

A Simple Proposal For Ain Makkah Almukkarmah An Application Using Augmented Reality Technology

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Summary

Makkah Al-Mukarramah is the capital of Islamic world. It receives special attention from the Saudi government's rulers to transform it into a smart city for the benefit of millions of pilgrims. One of the 2030 vision objectives is to transform specific cities to smart ones with advanced technological facilitation, Makkah is one of these cities. The history of Makkah is not well known for some Muslims. As a result, we built the concepts of our application "Ain Makkah" to enable visitors of Makkah to know the history of Makkah by using technology. In particular "Ain Makkah" uses Augmented Reality to view the history of Al-Kaaba. A 3D model will overlay Al-Kaaba to show it in the last years. Our project will use Augmented Reality to build a 3D model to overlay Al-Kaaba. Future work will expand the number of historical landmarks of Makkah.

Keywords:

Augmented Reality, AR, Makkah Al-Mukarramah, Al-Kaaba, 3D models

1. Introduction

Augmented reality is an interactive technology that enhances/augments the physical real-world with computer-generated information to the object. AR is the enhanced version of the real world. AR is the technology based on projecting 3D objects. AR allows simulation of real objects with 3D virtual objects. In the last few years, many applications have been developed by using augmented reality technology. We will try to mention some examples. Manasek AR [34] used to view information about Makkah. City View AR [35] is used to overlay the building with the 3D object. Epic reality [36] is used in Dubai to enhance tourists' travel experiences. Florence travel guide [37] is used in Florence to discover the city using AR and GPS. For sure, there were other examples we could not list here. City View AR and Manasek AR, are applications among the most successful applications (a successful example of augmented reality technology. But City View AR is not used in the city of Makkah (does not work), Manasek AR does not support projection Three-dimensional models. We were inspired by the idea of Ain Makkah to achieve the

vision of 2030 to transform Makkah to a smart city, since applying Ain Makkah supports the projection of three-dimensional models in Makkah.

2. Background

The concept of augmented reality appeared at the beginning of the 1960s through Sutherland's work, since he used 3D technology to make his helmet, which is (Head-Mounted Displays), the concept of augmented reality emerged from this innovation. Augmented Reality is defined as an interactive experience of the real-world environment, through which models in the real world are improved by the computer, we also need multiple sensory methods, including visual, tactile, sensory, physical, and auditory. It combines the real and virtual worlds and the interaction between them at the same time with the accurate illustration of virtual and real things through 3D. [1] [2] Both Azuma, Furth, and Carmigniani defined augmented reality (AR) as the mixing of interactive digital elements in real-world environments with an interactive world created by computer in the form of a single environment through which a person interacts, such as text, video, graphics, and GPS [3][4][10].

AR type:

There are four types of augmented reality: Marker-based that uses cameras and visual cues. Marker-less that relies on positional data such as a mobile phone's GPS, Projection-based and Superimposition-based AR.

1. Marker-based AR: A marker, which is a special visual object like a special sign or anything, and a camera are used to initiate the 3D digital animations. The system calculates the orientation and position of the content effectively. This type depends on the images that are known through the camera and used as a location for the virtual assets placed in the scene, they are mostly in a black and white color that enables them to know the contrast accurately between them

and correctly using the camera. The Augmented Reality signs consist of one or more shapes, the basic one that consists of black squares opposite them are white squares. It also uses the camera with AR software to detect augmented reality signs that have been defined as the location of virtual objects and the user begins to interact with them through the texts that appear on the screen [6] [7] [8].

2. Marker-less AR : Images are collected online and displayed at any location of their choice or may also be collected through GPS to determine which content the user receives or is located in a particular area. Compass and gyroscopes can also be used since in this type there is no need for a marker to place objects in real space and virtual objects integrated into a real 3D environment in real-time, augmenting them to the user’s perception of the real world and its interaction with it [5][7] [8] [14].

3. Project-based AR : This type relies on artificial light that is directed at tangible surfaces to detect the user’s interaction with these physical surfaces. It also displays digital images on physical objects, interactive or non-interactive, for example, showing you if your future refrigerator will fit in the space or not. This genre is used in science fiction films [7][13].

4. Superimposition-based AR: In this type, the basic element is replaced with another default element that is chosen by the user, who chooses it from the available application services such as the menu, meaning that there is a simulation on the ground. But by default, one of the examples is the famous IKEA application [7].

AR system:

A mobile system is a system that allows the user to move around by using a wireless system and is not constrained to one place. There are five categories of the mobile system:

1. Fixed indoor system.
2. Fixed outdoor system.

These two categories can’t be moved around, users must use these systems whenever it is set up because they do not use GPS tracking. The fixed outdoor system was discussed in just one paper because of inflexibility.

3. Mobile indoor system.
4. Mobile outdoor system.

The mobile outdoor system uses GPS, unlike a fixed system.

5. Mobile indoor and outdoor system.

One of the systems studied in (method Costanza’s eye-q [49]) is shown in Table(2) below. This is because this system was developed as a persona.

Table (1) and Table (2) show the studies in the table for system types and what is used for every interface, display, and tracking [1][29].

Table (3) shows the meaning of the shorthand for terms used in Table (1) and Table (2).

System type	Method	Application domain						Tracking and registration					Display	Interface
		Advertise	Ent and Edu	Info and nav	medical	General	Optical	GPS	wireless	mechanical	sensor			
Fixed indoor	Bichlmeier et al. [34]				X		IO, OI, MB						HMD	tangible
	Mistry et al. [28]			X			OI					RFID	spatial	tangible
Fixed outdoor	uang et al. [10]		X								X	spatial	tangible	
Mobile indoor	Mageshta et al. [39]		X				ML					Handheld	tangible	
	Lee et al. [23]					X	IO					HMD	multimodal	
	Aravantis et al. [42]		X				IO					HMD	tangible	
	Reitmayer et al. [17]			X			MB				Inertial	HMD	shared	

Table.1 Fixed indoor/outdoor/mobile indoor system

System type	Method	Application domain						Tracking and registration					Display	Interface
		Advertise	Ent and Edu	Info and nav	medical	General	Optical	GPS	wireless	mechanical	sensor			
Mobile outdoor	Chen et al. [46]			X			ML	X				inertial	spatial	tangible
	Wang et al. [48]			X			X	X				inertial	Handheld	tangible
	Schneider et al. [47]		X				X	X				rotation	HMD	tangible
Mobile outdoor and indoor	Mistry et al. [20]					X	X						spatial	multimodal
	Feldman et al. [22]					X				X		Inertial, RFID	Handheld	multimodal
	Costanza et al. [49]					X							HMD	tangible

Table. 2 Mobile outdoor/indoor and outdoor system

Abbreviation	Meaning	Abbreviation	Meaning
Advertise	Advertising	IO	Inside out
Ent and Edu	Entertainment and Education	OI	Outside in
Info and nav	Information and navigation	MB , ML	Mark-based Mark less

Table.3 the meaning of the shorthand

AR algorithm:

When we searched for algorithms used in Augmented Reality (AR) technology, we found that there was no algorithm usually used, since programmers used basic algorithms and developed them to suit the type of Augmented Reality (AR) used. As shown in figure 1 there are six approved algorithms that we found through research and that may correspond to our project. The six approved algorithms that we found through research and may correspond to our project.

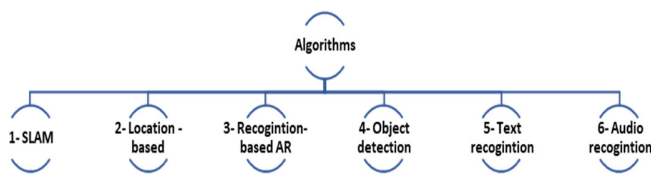


Fig.1 six algorithm

3. Related Work

There is a lot of works using the Augmented reality here we are shows the similar applications of our idea:

Wadi Makkah:

It's the simplest application that makes use of existing augmented reality technology.

We believe it has been launched in the market for testing because it has pull again..A method currently and its purpose is to display the products of the emerging Wadi Makkah Company, which displays 38 products from Wadi Makkah products if the camera is directed over the logo printed in the brochure with the ability to display more details around it at the headquarters on the product..The application shares with us the idea of showing the 3D model without taking photo but our idea shows the user all the model sides and the inside of It. [1]

Taking advantages of augmented reality technology in museum visiting experience (paper):

The study proposes that Egyptian museums by developed with augmented reality technology, for the user downloading the application, accessing the camera, and then taking photos the artifact. There are three options available in the application:

- Display all of the piece's information that is usually only accessible to museum professionals.
- Makes a comparison between similar artifacts for him.
- In all respects, the piece, as some museum pieces cannot be seen from all sides .[2] .This document is similar to our idea in some side which is will display information on the archaeological site in sections rather than all at once, eliminating the need to picture it.

Alkadi (paper):

It's a machine way of creating a map that explains the historical locations in Medina from Islam's early beginnings. Multiple investigations were carried out across several phases to track and record the locations and features of each heritage landmark on the digital map. Finally, an app was released that enables customers to access, analyze,

and explore data stored on landmarks for educational and cultural objectives.

Gafeer (paper):

To document Jerusalem's Islamic architectural heritage, the researcher developed a three-dimensional virtual model using image modeling technology. Due to the inability to document them from Al-Aqsa Mosque due to the security restrictions placed in the area, images from previous literature and other references were used. The world tool kit, which is an application interface for developing virtual reality applications, was to develop the 3D world [3].4. Existing Systems.

4. Methodology

Ain Makkah is spatial displays digital information on physical objects it works on a smartphone as an input device it uses a digital camera to identify the object, GPS to measure the position of the object, accelerometers, and compass uses to measure the directions. It utilizes Marker-based augmented reality to show the history of Makkah Al-Mukarramah for the visitors by projecting a 3D model on Al- Kaaba. An internet connection is not required in the Ain Makkah service because when the place is located the 3D models stored on the application will be retrieved from the application and the historical information will be retrieved from the database based on the period of time that users choose. The application allows visitors to choose the period time to know and show the history.

A. System Requirement

The system requirements are description of functionalities and features of the system. Also, it can explain the characteristics that needs to use in certain hardware or software and involves functional and non-functional requirements.

1) Project stakeholders:

Visitor: Who can contact directly with the application to show 3D models for Al- Kaaba.

2) Functional requirements:

The functional requirements determine the processes and tasks which the system and representatives must perform.

• For system:

1. The user shall give access to the camera.
2. The user shall tap on the Kaaba to show a 3D model of Kaaba before years.
3. The user shall zoom on the Kaaba to show its inside

- For visitors:

1. The user shall point the camera to the place.
2. User should read instructions to use the system.
- 3) Non-functional requirements:

Non- functional requirements are properties or constraints of the system's services or functions such as performance constraints, authorization constraints, constraints on the development process, standards, etc.

- Look and feel requirements

Interfaces will be clear and simple.

The application will have quick responses and smooth movement between different interfaces.

The font color and size will be suitable and clear.

- Availability

We expect the app to be available for the user as soon as they go online the device used must comply with the application system.

- Usability :

We expect the app interfaces and icons to be clear to the user so that it is easy to understand how to use the app.

The application speed responses to user input and commands.

We expect the user to be able to interact with the system efficiently and easily by having a code to inquire about problems that he does not know how to operate.

- Performance :

We expect the application interface to appear in the fewest possible seconds after the user opens the system. Every request must be processed within 6 seconds.

- Efficiency:

We expect system speed to respond to user commands.

B. Proposed Solutions

The proposed solution are explain the basic step in application can achieving system requirement.

1. When a visitor downloads the application and points the camera to Al-Kaaba, the application will identify it and overlay it with a 3D model of Al-Kaaba from years before.
2. The Application helps visitors of Makkah to know the history of Al-Kaaba. using Augmented Reality technology visitors can see Al-Kaaba's history in a 3D model.

5. Use Case Diagram

“A use case collects scenarios. By writing out the main parts of your process, including alternative paths, you'll have a clearer outlook on the scope of your project. (lucidchart.com, 2021).

This diagram shows the user's interaction with the system. Explains the user's role in the system and the powers granted to him. The user allows the camera access system to drop 3D models of the Kaaba and drop historical information on the models, the user can also access the help screen to learn how to use the system shown in figure 2.

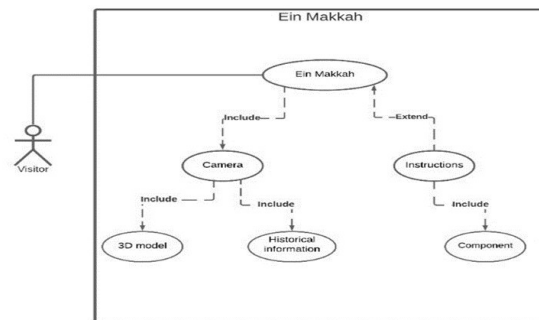


Fig. 2 System's use case diagram.

6. System architecture

The system consists of four components: Database, Pilgrims, and Visitors, Holy Mosque, and Mobile Application. The application can be downloaded for free. The application will enable the user to interact with the 3D module and see the inside out of the Kaaba; also the user will get help and learn the instructions for how to use the application.

The database stores the module of the Kaaba, the historical information, and the instruction.

The user can enter the application without signing in, so the first interface will show the logo interface; see the camera and the instruction button on the homepage; select any expansion to the Kaaba structure, and show the module on the screen. Also, they can see the Kaaba structure from the

inside and out. The user can learn about the application through the instruction. Shows in figure 3 .

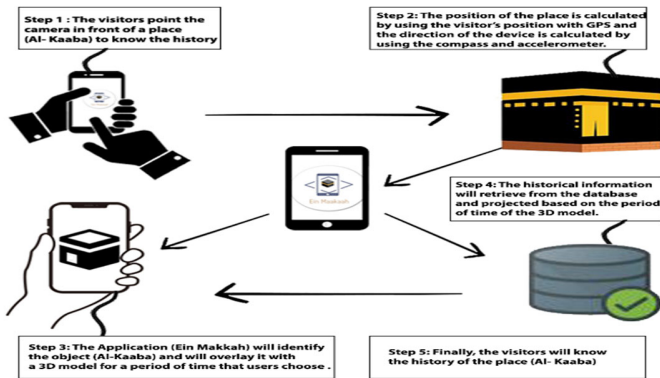


Fig. 3 System Architecture.

7. Implementation

In order to complete the project, by implementing the project idea of the practical part, which entails projecting, a three-dimensional model in a realistic environment. This was performed in three stages as follows:

1-Front-End(interfaces): The first stages are using the Unity application to build the program interfaces and create application interfaces by making them flexible and clear for the user's usability.

2-Back-End (Projection): At this stage, a 3D model of the Kaaba has been created using the Unity application in order to create the process of projecting the Kaaba model while showing all four aspects of the user if the camera is pointed at the Kaaba, and the model will not appear for any other similar shape.

3-Database: The third stage is building a database on Firebase. The historical information was taken from Reasah Alharmain. It's a Saudi government agency responsible for Al-Masjid Al-haram and Al-Masjid Al-Nabawi facilitated by its religious, technical, and administrative departments.

In building Ain Makkah application, we will use this algorithm that have been developed and adopted significantly in Augmented Reality applications and other feature:

1. SLAM (Simultaneous Localization And Mapping) algorithms: which originated in robotics research, can alternatively provide a geometric position for the AR system.
2. AR core: Fundamentally, AR Core is doing two things: tracking the position of the mobile device as it moves, and building its own understanding of the real world .

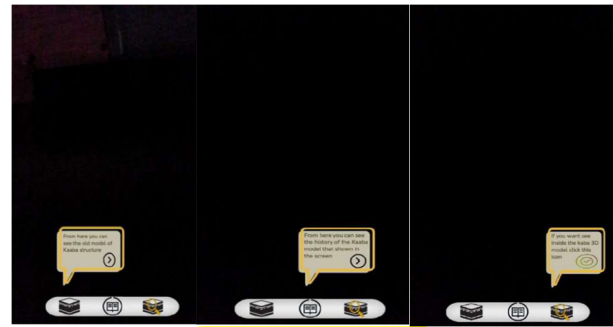


Fig. 4 Instruction interface.



Fig. 5 Interfaces of application.

8. Testing

Test case ID	Test functions	Test steps	Actual results	Pass/Fail
1	Camera Validity	Go to your device settings and go to camera privacy and give the camera the permission for the Ain Makkah app	The camera validation process will be successful and he can start using the program	Pass
2	Camera pointing	After opening the application and giving permission to the camera, point your device towards the Kaaba	The dimensions of the Holy Kaaba, i.e. the stereoscopic, will be known, and therefore the 3D model will be dropped.	pass
3	Pop up	When user open camera the pop up that has the instructions to how use the application will show. The pop up is for all components. The pop up has button when click the button the next instruction will show	The instructions popped up for all components in interface	pass
4	Outside button	After opening the application and see pop up can press the outside button to display what is the years of model	show what is years the model.	pass
5	click on the history button	After opening the application and see pop up can press the history button to display the text in the panel	All custom information about this 3D model will be displayed	pass
6	click on the inside button	After opening the application and see pop up can press the inside button to show how Kaaba from inside	Display Kaaba from inside in image format	pass

Table.4 Test the application for user

9. Future Work

In the future, we are thinking about applying our improvement plan to make the application more adequate than it is. Our plan starts with four point :

- Enable the information narration service by the user's audio system.
- Availability of another service in the application that shows the user a copy of the Prophet's Mosque.
- Availability of an information display service in case the user touches the anthropomorphic, for example (the Black Stone).
- implement an IOS version of the application.

10. Conclusion

In terms of our application's idea, it's an app that uses augmented reality technology by aim the camera at the Kaaba and display a three-dimensional model of the Kaaba's shape in a specific model of expansion from outside and inside, as well as information on the Kaaba at that time. There is another service that will help users to understanding how to use the application without any need for learning. By doing an Internet search or ask about application's operation, this service called instructions.

Modern technologies and software are employed in this project, and programmers will find it simple to learn how they are programmed. These technologies can be used in a variety of other industries, including education, since an application might be developed to display science, tourism, and so on. These technologies were used in this effort to illustrate the history of Makkah. Visitors can learn about history through 3D objects rather than just images and information.

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