An Empirical Study of Developing an Adaptive Location-Based Services Interface on Smartphone

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Abstract. A mobile market shows that the global LBS (Location-Based Service) market is noticeable and continues to grow rapidly. With the coming of mobile applications, the requirement of the small screen interface (SSI) is even more reinforced because of the need for more functions and contents on the devices. This research explore an empirical study of user access to PoI's (Point of Interest) information of the map view display (MVD) and list view display (LVD) meeting the user's needs base on the principle of adaptive and intuitive visualization on Smartphone. Further, the prototype of LBS on smartphone was emulated by VB.Net program, which interfaces are evaluated through objective measurement and subjective investigation. Our study's results appear cognition of symbols that affects operating performance, so the suggestion is towards using LVD more effectively than MVD on LBS applications. The findings of the study will be helpful to enrich functionality and customization of the LBS appearance on smartphone.

Keywords: Location-Based Service, Point of Interest, Map View Display, List View Display, Adaptive Visualization, Small Screen Interface.

1 Introduction

About recently years, mobile networks are widely deployed in global mobile market (including Taiwan) and income from telephony services had proven to be significant to mobile operators. As well as according to figures from market researchers Canalys point out shipments of converged smart mobile devices, namely smart-phones and wireless handhelds, rise by 170% year-on-year in first part of 2005 in Europe and Middle East as, in contrast, standard mobile phone shipments rise by only 11% [1]. By the way, in some countries such as Japan and South Korea, mobile Internet use is growing rapidly. For example, NTT DoCoMo reports, that the number of i-mode subscribers now exceeds 38 million, which is nearly half of all cellular phone subscribers in Japan [12]. Reed stated "telecommunication companies are making huge investments and they know LBS technology is a key application from which they can generate revenue"[15]. While mobile users operate the add-value service, they suffer some possible problems of the lack of screen space. The display of dynamic PoI information on the map shall be tailored to the needs of users, thus the PoI information

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must be simple and intuitive without overly complex information. The objectives of the study are listed below:

(1) To develop two kinds of displays in a prototype of LBS interface, which displaying dynamic PoI's information in the map in an adaptive and clear way base on meeting the design principles of mobile interfaces. (2) To evaluate and compare performance of the prototype through the rigid experimental evaluations.

2 Related Concepts

LBS can provide various services to a user based on the user's location. This add-value service in the broadest sense is any service or application that extends spatial information processing or geographical information services (GIS) capabilities, to end users via the internet and/or wireless network [7]. The Open Geospatial Consortium (OGC) stated LBS is defined as a wireless-IP service that uses geographic information to serve a mobile user, or any application service that takes advantage of the position of a mobile device [13]. These services help to answer questions such as "Where can I find a Chinese restaurant?" or "Where is the nearest friends?" etc. For example, in Japan, NTT DoCoMo expresses a "friends finder" service on its iMode system [10]. Therefore these are usually combined with a digital map associated to the user location. Previous studies have proved that a visual communication of geographic information in the form of maps is high on the users' wish list of LBS [8]. During this visualizations process, cartographic methods and techniques are applied. These methods and techniques can be considered as a kind of grammar that allows for the optimal design of maps, depending upon the application (Figure 1) [9].

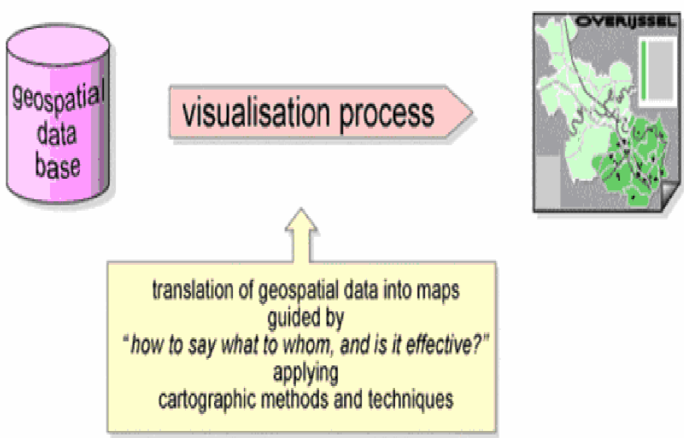

Fig. 1. The cartographic visualizations process

Representations may be presented symbolically, graphically, or iconically and are often differentiated from other forms of expression (textual, verbal or formulaic) by virtue of their synoptic format and with qualities traditionally described by the term ´Gestalt´. The adaptive geovisualization service will produce mobile maps which the user gets the possibility to specify the information he needs for his purpose, the system selects the necessary data and omit unimportant details. Dunlop, Ptasinski, Morrison, McCallum, Riseby, Stewart present two types of views providing both map and list-index information access: (1) MVD (Fig 2a) (2) LVD (Fig 2b)[4].

Fig. (2a). MVD

Fig. (2b). LVD

In the past one of the problems with using menus is that they take up a lot of space on the screen. Two solutions are the use of pull-down or pop-up menu [14]. Most windowing systems provide a system of menus consisting of implicit or explicit pop-up menus [11]. As well as Crampton describes taxonomy of interactive functions in geo-visualization and argues that a highly interactive map provides many of theses functions, whereas a non-interactive map (e.g. a scanned raster map) does not offer any interaction possibilities [3]. Interactivity is mostly used to compensate for the small displays and not for enhancing the user experience. Thus while small display interface design processes, consideration of user aspect is indispensable. Reichenbacher expressed graphical means to put a visual emphasis or focus on several features are [16]:

- highlighting the object using a signal color, e.g. pink or yellow (color)
- emphasizing the outline of the object
- enhancing the LoD(Level of Detail) of the object against that of other objects
- animating the object (blinking, shaking, rotating, increasing/decreasing size)
- clicking on a graphics object you are able to drill-down to more detailed information of that object [6].

Whereas some projects there are few studies which dealt with the map displays on mobile devices. Such Reichenbacher has studied the process of adaptive and dynamic generation of map visualization for mobile users [16]. Besides, Jern plays a major role in a dynamic user interface enabling the user to take a more active role in the process of visualizing and investigating data [6]. Graphics and icons can help support the function of the table of contents. In addition to the many new tools to highlight their functionality, they can be even more effective as guides through and around a product.

3 A Prototype of a MVD/LVD Mobile Visualization

Prior to actually touring through the unknown city, a user may plan the sightseeing tour in a restaurant and request information related to the sights PoI. Consequently, the most important feature is the list of available PoIs and related detailed dynamic information.

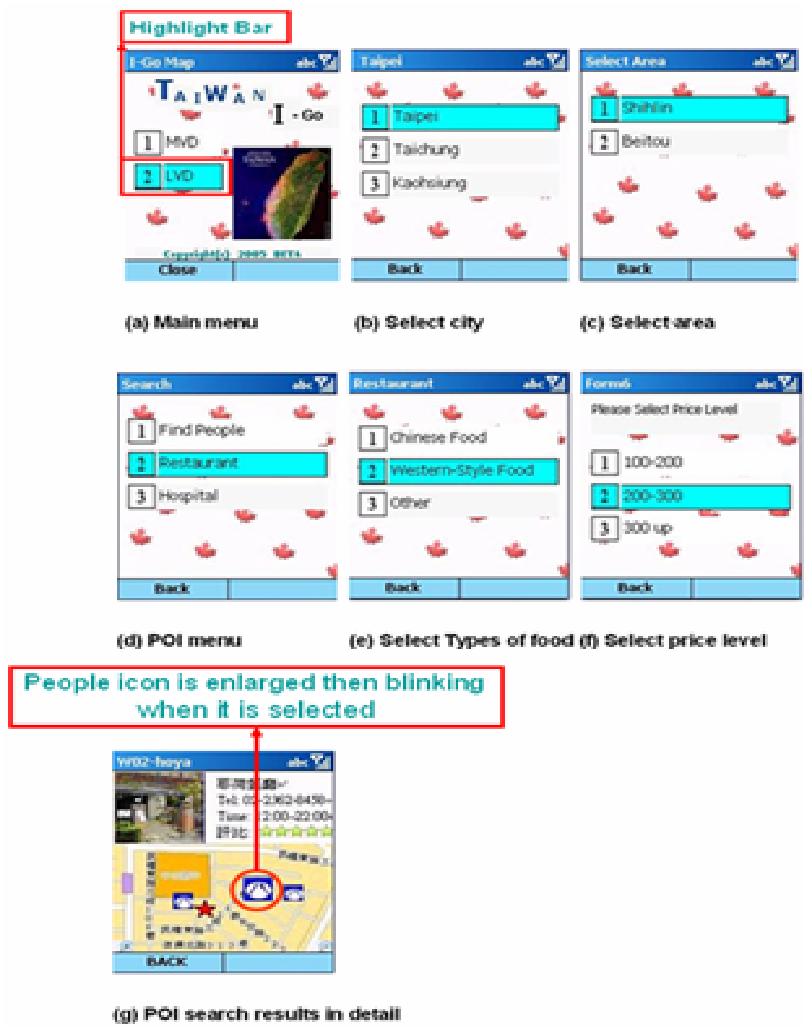

Fig. 3. Interface flow of a generic restaurant finder application (LVD)

Fig. 4. Interface flow of a generic restaurant finder application (MVD)

The procedure of usage is showed in Fig. 3, which LVD in LBSI allows the users to access the list of the two selections of a main menu (3a), from which the users can select a city (3b), to select which located area (shihlin) (3c), show the located map of shihlin (3d), after clicking menu button, to select the icon of restaurant in Hide Pop-up POI menu (3e), user can choose one of three types of food which is favorite and your preference price level (3f), all the icons of restaurants will be showed in visible area on screen, on the map individually, it is enlarged then shaking up and down when the icon is selected that user will focus on it as well as the usage of a pop-up information box that gives further details about the identity of a selected restaurant(3g).

(1) The LVD provides rapid way to access information by method of query filters which are predefined for different types of attractions and designed for step by step selection as lists for choice (see figure.3).

(2) MVD can provide utilized information by icon of query filters (see figure.4).

4 Design of Experiment

4.1 Subjects

The participants were undergraduates. Hence, we assumed that the variance of different groups were all equal. Each participant was randomly assigned into one of two groups, the control group or experiment group. Table 1 gives a summary of the profile of the subjects.

Table 1. Profile of the subject

Average	22 Years old	
Gender	Male (50%)	Female (50%)
Smart-phone Experience	Yes (50%)	No (50%)
LBS Experience	Yes (0%)	No (100%)

Participants are parted two groups, there are six subjects in each group. Each group based on two guiding tasks of POI directions successfully. These sets of tasks, referred to as task 1 and 2, were randomized across the two environments (see Table 2). Each ordering of the tasks and environments were replicated 6 times, requiring 12 participants in total.

Table 2. Within-subject design of the experiment

Display / Task	LVD	MVD
Task 1	Group 1	Group 2
Task 2	Group 2	Group 1

4.2 Experimental Variables

Two independent variables are considered in the study:

(1) The type through MVD or LVD interfaces of LBS on smart-phone; and (2) Through two different tasks which include service of friend finder and restaurant finder for accessing POI information. The following dependent variables were measured to characterize user efficiency and usability:

1. Operating time: time of operation the tasks of finding their POI (friends or restaurants).
2. Clicks: times of clicks of assigned task performance in all procedure.
3. Error of clicks: error times of clicks of assigned task performance in all procedure (other clicks without correct route which include backward).

4.3 Research Hypothesis

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 independent T-test. Our hypotheses for the experiment were that below:

1. By operating time, which display provided better user performance between LVD and MVD?
2. By clicking times, which display provided better user performance between LVD and MVD?
3. By error of clicking times, which display provided better user performance between LVD and MVD?

4.4 Experimental Procedure and Data Collection

Each user was first asked to familiarize with the interface for approximately 5minutes. No 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 seen as important, only 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.

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

5 Results and Discussion

In this chapter, the performance of all participates was evaluated by these three indicates: operating time, Clicks, Error of clicks and post-questionnaire.

5.1 Operating Time, Clicking Time and Error of Clicking Time Aspects

As shown in Table 3,

Table 3. The t-test for average operating time, clicking times and error of clicking time of independent populations (α=0.05)

Dependent Variable	Operating Time		Clicking Time		Error of Clicking Time	
Independent Variable	LVD	MVD	LVD	MVD	LVD	MVD
Mean	42.58	77.05	6.08	8.42	1.17	3.52
Standard Deviation	35.76	35.51	2.234	2.151	2.855	4.981
Sample Size	12	12	12	12	12	12
Degree of Freedom	22		22		22	
T-value	-2.369		-2.606		-1.659	
P-value	0.027*		0.016*		0.111*	

1. 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 using LVD group spent significantly less training time than MVD group.
2. 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 LVD group spent significantly less clicking times than MVD group.
3. There is no significant difference in error of clicking times when using LVD versus MVD visualization.

As a result of measurement clearly indicate LVD visualization was more effective than MVD visualization.

5.2 Questionnaires Aspect

Participants are given the questionnaires to response their opinions. These suggestions and comments are summarized below. Although the visualization of MVD (pictorial) was reasonably effective in providing users with overview of some aspect of their LBS functions, also giving them sufficient access to necessary details of events, the MVD was less effective than the visualization of LVD. Majority of the users commented that if there were pop-up legends it would be acknowledge more helpful. Users are asked about content of display; some users suggested that more extra information should be increase about PoI which shows information of restaurant as possible as in detail.

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