Development of the MARHIME App Embedding the Mobile Augmented Reality for Hearing-Impaired Museum Visitors Engagement Model

Esraa Jaffar Baker, Juliana Aida Abu Bakar, Abdul Nasir Zulkifli, Azizah Che Omar

Abstract: ***Mobile Augmented Reality (MAR) has matured significantly over the past decades and has evolved from the conceptual idea of augmented reality experience to its actual practical applications used on smartphones. Researchers have resolved to employ the concept of engagement in designing the MAR applications to attract museum visitors' interest and ensure a more effective learning environment. However, most of these MAR applications are largely tailored to normal hearing visitors while the hearing-impaired (HI) visitors are less supported. The HI visitors have to go through unpalatable experiences and eventually become dissatisfied with their museum visit. This paper elaborates on the process of designing and developing a Mobile Augmented Reality for the HI museum visitors' engagement (MARHIME) app. The purpose of this app is to engage the HI museum visitors through the AR content intended in order to replace their imperfect or missing hearing senses. The MARHIME app's design has gone through several refining and evaluation sessions based on the predetermined objectives. The app has to possess the necessary features in order to achieve these objectives. The app has been designed and developed specifically for an ancient Iraq museum which contains many artifacts that reflect the history of Iraq as well as the history of humanity in general.***

Index Terms: ***Mobile Augmented Reality, Engagement, Museum, Hearing Impaired, MARHIME***

I. INTRODUCTION

There is a growing interest among the MAR researchers to enhance the museum visitors' experiences in learning, engagement, enjoyment and personalized manners. This can be seen in the previous studies on the interactive museum MAR applications such as [1], [2], [3], [4] [5], [6] and [7]. These aforementioned studies have indicated that museum MAR applications are capable of providing the needed support for visitor-driven guidance in order to access the museum in a learnable fashion. However, [8], [9],[10] mentioned that most of the existing museum MAR applications were unable to adequately engage users.

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The issue of user engagement is an important concept in museum visits because engagement enhances user enjoyment, learning and acceptance [11], [10]. Engagement depicts the act of raising users' attraction and interest in a pleasing manner in order to get their attention to performing activities at the museums [12]. Nevertheless, there is still lack of study that explores the MAR user engagement among the HI especially among the HI museum visitors and tourists. It is unfortunate that the HI visitors are having huge difficulties not only with accessibility issues within the museum but also with the engagement experience [13], [14]. Likewise, little is known on how the HI can have an engaging experience within the museums. There is lack of studies focusing on the engagement of the HI particularly during their museum visits. Hence, this paper elaborates on the design and development of the MARHIME app for the purpose of engaging the HI museum visitors with MAR and also to validate the MARHIME conceptual model [15], [16].

II. TECHNICAL REQUIREMENTS

Technical requirements are basically a set of complete specifications that need to be met to allow an application to operate properly. There are several technical requirements that need to be met to achieve the required efficiency and effectiveness. Therefore these requirements are chosen for optimal performance of the MARHIME app.

The usage of the MARHIME app requires the display of augmented 3D computer generated objects. For this reason, this study uses a smartphone. The MARHIME app works on a mobile device with a minimum operating system (OS) of Android version 2.3 and also includes a set of application programming interfaces (API). In addition, it is necessary to have a processor of at least 1.4 GHz, 2GB of RAM and screen resolution of at least 1024 x 600 for the app to operate smoothly and hitch free. The app requires an android device with a graphic user interface (GUI) for better engaging the HI visitors in the museum through the adaptation of several types of multimedia objects such as image, text, video and 3D model. These objects are expected to provide the HI visitors with complete information pertaining to the artefacts in the museum. For this study, a Samsung Note 5 with specifications that include; Android 5.1.1 OS, 32GB storage, 1.5 GHz octa-core processor, 1440 x 2560 pixels resolution and 16 megapixel rear camera was used.

The presence of the rear camera of a smartphone is very important in tracking the AR markers. These markers are usually predefined images printed on a piece of paper and placed on the scene to identify the place where virtual object is to be presented. The tracking method involves registering what is being captured by the camera and linking it with a virtual object. Marker based tracking is much easier to implement and suitable for indoor AR applications such as the use of the MARHIME app for indoor museum environment. Details on the use of the AR markers will be addressed when discussing the MARHIME app development.

III. MARHIME ARCHITECTURE

This study proposes the MARHIME app which has been developed based on the MARHIME conceptual model as discussed in [15], [16]. In developing this app, mobile simulator architecture was first designed using an assembly process for the MAR environment. The assembly process is suitable for designing the MAR architecture as the assembly task itself requires making a sequence of operations and procedures. A two-dimensional (2D) sketch is normally used in the assembly process to guide users in the phases involved in the assembly steps. This sketch contains a list of labelled portions and phases and how they are executed or accomplished. Thus, 2D sketch is used in this study to design the MAR architecture. The architecture consists of several components that include; development tools, AR markers and scenes to complete the assembly procedure as shown in Figure 1.

As illustrated in Figure 1, the architecture of the MARHIME app shows that the app design passes through different stages through the use of several tools. The utilization of the MARHIME app requires interaction of the device's camera with the AR markers as depicted in the development tools section. The architecture requires a new database to be created from the Vuforia AR toolkit online database to set the target markers for each of the museum artefacts. A single target-based image is selected with customized dimensions and uploaded to add a target to the database. This allows the activation of the authoring part in the Unity3D software. Overall, to materialize this architecture requires the use of four software; Windows Movie Maker, 3DS Max, Vuforia Software Development Kit (SDK) and Unity3D.

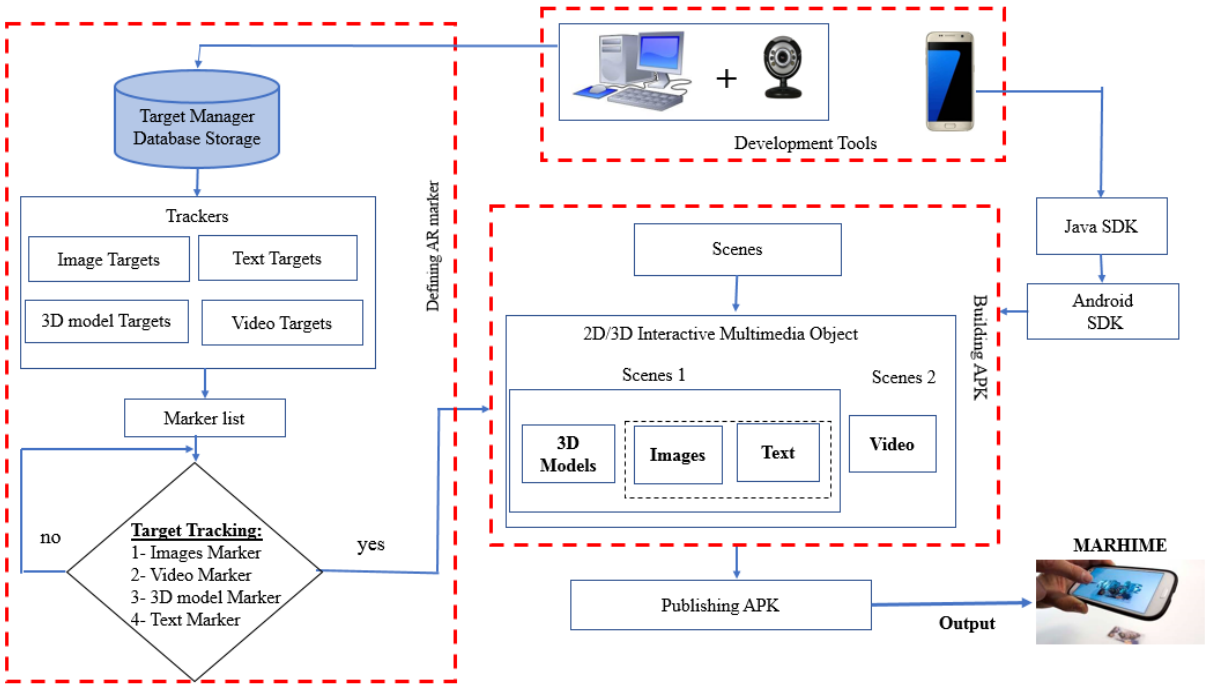

Fig. 1 Architecture of MARHIME App

IV. APP DEVELOPMENT

The MARHIME app was designed specifically for engaging the HI museum visitors and the development of the app involved two main stages. The first stage handles the creation of content while the second stage deals with the integration of the app on the mobile device. The roles of the previously mentioned software for the MARHIME app development include; compiling videos of the artefacts (Windows Movie Maker), creation and modification of the 3D models (3DS Max), Android development SDK (Vuforia SDK) and development and deployment of MARHIME app into the android device (Unity3D).

A. Contents of the MARHIME App

Considering the first stage that involves the creation of contents, this phase began with the gathering of information that is relevant to the app. The contents of the MARHIME app consist of images, videos, text and 3D models (in suitable smartphone requirement format) gathered for the three artefacts from the Iraq museum. The main reason for requiring images, videos, text and 3D models of each artefact is because the target users are the HI.

Thus, it is important to utilize appropriate objects in order to capitalize on their visual senses due to the limitation of their hearing senses. The contents of the MARHIME app also cover the features and history of the selected artefacts.

The use of the MARHIME app in the museum requires the use of the AR markers. These markers as shown in Figure 2 must be used in order to access the virtual objects. The MARHIME app will display and superimpose the respective virtual objects (image, text, video, or 3D model) onto the mobile device screen once a marker has been recognized. The Vuforia software marker manager was used in creating the marker. A device database was created using the Vuforia online database and a new target has been identified and given a name. For the MARHIME app, the targets include image, text, video and 3D model. The target dimensions or size were set and then the target image file was uploaded to the Vuforia database. With Vuforia, the marker can be saved in either JPEG or PNG image file format. The Unity3D software was used to integrate the contents of the MARHIME app in three phases that include; 3D modelling, video, text and finally using the augmented reality SDK.

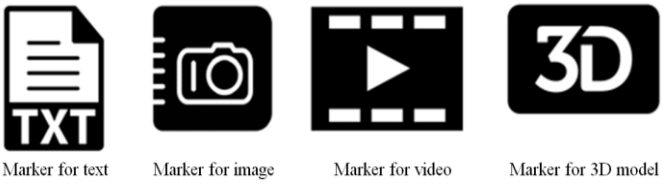

Fig. 3 Image-based markers for the MARHIME app

B. Integration of MARHIME on Mobile Device

In order to create the augmented reality environment, Vuforia was used. Several features were determined for MARHIME as highlighted in the previous subsection and set in Vuforia. These features comprise of image targets, text targets, 3D model targets, video targets and the SDK project file for the Android development. The marker project file was downloaded from the Vuforia database after the images were uploaded as target markers. A Unity Editor file was selected to match the authoring development of the Unity3D software. Then the augmented reality unity project was set up with Vuforia SDK, saved and downloaded for further development in the Unity3D software. This implied that, the development of the MARHIME app requires the merging of Vuforia and Unity3D software. The application also used C++ during the development phase. The overall development of the MARHIME app that includes compilation, visual development, interaction, content presentation and deployment to mobile device, employed the use of Unity3D.

The main interface of the MARHIME app includes four main icons consisting of three artefacts and a game. In addition, icons for navigation to social media sites were also included as shown in Figure 3. These icons are stored in the Unity workspace. For the MARHIME app, a raw image was inserted and saved in the Unity workspace functioning as the app's background. Since the app requires a scene exchange, an object named Manager was created and the script written in C++ for the corresponding icon was attached to the object. Therefore, when a marker is scanned, the virtual content that is attached to the marker appears on the mobile screen.

The main objective of the MARHIME app is to engage the HI during their museum visits through the use of the MAR. The app is a tool that helps the HI to heighten their visual senses due to the absence or lack of their hearing senses. All the MAR elements of the MARHIME conceptual model were implemented in the design and development of the MARHIME app. The app comprises of virtual contents in the form of text, image, 3D model and videos which were coded into the AR markers so that the HI can view the virtual contents when placing the markers in front of their smartphone camera. Figure 3 shows the wireframe for the main components of the MARHIME app.While Figure 4 shows the wireframe for all the artefacts in the MARHIME app. Both Figure 3 and Figure 4 represent the total package for the MARHIME app. The interfaces and steps in viewing the image, text, video and 3D model for each artefact have also been highlighted. However, it is important to show the relationships between the elements of the conceptual model and the developed app. The following section provides some insights about the elements of the MARHIME conceptual model that have been embedded into the app.

V. ELEMENTS OF THE MARHIME CONCEPTUAL MODEL

i. Aesthetics: Aesthetics as defined by [17] describes the visual beauty of computer-based environments or the study of natural and pleasing computer-based environments. Aesthetics element focuses on the look and feel. Aesthetics is important to the HI because quality illustrations and presentation which are colourful and realistic in style conform to their developmental, cognitive, cultural and emotional needs [18]. The HI are attracted to nice looking interfaces, coloured buttons, style, and feel to visual senses with the AR objects. This is evident in the developed MARHIME app such as when viewing the splash screen and attractive colours for buttons as seen in the main menu design and general attractive screen design for each interface.

ii. Usability: Usability refers to the consistent information and ease of use based on the functionality of an application as perceived by the user [19]. The element of usability in the MAR application is important to the HI because technology presents an enormous potential to help the HI by providing their needs to perform tasks easily and efficiently [20], [21]. Thus, usability of the MARHIME app is significant as this element is concerned with specific features to use. In the MARHIME app, the HI can easily use videos, camera, select the options in the main menu and move from screen to another. One notable usability trait that has been observed in the MARHIME app is the help screen for the HI visitor to understand the navigation of the interface as shown in Figure 3.

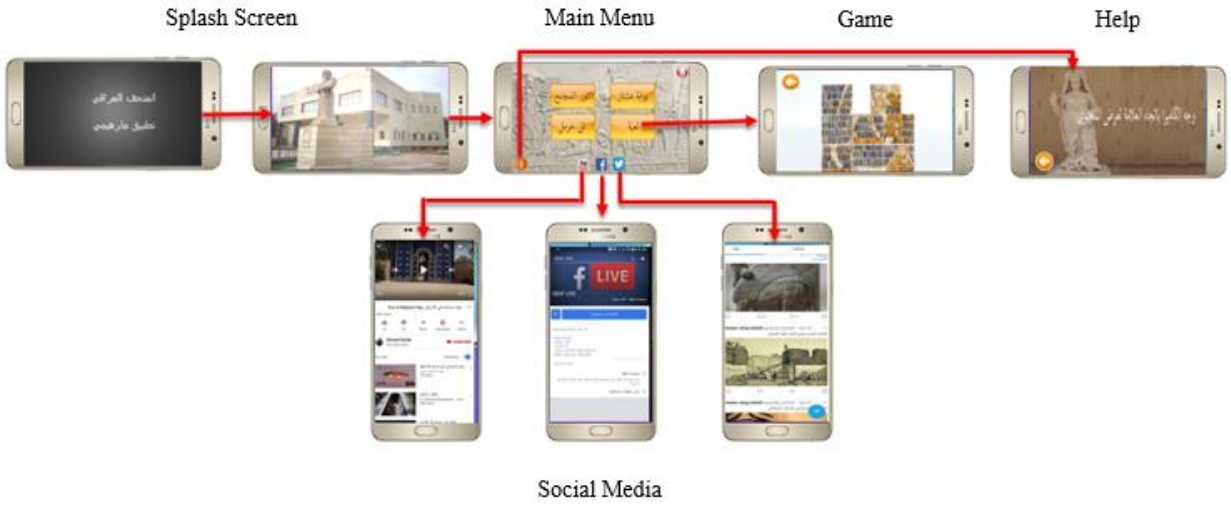

Fig. 3 Wireframe of the MARHIME app

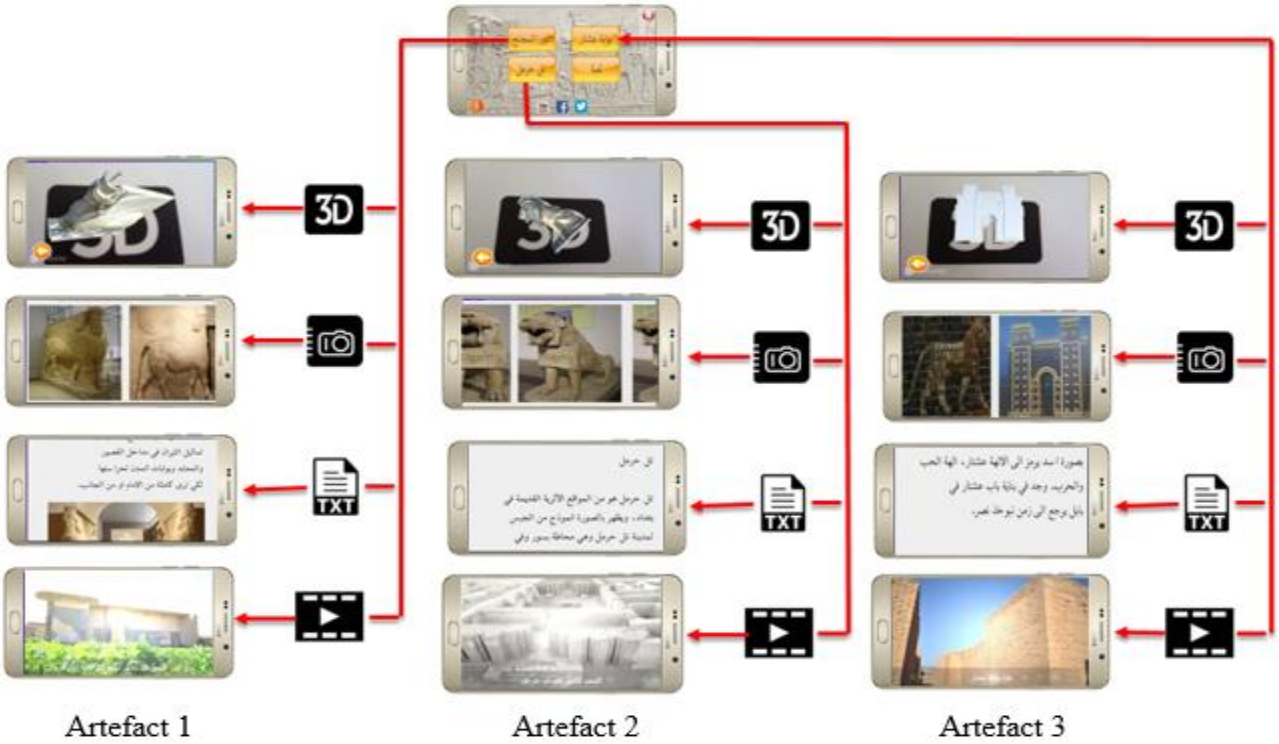

Fig. 4 Wireframe of the Artefacts in the MARHIME app

iii. Interaction: It is a form of awareness of being in control towards the application whereby interactivity, information and feedback are given upon an action. This implies that the social relation and connection between the user and the application is referred to as interaction [22]. Interaction as part of a computing process, considers how users understand and interpret multimedia signals at the perceptual, cognitive, and affective levels, and how they interact naturally by embedding the cultural and social contexts as well as personal factors such as emotion, attitude, and attention. Interaction is important to the HI because any application without enhanced interactivity would be ineffective to them as users [23].

iv. Motivation: [24] defined motivation as the drive towards involvement in order to achieve a target. Motivation as an element of MARHIME is the act which encourages action or target activity to be performed by the HI. Motivation determines the participation, hard work and continuous learning of an individual [25]. When considering the MAR application for the HI, motivation is an issue of concern since they are mostly passive users, thus it is expected that the app can arouse or sustain interest of the HI visitors to the museum and whether it can enhance their learning and engagement [26]. In view of this, the MARHIME app has been designed in an interactive and self-regulated environment.

This is evident in the infusion of social media in the app to increase the excitement of the HI visitors with the museum exhibition and also allowing the users to share with other HI groups on the social media platforms.

v. Satisfaction: Satisfaction addresses the act of being content and fond of an application [27].

Members of the HI community have a higher thirst for satisfaction when adopting the MAR application. This is because their shortcoming in hearing spikes their satisfaction desire level due to the fact that they are limited to use other senses such as sight to attain an engaging MAR experience [25]. The MARHIME app aims at satisfying the HI visitors by being implemented using the AR technology. Therefore, the users do not experience hitches, lags or unexpected shutdown when operating the mobile with the markers. In addition, the implementation of image, text, video and 3D model for observing the artefacts provides an all-round experience for the HI users as they totally engaged and thoroughly enlightened.

vi. Enjoyment: Enjoyment is the experience of fun, enjoy and entertainment [28]. Enjoyment is very crucial in the development of the MARHIME app since most of the time the HI visitors are unreceptive [25] and therefore it is important in integrating something fun to engage them during their museum visit. For this reason, the game scene (puzzle) was incorporated into the MARHIME app. Puzzle is known in engaging users as the aim is always to get it solved. Therefore, the view of a scrambled puzzle game within a museum visit spikes a level of enjoying the total package of the MARHIME app as a whole.

It is evident from the discussions above that the six elements of the MARHIME conceptual model have been infused into the MARHIME app. This further establishes the suitability of the MAR application in engaging the HI visitors to the museum.

VI. CONCLUSION AND FUTURE WORK

This paper has discussed and elaborated on the development of the MARHIME app for the purpose of engaging the HI museum visitors through the use of the MAR technology. It continued to discuss on the technical requirements, MARHIME architecture, and the app development covering the contents of the MARHIME app and integration of MARHIME on mobile device. It also discussed all the six embedding elements of the MARHIME conceptual model in the MARHIME app. Future work includes evaluation of the app among HI teachers, museum staff and experts. This paper is expected to provide guidance for the future MAR app developments in engaging the HI during their visits to the museum.

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