times than the MVD group.

Dependent Variable	Clicks Times	
Independent Variable	LVD	MVD
Mean	6.08	8.42
Standard Deviation	2.234	2.151
Sample Size	12	12
Degree of Freedom	22	
T-value	-2.606	
P-value	0.016*	

Table 5. T-Test for average clicking times of independent populations ($\alpha=0.05$)

Dependent Variable	Error of Clicks Times	
Independent Variable	LVD	MVD
Mean	1.17	92
Standard Deviation	2.855	4.981
Sample Size	12	12
Degree of Freedom	22	
T-value	-1.659	
P-value	0.111	

Table 6. T-Test for error of clicking times of independent populations ($\alpha=0.05$)

4.1.3 Error of Clicking Times

As shown in Table 6 there is no significant difference in error of clicking times when using LVD versus MVD visualization.

4.1.4 Result of objectivity

From the measurements of this experiment shown in table 4 and table 5 the study clearly indicates that both, the operating time and the mean number of clicks are lesser in LVD than MVD, no matter what task, task1 or task2 was selected. The result of error of clicks was not significant, which may be due to the complexity of scenario and the user sample size not being large enough to reveal the effect between the two displays in the experiment. According to Standard Deviation of MVD 4.981 reveals each user recognize symbol of MVD

so divergence. Hence, the symbol of the icon is the main factor for efficiency while each user operates LVD and MVD. In a nutshell, LVD visualization was more effective than MVD visualization.

4.1.5 Post questionnaire analysis

In order to comprehend users' preference and opinion in more detail, in addition to objective evaluation, this study uses a post experiment questionnaire after experiment to collect subjective data for analysis. The second construct inside the questionnaire about some symbol items is revised from Rajinder (2004). Others designs of querying items refer to related previous studies (Reichenbacher, 2004 ; Masoodian and Lane, 2003) where content validation was appropriate within the target context. Composite reliability of questionnaire reflects the degree to which the construct is represented by the indicators. All results, as reported in table 7 almost exceed the recommended value of 0.7 for composite reliability.

Construct	# items	Composite Reliability
Interface Investigation	6	0.74
Symbol Investigation	7	0.75
Content of Display Investigation	3	0.72

Table 7. Estimates of composite reliability

Construct	Mean	S.D
Interface Investigation	4.33	0.569
Symbol Investigation	4.46	0.186
Content of Display Investigation	4.22	0.484

Table 8. Result of construct

Further, mean values of three constructs are all above 4 (see Table 8), i.e. between agree and partially agree. Although users' opinions showed that satisfaction is high in three constructs, they also present some suggestion in the questionnaires. These suggestions and comments from the users are summarized below. Although the visualization of MVD was reasonably effective in providing users with overview of some aspect of their LBS functions as well as giving them sufficient access to necessary details of events, overall it was less effective than the visualization of LVD, which made them operate intuitively and easily.

- Subjective results indicate that two-third of the users totally agreed and responded that the size of the symbols was ok, while one-third of the users only partially agreed and felt that it would be easier to recognize symbols on the Smartphone mobile map if the sizes of pictorials were bigger than the original. All users responded that they only partially agreed to the question whether the symbols were expressive enough. Most of the users commented that all the icons were not expressive enough and they were unable to relate it to the real world. For example, the icon of hotel featuring a symbol of a building and two beds led many users to misunderstand it. The post-questionnaire revealed that the Fork and Knife symbol for restaurants in table 1 was almost always

recognized correctly as opposed to the icon of the hotel which was always misunderstood. When users were asked about what kind of symbols in their opinion were more expressive, they suggested using symbols that were more familiar with general standards of everyday life and could be recognized easily.

- Objective results indicate that recognizing symbol intuitively is a critical factor in operating MVD effectively. Finally, results of both subjective and objective criteria show that the symbol-based interface (MVD), which is designed to focus on user symbol cognitive level, should adopt simple and intuitive icons that are more helpful for humanize interfaces.
- Majority of the users commented that having pop-up legends would be more helpful. When users were asked about the contents of display, some users suggested that the level of information displayed should be increased for PoI and should show as much detailed information about a restaurant as possible.

5. Conclusions and future work

The main design principles to implement two diverse displays of LBSI and use Smartphone to access LBS information are guided by the display of I-mode and the current study of SSI (Dunlop et al., 2004). Subsequently, an empirical experiment conducted to investigate the effectiveness of the pictorial and textual visualizations of the prototype has shown that the list style generally outperforms the pictorial style when they are used on their own. In the other aspect, the post-questionnaire investigates users' preference of display in detail. The chosen design methodology, user interface concepts, and the technical considerations for implementation have been discussed in detail. It is expected that when both of these visualizations of the prototype are used together in real-world settings, they will provide the users with effective and intuitive access to their PoI information. It is feasible to fulfill PoI on-map presentation on smart phones with small displays. The prototype of the Smartphone offers a ubiquitous tourist guide for the inner city of Taipei. This form of access would certainly be a major improvement over the use of conventional paper-based methods for the same purpose. The mobile maps of LBSI have provided mobility, accessibility, actuality and extra information about users' preferences. Finally, the applicability of adaptation within a mobile geo-visualisation service through a prototypical implementation has been proven.

6. References

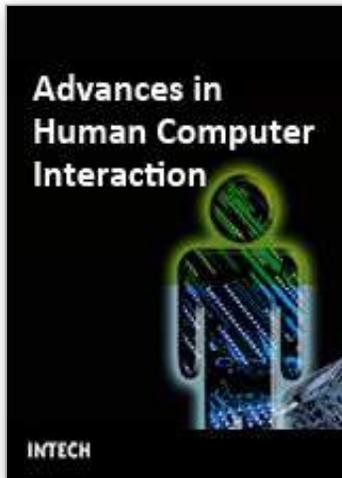
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