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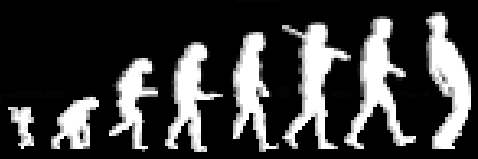

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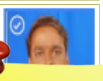
***	**Dr. H Chidananda** CSE Department Rao Bahadur Y Mahabaleswarappa Engg. College,Ballari - Ka	
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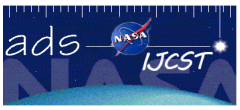

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RESEARCH ARTICLE OPEN ACCESS

Analysis and Implementation of Location-Based Augmented Reality Mobile Application for Searching Tourist Attractions and Culinary Places in Phnom Penh City, Cambodia

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ABSTRACT

Mobile devices have become more popular and beneficial in today's life because of the emergence of new functionalities. Beside the basic existing functions such as calling, messaging, mobile devices have been used in various tasks to help the user in their daily life activities such as finding locations; among others. Augmented reality is a new technology that integrates the virtual world of a smart phone with the real world of nearby locations as seen by the user. Location based services are playing an important role in a day-to-day life with a better enhancement of mobile and wireless technologies. Nowadays Augmented Reality (AR) and Location Based Service (LBS) have become more popular and have been developed in mobile device in various solutions. AR based LBS system on mobile devices are perfect companions for looking for a particular location. With the combination of AR and LBS, the application can display information on nearby landmarks along with directions to that location, and provide relevant information for the location. The aim of this paper is to describe about the android based application of integrated Augmented Reality and Location Based Service, which is implemented to provide the android mobile user to search tourist attractions, culinary places, map view and route of those places in Phnom Penh city, Cambodia. This application is conducted by using Wikitude SDK 5.2.0 and Google Maps API. According to system testing, the result indicates that the application usability assessment is achieved with a high rate 91.72%. This means that the Camtour AR application works well and be ready to be used in the market.

Keywords:- Augmented Reality, Android, Location Based Service, Wikitude SDK

I. INTRODUCTION

Augmented Reality is the combination of digital information with physical real world environments in a real-time session augmented by overlaying the real world with virtually generated renders such as graphics, text, video, sound that provide the enriching and complementing reality with immersive capability to view content information, navigate, communicate and change the way users interact with their environment (Azuma, 1997).

The use of Augmented Reality has become more popular and evolved widely nowadays, no longer limited to the PC or Laptop, but it has been extended to the smart phone and portable devices as well. Currently, Augmented Reality technology has been implemented and developed in various fields and provides a different sensation based on mobile devices. There are many applications that implemented AR technology from collaborative to commercial applications (Azuma et al., 2001), (Donggang Yu, Jesse Sheng Jin , Suhuai Luo, Wei Lai, 2009). In addition, they have been explored in tourism to improve tourists' experiences (Kounavis, Kasimati, & Zamani, 2012), (Fritz, Susperregui, & Linaza, 2005).

Location Based Service (LBS) is an information service which is accessible with mobile devices via the mobile network and which utilize information on the geographical position of the mobile device (Virrantaus et al., 2001). LBS is service which utilizes to guide user based on location and guidance will be the assistance of augmented view (Alappanavar, Ankeeta Bhujbal, 2013). Location-based data and information are becoming more significant in recent times. Many works can be done with those data and information, such as finding route, finding each other location, socializing, and many more.

Location based Augmented Reality application is a type of augmented reality application, which is being widely developed today. Mostly, the location based Augmented Reality requires access to various built-in component of the device, such as Global Positioning System (GPS), and many more. Using Global Positioning System to determine the coordinates of where the user is at that time and search for the information about nearby

surrounding locations. This can help the user know what is around the location they were at that time.

Cambodia is located in Southeast Asia mainland, covering a land area of about 181,035km^2 with a population of approximately 15 million. Cambodia is one of countries in Southeast Asia which full of charming natural and historical tourism sites, culinary places, cultural and traditional attractions (Chheang, 2008).

Phnom Penh, known as the 'Pearl of Asia', is the capital and largest city in Cambodia. It is now a cultural, commercial, and political center that offers a unique combination of traditional charm and urban bustle. The alluring capital city also features a wide variety of historical and cultural attractions, along with myriad chances to sample local Cambodian culture. Phnom Penh city is one of the interesting and alluring cities for tourist attractions and culinary places in Cambodia. In recent day, most tourists and local people are difficult to find the tourist attractions and culinary places because they do not have adequate information about those locations. Some of them still use the conventional map to search for location. This way is taken into account not effective and efficient for such activity. Moreover, the Cambodian government has not yet take advantage of advanced mobile technology to widely distribute or explore the existing tourist attractions and culinary places information in Cambodia.

To address this issue, this paper present a mobile application based on location based Augmented Reality (AR), which aims to help the mobile user for searching the tourist attractions and culinary places through the use of their mobile phones. The proposed application, called Camtour AR, displays all the needed information about the mobile user's nearby tourist attractions and culinary places in a mobile camera view. The Camtour AR also provide route feature and track the user's position from start to the end point.

II. RELATED WORKS

Currently, mobile location based AR has become popular in recent advanced technology. It has been utilized and implemented for developing systems with various purposes. With the growing popularity of smartphones, mobile location based AR applications have started to play an important role in the tourism industry. These applications assist tourists to access context aware information on locations which increase their knowledge about the area. Moreover, mobile location based AR applications allow users to explore the world by adding new layers of location based information to their reality and to create list of their favorite point of interests (POIs) by using this information (Kounavis et al., 2012).

Many researches of location based AR have increasingly been studied and carried out in recent years. The research conducted by Brata and Liang, has developed a mobile AR application about the bus stops in Taipei. The developed application based on Android platform, called BusAR. The feature of BusAR is to find the location of the nearest bus stop and the route path to get there. The bus stop is assigned as augmented reality entity, called point of interest (POI). The POI gives the detail of information like bus stop name, distance from user to the bus stop, route name, upcoming bus name and bus type, and estimated time when bus will arrive in specific bus stop. Additionally, this application can guide user to the nearest bus stop by informing him when to turn left or turn right without changing his application screen (Brata, Liang, & Pramono, 2015). Research conducted by Tsai and Shie, has developed a location based mobile augmented reality application of hot springs tourism in Yilan county. This application is divided into two modules, which are AR module and map module. The AR module utilizes the POI with two-dimensional virtual image in real view; which allows user to find the location of hot springs. Whereas the map module utilizes the Google map service to provide the corresponding position and for displaying the hot springs information and route guidance (Hui, Hung, Chien, Tsai, & Shie, 2014).

III. BASIC THEORY

3.1 Augmented Reality

Augmented Reality is a technology where users can see the real world, with virtual objects superimposed upon the real world (Azuma, 1997). The virtual objects are computer-generated data, such as text, graphics, sound, video, and GPS data. Generally, the real-world view is capture by the camera of a computer, mobile phone or other electronic devices. The superimposition of the computer-generated data on the view captured by the camera in AR improves a user's perception of and interaction with the real world (Azuma et al., 2001). Currently, AR mostly has been utilized and carried out in mobile platform environment. Mobile AR has been implemented efficiently in various innovative applications, for instance in the following areas (Krevelen & Poelman, 2010).

1. *Medical*
   Doctors can utilize Augmented Reality approaches as a tool for visualization and as a training tool for surgery implementations. AR can be used as video see-through HMD

to overlay Magenetic Resoaance (MR) scans on heads and provide views of tool manipulation hidden beneath tissue and surfaces. AR is also used and tested in medicine with live overlays of ultrasound, Computed Tomography (CT), and MR scans. It is also used in surgery section for assisting physician or surgeon in order not to make mistakes during surgery.

2. *Entertainment*
   The AR that used to apply in the entertainment industry is to create AR games, but also to increase visibility of important game aspects in life sports broadcasting. In these situations, where a large public is reached, AR can also work as advertisers to show virtual ads and product placements.
3. *Education and training*
   The Augmented Reality can be used in education is to employ screen-based AR with Web3D to support engineering education. It is also implemented in collaborative edutainment in the multi-user mixed reality system.
4. *AR for the office*
   Besides in games, collaboration in office spaces is another area where AR may prove useful, for example in public management or crisis situations, urban planning, etc. AR is used for 3D presentations in a mixed reality meeting room.
5. *Manufacturing and maintenance*
   Another category of Augmented Reality (AR) applications is the assembly, maintenance, and repair complex machinery. Complex machinery or structures need a lot of skill from maintenance personnel and AR is crucial in this area. For instance, provide "X-ray vision" or automatically probing the environment with extra sensors to instruct the user attention to problem sites.

3.2 Android

Android is an open source architecture; which used to develop applications for mobile devices. Android works on Linux Kernel. Android was developed by Open Handset Alliance (OHA) (Conti, 2008). In the other terms, Android is a software stack for mobile devices that includes an operating system, middleware, and applications (Holla & Katti, 2012), (Gu, Wang, & Ma, 2014), as seen in Figure 1.

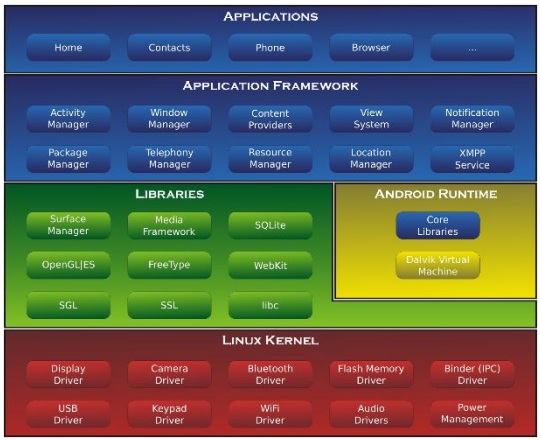

Figure 1. Android System Architecture (Gu et al., 2014)

- Linux Kernel: Android utilizes the Linux version 3.6 for core services in the system, such as security memory management, network stack, and driver model. The kernel also performs as an abstraction between device hardware and other hardware drivers.
- Libraries: Android has a set of libraries that applied by the components of the Android system such as WebKit, SSL, SQLite and many more.
- Android Runtime: It provides a set of core libraries that enable Android developers to write the Android application using standard Java programming language. Every Android application run in its own process.
- Application Framework: This layer provides many higher-level services to applications in the form of Java classes. Application developers are allowed to use these services in their applications. The key services of Android framework are Activity Manager, Content Providers, Resource Manager and etc.
- Applications: is the layer that directly connected to the users. The users can find all the Android application and write the application to be installed on this layer.

3.3 Location Based Service

Location Based Service (LBS) is information service that accessible with mobile devices through mobile network and using the ability to make utilization of the location of the mobile device (Virrantaus et al., 2001). In other words, LBS can be described as an application or system that is depended on a specific location. LBS consists of two categories, which are triggered and user-requested (D'Roza & Bilchev, 2003).

In a user-requested scenario, the user is getting the position once and utilizes it on

subsequent requests for information that depends on specific location. This kind of service generally involves both individual location (finding where you are) and service location (where is the nearest). For example, the kind of this service of LBS is navigation (map) and direction (routing information).

On the contrary, triggered LBS depend on prearranged condition, when accomplished it will get the specific position of a device. An example is when the user passes the limit of a mobile network. One more example is in emergency services, it will activate a call to the emergency center and request location automatically from the mobile network.

3.4 Global Positioning System

Global Positioning System (GPS) is a system which comprised of an array of over 30 satellites in low earth orbit that give signals that can be detected by a receiver on the earth's surface. The system is developed and administered by the Department of Defense of the United States of America (Milner, 2016). The system allows any device that has a GPS sensor, and can receive a clear signal from at least 4 satellites, to determine an accurate location of the user, in real time, all over the world. With the benefit of the satellites' signal, the receiver can triangulate its location accurately. The system utilizes the standard coordinate system (longitude and latitude) that can be used on any application or physical map.

3.5 Software Development Kit

With numerous benefit of software development kit (SDK), many developers have utilized it to develop numerous applications in diversity of purposes. Nowadays, many Augmented Reality (AR) SDKs have been carried out by developers for developing various mobile applications. The Augmented Reality SDKs include Metaio, Vuforia, Wikitude, D'Fusion, etc. The comparison of various Augmented Reality SDKs and their features have been studied by (Amin & Govilkar, 2015).

Augmented Reality SDK is a set of tools and libraries that provided to developers for developing Augmented Reality applications. It assists to facilitate many components within the AR application such as object recognition, object tracking, location based AR, content rendering and visualization (Rattanarungrot, White, Patoli, & Pascu, 2014).

The Wikitude SDK is a powerful software developer kit which allows the open development of marker-less AR experiences, by providing developers with tools and libraries to either create their own AR applications, or improve their existing with an AR camera-view engine. This SDK comprises of some features such as image recognition and tracking, 3D model rendering, video overlay, location based AR and many more. Wikitude API browser combines every sub system into the browser application, including POI data and channel publishing information. The browser application is a representation of standalone architecture. This architecture gives benefit that the application does not rely on the wide area network (WAN) connection (Butchart, 2011). For the development of location based AR with the Wikitube SDK, the object position which overlay on the mobile screen is known through the user position. The user position is received either by the mobile communication network or GPS. The user direction is determined by the digital compass and accelerometer sensor is used to detect the orientation of the phone screen.

IV. SYSTEM DESIGN

4.1 System Architecture

System architecture is a conceptual model which defines interaction between system components and information flow. The system architecture of the whole system of Camtour AR is presented in Figure 2.

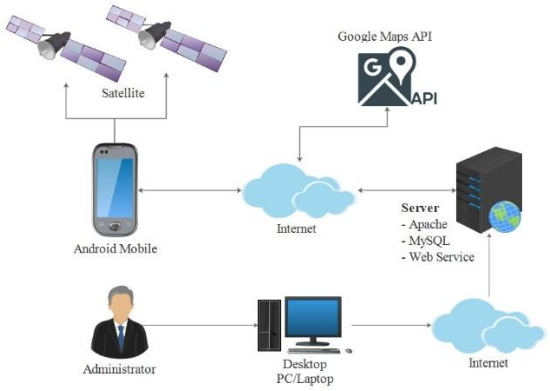

Figure 2. System Architecture

The android mobile device with installed Camtour AR application require to have an internet connection for receiving the information of data (tourist attractions and culinary places). The mobile devices are equipped with GPS receiver feature and internet service. GPS receiver connects to satellite directly to receive the location coordinate data of mobile device. The application requests and receives data from database server through web service in JSON format. Administrator has rights to access to the database server for managing data from Desktop PC or Laptop.

4.2 Use Case Diagram

Use case diagram is a diagram that represent the user interaction and system behavior. The following use case diagram represents the Camtour AR application major relationship with the users. In Figure 3, represents the use case diagram of Camtour AR.

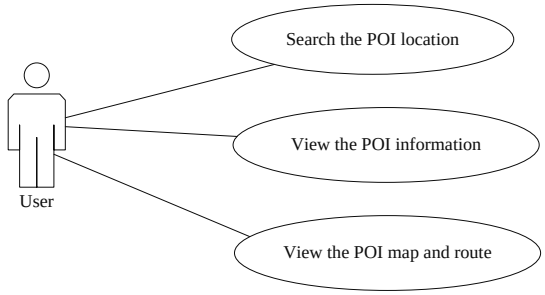

Figure 3. Use Case Diagram

- The user can search the POI location by using augmented reality view, two-dimensional POI objects are loaded and overlaid on the screen in real time view environment.
- The user can view the POI information by clicking on one of the POIs which overlaid on the mobile screen.
- The user can view a route on map of the selected POI which is available in the application.

4.3 System Flowchat

Figure 4 presents the flowchart of the Camtour AR system. When the user start searching the location, it will display the camera view on the mobile screen. It will check the condition about GPS service whether it enables or not. It also checks the Internet connection whether it is active or not. If both conditions are passed successfully, it will load all defined two-dimensional POI objects or markers on the screen. In contrast, it will display augmented reality camera view without any POI objects. Then, the user can select or click on one of POIs to view the detailed POI information. After displaying POI information, user can press back button which will re-display augmented reality camera view. If the user presses the back button again, it will come out of this screen and go to main screen.

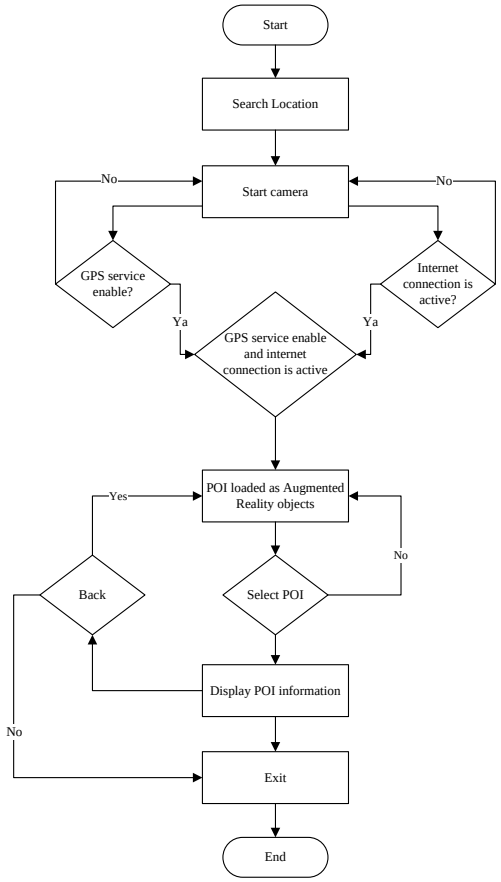

Figure 4. System Flowchart

4.4 System Components and Tools

The system hardware which is utilized to implement the system in this work has computer specification with processor Intel Core i5 2GHz, memory (RAM) 4GB, Display Intel HD Graphic 4000/NVIDIA GeForce GT 740M, HDD 1TB. The implemented augmented reality system was tested in the following hardware and software environment: Galaxy Note 2 GT-N7100, Android 4.4.2 KitKat, processor Quad-core 1.6GHz Cortex-A9 and GPU Mali-400MP4, memory 2GB, display 5.50 Inch rear camera 8 megapixel advanced built-in sensors such as 3G/4G, GPS, digital compass and accelerometer sensor.

V. SYSTEM IMPLEMENTATION

The mobile-based augmented reality application developed in this work utilizes coordinate data. The coordinate data is an important component in this research because these data are used to determine the location of tourist attraction and culinary places. These data are retrieved from Google Map. This system is implemented on Android powered mobile devices. The system coding development is conducted on

Android Studio IDE. The augmented reality SDK utilized in this research is Wikitude.

5.1 System Overview

The Camtour AR application has utilized the location based augmented reality for searching the tourist attractions and culinary places in Phnom Penh city, Cambodia. Besides, the application also provides a location and route feature for user for heading from start point (current position) to the end point (destination). It also provides new experience and easy way for international tourists and local people who like exploring or travelling.

5.2 Interface Implementation

Camtour AR consists of five main features or functions. The features are explained as the following:

a. Main menu feature is presented in Figure 5, namely main interface when the application starts.
b. Search location feature is presented in Figure 6, is interface for overlaying the POI location marker in the form of two-dimensional object using AR technology.
c. Distance adjustment feature is presented in Figure 7. The application displays the POI location marker on the screen according to distance which adjusted by user.
d. Location list feature is presented in Figure 8, list all the available tourist attractions and culinary place that most visited by international tourist and local people in Phnom Penh city.
e. Location map and route interface are presented in Google map. It is shown in Figure 9.

Figure 5. Main Menu Interface

Main menu feature is shown in Figure 5, is the interface when the Camtour AR application starts firstly. Five buttons are available to use in this interface. "Search Location" is used to search all determined location of tourist attractions and culinary places around mobile user by using AR method. "View Map" is used to provide a location information and route on Google map. "How To" feature is used to explain to the user how to use the application properly. "About App" feature is used to explain what Camtour AR does and developer's information. "Exit App" feature has a function to quit the application.

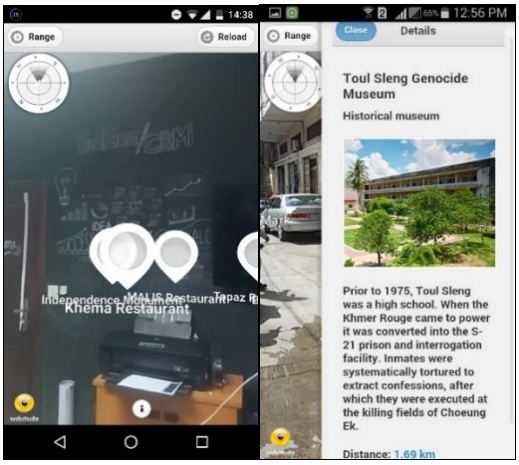

Figure 6. POI location interface (1), a POI location description interface (2)

The search location feature utilizes AR approach with the combination of built-in camera feature which available on mobile device. This feature is used to search the POI location and overlay the POI marker on the screen. The POI marker is presented in the form of 2D and text on the interface. The interface presented in Figure 6, is an interface when the user press one of the POIs on the screen, and then the result will be displayed as shown above. The radar feature given in this feature is utilized to help the user for locating the detectable location direction.

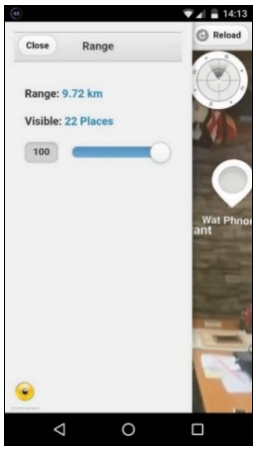

Figure 7. Distance Adjustment Feature

The distance adjustment feature interface is presented in Figure 7. This interface is utilized to adjust the distance of tour location that will be detected by application around the mobile user. This function presents the amount of detectable locations according to distance adjusted by the user using slider. The distance adjustment function will help the user for locating the nearest location from the mobile user position in the specified distance.

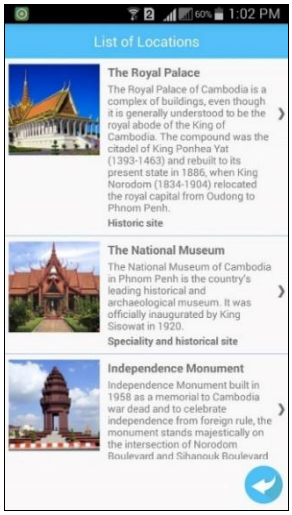

Figure 8. List of Locations Feature

The location list function which shown in Figure 8, represents the location information (tourist attractions and culinary places), which is available in the application in the form of list view. For more location information, the user just scroll down by touching the screen and pull up.

User can view the location and route information on Google map by pressing on one of the given location information as shown above.

Figure 9. Location and Route Feature

The location and route feature that shown in Figure 9, assist the user for locating the location position. Also, the route can be seen on Google map. In this feature, some additional features are available for users. The location route really help the user for heading to the destination properly. Furthermore, the user can view the given map in terrain and satellite mode. The user can view a short clip video of those places through YouTube interface and view the review of those places via TripAdvisor interface with provided icons which available on the bottom row of the page.

VI. SYSTEM TESTING

The system testing is a most often utilized for verifying and validating the quality of software (Shao, Khurshid, & Perry, 2007). The testing is done by checking all the functions or source code. It is successfully utilized on android devices. As the result, the application has been successfully implemented; hence it means that the system has integrated the software with the hardware used in conformity with the system requirement of application. The location testing is conducted in Phnom Penh city, Cambodia. After completing the test above successfully, the next test is conducted for assessing the usability of application interface and features, called usability testing.

6.1 Usability Testing

The usability testing, it is done with the questionnaire on user assessment of the application. The questionnaire-based usability evaluation method has been widely used for evaluating the usability of a system (Zaharias & Poylymenakou, 2009). The usability of a system covers four aspects such as effectiveness,

efficiency, learnability and satisfaction. Effectiveness is measured based on accuracy and completeness with which users achieve particular goals by using the application. Efficiency is measured based on accuracy and completeness of goals achieved in relation to resources in the application. Learnability is measured based on how easy for users to complete basic tasks the first time. Satisfaction is measured based on freedom from discomfort and positive attitudes toward the use of the system (Ullah, 2016). The Likert scale is to requires a respondent to answer to a series of statements by pointing out if he or she strongly agree, agree, undecided, disagree, strongly disagree (Croasmun & Ostrom, 2011). This system will utilize the Likert scale for measuring the satisfaction of the system.

Before completing the questionnaire, 30 respondents had been asked in advance to try to install and use this application on their own android devices. Respondents are either local people or tourists who are staying in Phnom Penh city. After that, respondents were asked and respond to the statement on the questionnaire based on the usability aspects that mentioned above. After the questionnaire data is processed and analyzed successfully, the outcome of statement evaluation of each usability aspect is depicted in Table 1.

Table 1. The result of statement evaluation of each usability aspect

Code	*Statement*	*Value*
Satisfaction		
S1	I am comfortable and enjoy using the Camtour AR	100
S2	The interface of this application was pleasant.	90
S3	I would recommend this application to other friends for using the Camtour AR application for searching tourist attractions and culinary places in Phnom Penh city.	96.67
S4	I would like to install this application on my mobile phone for searching tourist attractions and culinary places information which available in Phnom Penh city.	100
S5	This system has all the functions and capabilities I expect it to have.	86.67
S6	The Camtour AR provide more knowledges about tourist attraction and culinary places information in Phnom Penh city.	80
Learnability		
S7	I thought that Camtour AR application was easy to use and learn.	93.33
S8	The background and other user interface components of each interface in this application are familiar and consistent.	90
S8	The color combination in the whole Camtour AR application is good.	100
S10	The language that used in every sentence or phrase is easy to understand.	96.67
S11	The information (on-screen messages) provided with Camtour AR is clear.	93.33
Effectiveness		
S12	I found the various functions in the Camtour AR application were well integrated and work well.	86.67
S13	The information was effective in helping me complete the tasks and scenarios.	90
S14	The Camtour AR application gives a good response for all working activities.	96.67
Efficiency		
S15	The application does not take long time in getting information of a location.	93.33
S16	The Camtour AR take less than 3 second to load map and route.	83.33
S17	This application loads each function or activity fast as I expect it to have.	90

The assessment result of 30 respondents is presented in Table 1, in which 17 questionnaire statements are grouped by each usability aspect.

The average outcome of each usability is obtained by dividing the total of measured value of each aspect with the total of statements. The result of average calculation is shown in Table 2 for each usability aspect, namely satisfaction is achieved with 92.22%, learnability is achieved with 94.67%, effectiveness is achieved with 91.11% and efficiency is achieved with 88.89%.

Table 2. The Average of Usability Evaluation Result

Satisfaction	Learnability	Effectiveness	Efficiency
92.22	94.67	91.11	88.89

The satisfaction involves the respondents' joy of using the application. The Camtour AR application provides clear and nice interfaces for the user. The color utilization applied in the application is good and consistent. This factor also make respondents feel comfortable and satisfied using the Camtour AR application. The respondent is wiling to advise the other mobile users to utilize the Camtour AR application for searching tourist attractions and culinary places in Phnom Penh city, Cambodia.

The learnability aspect covers the ease of users in accomplishing basic tasks for the first time they utilize the application and together with easy to understand and learn. This shows that the user can utilize the Camtour AR application smoothly without any problem because the application includes the instruction how to use it. The background and user interface components used in the application are familiar and consistent. The language used in the application is clear and easy to understand. These points motivate the user more enthusiasm to utilize the application.

The effectiveness aspect involves the user's completeness and success for achieving a particular goal by utilizing the application. The information used in the application is effective in assisting the user to accomplish the task. The application provides a good response for every activity; which used by the user.

The efficiency aspect involves the task time the user takes to successfully complete a task. The Camtour AR application takes less time to get the location information. The application loads each activity fast as the user expect to have. This points out that the application is efficient in completing the task quickly and accurately.

The average of usability evaluation result which shown in Table 2 is interpreted into the graphic. The graphic of usability evaluation result is depicted in Figure 10. The graphic indicates that the whole measured aspect is accomplished with high usability level. This means that the Camtour AR application is suitable and ready to be used in the market.

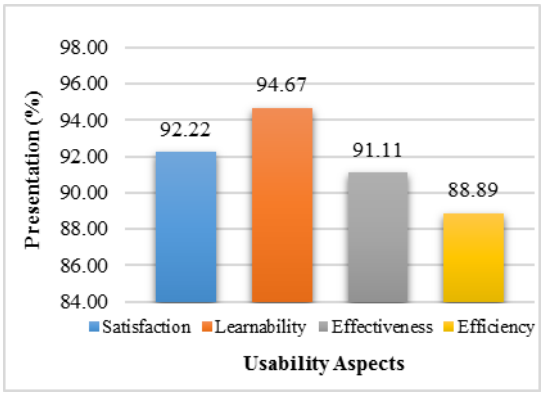

Figure 10. Graphic of Usability Evaluation Result

For measuring the usability of the whole Camtour AR application, it requires to utilize the formula for calculating the usability presentation value. The usability presentation value is mean of each usability aspect such as satisfaction, learnability, effectiveness and efficiency. The equation can be seen in (1).

$$Usability\ (\%) = \frac{A + B + C + D}{4} \times 100\%$$

Where:
A = satisfaction aspect value
B = learnability aspect value
C = effectiveness aspect value
D = efficiency aspect value

Based on the equation (1), the usability value can be calculated as the following:

$$Usability\ (\%) = \frac{92.22 + 94.67 + 91.11 + 88.89}{4} \times 100\%$$

$$Usability\ (\%) = 91.72\%$$

The result points out that the usability level of the whole Camtour AR application is achieved with 91.72%.

VII. CONCLUSION AND FUTURE WORK

This paper presented the implementation and evaluation of a mobile AR application for either local or international tourists for searching tourist attractions and culinary places in Phnom Penh city, Cambodia. The developed application runs on Android powered mobile devices. The application utilizes a location-based augmented reality technology. This technology allows the mobile user to look for nearby those places in a mobile camera view. Also, it allows the users to view map route that direct them head for the destination. The Camtour AR's purpose is to grasp the chance of using the AR technologies to

improve the user experience for travelling and overcome the difficulties they face. The Camtour AR can help mobile users for finding tourist attractions and culinary places easily and quickly. The application evaluation was done successfully to measure the usability of Camtour AR application interface. Based on the result of system assessment, it points out that the system usability level is achieved with 91.72% and ready to be used in the market. As a future work, the system can be extended to cover different cities and provinces in Cambodia.

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