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ABSTRACT

Mobile applications (APPs) are adopted and downloaded widely around the world. Those APPs are those for examples linking to enterprise applications, management information systems, education systems, and healthcare systems. Thus, the importance of potential development APPs is hung. The objective of this study is to elicit design principles for ensuring the interactivity of smart parking APPs to be used especially in the city. This study conducted a systematic review on the past literature of interface design and case studies on seven smart parking APPs on the market in order to develop a design framework for smart parking APPs, which include a list of design principles. Then, four experts of APP design were involved in a series of interviews to improve the readability and usability of the framework. Finally, this study identified 11 principles for improving the interactivity of smart parking APPs, which are useful to the situation when users need to interact with a smart phone urgently in a small-touch-screen environment.

Keywords: mobile applications, interactivity, smart parking, design principles and case studies.

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INTRODUCTION

The advancement of information technology infrastructure, hardware, and software has caused the smart phone becoming a ubiquitous computing platform for our daily life (Ballagas *et al*., 2006). In addition, the number of smartphone users is growing quickly. Mobile applications (APPs) are adopted and downloaded widely around the world for the use not only in personal occasions, but also business purposes. Those APPs are those for examples linking to enterprise applications, management information systems, education systems, and healthcare systems. Thus, the importance of APPs is growing, and the potential development of them is hung.

At the same time, smartphones include a range of functions of traditional mobile phone, digital camera, Internet, global position system, near field communication, Bluetooth, infrared ray, and many other functions. Thus, the applications for downloading are increasing as well. Another advantage of smartphones is the touch screen. Different from traditional computers, the touch screen enables users to interact with the software instantly by figures or pens rather than large a keyboard and mouse. Thus, they are more portable than normal computers or even notebooks in various kinds of situations. Traditionally, the development of web pages tended to integrate a range of functions and items in a single page. Yet, this principle may not be applicable to mobile applications (APPs) since the screen of the smart phone is small and it has a touch screen for interacting with applications. Thus, there is a need to study what design principles are suitable to APPs development in terms of interaction concern.

Nowadays, the increase and growth of transportation tools is growing fatly. Thus, it is relatively harder to find parking space especially in the city (Monzon, 2015). In a crowded city, people drive their cars slowly, and finally arrive the car park. However, the car park may provide no space. Therefore, parking problem needs APPs to deal with. Although there are various kinds of smart parking APPs available in the market, very few of them are with good design. Most of them are hard to use because of the poor interaction between APPs and the users.

The objective of the study is to elicit design principles for ensuring the interactivity of smart parking APPs to be used especially in the city. For the smart parking APP, it particularly can be used in the situation when drivers need to interact with it for finding a parking space urgently through a small touch screen. Thus, the elicited principles can help the driver to quickly find the parking spaces through the use of smartphones. It is also hoped that the principles can increase the download number of smart parking APPs.

LITERATURE REVIEW

Smart Phone Applications

Smart phones have become the electronic products used by most people in the world. Smart phones can help users to make phone call, have contact with others, process information, access to multimedia and Internet access, etc. In addition to more and more powerful processor cores and more advanced operating systems, the peripheral technologies of smart phones such as the development of wireless networks and the advancement of telecommunications technology all allow the very fast growth of the smart phones in terms of quantity and in speed (Balasubramanian *et al*., 2002; Hsu,2014).

When defining smart phones, Zheng and Ni (2006) believe that in addition to the traditional phone call and Short Message Service (SMS) features, smart phones also have the abilities to connect wireless networks and personal information management. In addition to that, because of the development of the Internet, users can get information from the Internet faster, which allows the users to access to the latest information as well as to solve their needs more quickly and easily (Sarker & Wells, 2003). As more and more people are having smart phones, developers are also aware of the importance of mobile applications and are actively develop a variety of applications as well (Hwang, Shiau, & Jan, 2007).

User Interface Design

The interface is the device that can allow interactions between the machine system and the users. It is through the interface that the machine system and the users are able to communicate and interact with their messages. The interface also let the users, through decision-making operation, to achieve the intended intention. It is also the interaction between human and the machine equipment that allow the users to have more efficient interaction with the information devices (Preece, 1993).

Norman (2013) believes that the key interactive interface design should be the system's ability to response immediately, which means it cannot make the users to wait for too long. Interface communication is just like the usual conversation between two people, which must have the characteristics of interactive dialogue, and the corresponding tips of feedback when implement of the action can be the use of the sound, the changes of button or animation, etc., so as to make the system more interactive and user-friendly.

Shneiderman and Plaisant (2010) made several recommendations, and the excerpts are summarized as follows: Firstly, the system must strive for consistency (Strive for Consistency): let the user have a consistent operation mode, the same picture, terms, tips, instructions or the same operating procedures, etc., which will allow users to spend less time when using the mobile applications. Secondly, offer informative feedback (Offer Informative Feedback): If the user makes a very important operation, the system should give him a clear notice. The design dialog should produce the yield closure (Design Dialog to Yield Closure). The system should design dialog to yield closure that clearly inform the user's status whether he is at the starting point, in the progress stage or at the end of operation. Thirdly, offer simple error handling (Offer Simple Error Handling): let the user know what kind of error he has made and to provide a simple solution that allows the user to leave the wrong operation. The system must also provide the opportunity for the user to correct his wrong actions. Fourthly, to support the user's internal locus control (Support Internal Locus of Control): let the user feel that they can take the initiative to control the system. Through their own control, they hope they can get the desired results, rather than simply respond to the system. Fifthly, to reduce the user's short-term memory load (Reduce Short-term Memory Load): According to the study, human memory can only remember 5 to 9 things for a short period of time. In order to let the users avoid receive too much information at the same time, a concise and simple interface should be provided.

Apple (2013) has put forward the principles of the iOS interface design, some of the key excerpts are: Focus on the Primary Task, Elevate the Content People Care About, Think Top Down, Give People a Logical Path to Follow, Make Usage Easy and Obvious, Use User-Centric Terminology, De-emphasize Settings, Brand Appropriately, Make Search Quick and Rewarding, Be Succinct, in the development of Apple iOS, use the UI provided by Apple to design (Use UI Elements Consistently, Consider Adding Physicality and Realism, Delight People with Stunning Graphics, Handle Orientation Changes, Make Targets Fingertip-Size, Use Subtle Animation to Communicate, and Ask People to Save Only When Necessary).

Interactivity of the Smart Phone

The so-called interaction refers to the feedback that a receiver generates for the message content as well as for the source of the message. Through constant feedback from the user, the source of the message and the receiver can continually correct the contents of the message in order to achieve a more effective two-way communication (Wiener, 1948). Wobbrock, Myers, and Aung (2008) pointed out that it is important to be able to use mobile devices and interact with them anywhere. People will not want to use their mobile devices at a fixed location. Liu (2003) proposed to use active control, two-way communication and synchronicity to measure the interaction of the site. McMillan and Hwang (2002) used mobility on practical operational services, and applied "Measurement of Perceptual Interaction: the discussion of role of control, time and communication in perceptual interaction" to explore the theme of: User Control, Time, and Direction of Communication.

METHODOLOGY

This study explores the design criteria for "smart parking APP", which firstly through the literature analysis of the smart phone applications, user interface design, and smart phones interactions, and then we pinpoint the relevant literature for sorting out. The literature review is a comprehensive analysis of a large number of studies collected on a certain topic. The literature review requires a comprehensive analysis of the literature, summarizing and analyzing the materials so that the materials are more concise and logical. It is necessary for us to carry out a more specialized, comprehensive, in-depth and systematic discussion of the consolidated literature. The study should have the ability to synthesize, analyze and criticize the literature, as well as to integrate and develop the advantages and disadvantages of the literature that correspond the research theory direction and hypothesis based on the discussion and research results (Burton & Steane, 2004).

This study conducted a systematic review on the past literature of interface design and case studies on seven smart parking APPs on the market in order to develop a draft design framework for smart parking APPs, which include a list of design principles. Then, four experts of APP design were involved in a series of interviews to improve the readability and usability of the framework.

Research process

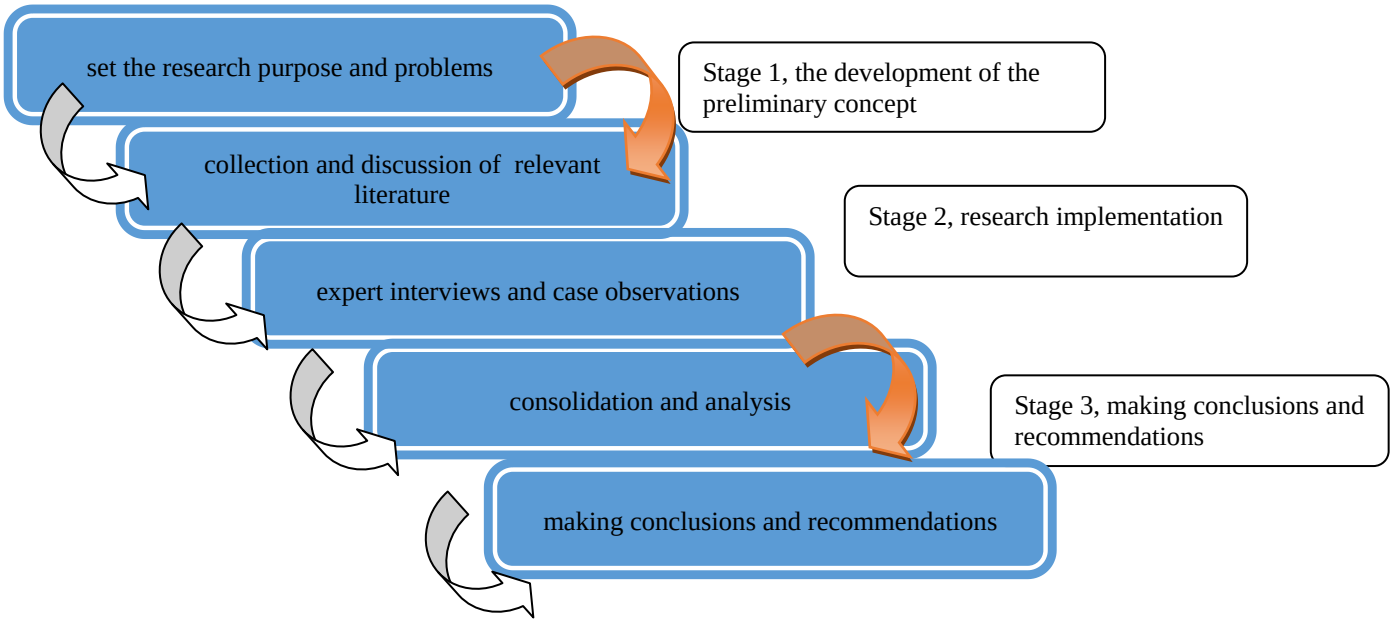

Figure1: Research process. The study organizes.

First of all, through the collection of literature analysis of the smart phone applications, user interface design, and smart phones interactions etc. then we pinpoint the relevant literature for sorting out and developing the preliminary concept of design principles. Secondly, based on the preliminary concept mentioned above, through the interview with experts in the field and case studies, we have suggested a comprehensive analysis of a set of design principles. Finally, making the conclusion and recommendations as the results of this study to sum up design principles and propose the design method for the designers.

RESULTS AND DISCUSSIONS

In the past 20 years, government agencies in various cities have been actively building and designing Parking Guidance and Information (Cheung & Varaiya, 2007). The monitoring of the parking lots and the monitoring of the parking spaces (Cheung & Varaiya, 2007; Mimbela & Klein, 2000) allow the parking guidance and information system to save the driver's time effectively (Waterson, Hounsell, & Chatterjee, 2001).

Parking lots in Taiwan are divided into two categories: public or private parking lots. Public car parks are either managed by local governmental departments, or outsourced the tender operation to others (Lee & Hoh, 2010). Based on the concept of public services, almost all public car parks provide the parking guidance and information system as well as smart phone APPs. As to private parking lots, Taiwan-Parking and Dodohome are the mainstream, but they do not provide relevant parking information. As to mobile APPs, public institutions have launched “iTaipei Parking” from Taipei City, "Taoyuan Easy GO" from Taoyuan City, "Hsinchu City Easy Parking" from Hsinchu City, "Taichung e Parking" from Taichung City, "Tainan Easy Parking" from Tainan City, and "Kaohsiung Easy Parking" from Kaohsiung City. The above applications are mainly for providing information of the site locations and parking spaces remained at the public parking lots. As to the private sectors, the relative information on public and private car parks is consolidated by "parkinglotapp.tw" and shown in the following table.

Table 1-1 Taiwan's Smart Parking APPs

APPs	Layouts	Number of parking spaces	Update the remaining parking spaces instantly	Parking guide	Parking Space for the types of Vehicles	Other functions
iTaipei Parking	Image Button	V	V	V	Car/motorcycle/ electric car	Show some of the administrative area’s roadside parking spaces

Taoyuan Easy GO	Image Button	V	V	V	Car/motorcycle electric charging station	Roadside parking fee reminder / Ubike
Hsinchu City Easy Parking	Image Button	V	V	V	Car	Roadside parking section / roadside parking fee inquiries
Taichung e Parking	Image Button	V	V	V	Car	Roadside parking fee inquiry / pay roadside parking fee
Tainan Easy Parking	Image Button	V	X	V	Car/motorcycle	Check roadside parking fee is due
Kaohsiung Easy Parking	Map	V	V	V	Car	Parking fee Search / tow query
parkinglotapp.tw	Map	V	V	V	Car	Able to report parking spaces are full / mobile phone can pay for parking fees (limited to cooperative parking lots)

From the above, we learn that all the metropolitan areas in Taiwan have built relevant smart parking APPs. As the Taipei City Government is currently working hardly in connecting the open data, the parking lots in Taipei City's are also the most in the Taiwan Metropolitan Areas, as well as Taipei City has the heaviest traffic load, therefore we have chosen the Taipei City area as an example to be the main reference for this study.

This study elicited a series of interactive design guidelines through reviewing on the past literature, interviewing experts, and studying APPs cases that include three categories: (a) user experience; (B) visual interface design; (C) interactive mechanism and the response of the system. In total, this study identified 11 principles for improving the interactivity of smart parking APPs including (1) easy to use, (2) help to learn, (3) to reduce the memory load, (4) easy to see, (5) consistency, (6) efficiency, (7) feedback, (8) avoid mistakes, (9) end the dialogue, (10) validity, and (11) fast display. Details are summarized as follows:

A.	User experience		Enhancing designs and plans from a "user experience" point of view to understand user requirements to provide ease-of-use application to attain the objectives of users.
	1.	Easy to use:	Image button can clearly express the meaning of the function by icon. The design of image button can provide clear information to the users, so that the users know how to operate or know the meaning of the button at a glance, which can allow the users to quickly understand the function of the button and then operate correctly.
	2.	Help to learn:	Provide navigation assistance for the initial users, as well as having simple instructions to help the users when they turn on the APPs. The system should be able to meet the needs of both the generic users and the experienced user, as well as to achieve the desired goal by methods that suitable for each user.
	3.	Reduce the memory load:	The overall presentation of the message structure is logical and consistent so that users do not have to spend a lot of time or brain power to remember the details of the operation process.
B.	Visual interface design		Unequivocal visual information and the recognition easier enhance the efficiency of the user interaction and communication; good visual interface ensures the consistency and the fluency to reduce user's adaptive and helping out promoting user's interactive experience with smart phone applications.
	4.	Easy to see:	The appropriateness of interface font size as well as the properness of the word spacing and line spacing of the interface are also very important.
	5.	Consistency:	The overall visual style, color and layout style should be consistent. Try to maintain the space consistency of the applications, so as to let the users keep the habits. The similar or the same functions should have the same design. In this way, it not only can avoid causing the user's

			confusion, but also allow the users spend less time in adapting or learning it.
	6.	Efficiency:	The users feel fluency when sliding the page interface so as to promote a satisfactory operating experience. System response and the speed of the display must be also considered.
C.	Interactive mechanism and the response of the system		Emphasizing fully integrated systems development on hardware and software application program, helping user getting a response quickly, handling the working order and procedures, supplying information accuracy, and being effectively stabilize to obtain the latest information to meet the needs of the users.
	7.	Feedback:	The system should be able to provide a meaningful and understandable feedback to the user's operation so that users can understand that they have successfully achieved a certain setting or target. If the user makes a very important operation, the system should give a clear response. A graphical representation of the system loading page or response latency should also be provided.
	8.	Avoid mistakes:	When the user has a wrong operation, the system should not only let the user know what kind of error he has made, but must also provide a simple solution to allow the user to leave the wrong operation. The interface system operation should be stable, and the interface operation should have a function to return back to the previous page. The APP design should avoid as much as possible having error condition without prior warning.
	9.	End the dialogue:	A series of actions should be organized into three parts: the beginning, the mean, and the end. When the action is over, the APP should provide a feedback to let the users know that the action has been completed, that is, when the user clicks on any function or parking lot, the corresponding result will be bounced in order to let the user know that the action has been completed.
	10.	The Validity:	The link function is valid and can be accurately linked to the correct page. Place the most important functions on the top (Think Top Down). When the users want to use some certain important features, they can spend less time in operating it so as to quickly meet the needs of the users. Do not place the low functional keys or useless functions on the interface in order not to cause the confusion of the users.
	11.	Fast Display:	The pages can be quickly presented when the users click on them. For the users, the user satisfaction for the mobile application can be increased if the waiting time for response can be reduced.

CONCLUSION

The objective of this study was to elicit the design principles of an excellent interactive smart phone APP, and to solve the demand for public parking in the urban traffic infrastructure. This study was aimed at eliciting design guidelines for the intelligent parking APP for high interaction, real-time, portable, car-driven, small-screen environment that requires high interactivity. Through the literature review, interview with four experts in the field, urban intelligent parking APP case study (seven Taiwan Metropolitan area intelligent parking APP cases), we have concluded a comprehensive analysis of a set of interactive design guidelines framework. Such set of design guidelines has 11 main points: 1. easy to use, 2. help to learn, 3. to reduce the memory load, 4. easy to see, 5. consistency, 6. efficiency, 7. feedback, 8. avoid mistakes, 9. end the dialogue, 10. validity, and 11. fast display. This study found that the proposed interactive design criteria can be used in the actual design, to enhance the interaction between APP and the user, and can provide references for follow-up developers.

As in the past literature, most of the main features of the field of research are: computer screen display, computer operation, e-commerce or database system development ... and so on as the main direction. However, this study is mainly aimed at real-time, portable, car-driven, small-screen mechanisms as our main research focus, especially in the field of highly interactive smart phone APP field to explore its design principles. Therefore, the application of the field is relatively different from the environment of computers. Under such circumstances, the study of the interactive design principles can be extended to the scope of application, such as: in case of emergency, it can also be applied to develop the real-time intelligent APP used by police and fire system, or applied on the rescue intelligent APP used in the disaster rescue ... and so on. As for the industry, the design principles can also be provided for the developers to be used in their development, so that they can design the smart phone APP that is actually more interactive to the users, as well as having more mobility and real-time functions.

There are several limitations in this study. When applying the APP design principles in different systems, different needs of the

usage scenarios, or different culture or operating habits in other country, the developed principles may needs revision. Our suggestions for future research are to study how the principles are applied in different types of APP, and compare the different designs principles in different types of APP. Future research can also explore whether there will be any significant impacts from different sizes of smart device for the users when they use the APP.

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