AN EXPLORATION OF USM EXPEDITIONS KIT (U-Trek): A CONCEPT OF USABLE INTERACTIVE APPLICATION

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Abstract

Universiti Sains Malaysia (USM) has been recognized amongst one of the largest universities by student enrolment in Malaysia. There are about 30,000 students at its 17 Academic Schools in USM main campus spanning across a land area of 416.6-hectare (~296 football fields), up to date. Every year, thousands of newcomers enrol in USM main campus have difficulty recognizing new places and buildings considering the area coverage of the campus is wide. There is also a lack of a convenient system to keep the USM communities updated with the latest event information held in the USM main campus. Taking these facts into account, USM Expeditions Kit (U-Trek, a mobile application) is proposed with the aim to provide an interactive mechanism to USM community and/or even to the public to explore the USM main campus and to keep track of events. This allows the USM community and public to become more familiar with conditions of the USM main campus environment and to systematically manage events. Specifically, U-Trek is equipped with GPS navigation, virtual reality (VR) campus tour, augmented reality (AR) interactive camera as well as USM main campus event management functionalities.

Keywords: Augmented reality, Interactive application, Mobile application, Usability, Virtual reality.

1. Introduction

Universiti Sains Malaysia (USM) is the first Accelerated Programme for Excellence (APEX) university in Malaysia. APEX, in general, is a fast track developing programme that helps tertiary institutions achieve the world class status. Annually, thousands of new students, i.e., undergraduate or postgraduate, will register themselves into USM and orientation will be introduced to new students to allow them to become more familiar with the new environment [1]. One of the orientation activities includes the campus-walk exploration. However, the explored areas are not wide enough (since USM main campus that spans across a land area of 416.6-hectare site is too huge to explore) and thereby, it is insufficient to give a crystal-clear view of USM environment to the new students. On top of that, majority of the USM communities and public are not kept updated with the latest event information held in the USM main campus. It is noteworthy that lots of events will be held in USM main campus occasionally and the event organizers will promote their events to the USM community and public via setting up the event information booth, distributing flyers, pasting posters and/or social media advertising such as USMinfo [2]. Unfortunately, majority of the USM community and public tend to miss out those important events considering they are unaware of these activities.

Abdul Rahman et al. [3] and Chou et al. [4] indicate that it is essential to have a user friendly and usable application so that users will be able to enjoy its functionalities. In addition, the looks and feels of such application make it more meaningful. According to Chen et al. [5] and Wang et al. [6], GPS navigation apps have gained in popularity nowadays since their functions have the capabilities helping users arrive an unfamiliar destination speedily and effortlessly. On top of that, virtual reality (VR) technology demonstrating the real environment allows users to observe virtual environments and feel like as if they are there. Specifically, this VR technology contains three main characteristics, i.e., immersion, interactivity and imagination [7]. Augmented reality (AR, variation of VR) is also an advanced and sophisticated technology to enhance users' learning interest [4, 8, 9]. A correct image processing technique is needed to ensure that the application can be interactive and usable to be used [10, 11].

USM main campus has quite a complete facilities and infrastructures such as 17 Academic schools, sports venues, cafeteria, hostels and so forth [2]. Among them, it is noteworthy that USM Archeology Gallery and Tengku Fauziah Museum have been recognized as hidden gems in USM [12]. All these buildings and landmarks' names and numbers, unfortunately, make no sense at all. USM is like a maze to USM community or public during their first visit and thus, there has a much higher chance of getting lost in the campus considering they may lack background information about these places.

With the aim of helping the USM community and public attain and maintain a healthy balance among life, work, and study, it is also worth to mention that lots of events have been organized in USM main campus for them to take part [12]. However, USM communities and public demonstrated low levels of awareness of these activities, regrettably, because of their busy working and academic schedules as well as the lack of visibility. Additionally, the event organizers might suffer from budget constraint to promote their events in USM since they might not be able to find sufficient sponsorships to support for these events. As a result, most of these events do not get an overwhelming response from USM community associated with

the lack of publicity. There is also a must for the USM community and public to register themselves for their interested events in the event booth manually. This registration method is time-consuming and tends to make the situation worse.

The main objective of this paper is to propose a university application (USM Expeditions Kit, U-Trek) with the aim to encourage the USM community and public to explore the USM main campus in an interactive way, to keep them on track of all the events held in USM main campus and to help them register their interested events online.

In general, this paper is structured as follows. Section 1 provides an overview and motivation to introduce the USM Expeditions Kits, U-Trek; Section 2 provides related studies to give the readers a general overview of the areas of this particular study: (i) Preliminary studies and (ii) A system requirements; Section 3 explains the system architecture and the modules involved in U-Trek; Section 4 explains the overall discussion and finally section 5 ends with the conclusion.

2. Related Studies

Table 1 is the feature comparison table of 5 local university applications. It is clearly shown in Table 1 that most of the local applications do provide location description to the users. However, some of them suffer from shortcomings in terms of providing insufficient location information, e.g., USM Survival Kit gives no information regarding the School of Languages, Literacies, and Translation. On top of that, GPS navigation is an unpopular feature in most of the local university applications associated with the fact that USM Virtual Tour and GuideMe@UTM do offer the navigation feature.

Taking these facts into account, users are forced to employ another GPS navigation application if they wish to obtain the route information. Among these aforementioned 5 applications, it is noteworthy that USM Virtual Tour is the only application with AR technology that allows users to learn point of interest information in an interactive way, while UKM Explorer is the only local application that integrates the VR campus tour. However, the event related functionalities such as event information, online registration and notification were not included in all local university applications, unfortunately, as shown in Table 1.

Table 1. Feature comparison of local university's applications.

Features	USM Survival Kit	USM Virtual Tour	UKM Explorer	UNIMAS Now	Guide Me@ UTM
Location description	√	√	√	×	√
GPS navigation	×	√	×	×	√
AR-related functionality	×	√	×	×	×
VR campus tour	×	×	√	×	×
Event description	×	×	×	√	×
Event registration	×	×	×	×	×
Event notification	×	×	×	√	×

Table 2 shows the feature comparison of 5 international university applications. It is clearly tabulated in Table 2 that 3 out of 5 international applications do provide location description to the users and 4 of them are equipped with the GPS navigation guiding the user from current location to their desired destination. It has also been reported in Table 2 that there is no international application providing the AR-related functionality to the user, up to date. However, it is noteworthy that Yale University and University of Texas are two leading university applications with integrated VR campus tour feature. The users are, thereby, able to explore the campus environment virtually and independently with the aid of VR-related functionality. Apart from that, it is also clearly shown in Table 2 that all international university applications give access to the event information allowing the users to grab the first-hand events' details. Nonetheless, most of the international university's applications are still not integrated with event online registration and notification features.

Table 2. Feature comparison of international university's applications.

Features	University Club of New York	Yale Mobile	Oiler Mobile	UTD Mobile	UNOmaha
Location description	×	×	√	√	√
GPS navigation	×	√	√	√	√
AR-related functionality	×	×	×	×	×
VR campus tour	×	√	×	√	×
Event description	√	√	√	√	√
Event registration	√	×	×	×	×
Event notification	×	×	×	×	√

In this particular paper, USM Expeditions Kit (U-Trek) application equipped with the location-related features, virtual reality (VR) campus tour, augmented reality (AR) interactive camera, AR poster tracker coupled with event-related functionalities is proposed and reported. A mobile application on Android will be developed for Clients, while a web application will be introduced to Admin for them to manage the data in U-Trek mobile application.

2.1. Preliminary Study

A survey was conducted to get the feedback from respondents who are currently using USM applications in March 2020, i.e., USM Survival Kit and USM Virtual Tour. Accordingly, 5 questions were asked during the survey with Google Forms. This survey form was randomly distributed to USM community and public with different educational backgrounds. A total of 60 responses have been collected throughout this survey and analysed. We follow similar path of work by Hussain et al. [13] where they utilised a small set of respondents to provide the need or basis on the proposed work.

Table 3 shows the information gathered from these 60 respondents throughout the survey. Among these respondents, majority of them are predominantly USM students, followed by public (outsider) and USM staff. 49 out of 60 respondents are

with undergraduate educational qualification, while 66.7% of respondents (~40 people) have relevant experience with the USM existing application (e.g., USM Survival Kit / USM Virtual Tour).

Table 3. Survey respondent information.

	Frequency	Percentage (%)
Identity		
USM student	49	81.7
USM staff	5	8.3
Public (Outsider)	6	10.0
Educational Background		
SPM / STPM	4	6.7
Certificate / Diploma	2	3.3
Undergraduate (e.g. bachelor's degree)	49	81.7
Postgraduate (e.g. master, PHD)	5	8.3
Other	0	0
Have you ever tried USM existing application (USM survival kit / USM virtual tour) before?		
Yes	40	66.7
No	20	33.3

Table 4 shows that among these 40 respondents, 95% of them claimed that USM survival kit was their most frequently used USM application. It is interesting to note that most of the respondents are still satisfied (satisfaction rate of 3) with the USM existing application, in general. In relation to dissatisfaction were considered for USM existing applications: (i) very limited features; (ii) lack of information; and (iii) less information. 2.5% of respondents choosing 'other' option feels that the current USM application is not that responsive. In order to minimize these limitations, most of the respondents suggested that USM application should be equipped with additional features, i.e., event-related functionalities, location-related functionalities and VR/AR interactive functionalities. Additionally, it is also recommended that USM application should provide a better public transport map, search function for places and current live position of buses. 92.5% of the respondents would give a try on the 'improved' version of application that can help them explore USM.

Table 4. Survey questions result.

	Frequency	Percentage (%)
What is your most frequently used USM existing application?		
USM Survival Kit	38	95
USM Virtual Tour	2	5
Rate your overall satisfaction with your experience in using USM existing application(s).		
1	0	0
2	4	10
3	26	65
4	9	22.5
5	1	2.5
*What aspect(s) are you dissatisfied with existing applications?		
Lack of information	23	57.5
Less interactive	25	62.5
Limited features	25	62.5
Difficult to use	6	15

Other	1	2.5
*What is/are your recommended feature(s)?		
Provide event-related functionalities	25	62.5
Integrate with interactive feature (VR/AR)	26	65
Embed with location-related functionalities	22	55
Other	2	5
Imagine if you can use an application that can help to explore USM (e.g. VR/AR interactive feature, event and location information). Would you like to give a try?		
Yes	37	92.5
No	1	2.5
Maybe	2	5
Note:* indicates that respondents may choose more the one options.		

Figure 1 illustrates the comparison mapping of the feature available in existing applications. It can be noted that none of the identified applications utilised AR-related functionalities, VR campus tour and event registration, respectively. In fact, four of these applications (i.e., USM Survival Kit, UNIMAS Now, GuideMe@UTM and UNOmaha) do not provide any of these functions at all and the remaining applications utilised at least one function. We believe that each of these applications serve with different purposes in their respective universities.
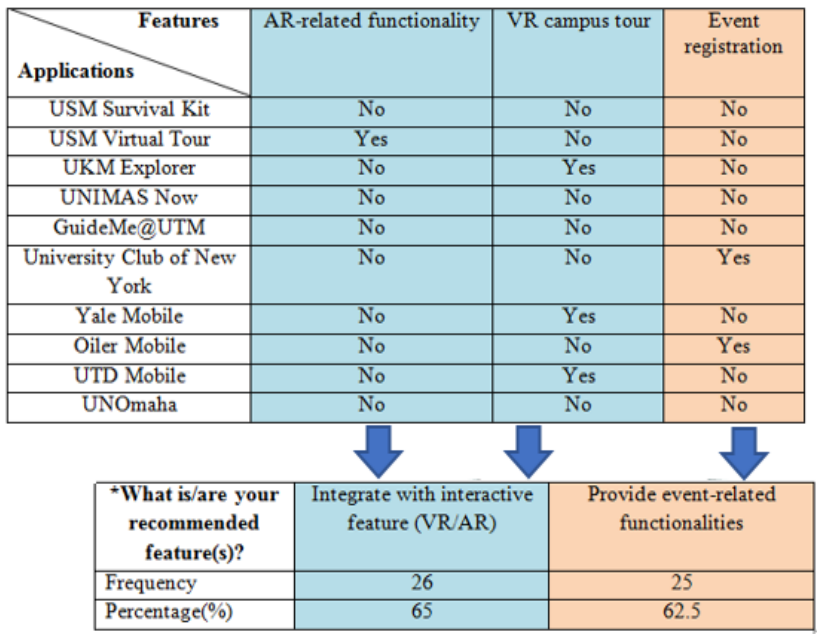
Features \\ Applications	AR-related functionality	VR campus tour	Event registration
USM Survival Kit	No	No	No
USM Virtual Tour	Yes	No	No
UKM Explorer	No	Yes	No
UNIMAS Now	No	No	No
GuideMe@UTM	No	No	No
University Club of New York	No	No	Yes
Yale Mobile	No	Yes	No
Oiler Mobile	No	No	Yes
UTD Mobile	No	Yes	No
UNOmaha	No	No	No

*What is/are your recommended feature(s)?	Integrate with interactive feature (VR/AR)	Provide event-related functionalities
Frequency	26	25
Percentage(%)	65	62.5

Fig. 1. Mapping of Comparison of feature available in existing application to survey.

According to the survey results, integrated with interactive feature (VR/AR) and equipped with event-related functionalities in current USM applications are the top two most recommended features from the end users. Based on literature review, AR-related functionality, VR campus tour and event registration are not available in most of the local and international existing applications. It is clearly shown in Fig. 1 that only 1 out of 10 local and international existing applications has the AR-

related functionality and/or event registration, while only 3 existing applications are embedded with VR campus tour. Based on these inputs/findings, USM Expeditions Kits should be equipped with interactive features and event-related functionalities to meet the end user's requirements and needs.

2.2. System requirements

U-Trek is specially designed to USM community and public to ease their life in USM main campus. U-Trek has similar capabilities as of other existing systems in terms of the location and event-related functionalities. However, U-Trek has been equipped with more functionalities in relation to virtual reality and augmented reality. The main capabilities of U-Trek are listed below:

- Provide clear location and event information to the users.
- Provide navigation function to guide the users from current location to a specific location.
- Allow the users to register an event online as well as to receive event notification.
- Provide a virtual campus tour to the users with the aid of VR technology.
- Recognize the event poster and overlay the additional information in the camera view with the help of AR technology.
- Provide augmented reality interactive camera to capture photo with 3D virtual mascots and allow the users to claim their mystery gifts from USM bookshop (Full collection is uploaded to social media completely).

3. Proposed Solution

Figure 2 shows that U-Trek consists of five (5) main modules: (i) Location Management Module, (ii) Virtual Reality (VR) Campus Tour Module, (iii) Augmented Reality (AR) Module, (iv) Event Management Module, and (v) Admin Management Module.
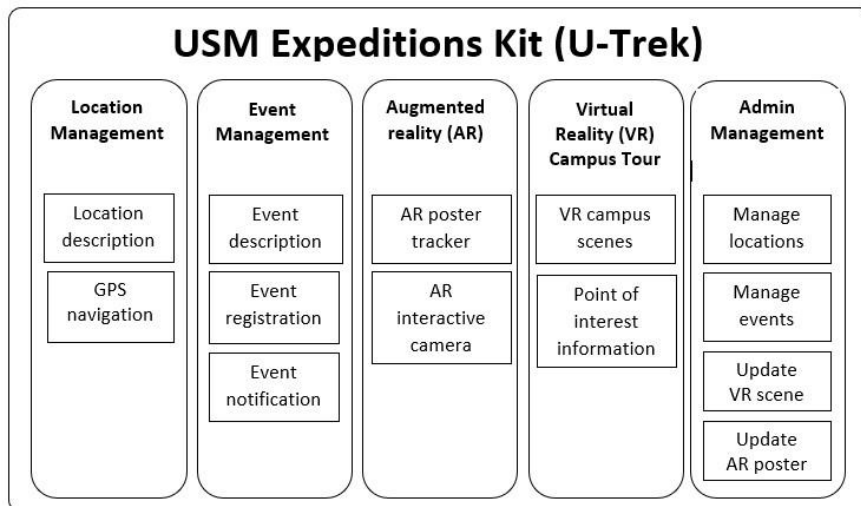

Fig. 2. U-Trek modules.

3.1. Location management module

The user can access to location official web page to get the location information such as contact, address, coordinate and description. U-Trek will be integrated into device's map application to navigate users from their current location to their desired destination.

3.2. Event management module

Event information such as venue, time, date, fee and description will be displayed. Users can not only register their interested event online, but also can check their registered events list. Additionally, a location-based notification will also prompt users regarding today's event held in a particular geofence. The notification works in both foreground and background of the U-Trek.

3.3. Augmented reality (AR)

This module consists of two main features, i.e., AR interactive camera and AR poster tracker. The main aim of AR interactive camera is to encourage the users to explore the point of interest (POI) in the campus by themselves, while the purpose of AR poster tracker is to display extra event information in the AR mode.

3.3.1. AR interactive camera

Each point of interest represents one mascot store and has one virtual mascot representative. Users are allowed to take picture with 3D virtual mascot in each mascot store. The pictures captured will be saved in the device's gallery automatically once the capture button is clicked. These pictures can be uploaded and shared across social networks. Map is also provided to ease users to track mascot store locations. It is noteworthy that the user can claim a mystery gift from the USM bookshop if the user collects and uploads those pictures with different mascots to social networks successfully. Bear in mind that the pictures uploaded and shared must contain POI plaque; Else, the pictures will be considered invalid.

3.3.2. AR poster tracker

By just focusing the poster with a camera equipped with AR poster tracker app, an additional event information will be overlaid in the camera view provided the poster is recognized. Additionally, 'Refresh' button can be used to clear the AR scene before screening the next poster. Anyhow, this feature is only applicable to track/screen those posters with 'AR poster tracker' logo.

3.4. Virtual reality (VR) campus tour

Equipped with the VR technology, USM environment in the VR mode will be illustrated. This feature is designed to be user-friendly considering instructions will be provided before entering the VR scene. Sound is also integrated as a virtual commentator to introduce the scene, while the 3D virtual mascot is incorporated to promote interactivity and user engagement. Each POI will have its own unique information icon and the POI information will be displayed if the information icon is hovered.

3.5. Admin management

Locations and events information could be viewed, created, updated and/or deleted. The VR scene information (i.e., background, sound, POI name and information) as well as the image target, event information and sound of the AR poster tracker can be updated.

Figure 3 shows the overview of the system architecture diagram of U-Trek. U-Trek basically consists of 2 users: (i) client, and (ii) admin. Specifically, USM community and public will be the client and they can access to U-Trek via mobile application. It is a must for the client to use an Android mobile device with android version 7.0 or above to access the mobile application. On the other hand, admin will access to the U-Trek web application via the desktop's web browser or laptop's web browser. The web server is WampServer with local host used to send and receive the requests from / to the cloud database. Accordingly, both mobile and web applications share the same cloud database, i.e., Firebase Real time. Internet is required to access the cloud database from mobile and web application.
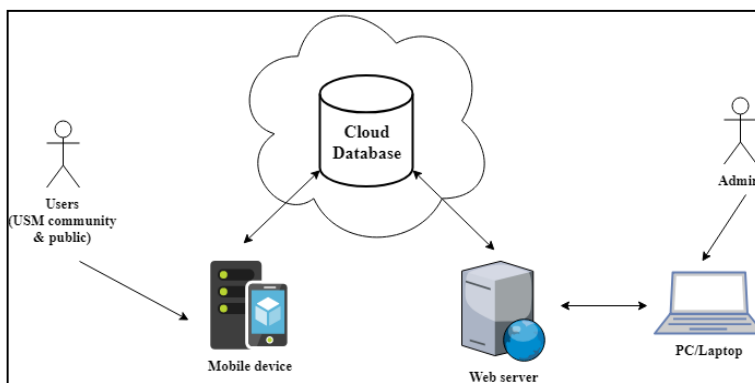

Fig. 3. U-Trek architecture diagram.

3.6. U-Trek Mobile Application Architecture

Figure 4 shows the mobile application architecture of U-Trek. It is worth to mention that the presentation layer can be accessed by either the USM community or public. Specifically, AR interface is used to present the camera view; VR interface is adopted to demonstrate the VR dual display for the VR headset; Notification interface is to ensure easy access to the event notification when U-Trek application is running in the background; Application layer is the layer that specifies the mobile application's main functionalities, i.e., location navigation, event registration, event notification, VR campus tour, AR interactive camera and AR poster tracker; Data service layer defines the database connected to mobile application. U-Trek mobile application adopted Firebase Realtime Database, noSQL database where the database is set up in the cloud server to store all the application data.

3.7. U-Trek Web Application Architecture

Figure 5 shows the web application architecture of U-Trek. The presentation layer is only accessible by the admin. Accordingly, data presentation interface is used to present the database data in charts and graphs forms with a better visualization;

Application layer specifies the web application's main functionalities, i.e., manage locations, manage events, update AR poster and update VR scene; Data service layer states the database connected to web application. U-Trek Web application used Firebase Realtime Database, noSQL database where the database is set up in the cloud server to store all the application data.
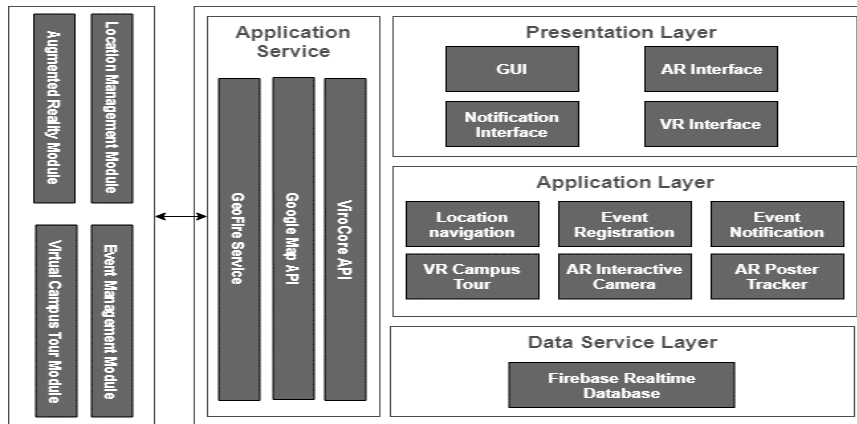

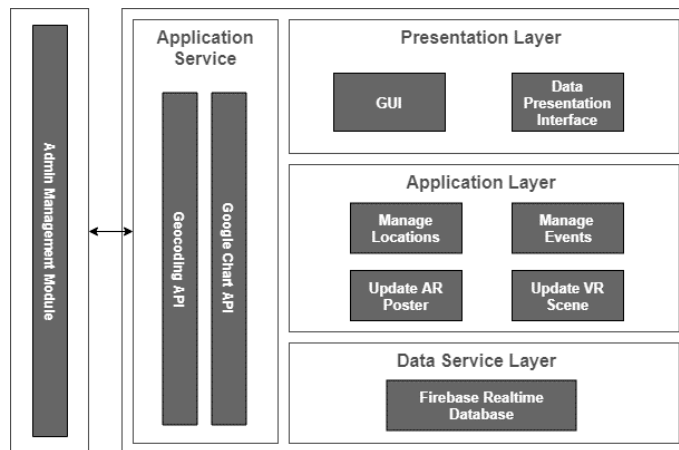**Fig. 4. Mobile application architecture.**

Fig. 5. Web application architecture.

3.8. Admin management

Augmented reality (AR) is the new sort of technology offering users to experience things in fun and interactive ways. Marker-based augmented reality equipped with camera and visual cues was used in this specific project. Figure 6 illustrates the simplified algorithm of marker-based augmented reality. Accordingly, binary image is the input for image processing; the binary image is then processed using an image processing technique to detect the AR marker. The location of the marker could be determined provided the AR marker is able to be detected. The marker's location could be subsequently used as the input to identify the pattern. The pattern is indicated as the relative six degrees of freedom (DOF) position of the camera in

real time, i.e., 3D position and 3D orientation of an object. The original image and the virtual components are then combined using the computed pattern. Finally, the augmented image is rendered on the display screen of the mobile device. The AR applications of this project are well comprehended from Figs. 7 and 8 illustrating the virtual objects in the real-world environment.
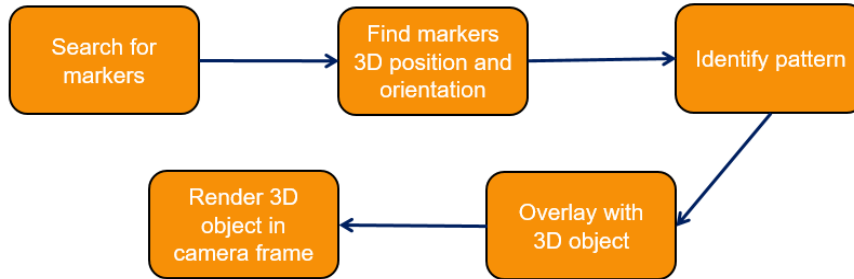

Fig. 6. Marker-based augmented reality algorithm.

Fig. 7. AR interactive camera.

Fig. 8. AR poster tracker.

3.9. Virtual reality development algorithm

Virtual reality is an interesting technology allowing the users to catch a glimpse of the atmosphere of the place in advance before heading to the actual destination. Figure 9 shows the simplified virtual reality process and Table 5 indicates how the algorithm being applied in the application. To create a satisfactory VR application, three vital criteria must be considered.

3.9.1. Development direction

There are two primary areas of VR development, i.e., desktop and mobile. Mobile development is used, and it is restricted to the Android platform only in this project. Accordingly, the Android version of mobile devices must be 7.0 and above [14] to support ViroCore framework [15].

3.9.2. Content

The contents basically encompass of both graphical sand audio contents. Adobe Photoshop CS6 and Pano Fetch (a Google extension tool for downloading 360-degree panoramas from Google Street View) are used to obtain the graphical content to support VR campus tour. In terms of audio content, sound plays an important role to boost immersion and bring user's impression to a new level. In this respect, sound is incorporated into VR scene to introduce and explain to the user.

3.9.3. User interface

The interaction between the users and VR application is considered. New abstraction is basically required to be evaluated on specific controllers. These controllers are used to control the transitions between VR scenes as well as to manipulate POI information. This criterion is important to improve the user's experience in term of application interactivity.

The VR application of this particular project could be further understood from Figs. 10 and 11 which show the snaps that give a more comprehensive view on the actual essence of the USM main campus.

Fig. 9. Virtual Reality Process.

Fig. 10. VR Scene.

Fig. 11. POI information in VR scene.

Table 5. Flow Chart of VR and descriptions.

Flow Chart	Descriptions
	The detailed flow chart for virtual campus tour feature. Firstly, the system enters VR mode and displays virtual tour instructions. Next, the system displays the first VR scene. If the user hovers on POI icon, POI information is shown. Otherwise, if the user clicks on next scene button, the system displays the next VR scene.

3.10. User Acceptance Test (UAT).

Table 6 highlights the feedback that are gathered from 20 respondents from the user acceptance test (UAT) on the USM Expeditions Kit (U-Trek) application. It implies that 65% of the respondents are strongly satisfied with the application whereas 35% of the respondents are satisfied with the application.

From the perspective of application usability, the result shows that 60% of the respondents agree that U-Trek is easy to use, 35% of them feel that U-Trek is extremely easy to use and the remaining 5% of respondents have the moderate feeling towards the usability. The 20 respondents also claim that they (i.e., 55% of them) are strongly satisfied with all the information obtained from the application regarding USM''s location and event.

Regarding any suggestion to improve the proposed application if there are any drawbacks, none of the respondents claim anything which indicates that they are happy with the current implementation. We probe further by asking the respondents if U-Trek is made available in Google Play Store whether they would like to download and use it respectively, 85% of respondents claim that they will download the application whereas 15% of respondents may consider downloading the application.

Finally, based on the result obtained on the feature that the respondents favour the most, virtual campus tour (VR) is ranked as the most popular feature among the 6 main features implemented in this application. AR interactive camera with the second most popular with the 20%. For location navigation, event notification and AR poster tracker received 5% each, respectively.

In conclusion, from the gathered results, it shows that the respondents are generally satisfied with all the presented features integrated in the U-Trek application. We believe that this application can be further improved and enhanced in term of its functionality and usability before it is ready to be deployed in holistic manner.

Table 6. User acceptance test result.

	Frequency	Percentage (%)
Q.1 Are you satisfied with all the features implemented in this application?		
Strongly Unsatisfied	0	0
Unsatisfied	0	0
Moderate	0	0
Satisfied	7	35
Strongly satisfied	13	65
Q.2 How well do you think is the application usability?		
Extremely Difficult	0	0
Difficult	0	0
Moderate	1	5
Easy	12	60
Extremely Easy	7	35
Q.3 Respondents of this application are able to obtain all the information they need regarding USM's location and event.		
Strongly Unsatisfied	0	0
Unsatisfied	0	0
Moderate	0	0

Satisfied	9	45
Strongly satisfied	11	55
Q.4 What feature(s) you think this application is still lacking? (State NA if it is not applicable)		
N/A	20	100
Q.5 If the full version of this application is made available in Google Play Store, will you download and use it to assist you on your journey in USM?		
Yes	17	85
No	0	0
Maybe	3	15
Q.6 Choose one feature implemented in this application that you like the most?		
Location navigation	1	5
Event registration	0	0
Event Notification	1	5
AR interactive camera	4	20
AR poster tracker	1	5
Virtual campus tour (VR)	13	65

4. Discussion

It can be noted that the results from the survey indicated users (i.e. predominantly university students) facing significant challenges to use the current USM applications (i.e. USM survival kit & USM Virtual Tour). There was lack of interactivity, lack of information and limited functionality to be used as claimed by the users. Based on the gathered evidence, USM Expeditions Kit (U-Trek) was proposed to bridge the gaps.

The proposed mobile application can be considered as user friendly and provided with more interactive functionality that improved the three main issues as mentioned. It embedded with GPS to track the journey from place to another, augmented reality (AR) camera to view information and playing games and virtual reality (VR) to ensure students or visitor experienced liked they were physically in the USM.

The proposed functionalities signify the better improvement that had been made to ensure the users can utilized the application accordingly. This work provides significant contributions by highlighting the methods or techniques that can be used to develop an interactive mobile application in a simple way.

This work is the proof of concept that interactivity of the systems can be further enhanced by utilizing various latest techniques such as augmented reality and virtual reality. With the latest Covid-19 pandemic for instance, students from far unable to attend the university physically. Therefore, the proposed solution can span the gaps when students able to look and feel the university environment in safe and interactive manner.

5. Conclusions

In short, USM Expeditions Kit (U-Trek) can provide users the detailed location and event information. In terms of location-related functionalities, navigation feature could serve its role in giving detailed route information, while the AR interactive

camera offers an interesting platform to motivate U-Trek users to explore USM themselves. On top of that, it is noteworthy that the users, especially the public, can enjoy the virtual campus tour considering they can have a glance on the USM environment with 3D effect.

In terms of event-related functionalities, USM community can also keep track of the campus events with location-based notification. Additionally, they could also gain additional details in AR mode by just rising the camera to the event poster. USM community and public can also enjoy the benefits of online event registration. Apart from that, a web application is offered to the admin to manage the data of U-Trek mobile applications in a more convenience way.

It is also worth to mention that U-Trek could increase the usability of virtual campus tour, improve the experience of location navigation to the AR indoor navigation as well as filtering and searching functions for events. For future improvement, more functionalities will be improved especially in regard to AR and VR. U-Trek is a promising application which highlight the possible functions and techniques that can be utilised in one application.

Although the application is focusing in USM environment, it would be useful to the developer or researchers to use this application as a template or guide to develop other mobile applications.

Acknowledgments

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