3D Virtual Reality Using 360 degree Photography for *Umrah* Training

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ABSTRACT
This paper investigates and proves the potential of using 360 Degree Photography technique in developing Virtual *Umrah* application. This technique serves as an interactive tool to enhancetechnology based on learning and training and these findings lead to the idea to develop Virtual *Umrah* application. These techniques are dividedinto two components namely Virtual Environmentand Virtual Object. The Virtual Realityof 360 Degree Photography technique is a learning based environment, essential to help educators overcome the limitations in traditional training sessions. This technique is beneficial to help users to understand better by providing the simulations of real-world using image based model with high degree of realistic user experience and interactivity. The Virtual *Umrah* modules show the real activities of the *umrah* ritual and help to generate ideas to pilgrims on what they have learnt.

Keywords: **360 degree photography, virtual environment, virtual object, rendering, *umrah***

1. Introduction

Information and communication technology (ICT) refers to the technology of acquiring, storing, processing, and disseminating information through the use of computer technology and telecommunications (Hameed, 2010). Recent advances in ICT have affected the way teaching and learning (T&L) is delivered in the training. Training is one of the most important aspects which need to be continuously improved parallel to the development of the nation. This is to ensure that the future generation is well-prepared to be competent in the new technologies. Prospective *umrah* pilgrims, especially in Malaysia will usually turn up in a training session to prepare themselves before performing *umrah*. Normally, this training is included in the *umrah* packages by travel agencies. Training sessions conducted by instructor run using traditional method of power point slides for presentations. Depressed, majority the agencies only use flyers or pamphlets as a method to deliver relevant information for future pilgrims to perform *umrah*. So, this problem has caused misunderstanding on how the exactly practicing the ritual of *umrah*. Rahim et al. (2013) presented a framework as a guideline to the other researchers in order to provide a realistic experience for user in performing *umrah*. Thus, the misunderstanding of the ritual of performing *umrah* can be solved.

In the field of informatics and computing, virtual reality (VR) technologies have been identified as a tool that able to provide information accurately and clearly for potential *umrah* pilgrims during the training. Techniques 360 Degree Photography (360 DP) is one of the techniques in image-based modeling approach that able to provide an initial overview to

pilgrims about the real situation in Mecca or Medina. With this technology, the learning process of rituals in *umrah* can be more explicable and also able to give real experience to pilgrimsduring training session. At the end, the pilgrims feel more confident to do *umrah* rituals if this technology is been used during the training session.

360 DP techniques have two components namely the virtual environment and virtual objects. Virtual environment is represented as an environment component in Virtual *Umrah* (VU) with represented or visualized the panoramic in the Mecca or Medina such as are of Miqa, Tawaf, Sa'i, Shaving, Ziarah and so on. These components can serve as a virtual tour for pilgrims. In this component, the features such as hotspots and maps used to assist the pilgrim in navigating, manipulating and control the virtual environment to avoid lost in the virtual tour. Components of virtual objects are represented as an object like pilgrims apparel ihram, prayer veil, equipment for the needs of the visit, an important monument and so on. Virtual objects will also be used as a hotspot in the exploration of VU.

In this paper, the discussions are focusing on designing virtual environment for VU using 360 DP techniques in technically. This can bring great contribution to *umrah* pilgrims especially in learning and practicing the *umrah* rituals in sequence. Component environment and virtual objects will be described in detail. In addition, image-based modeling approach will also be discussed.

2. Related Work

In this section, we will describe relatedwork that associated with the use of image based model in virtual environment. Then, we also study any related research regarding virtual *umrah* or hajj.

2.1 The use of Image based model (IBM) in Virtual environment

There are three types of virtual reality application in modeling techniques that have been classified as Geometric Based Model (GBM), Image Based Model (IBM) and Hybrid Based Model (HBM) (Arif et al., 2009). VR applications in the category of GBM have greatly developed (Liarokalis, 2004; Bergumusco, 2001; Kaczmarek, 2008; Gabbard, 1999; Oyarzun, 2005). The GBM is an approach that used geometric source. This approach is produced using any multimedia such as 3D'S Max, Maya, AutoCad and so on. In contrast, IBM in which resources for designing virtual reality applications are from the original image. HBM is a combination of IBM and GBM.

IBM approach has several advantages, firstly it yield high image quality and faster rendering process. The environment can be visualized as a real image using techniques 360 DP. In addition, IBM is able to provide an interactive panorama environment enable the control environment using mouse and keypad only to explore the environment. In addition, by using this approach, the users can get a real experience as actual in the environment.

According Sommerer (1999) the use of image is very useful and important in a virtual environment. Arif et al., (2009) describe that IBM is an effective alternative to traditional methods of virtual reality techniques. This model is constructed by using the images to create a virtual environment (Fleishman et al., 1999). This model has been widely used in various applications in virtual tour (Fay and Zhi-Hao, 2008). IBM technique derives from a combination of original images taken by the camera and lens that are appropriate to form a panoramic image.

The approach uses to determine the level of the more obvious realities for using images of real resources, thus helping to increase the level of feeling as immersive in a real environment. Furthermore, the use of images can solve some of the problems inherent in traditional learning for virtual reality techniques to create an interactive panoramic environment. It is also enable users to experience like being in the real world (Arif et al., 2009).

2.2   Virtual *Umrah* or Hajj
The growths of Information and Communication Technologies (ICT) have caused the volume of learning materials in recent years accelerated dramatically. The sudden surge in the amount of the learning materials has initiated to issues regarding the quality of the existed materials. According to M.Fitri et al. (2011) there are many existing *umrah* supplementary learning materials in the market but has failed to provide clear understanding to users, particularly the pilgrims. The authors also have stated that the existing learning materials styles of *umrah* should be altered into an active learning method to offer a better learning aid to the users (M.Fitri et al., 2011). Similarly, Hameed has suggested an educational model of Hajj to provide trusted and comprehensive information on the whole process of Hajj and related activities. Apart of that, from his literature reviews and surveys, he discovered that very limited learning materials pertaining *umrah* in the market (Hameed, 2010).

Besides the issue of quality learning materials, the issue regarding the methods of delivering is also a concern. Existing software only uses conventional methods such as texts and pictures in delivering knowledge about *umrah*. This situation leads to misunderstanding among the pilgrims especially on *umrah* activities. There are lots of researches that have been conducted to overcome the limitations. M.Fitri et al. (2011) in his research has recommended of using multimedia authoring technique that integrated with virtual environments and persuasive technology design. Moreover this proposed technique can offer supplementary learning materials that support active learning and self-directed learning environment. Other than that, the authors also have developed a 3D simulation that uses virtual environment technique called 3D Tawaf. This 3D Tawaf simulation acts as an interactive training method for Hajj education in Malaysia by providing user a scene of Tawaf (one of Hajj pilgrimage rituals). The main contributions of virtual environment technique are to provide flexible control for the users and deliver a user-friendly and flexible environment (M.Fitri et al., 2011). Yasin et al. (2012) has also proposed virtual environment technique to simulate real environment in performing one of the rituals in Hajj. The virtual reality is been implemented in assisting the pilgrims in their training of Sa'i. The Sa'i training is developed in 3D environment using an avatar so that Hajj trainers can be totally immersed into real environment through the simulation and thus increasing their understanding on the ritual of Sa'i effortlessly.

Many existing websites regarding hajj and *umrah* usually have neglected few important aspects in designing a website such as useful and usability concepts. According to Al-Aama (2008) to accommodate those problems, the author has introduced six steps of methodology in designing a website that are based on user-centered approach. This approach focuses on the users or pilgrims. It starts by identifying the requirements, followed by building of a prototype, then executing usability testing and lastly is the process of evaluating the design. This proposed methodology can produce a usable website for a pilgrim to find the intended information easily and smoothly.

3. 360 Degree Photography

360 DP techniques are implemented in this study. Thus, photography skills are needed to produce 360 DP. There are two components involve namely virtual environment and the virtual object components. In this section, we give detailed explanation of each component used in the study. 360 DP is a technique categorized as IBM in virtual reality technology (Othman et al., 2002; Fleishman et al., 1999). This technique can be used to create a virtual environment that allows users to view a 360 degree panoramic view make the choice to see the sights in a dynamic and exciting environment and creating consumer curiosity which in turn will continue to explore the environment. Pilgrims can explore the environment using the features such as hotspot, the panoramic controller and a map that showing the location of the pilgrims.

3.1 Virtual Environment (VE)

VE components consist of panorama include planar, cylinders, cubes and spheres as shown in Table 1. Cube panoramic is selected to be use in this study that represent the environment from 360 horizontal and vertical views. The cube panoramic allows the pilgrims to view, navigate, manipulate and control the virtual environment using the input and output peripherals flexibly and comprehensively. The pilgrims are able to move around the Kaaba, perform the rules of Sa'i and walk through the area of shaving where the pilgrims can see and identify the nearest store. 360 DP is a technique categorized as IBM in virtual reality technology (Othman et al., 2002; Fleishman et al., 1999). This technique can be used to create a virtual environment that allows users to view a 360 degree panoramic view, make the choice to see the sights in a dynamic and exciting environment and creating consumer curiosity which in turn will continue to explore the environment. Pilgrims can explore the environment using the features such as hotspot, the panoramic controller and a map that showing the location of the pilgrims.

Table 1: Types of panoramic and indication

Types of panorama	Regular
Planar	Panorama of horizontal lens "wide-angle". There is a straight line that forms a curve in the image without distortion while flattening curve shows no picture.
Cylinder	Panorama of cylindrical lens manufactured using "wide-angle" taken in "single-row". Panorama of this type will not be generated if using a lens of "fish-eye".
Cubic	Panorama of the cube placing observers in the middle sphere. From the position of the observer can look left and right and up and down. To produce a panorama of the cube, the designers have to take the picture 360 degrees from left to right, 45 degrees from above and below 45 degrees of view.
Sphere	Panorama of the same as the cube, but the difference is the decision resulting image is a single image using the lens "fish-eye".

In 360 DP techniques, there are two types of view which are inside-out view and outside-in view. Inside-out view can generate the virtual environment whereas outside-in view can produce virtual objects. The inside-out view is a concept that indicates a user standing in the middle of an area and see around him. The maximum exposure is equal to or less than 360 degrees, as shown in Fig. 1 in the form of either a horizontal, sphere, cylinder or cube (Andrew, 2003). The image will be displayed in the form of horizontal or vertical. If the image is taken as 360 degrees, it is a full panorama while if taken less than 360 degrees about half of it is panoramic. By using the panorama technique, the user is able to interact with the system by moving around the environment either left or right, to zoom in or out, and move to another hot spot.
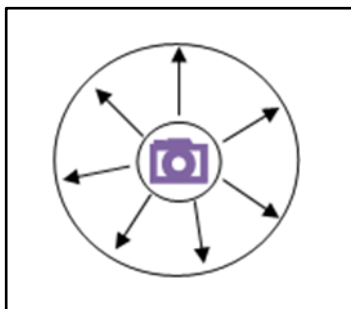
Fig 1. Inside-Out View Technique

3.2   Virtual Object (VO)

The virtual object can be produced using the outside-in view in the 360 DP. In this technique, the pilgrims can view and manipulated the virtual object such as the ihram, Kaaba, Hajaratul Aswad and others in 360 degrees. With the virtual object, pilgrims can navigate ihram attire component such as turning the object in 360 degrees and information on each hotspot available on the object.

Technical concept of virtual reality panorama method enables the control object model. The technique is implemented in the component of object. The components of the object can be viewed as a whole 360 degrees by rotating the object but limited to only look at the exterior. In this technique, the camera will be placed on the outside of the object with the static but the camera around the object 360 degrees. Fig. 2 shows an outside-in view.
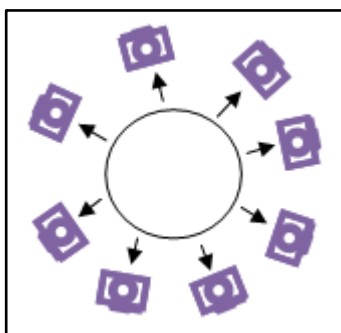
Fig 2. Outside-In View Technique

3.3   Stitching Image Process

Arif et al. (2009) defines that the stitching is merging several images with superimposed FOV (field-of-view) to produce a panoramic image. Stitching process is a combination of both vertical and horizontal images that will form a panoramic image. The combination of these images will produce images in a 360-degree panorama. According Othman et al. (2002) stitch is the process of blending a series of photographs, taken in a circular view, into- one seamless panoramic image, which is automatically generated. These images were than systematically stitched and aligned to provide a 360 "panoramic view".

According Shenchang (1995) the purpose of the stitching is to produce images of panoramic images obtained from a combination of images. Images from a camera with a 360-degree, turn in one direction only. The camera is placed at the center environment using a tripod. Fig. 3 shows the assembly and the position of the camera with a tripod to capture the images that will be combined.
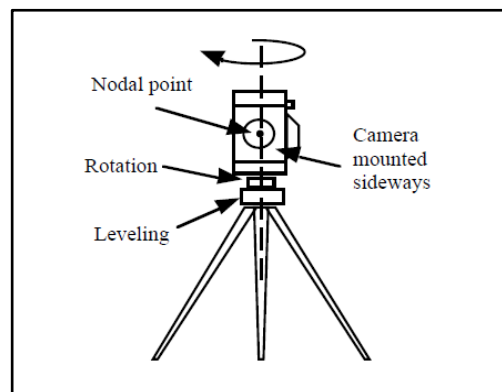

Fig 3.Camera installation
Source: Shenchang (1995)

The stitching process is also known as the implementation of an image combining a collection of images that have a Field Of View (FOV) small for producing panoramic images that feature a large FOV. Features a large FOV required to produce the resulting panoramic because the scenery is very broad and could allow consumers like you're in a real environment. So, it is required to determine the level of reality that high when users explore tour of VU applications. Fig. 4 shows the hierarchical stitching process images to produce a panoramic image.
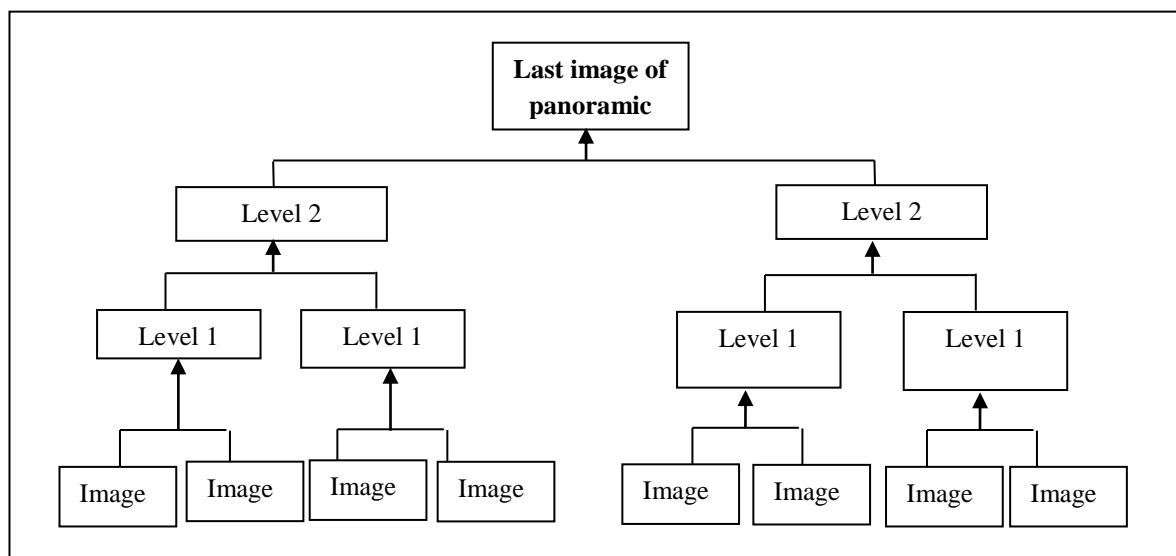
6

Fig 4. The Hierarchy of Stitching Process
Source: Arif et al (2009)

The elements of 360 DP using cubic panorama of modules implemented in Sa'i, Shaving, Visits and Miqat. In Sa'i module, Cubic panoramic developed to describe the environment in Mount of Safa and Marwah. Then, in shaving module, shop for shortening the environment is described using this technique. The module of visits also implements this element in which all the important places of visits in the module are visualized in VU. In the state of Ihram, the picture described by presenting an environment that should be visited by pilgrims of *umrah*. The Fig. 5 below shows a diagram of cubic panoramic implemented in the VU application to provide a more clear and precise to *umrah* pilgrims.
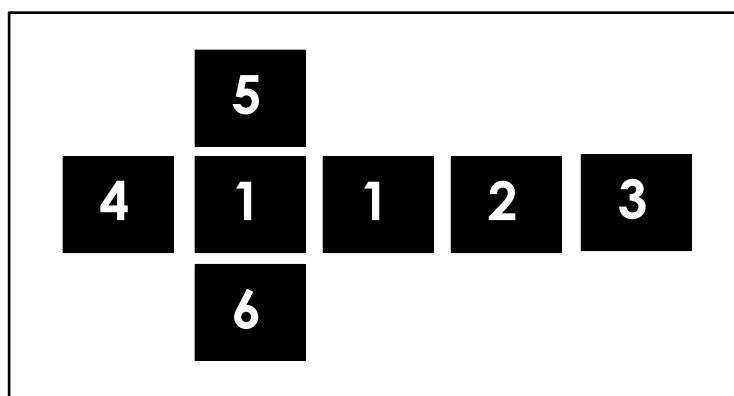

Fig 5. Illustrations of the Cubic Panoramic

360 DP techniquehas been identified as a technique that can be used in the development of VU. 360 DP technique was determined to be used in the study because it can presents a real of environment in pursuing ritual of *umrah* in the form of a virtual reality that allows users to interact in three dimensions. This technique requires only a source of original images that can reflect better the actual visualization of the *umrah* environment. Implementation of these techniques can save time and costs. Thus, a technique identified is suitable for use in the study. Fig. 6 shows the process of 360 DP techniques in virtual *umrah* development. This technique is adapted from Rahim et al. (2011) that used this technique in virtual museum environment.

In this technique there are two components involved environment and object. In VU application, the environment component shows the panoramic of the environment when the pilgrims perform the ritual of *umrah*. Cubic Panoramic has been selected in VU. The process of capturing image is realized by photographing objects in 360 degrees. The inside-out views technique is used to create the environment component. Then the object component can show the artifacts that can be found in the gallery and can be manipulated in 360 degrees. Image can be produced by capturing the image in 360 degrees. For this component, the outside-in views technique is used. When the images have been produced, the rendering process will be conducted to create an interactive virtual tour. In this process, the images from the environment component and object component will be merged through stitching process. Thereafter, every component will be included hotspots according to the needs of each component, and finally, every component will be linked together by using node to form a complete virtual tour.
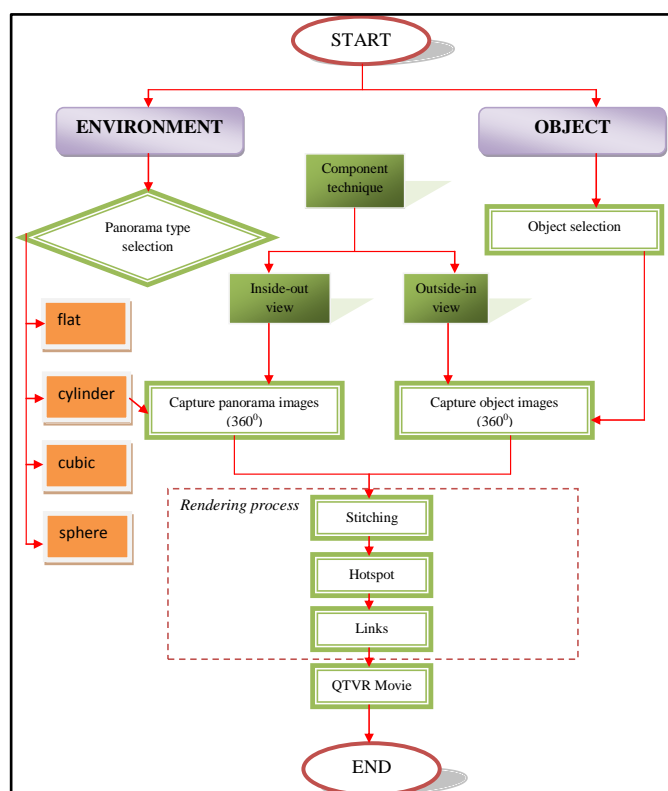

Fig 6. 360 Degree Photography Technique

4. Image based Virtual Tour navigation

From the scene representation point of view, the panoramic view is the collection of all light rays toward one specified position (Kabisch, 2005). The parameters determine the range of viewing directions. For the cubic, spherical and cylindrical panoramas, different viewing direction ranges are used. This application will also enable users to navigate from their starting point to other place according to their own needs. Hot spots are created to identify regions of an environment and object for interactions, such as navigation or activating actions.

This application enables users to walkthrough around the application. The idea is to give users an idea of what exactly happens in ritual of *umrah*. Few hotspots are prepared for users to further explore the environment and object too. This will help the user's understanding of the process or activities involved in the ritual of *umrah*.

5. The Navigation, Manipulation and System Control of Virtual *Umrah*

VU is purposely designed for directing pilgrims to what they are going to perform after they learn the steps by steps the ritual of *umrah*. The VR system provides users with panoramic view of the locations where the pilgrims need to perform the ritual such as Tawaf, Sa'i, Shaving and Ziarah. The objective of this system is to give an idea of how the actual environment in the Mecca and Medina looks like.

Stitching of images will be collaborated with proposed framework to be published as the application. This application will also provide users as the real pilgrims to get involved in performing the ritual of *umrah* even though they do not in the Mecca. This will help them to enhance the sense of belonging to the environment.

At the beginning of the module, the pilgrims will be presented to the introduction or overview of the *umrah* rituals such as the preparation and rules. Next step is where the user will go through the virtual environment. During this step, users will experience individual virtual walkthrough and they will performed assign task where they need to follow the steps by steps. This is where interaction involved and users generate their own understanding with self-learning in performing *umrah*. Then, user can repeat the steps according their choices until they can fully understand how to perform *umrah*. This phase require user to make use the information and experience they already gone through.

6. Results and Discussion

In this section, we discuss in detail about 360 DP techniques that has been applied throughout the implementation of VU. 360 DP consists of two components namely virtual environment and virtual object.

6.1 Virtual Environment

Fig 7. Output of Virtual Environment: Scene Panaromic

Fig. 7 illustrates the outcomes of using virtual environment in VU application. The virtual environment component in this application is panoramic environment in Sultan Mahmud International Airport. Eight different POV images of the environment are captured and have been applied with inside-out view technique. Then to propose a cubic panoramic environment, up and down images are also captured and combined with existed eight images as mentioned above.

6.2 Virtual Object

Fig 8. Output of Virtual Object: Steps in Usage of Ihram Clothing

Fig. 8 demonstrates the outcomes of using virtual object in VU application. The virtual object in the application is an individual that wearing ihram. Nine POV images are captured and have been applied with outside-in view technique.

7. Conclusions and Future Work

This application described in the paper is needed for pilgrims' usage since it is difficult for them to go to the Mecca and Medina for practice because of the long distance. Many VR advantages have been highlighted in this paper. Instructors must work harder to find a way to implement Panoramic VR in knowledge sharing. Hence, there are some elements which might differ if VR is to be implemented in other subjects. The ritual of *umrah* needs pilgrims to be actively involved throughout the process in order to understand the steps of *umrah* ritual and also to get a real visualization of the real environment in the Mecca and Medina. For future work, developers can also come up with an option of detecting others pilgrims' position during the walkthrough as a collaborative walkthrough. While, they can communicate with the instructor to enhance collaborative learning. The 360 DP VR can further enhance to other VR applications which will enable users to implement the multi-sensory experience around the environment.

References

Al-Aama, A. (2008). A Proposed Framework for the Development of Web-Based Systems for the Service of Muslim Pilgrims. Science, 20(2), 55-75.

Andrew, P. (2003). 3600 Photography. Switzerland: Rotovision SA.

Arif, W.N. W. A., Ahmad, W. F. W., Nordin, S. M., Abdullah, A. and Sivapalan, S. (2009). Designing 3 Dimensional Virtual Reality Using panoramic image.

Bergumusco, M., Avizzano, CA. Di Pietro, G., Burbagli, F. and Frisoli, A. (2001). The Museum Of Pure Form: System Architecture.

Fay, H. and Zhi-Hao, L. (2008). Stereo Panorama Imaging and Display for 3D VR System.

Fleishman, S., Chen, B., Kaufman, A. & Daniel, Cohen-Or. (1999). Navigating Through Sparse Views.

Gabbard, J. L. (1999). A Taxonomy of Usability Characteristics in Virtual Environments. Faculty of the Virginia Polytechnic Institute and State University.

Hameed, S. A. (2010). ICT to serve Hajj: Analytical study. International Conference on Computer and Communication Engineering (ICCCE'10), (May), 1-7. IEEE.

Kabisch, E., Kuester, F., Penny, S. (2005). Sonic Panoramas: Experiments with Interactive Landscape Image Signification. In: Proc. of International Comprehensive Anatomical Terminology, pp. 156–163 (2005)

Kaczmarek, A.L. (2008). Exploring Contexts of Use of Cultural Objects in Virtual Museums. Proceedings of the 2008 1st International Conference on Information Technology, IT. 19-21.

Liarokapis, F.,Sylaiou, S., Basu,A., Mourkoussis, N., White, M. and Lister, P.F. (2004). An Interactive Visualisation Interface for Virtual Museums.

M.Fitri,Y,A, Nasir, Z, Norfadziana, F.M. (2011). Virtual Hajj (V-Hajj). IEEE Conference on Open System (ICOS2011), September 25-28, Langkawi, Malaysia.

Othman, Z, Yaakub, A. R. and Zulkifli, A. N. (2002). Virtual Environment Navigation Using an Image-Based Approach.

Oyarzun, D. and Ortiz, A. (2005). Different levels of interaction in a Virtual Environment.

Rahim, N., Wook, T. S. M. T. and Zin, N. A. M. (2011). Developing Conceptual Model of Virtual Museum Environment Based on User Interaction Issues, IVIC'02, Lecture Notes in Computer Science, Springer, ISI Science Citation Expanded, pp: 253-260

Rahim, N., Isa, W. M. W, Rozaimee, A., Hamid N. A., Satar, S. D. M. (2013). A Survey on Components of Virtual 'Umrah. The International of Multimedia and It's Application (IJMA).Vol.5 (5). ERA

Shenchang, E. C. (1995). QuickTimeÒ VR – An Image-Based Approach to Virtual Environment Navigation.

Sommerer, C., Mignonneau, L. and Lopez-Gulliver, R. (1999). Time-lapse: an immersive interactive environment based on historic stereo images.

Yasin, A. M., Darleena, Z., & Isa, M. A. M. (2012). Avatar Implementation in Virtual Reality Environment using Situated Learning for "Tawaf". Procedia-Social and Behavioral Sciences, 67, 73-80.