

# Mobile Augmented Reality System Design Guidelines Based on Tourist's Emotional State

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**Abstract**— Individual's emotional states may change and influence their behavior when using mobile application. Studying the behavior and emotional state of user are necessary in the design of a Mobile Augmented Reality System and should be based on a good design principle. The design principle is useful as a guidance to develop a good mobile AR system. This paper will present a design guideline for Mobile Augmented Reality (MAR) for tourism. From the analysis of existing design guidelines of Mobile Augmented Reality (MAR) for tourism, an application design guidelines are proposed based on PAD's theory, Human-computer Interaction and Usability principles. The design principle is to reduce cognitive overhead of tourist, learnability and suitable context for users. Six design principles were examined in this analysis. The analysis identified eleven suggestions for design principles and these recommendations are offered towards the design principles and developing prototype application for tourist in Malaysia.

**Index Terms**— Design Guidelines; Emotional State; Human Computer Interaction; Tourism.

## I. INTRODUCTION

Mobile and wireless technologies enable the provision of novel applications that support visitors while on the move. Such applications include mobile travel guides [1-2] and location-based infotainment services such as GIS-based recommendations, annotation and bookmarking and mobile social networking [1,3,4,5]. In essence, these applications allow tourists to have seamless and ubiquitous access to travel-related information during their visiting experience, which is presented in a multimedia-rich way. At the same time, location sensor capabilities of mobile devices facilitate filtering of the travel information in order to be tailored to the travelers 'needs and wants' [6].

In order to make this interaction more enjoyable, applications must possess robust and usable interfaces, providing information to the user intuitively. Human-Computer Interaction (HCI) is the area of computing which investigates the design, evaluates and implements interfaces for humans to interact with computer systems in an efficient and intuitive way [7]. A Graphical User Interface (GUI) is one of the approaches to HCI, which allows direct manipulation of objects or menus on a screen [8]. Another important approach to HCI is to use augmented reality to provide users with information of virtual and real objects in a more appealing manner [9].

To develop a good mobile AR system, the design of application is important to make it more interactive and user interaction must be considered. The design principle is useful as a guidance to develop a good mobile AR system.

In developing a design guidelines there is a need to study the behaviour and emotional state of user that will be affected. The design guidelines will then be used to design a good user interface for mobile AR tourism application.

## II. LITERATURE REVIEW

### A. Mobile Augmented Reality

The concept of Mobile Augmented Reality (MAR) was developed around the mid-1990s, applying Augmented Reality (AR) that overlays virtual object with real objects in mobile settings, in different environments, spaces and desktop [10]. MAR combines wireless communication, location-based computing and services (LBS), and augmented reality to create an integrated interactive environment. The ongoing rise of MAR has become evident with a large body of publications describing enabling development platforms and applications such as Layar, Wikitude and Junaio [11]. MAR introduces a novel interaction system between the user and the system; users point their devices in the direction of an item of interest and the camera output augments the display with additional information about the environment [12].

### B. Mobile AR for Tourism

For this research work, tourism was selected as a focus topic for mobile AR. The system functions as a tourist guide while they travel around the country and fulfil their needs such as suggestion of local place of interest, accommodation, gastronomy and shopping. This will be lead to social media because the tourist can share their experience with their friends while traveling. The social influence of AR technology has received considerable attention in recent years [16-17]. In order to develop mobile AR Tourism applications with high effectiveness, the user-centred perspective should be incorporated, and more understanding on the impact of characteristics of AR systems on human activities is needed [18] especially for tourist [19].

### C. Design Principle for Tourism MAR

The design principle is useful as guidance to develop a good mobile AR system. The mobile AR applications context presents challenges such as the lack of applications developing the standard applications have limited flexibility withstanding the use in other areas, the demand for improvement in accuracy of location, shortage of available screen space to display virtual information, and the necessity

of testing the acceptance of these new features [20]. MAR is the employment of AR concept in mobile devices, which means increasing user perception about the real world with virtual elements overlaying on it and synchronized to that real world, visualized through mobile devices [21]. Providing a good user experience implies studies about GUI design is important as innovative studies in this area [22-23]. Among the main challenges identified in the development of MAR applications, the focus can be on:

- Appropriate use of devices' sensors;
- Low accuracy of tracking technologies;
- A range of hardware and software features and limitations;
- User interface design variability;

Guideline recommendations or rules in user interface application development aim to assist developers faced the challenges of mobile AR system development. Sang et. al [24] identified 61 standard principles guidelines and integrated usability principles and use deletion standards; on whether the principles were objective or subjective and whether they were repetitive. Finally, they come out with 22 guidelines.

*D. Tourist's Emotional State and behavior on Design Guideline on Mobile AR*

Mehrabian and Russell's [25] PAD theory has been mainly used to explain consumer behavior in marketing studies [26]. According to this theory, all emotional responses to physical and social catalyst can be round up on three affective states: pleasure, arousal, and dominance (PAD)[25], as shown in Figure 1. Individual's emotional states may change and therefore influence behavior formulation when using the mobile application. Currently, researchers have stated that PAD's theory supports information technology adoption in conjunction with other established technology adoption theory [27]. Pinpointing the emotional impact of MAR application will be critical for understand the degree of user's satisfaction, morale, performance and generally their adoption behavior.

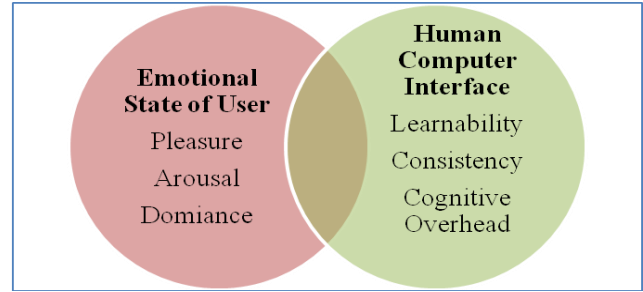


Figure 1 : Model of Emotional State and Concept of HCI

III. RESEARCH METHODOLOGY

In ongoing AR research the user is regularly not integrated into the system design process and there is little acknowledgement of user interface design principles in the development. As user experience and usability become the central goal in AR applications, it is important to include them as early as in the design process.

In this work, the factors of PAD's theory on Emotional State of User (Pleasure, Arousal and Dominance) are adopted and integrated with the three factors in HCI which are the Learnability, Consistency and Cognitive Overhead. These two elements of PAD's theory and HCI principles have been selected because it is related to mobile AR and tourist's emotional needs as they are important to the design of mobile AR.

40 design guidelines have been selected and are generally suitable to our research focus which is on mobile applications. We followed deletion standards by Sang et al [28] to come out with the design guidelines for mobile AR for tourism. The methodology that we have followed is as in Figure 2. The activities started by reviewing the related works in the literature in order to gain a detailed understanding of the design guidelines and principles of design for mobile application and mobile AR. Then analysis of the existing design guidelines was carried out to determine the appropriate design guideline based on the problems in mobile applications and mobile AR. Next, guidelines between different areas are compared and filtered based on the principles of design and factors that influence tourist in mobile AR in Table 2. Finally, a final specific design guidelines for mobile AR tourism is proposed.

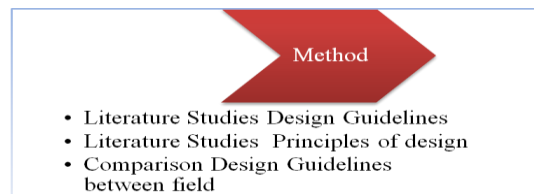


Figure 2: Methodology to Develop Design Guidelines for Mobile AR Tourism

Table 1 Elements of model of Emotional State and Concept of HCI and its definitions.

Elements	Factor	Definition	Reference
Emotional State	Pleasure	The degree to which the application evokes a pleasant or unpleasant emotion to users.	Mehrabian and Russell et al [25]
	Arousal	The intensity degree of the pleasant or unpleasant emotion.	
	Dominance	The controlling and dominant nature of the emotion.	
Human Computer Interfazce (HCI)	Learnability	The functions and the features of the application should be effective and easy to learn for users.	Sang et al [24]
	Cognitive Overhead	User's cognitive process for understanding or AR environment when interacting with the system.	Duh et al [35].
	Consistency	The generally used terms and interfaces should be maintained consistently to prevent confusion.	Sang et al [24]

IV. DISCUSSIONS

A. Analysis of Design Principles For Mobile Augmented Reality Tourism

Analysis of existing design guidelines between different areas such as advertisement, culture heritage and education are done based on a number of important principles need for design guidelines for mobile augmented reality. In design principles, using the context for providing content is needed to make sure the textual information presented is clear and user fully understand the UI's function, menus and operational design [29] [30] [31]. Sensor and marker technologies are needed to collect contextual information such as user location, user orientation and current task, in order to augment real world objects with contextual information in mobile AR system [32]. Next, for mobile AR it is important to reduce cognitive overhead to avoid any unexpected thing happen such as accident and its purpose to focus on the actual task instead of information resulting in poor user experience. Matching the

interface object affordances to the task requirements is important to make sure augmented virtual object is at the right position to make it looks real with the real object environment [33]. One suggestion is to shrink the exploration space to present the details of the POI suitable for maps especially for tourist [34]. Learnability is provide a user for easy to learn while using the application without need to repeat tutorial for a lot of times. As AR provides novel interaction techniques, the usage of interaction techniques has to be easy to learn and understand. The visual design of the interface for allowed users to have a clear and highly immersive interactive experience in interactive AR environment [31]. Finally, 3D interaction is one of the important roles in mobile AR because a lot of interactions are included in this type of system. To develop 3D interaction, the design for natural 3D interaction on the mobile devices is needed.

Table 2 A summary of the MAR design principle

Variable	Use The Context For Providing Content	Reducing Cognitive Overhead	To Provide Easy Learn Ability For A User	3D Interaction
<b>Design Principles</b>				
HCI Principles	√	√	√	x
Usability Heuristic for design MAR	x	X	√	x
MAR User Interface Guideline	x	X	√	x
Usability Principles	√	X	√	x
Principles of Tangible User Interface	√	√	√	√
Design Guidelines Implications for Quality UX	√	X	√	√

**B. Proposed Design Principle for Mobile Augmented Reality Tourism**

As shown in Table 3, the design guidelines proposed based on the variables that will influence design mobile AR for tourism as improvement from the previous works. Design guidelines can be used by developer to improve the development for mobile AR tourism and improve the

satisfaction of the users while using the mobile AR application. There are a lot variables but for this paper it will focus on the four main variables which are:

1. cover the content of information AR,
2. reduce cognitive problem,
3. Provide learn ability and 3D interaction of mobile AR application.

Table 3 Proposed Design Principle for Mobile Augmented Reality Tourism

Variable	Proposed Design Guidelines
<b>Use The Context For Providing Content</b>	<ol style="list-style-type: none"> <li>1. Use an active way for expressing information to obtain hidden information by operating the camera.</li> <li>2. The UI and font must be easy to read and not complex</li> </ol>
<b>Reducing Cognitive Overhead</b>	<ol style="list-style-type: none"> <li>1. Visual overlays should be sufficient contrast between overlays text and background.</li> <li>2. Optimizing the placement of virtual information need to be considered</li> <li>3. Overlay information presented should be able to identify areas that need attention</li> <li>4. Shrink the exploration space to present the details of POI</li> </ol>
<b>To Provide Easy Learn Ability For A User</b>	<ol style="list-style-type: none"> <li>1. Provide a tour guide on first use of purpose and how to use the application.</li> <li>2. Help menu should be provided and divided into many steps for users to remember easily.</li> </ol>
<b>3D Interaction</b>	<ol style="list-style-type: none"> <li>1. Design must consider virtual and real object match between them in one environment.</li> <li>2. Design for natural 3D interaction on the mobile devices.</li> <li>3. Support for spatial 3D interaction techniques</li> </ol>

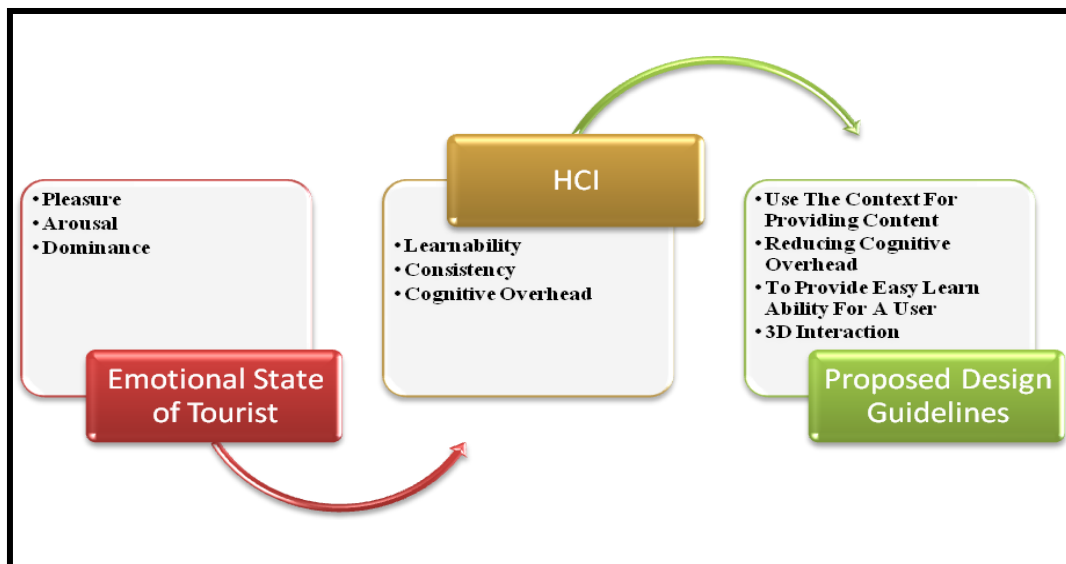


Figure 3: Work Flow of Proposed Design Guidelines

**V. CONCLUSION**

This paper proposed design guidelines for mobile AR Tourism based on the variables influencing the design of the system. Figure 3 shows that there are three main elements that need to be considered which are emotional state of user, principles of HCI and usability. These elements are important to study in this research to produce a good design guidelines for mobile AR. It will affect the user’s perception when they using the application while traveling in Malaysia.

Finally, this paper identified eleven suggestions for design principles. It is useful for developers who want to create a mobile AR tourism. From the analysis of existing design guidelines of Mobile Augmented Reality (MAR) for tourism, an application design guidelines are proposed based on Human-computer interaction principle and usability design that would fulfils the user’s requirement in a better way. Six design principles were examined in this analysis. The analysis identified eleven suggestions for design principles. These recommendations are offered towards

designing principles and developing prototype app for tourist in Malaysia. A good system based on the design guidelines will also give tourist a good tour experience. For future work, this design guideline can be evaluated by using usability test and technology acceptance model to ensure this can be use by the experts in mobile AR especially for Tourism. The model of emotional state and concepts of HCI can be used as a construct of survey to measure acceptance and usability of the application developed based on the new proposed design guidelines.

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