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Design, Development and Expert Evaluation of the MARHIME Prototype for HI Museum Visitors' Engagement

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Abstract

The smartphones provide easy access to experience Augmented Reality (AR). Mobile Augmented Reality (MAR) technology is adopted to enhance human's perception and help them to see, feel, and hear the environments in new and enhanced ways. Researchers have growing interest in the MAR environment to enhance museum visitors' experiences in engagement, enjoyment, learning and personalized manners. Most of the museum MAR apps are designed for normal hearing people. While the hearing-impaired (HI) visitors are less fortunate. Thus, the HI visitors have to go through unpleasant experiences and ultimately become dissatisfied with their museum visit. This paper discusses on the process of design, development and expert evaluation of the Mobile Augmented Reality for hearing impaired museum visitors' engagement (MARHIME) prototype. The goal of this prototype is to engage the HI museum visitors through the AR contents designed that replace their lost or missing hearing senses. The MARHIME prototype's design has gone through several refining and evaluation sessions based on the predetermined objectives. The prototype has the necessary features to realize these objectives. The prototype has been designed and developed specifically for the Iraq museum which was specifically chosen since it has some of the most famous and historical artifacts in the world.

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

1. Introduction

AR is the technology that expands our physical world, adding layers of digital information onto it. It does not create the whole artificial environments to replace reality with a virtual one [1]. AR appears in direct view of an existing environment and adds sounds, videos, graphics to it. This environment is based on an idea known as mediated reality which makes use of images, sound, graphics, GPS and video. The concept has been used similarly in various domains such as gaming [2], education [3], navigation [4], tourism and sightseeing [5], emergency management or search and rescue [6], and beauty and medical [7]. These domain applications have produced supportive aids technologies and devices which enhance users' reality perceptive in order to make life better for them. In the nutshell, AR reproduces a real-world scenario with a simulated environment, conventionally real-time and semantic context. Likewise, the concept has been implemented in many studies to provide support for disabled people as seen in the work of [8];[9];[10];[11];[12];[13];[14]; [15]. However, most of these studies focus on physical activities only. Also, none of these studies specifically explore AR as a support or guide in museums for HI people. Furthermore, it has been advocated that there is a need for AR contents to replace and remedy the absent senses for some disabled individuals [16]. It is pointed out that MAR can be used to support disabled

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individuals as an alternative instrument to their senses. For instance, HI people can use MAR to enhance their visual abilities. On the other hand, the HI can use MAR as visual signals guide in order to catch missing aural signals during their visit to the museums [17]. In addition, it has been discovered in the literature that most museums MAR applications are not designed to support HI visitors [18];[19]; [20];[21]. There is an absence of studies focusing on the engagement of the HI during their visit to the museum. Hence, this paper elaborates on the development and design of the MARHIME prototype for the purpose of MAR for engaging the HI museum visitors and also to validate the MARHIME conceptual model [22], [23], [24].

2. Components Related to the Elements of MARHIME

The components that allow the user to view the input and program response actions in terms of the prototype capabilities are shown in Table 1. These components are listed with respect to each interface that has been developed for the prototype. This study develops the MARHIME prototype highlighting three artefacts from the Iraq museum, including a game and connection to social media in order to increase the HI visitors' engagement with the prototype. Thus, the prototype suitably justifies its usage of granting the HI visitors with a palatable visit to the museum.

No	MARHIME Component	Aesthetics	Usability	Interaction	Motivation	Satisfaction	Enjoyment	References
1	Image	√	√	√	√	√	√	[25]; [26]; [27]; [28]; [29]; [30]; [31]
2	Text	√	√		√		√	[25]; [26]; [27]; [29]
3	Video	√	√	√	√	√	√	[25]; [26]; [27]; [28]; [29]
4	Colours	√						[26]; [29]
5	Help screen		√					[26]
6	Scan camera		√	√	√	√	√	[25]; [27]; [28]; [30]
7	Image target (AR object)		√	√	√	√	√	[25]; [27]; [28]
8	Video target (AR object)		√	√	√	√	√	[25]; [27]; [28]
9	Text target (AR object)		√	√	√	√	√	[25]; [27]; [28]
10	3D target (AR object)		√		√	√	√	[25]; [27]; [28]
11	Scroll horizontal and vertical bar		√		√			[26]
12	Rotate 360 degree		√		√		√	[25]; [27]
13	Random movement						√	[25].
14	Touch screen		√		√		√	[25]; [27]; [31]
15	Facebook link					√	√	[25]
17	Twitter link						√	[25]
18	Game		√	√	√	√	√	[25]; [28]
19	Video Time		√					[32]

TABLE 1. Components related to the elements of MARHIME

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3. Contents of the MARHIME Prototype

Considering the first stage that involves the creation of content, this phase started with the gathering of relevant information to be included in the prototype. The contents of MARHIME entail images, videos, text and 3D models (in suitable smartphone requirement format) gathered for the three artefacts from the Iraq Museum. The reason for requiring images, videos, text and 3D models of each artefact is because the target audience is the HI, therefore, it is important to insert appropriate formats in order to interact with their visual sense. The content of MARHIME also covers the features and history of the selected artefacts. The use of the MARHIME prototype in the museum requires the use of AR markers. These markers must be implemented with the installed prototype for proper functioning. The MARHIME prototype will display and superimpose the respective computer-generated object (image, text, video, or 3D model) onto the mobile device screen once a marker has been recognised. Therefore, 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 as shown in Figure 1. For the MARHIME prototype, the targets include images, text, video and 3D model. The target dimensions or size was set and then the target image file was uploaded to the Vuforia database. With Vuforia, the marker can be saved in either a JPEG or PNG image file format. For the MARHIME prototype, the markers were saved in JPEG as shown in Figure 2. The Unity 3D software was used to integrate the contents of the MARHIME prototype in three phases that include; 3D modelling, video text and finally using the augmented reality SDK.

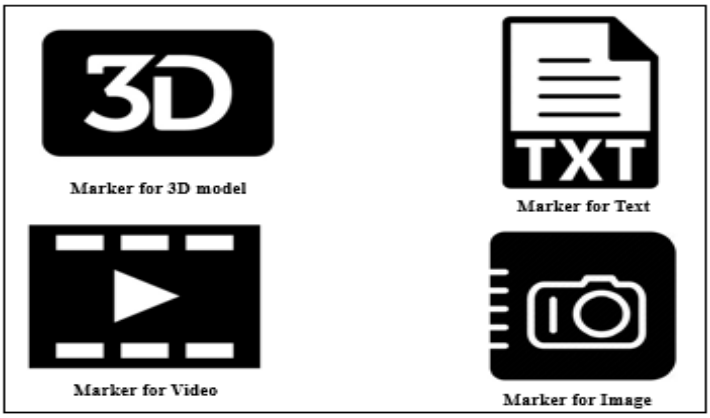

FIGURE 1. Architecture of MARHIME prototype

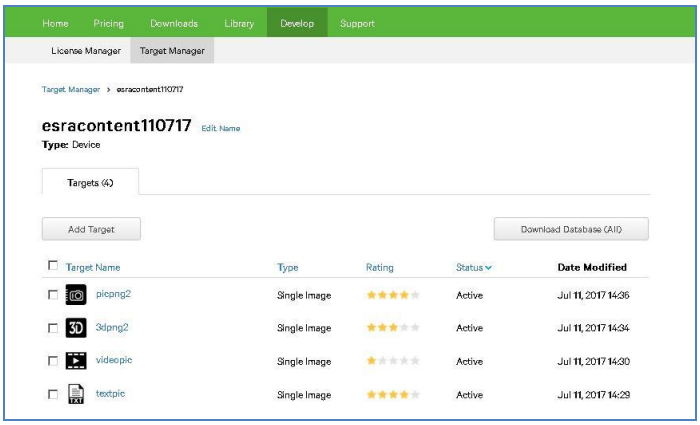

FIGURE 2. Vuforia database for MARHIME prototype

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4. MARHIME Prototype Evaluation

In order to evaluate the MARHIME prototype, it is important to request feedbacks about the prototype to know if it is suitable to achieve its objective, which is to engage the HI visitors to the museum. Four groups of individuals were involved in this session. The first group consisted of school teachers for HI in Malaysia and the second group were also school teachers for HI in Iraq. The third group consisted of Iraq Museum staff in Baghdad. The fourth group consisted of academic experts in AR and museum.

For the first group (teachers of HI in Malaysia), feedbacks were requested in terms of the interface and text of the MARHIME prototype. Figure 3 shows a session whereby a HI teacher with his students in Penang, Malaysia checking the prototype interface design.

FIGURE 3. HI Teacher and Students in Penang, Malaysia using the MARHIME prototype

The response from the teachers was that the MARHIME prototype is beneficial and useful for the HI and deaf community. The images of the artefacts are of different angles with captions are very helpful and the 3D features were interesting. The prototype is easy to understand even though it was in Arabic language, very simple and friendly to use. However, the teachers suggested that having the video in full screen mode would be more suitable, and a bit of colour should be added as the HI or deaf community are people who are attracted with visual things.

The second group of evaluators were teachers for the HI in Iraq. It was important to consult this group of individuals since the language of the prototype is in Arabic. In order to ascertain the suitability of the prototype, teachers who understand Arabic were consulted. The teachers also agreed that the MARHIME prototype is a novel development which is very advantageous in engaging the HI people. The teachers further commented that the ideas and interface is suitable for the HI. Figure 4 shows some of the teachers preparing their report on the suitability of the MARHIME prototype in engaging the HI people when visiting the museums.

FIGURE 4. Some of the HI Teachers in Iraq who evaluated the MARHIME prototype

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The third group of individuals was the Iraq museum employees. These employees interacted with the MARHIME prototype and responded that the prototype helps the HI museum visitors to understand, enjoy and consolidate with the artefact by knowing and learning about the historical background. The integration of 3D models, information, videos, and images, has generalized everything that benefits the visitor. The information given by the prototype is very valuable to the visitors and helps them understand these artefacts. In addition, the presence of a game in the prototype removes monotony and helps overcome the boredom. Thus, it is considered that this kind of prototype will have a positive effect for its use in museums as it has contributed in terms of science and knowledge to the HI people who receive less attention. Figure 5 shows one of the museum staff, giving her report after interaction with the MARHIME prototype.

FIGURE 5. Museum Staff giving report after using the MARHIME prototype

Finally, MARHIME prototype was evaluated by AR, multimedia systems and museum experts. The three (3) experts are PhD holders in their domains. The evaluation of the interface used Heuristic and Subheuristics method which is adopted using the questionnaire cited by [33]. These Heuristics are: Interface (IN), Multimedia (MM), and Interactivity (IV). All responses for experts were positive without further comments as shown in Table 2.

Heuristic	Items	Yes	No
Interface (IN)	The instruction given is clear and easy to understand.	3	0
	The interface design is attractive.	3	0
	The MARHIME application is easy to use.	3	0
	The colour scheme used is appropriate.	3	0
	Attractive display of the screen design.	3	0
	Appropriate interface.	3	0
	The readability of text suits the target.	3	0
Multimedia (Image, Video, Text, and 3D model) (MM)	Each multimedia elements used serves a clear purpose.	3	0
	Usage of multimedia elements is suitable with the content.	3	0
	The presentation of multimedia elements is well managed.	3	0
	The use of multimedia elements supports meaningfully the information provided.	3	0
	The quality of multimedia elements used is good.	3	0
	The use of multimedia elements enhances the content presentation.	3	0
Interactivity (IV)	The interactivity is easy to understand.	3	0
	The interactivity is not misleading.	3	0
	The help functions provided may be useful.	3	0

TABLE 2. Expert Responses for MARHIME Interface

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This implies that the MARHIME prototype is considerably a good prototype to be further tested upon by the HI visitors at the museum.

5. Embedding Elements in the MARHIME Prototype

In the implementation phase, all the elements that have been planned for designing the MARHIME prototype are embedded into the prototype. The prototype comprises of virtual contents in the form of texts, images, 3D animations and videos which are coded into AR markers so that the HI users can view the virtual contents when held in front of the camera. The elements of the conceptual model which include; aesthetics, usability, interaction, motivation, satisfaction and enjoyment were embedded into the prototype during the development stage.

A. Aesthetics

Aesthetics as defined by [34] describes the visual beauty of computer-based environments or the study of natural and pleasing computer-based environments. Aesthetics element is substantial to HI visitors because quality presentation which is realistic and colourful in style conforms to their cognitive, emotional and cultural needs [35]. In Figure 6, the HI visitors are attracted to the nice-looking interface, style and coloured buttons. In addition, the HI visitors fell to the visual senses with the AR contents.

FIGURE 6. Splash screen for MARHIME prototype

B. Usability

Usability refers to the consistent information and ease of use based on the functionality of a prototype as perceived by the user [36]. Usability element in the MARHIME prototype is necessary to HI because AR technology presents a massive possibility to support HI visitors by providing their needs to do tasks efficiently and easily [37];[38]. With the usability elements embedded in the MARHIME prototype, the HI can easily use videos, camera, select the options in the main menu and move from screen to another. In Figure 7 the MARHIME prototype helps the HI visitors to use the help screen easily by stating "Point the camera toward the marker to view the content" in Arabic.

Figure 7. Selected Help Menu for MARHIME prototype

C. Interaction

A form of awareness to control the prototype where interactivity, information and feedback are given on action. This implies that the connection between the user and the prototype or social relation is referred to as interaction [39]. Interaction as part of 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 serious to the HI visitors because any prototype without enhanced interactivity would be ineffective for them as users [40]. For example, as seen in Figure 8, the HI visitors were viewing the 3D model superimposition of the artefacts. It was observed that the HI could move his/her finger on the 3D model to understand more information about the artefact and resize the 3D model to view a clearer display. Likewise, the virtual objects move and rotate whenever there was rotation or movement of the marker by the HI visitor.

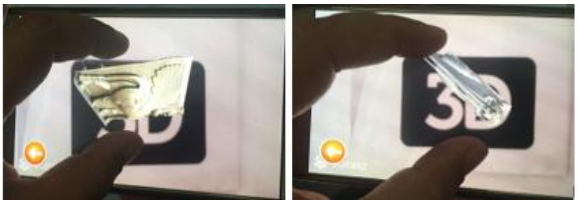

FIGURE 8. Interact with the 3D model artefact of the MARHIME prototype

D. Motivation

Motivation element is defined as the drive towards involvement in order to achieve a target [27]. Motivation as an embedding element on MARHIME prototype is the act which encourages action or target activity to be performed by the HI. Motivation element is an important issue to HI visitors, thus, it is embedded in the MARHIME prototype to enhance the HI visitors learning and engagment during their museum visit. For example, motivation embedded in the MARHIME prototype through social media as shown in Figure 9 increases the excitement of the HI user with the museum artefacts and allows the HI to share with the HI groups on the social media platforms.

FIGURE 9. Social Media Menus for MARHIME prototype

E. Satisfaction

Satisfaction element is the act of being content and fond of a prototype [43]. The HI community has a higher thirst for satisfaction when adopting the MAR technology. This is because of their shortcoming in hearing spikes their satisfaction desired level due to the fact that they are limited to use other sensors such as sight to attain an engaging MAR experience [42]. The MARHIME prototype targets at satisfying the HI user by implementing the AR technology. Therefore, the user will not experience lags and hitches or unexpected shutdown when operating the mobile device with the markers. Figure 10 shows a sample of the image, text, 3D model and video of one of the artefacts. The implementation of these objects in the

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prototype for observing the artefacts provides an all-round experience for the HI visitors as they were totally engaged and thoroughly enlightened.

FIGURE 10. A sample of the image, text, 3D model and video from the MARHIME prototype

F. Enjoyment

Enjoyment as defined by [41] is the experience of fun, enjoy and entertainment. Enjoyment element is very critical in the development of the MARHIME prototype since the HI visitors most of the time are unreceptive [42]. Therefore, it is important in integrating something fun to engage them during their museum visit. For this reason, the gaming scene (puzzle) as shown in Figure 11 was integrated into the MARHIME prototype. The 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 MARHIME prototype as a whole.

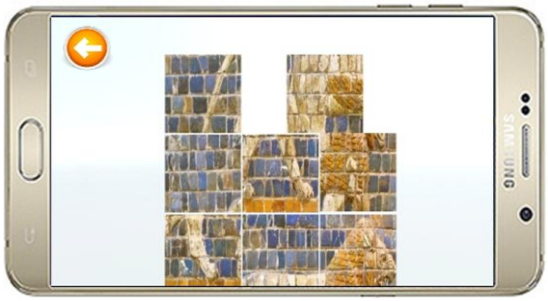

FIGURE 11. Puzzle game for MARHIME prototype

It is clear from the above discussions that the six elements of the MARHIME model which have been validated by the experts have been embedded into the MARHIME prototype. Furthermore, it establishes the appropriateness of the MAR prototype in engaging the HI visitors to the museum. The next step will involve a pilot study in identifying the limitations of the research instrument and the MARHIME prototype and these will be discussed in future publication.

6. Conclusion and Future Work

This paper elaborates on the design, development and expert evaluation of the MARHIME prototype for the purpose of engaging the HI museum visitors through the use of MAR contents. It discussed the six components related to the elements of the MARHIME model, the contents of the MARHIME prototype, and the evaluation of the MARHIME prototype by four groups of experts. The inclusion of the six elements into the MARHIME prototype is important in ensuring that the target users and in this case the HI are engaged whenever they use the prototype during the musem visit. Future works will include a pilot study in identifying the limitations of the research instrument and the MARHIME prototype and also user evaluation among HI museum visitors towards the use of the MARHIME prototype.

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