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AUGMENTED REALITY BASED DESKTOP HISTORY LECTURE: WONDERS OF THE WORLD WITH ANIMATED AGENTS

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Abstract

Use of Augmented Reality (AR) is widely studied in the context of cultural heritage with applications displaying buildings which existed in the antiquity, yet unfortunately stand as ruins today. In this study, we present a mobile application for demonstrating the use of AR as a means of learning history. Seven wonders of the world were taken as a sample lecture. 3D augmented reconstructions of the ancient buildings are reconstructed based on the original reconstruction drawings by archaeologists. These buildings are then displayed on a flat surface where markers are placed. Text overlays are also used to display the history about the wonders of the ancient world. The application is expected to increase student motivation and enthusiasm to learn more about the world heritage.

Keywords*:* Augmented reality, wonders of the world, desktop history lecture, cultural Heritage.

Introduction

Augmented Reality (AR) is a method to blend the real world imagery with computer generated artificial objects (Azuma, 1997). In other words, AR is an extension of a user's environment using artificial contents. As the nature of real world imagery, most of the augmented objects are 3D to make the synthetic objects suitable to real world. AR aims to simplify real world with helper objects like information boxes, live stream videos and etc. Also, another aim of AR is generating non-existing objects in real world to understand them properly. AR has been getting more popular day by day because of development of mobile, 3D headset devices, thanks to developments in computer graphics technologies and increasing computational power in those devices (Rivera & Meulen, 2014). As a result more realistic results can be achieved, making AR to be presented to a wider community (Azuma, Baillot, Behringer, Feiner, Julier, & MacIntyre, 2001). Therefore, AR is a newly research area for both academy and industry. Cultural herit-

age is hard topic to learn and teach without visual facilities. Besides, there are not many resources for each cultural heritage or not enough visualization to provide a thorough understanding (Kaufmann, 2003). Development of AR technologies contributed to cultural heritage by showing ancient or maybe non-existing objects onto real world (Koyuncu & Bostanci, 2007). For instance, Temple of Artemis at Ephesus which remains only one pillar today has been reconstructed. The only remaining structure among the seven wonders of the World is the Great Giza Pyramid in Egypt. Therefore, it is important to reconstruct these ancient structures. One usage of AR in cultural heritage is showing antique buildings as their old structures. So, that method helps to those antique buildings stay the same even though they were reconstructed. Another but similar thought is that instead of reconstruction in real buildings, we can reconstruct those buildings in AR world. Those approaches are accepted by archaeologists because of reaching new generations as the same as original buildings in both thoughts.

Background

Augmented Reality is a computer graphics problem. Instead of solving detection, tracking and other problems about AR and computer graphics, here we focused on other problems like accuracy and visualization of seven wonders of the World buildings properly. There are two main approaches for AR object tracking and positioning; marker-based and markerless (Bostanci, Kanwal & Ehsan, 2010). Marker is an element to identify the position of the artificial objects to render that object onto that marker. The marker should be as unique as possible to be vary from all other objects in the environment. The markers used in the study are shown in Figure 1. Those markers are a small copy of the models with an indicator images. The latter method mentioned earlier is the markerless systems. In same cases marker based systems is not efficient or not suitable at all instead of that markerless tracking systems could be used for specific problems such that outdoor or Geolocation based AR applications. That applications of AR is easier to use and implement using markerless tracking systems, that is why that method is more suitable. Another approach of implementing markerless tracking system is using feature extraction in the camera image to place the model on a osition or a place. In this method, the captured image from camera should be processed to extract the features and decide where the artificial object will be placed on (Bostanci, Kanwal & Clark, 2015).

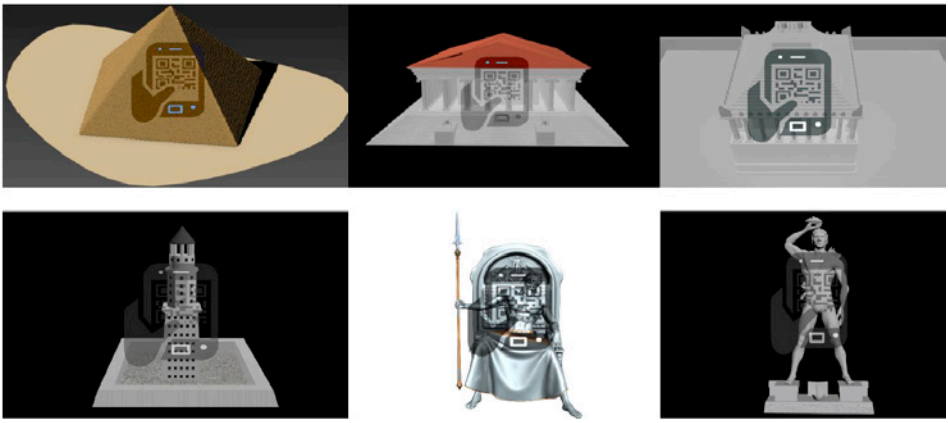

Figure 1: Markers for the models

Wikitude

Wikitude is a multi-platform Augmented Reality Software Development Kit (SDK) which was used here to detect and track marker objects. There are several SDKs for Augmented Reality in the wild as a product both in open source and closed source however most of them have the same capabilities and the same technologies used and they all have mastery on different aspects (Van Krevelen & Poelman, 2010). The following SDKs are the most popular among AR researchers; Wikitude, ARToolKit and Vuforia SDK (Amin &Govilkar, 2015). Wikitude has a large developer community and hence detailed documentation for developers in their website. Wikitude SDK for Android Javascript API and Wikitude SDK for Epson Moverio was used. Both SDKs use Javascript to define targets, objects which will be rendered, actions, music and other objects to support other synthetic objects.

Model Creation

Cultural Heritage may be the most important assets of the World history. So that, it should be clearly explained and reach to the students as accurately as possible to the original structures (Wolfenstetter, 2007). Because of those concerns, in this paper, we made use of reconstruction maps and images of seven wonders of the World which have been drawn by archaeologists. As seen in Figure 1 above, the markers consist of minimal size of the models which are created. There is a small icon in the marker which

looks like a mobile phone and a hand image which emphasis of scanning that image. Those markers will be placed on the desktop to show these models in students' desktop while studying these historical structures in a class environment. The models placed on the markers were generated in 3D Studio Max. The output file format of the 3D Studio is not suitable for Wikitude SDK. For this reason, the output had to be converted to WT3 Wikitude SDK supported format. There is an encoder in Wikitude toolbox to make the conversion. The output of the Wikitude 3D Encoder is suitable to render in the Wikitude SDK and place it on any marker. Wikitude Target Manager is required to create the targets which is actually markers. All the markers are combined in a WTC file and the file is given to the application which works with Wikitude SDK.

Great Pyramid of Giza

Great Pyramid of Giza is the oldest and the largest pyramid among the pyramid complex in El Giza, Egypt. As described above, Great Pyramid of Giza is the only one of the seven wonders of the World which remains safe today. The most impressive parts of the pyramid for visitors are the scale of the building, considering the engineering capabilities of the time. The pyramid height is 137m which was used 3 - 15 tons of granite blocks in construction of the pyramid (Edwards, 1972).

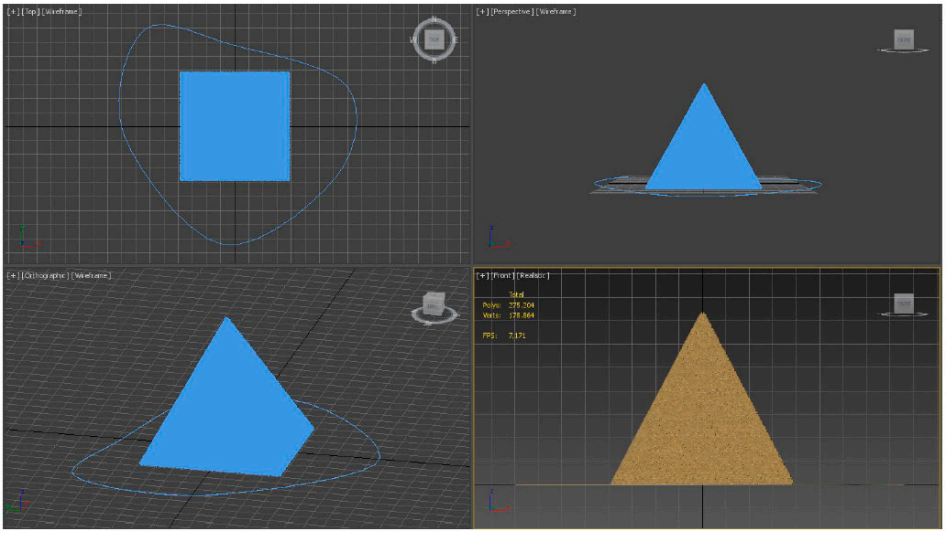

Figure 2: The Model of Great Pyramid of Giza

The pyramid shown in the Figure 2 has the real sizes as the Great Pyramid of Giza with scale of 1/2 in all axes. When rendering the model the image is scaled to approximately 1/60 size and that makes the model to scale at 1/120 of the real sizes when rendering and showing to user to make the model suitable for desktop. Also, there is another scaling factor used here for the marker sizes. The second scale operation combined the scale ratio with marker scale to generate the real scale ratio. That should make the model whether so small or so big (Woldegiorgis, 2014).

The pyramid was constructed by heavy blocks and that makes the view of the pyramid getting irregular and random. In this paper, those blocks has been created irregular to emphasis the same feeling effect of the pyramid . 3D Studio Max offers a tool that helps to create the irregular distribution of an object onto another object. To achieve that view of the pyramid, the primitive pyramid model is created in the expected sizes and rotation with a primitive box object created in any sizes and rotation because the object will be distributed on the pyramid. The Subdivide modifier of 3D Studio Max makes the pyramid object splits into small object pieces. The scatter object which is listed in compound objects makes the distribution the box object onto the sub-objects of the pyramid. At the end of the processes and the tuning, the model resulted the view which is shown in Figure 3.

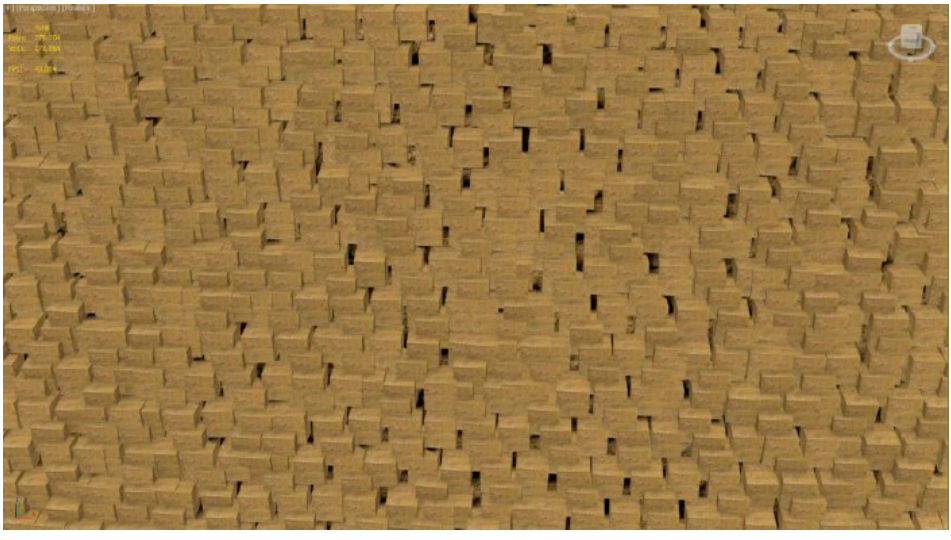

Figure 3: Irregular distribution of blocks in Great Pyramid of Giza

The Temple of Artemis at Ephesus

The Temple of Artemis was constructed three times in the ancient time but today it has been remained only one pillar. The third phase of the Temple of Artemis comprised of more than 127 pillars (Bammer, 1972). However the model which was created for this paper contains 100 pillars because of high polygons count and low FPS (Frames per Second) problem. Another approach to overcome the problem is reducing the detail in the model. The most detailed part of the model is that the pillars and their surface. However there is a trade off between detail and the pillar count. The second approach, reducing count of the pillars is not suitable to present the real history however the first approachmakes the model more The Temple of Artemis was constructed three times in the ancient time but today it has been remained only one pillar. The third phase of the Temple of Artemis comprised of more than 127 pillars (Bammer, 1972). However the model which was created for this paper contains 100 pillars because of high polygons count and low FPS (Frames per Second) problem. Another approach to overcome the problem is reducing the detail in the model. The detailed and less complex. Therefore the model contains less number but more detailed pillars inside. The reconstruction of the Temple of Artemis is shown in Figure 4 below.

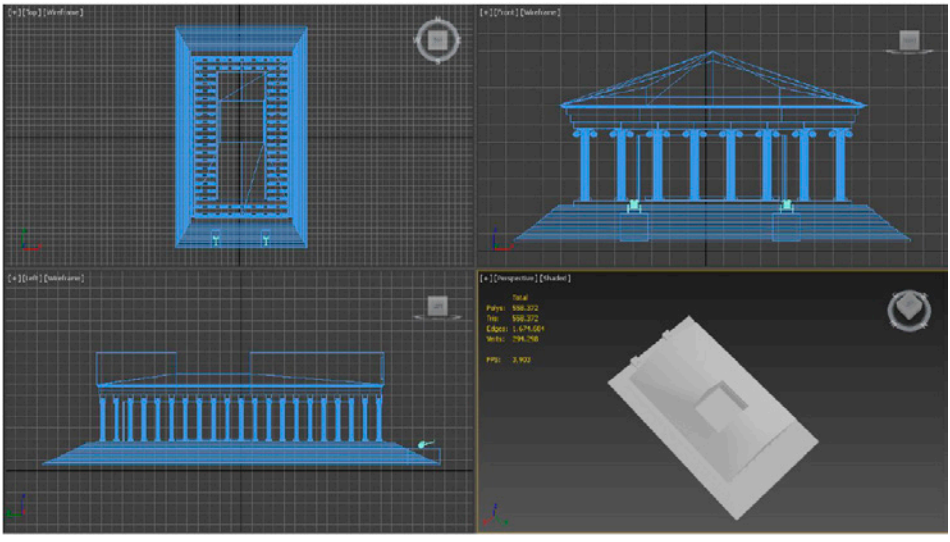

Figure 4: The Model of the Temple of Artemis at Ephesus

The pillars can be created by adding a cylinder and subtracting the 12 small sized cylinders. The small cylinders should be pass round the main cylinder before subtraction. At the end of the modeling the result will be shown in Figure 5.

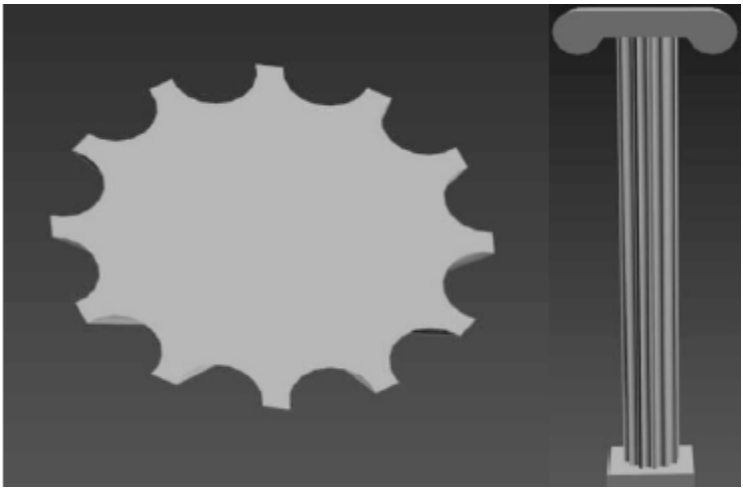

Figure 5: The Model of the pillar (top and front view)

Other details in the created model are the carriages and pool. The carriages have been added the model because of the paintings of the temple shows that the temple could have two carriages in front of the entrance. The model of the carriage was obtained from third party model repository and imported into the project. All other models and minimodels which are shown in the paper is built for this study from scratch. There is no information about the top view of the temple so the pool which is shown when user looks in the top view was put to enrich the model. The Artemis model is created in real sizes with scale factor of 1/3. In the application there is an additional scale factor with 1/180. As described in the above section, there is another criterion in the scale, marker sizes.

Mausoleum at Halicarnassus

The Mausoleum at Halicarnassus was built by 4 Greek sculptors which created each side of the mausoleum (Cook, Ashmole & Strong, 2005). The Mausoleum was 45 meters long and the Mausoleum has been created in real sizes without any scale factor in modelling. As described previous models the same rule applies to the Mausoleum, in the application there is

a scale factor with 1/180 and there is another criterion in the scale, marker sizes. The reconstruction of the Mausoleum at Halicarnassus is shown in Figure 6 below.

There are two carriages and 37 pillars in the 3D model of the Mausoleum at Halicarnassus and these are the same as the objects which was used in Temple of Artemis. The one of the reason to use the same objects in the two wonders is that one of the four sculptors who built the Mausoleum at Halicarnassus had managed the rebuilding of Temple of Artemis. The Mausoleum originally contains 10 pillars each side but there are 9 pillars each side in this work because we need to put proper size of pillars onto the original size of the floor. The stairs design in the top was made of a simple box object and array tool in 3D Studio Max. The array tool helps to decrease length of sides of the box object in each layer gradually. So the Mausoleum model can emphasis the same stairs as original one.

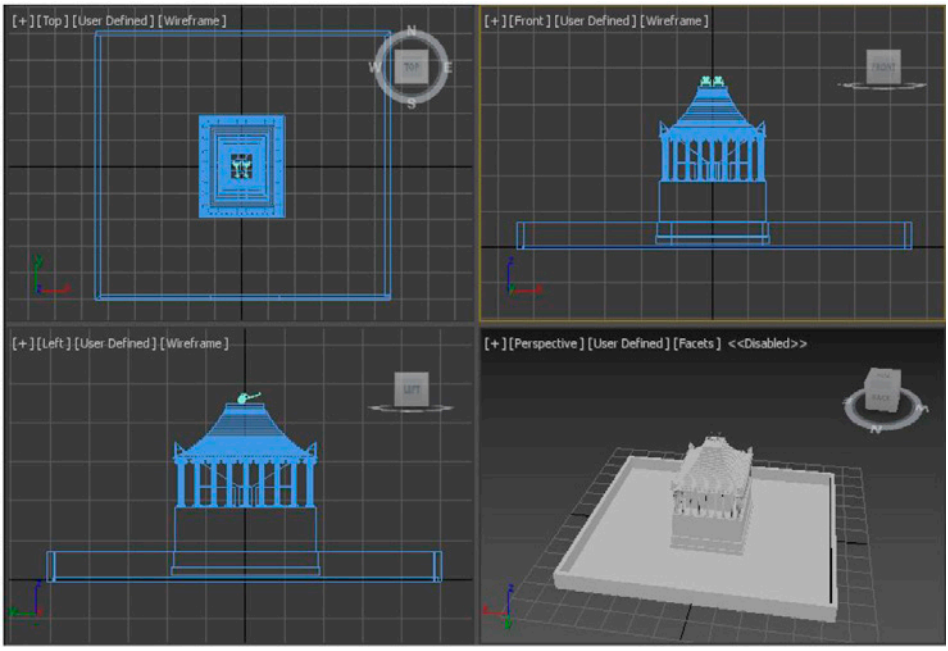

Figure 6: The Model of Mausoleum at Halicarnassus

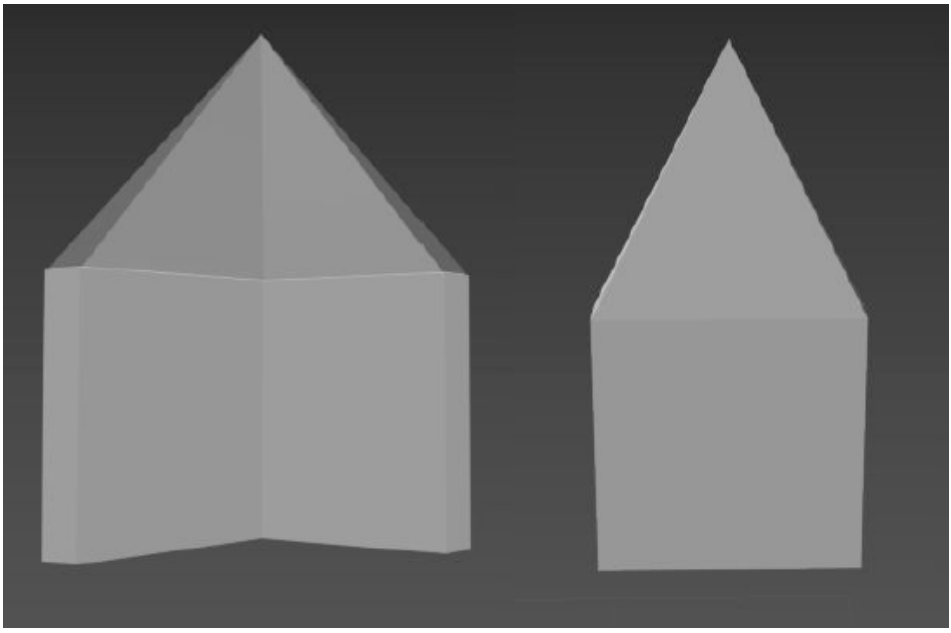

Figure 7: The Model of the decorations

The top side of the model contains 4 corner decorations and 58 side decorations which are shown in Figure 7. The corner decorations are made of 2 boxes in bottom and 2 pyramid objects in top. The side decorations is made simpler than corner objects. The objects used in the side decorations is a box object and a pyramid object.

Lighthouse of Alexandria

The Lighthouse of Alexandria, also called The Pharos of Alexandria, was the tallest human-made structure in the World (Laliberte, 2013). The lighthouse was 135 meters long and the Lighthouse has been created in real sizes without any scale factor unless in the application there is a scale factor with 1/180 with additional possible scale factor, the marker size. The reconstruction of the Lighthouse of Alexandria is shown in Figure 8 below. In the model the bottom part contains 160 lights in 4 sides. The middle part and top part contains 32 and 10 lights respectively. There are 202 lights in total and those lights helps to be seen by the ships' crew. Those lights are made of simple box objects with the suitable textures. The ground part filled with sea texture to emphasis that the lighthouse is standing on the sea.

The original lighthouse contains a moving light to focus on something near the lighthouse. However that light was not ready in this work however it may be added with a proper moving animation or a focusing animation to the animating helper character which will be described below sections.

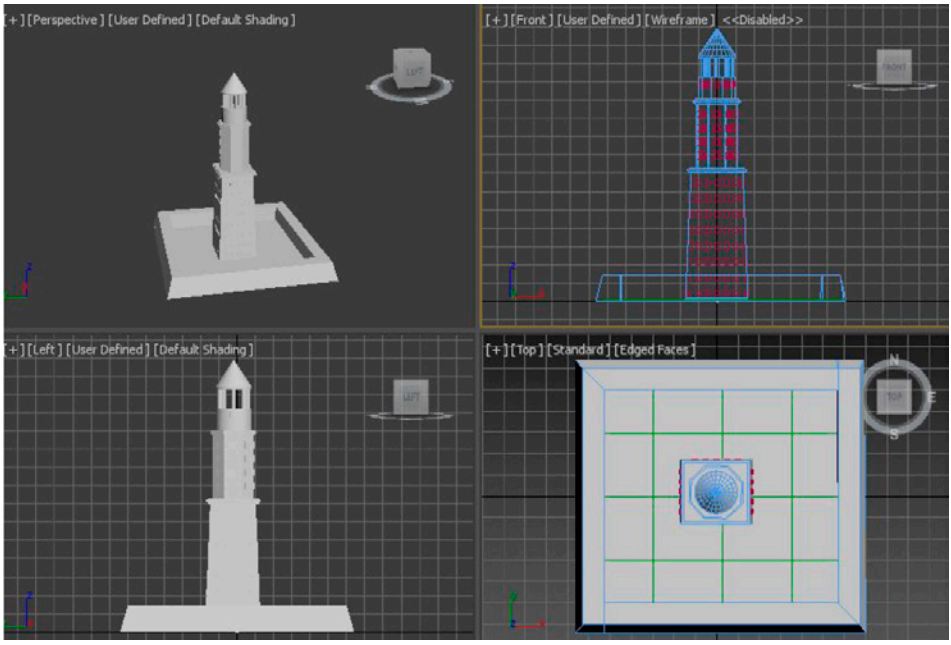

Figure 8: The Model of Lighthouse of Alexandria

Statue of Zeus at Olympia

The Statue of Zeus at Olympia model was bought from the external source (http://3dfoin.com/godstatue.html, 2016) due to complexity of the modelling. The Statue of Zeus is consist of a standing man with crown in his head, a throne and a spear model. However the model had have problems about texture which was implemented with the normal mapping. The Wikitude Android Javascript API does not support normal or bumping texture mapping. Due to these limitations, the textures rearrange with suitable technique which is used in the other models described above. The complex model produces high polygon count and low FPS problem. Due to this problem MultiRes modifier in 3D Studio Max modifier helps to reduce and optimize the Statue of Zeus model. The reconstruction of the Statue of Zeus at Olympia is shown in Figure 9 below.

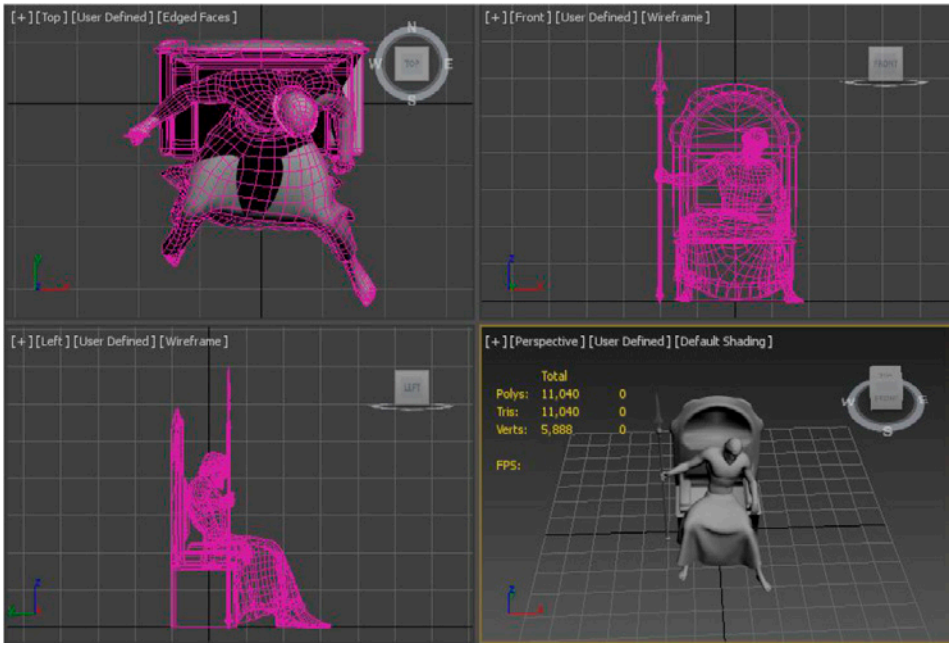

Figure 9: The Model of Statue of Zeus at Olympia

Colossus of Rhodes

The Colossus of Rhodes was bought from the external source (https://www.tinkercad.com/things/krqnNZxvTtw-the-colossus-of-rhodes, 2016) due to complexity of the modelling. The model consist of 2 parts; a platform and a man standing on that platform with a bowl in his right hand. Compared to Statue of Zeus at Olympia model, there was not any error in the textures or any other technical limits about the Colossus of Rhodes model. The only situation which have been faced with is that the model was contains lots of unnecessary parts for this paper therefore those redundant objects have been removed from the scene and have added a plane on ground with sea texture to emphasis the Colossus on the sea. The reconstruction of the Colossus of Rhodes is shown in Figure 10 in below.

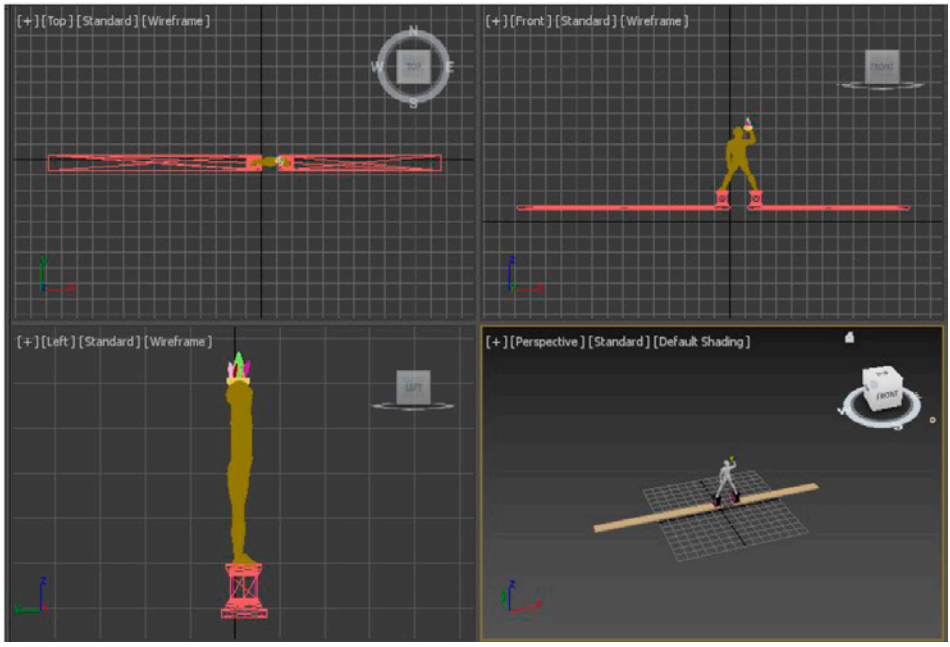

Figure 10: The Model of Colossus of Rhodes

Animating Helpers

In this paper, the aim is preparing an environment for students to study the seven wonders of the World. Therefore the 3D models and the text based information is not enough to motivate students and teach the topic effectively and efficiently. So, animated helpers have been added to each wonder scene to help students to listen history and critical information about the wonder. One of the simple Egyptian character was created using Character Generator by Autodesk (https://charactergenerator.autodesk.com/, 2016). That online tool helps to generate a character just by selecting general model, face, body, skin and etc. The characters will be generated with suitable skeleton. The prepared Egyptian character is shown in Figure 11 below. Using 3D Studio Max Animation feature and prepared skeleton, the walking animation was prepared easily. The character moves right hand and left leg together then that follows with left hand and right leg movement to represent the same walking behaviour as a human. Then, that walking animation repeated around the wonders just by rotating and repeating the same walking animation.

One of the native Egyptian speaker helps to vocalize the Egyptian character to teach the wonders. The native speaker used in this project helps to give the impression that a local person or a tourist guide is presenting the history of the wonder (Cohen, & Cooper, 1986).

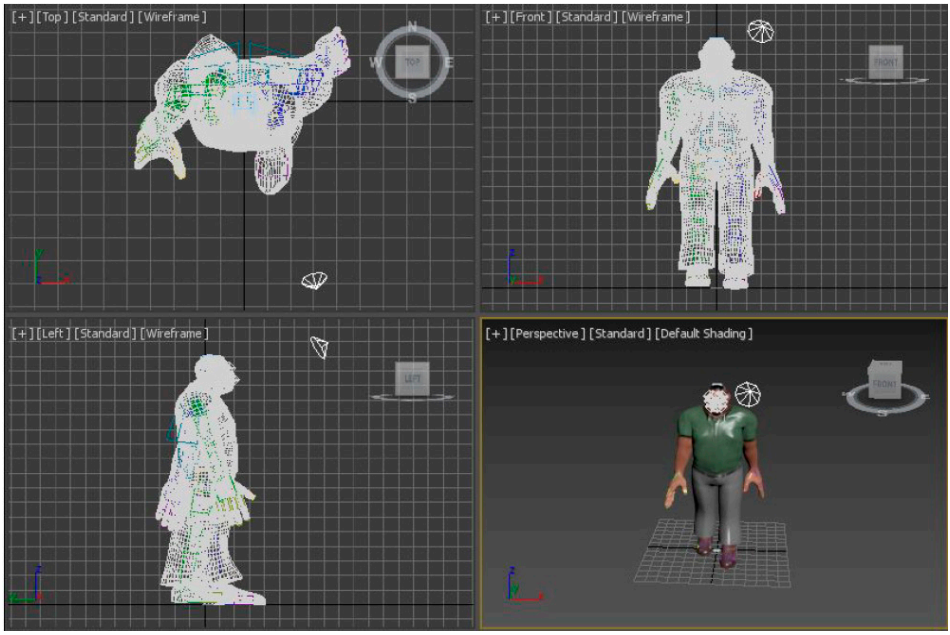

Figure 11: The Egyptian character

Results

The user interface was designed for Android mobile devices and Epson Moverio smart glasses. The application which aims to give as much as possible information about that wonders of the World was designed for this paper and the application was decorated with Android SDK built-in effects that improves the user experience and increment time that spend by the student. The main activity of the application was designed to give brief information about all the ancient wonders of the World. Each wonder image contains a link to its description and that descriptive page consists of the detailed information about the wonder and a small button at the bottom of the page. The button will trigger the Wikitude camera activity to detect the target and render the artificial objects.

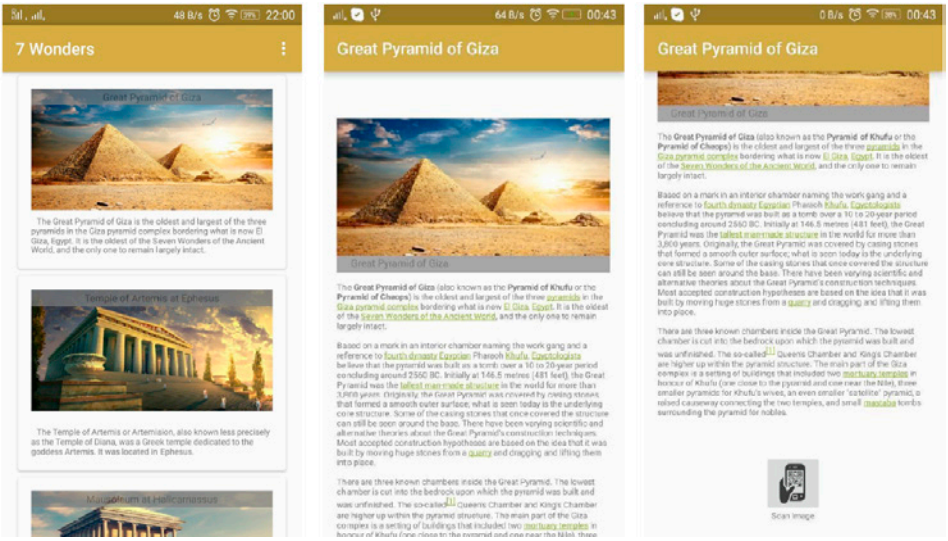

Figure 12: The user interface pages which was taken from mobile application

The icon of the application is shown in Figure 13. The icon which will be shown in the application list of the mobile device is an icon of Giza pyramid complex and a circular White border. That image was obtained from Google which use the icon in the search page to make users to explore the Giza pyramids. The icon was chosen because of users familiarity to it.

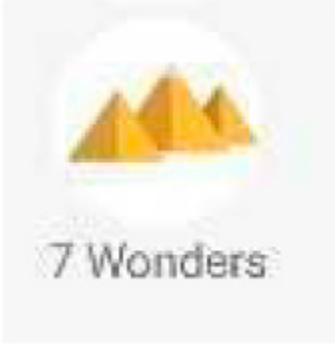

Figure 13: The icon of the mobile application

All the models were supported with the animating helper characters, musics and text overlays to expand the sense of AR. The text overlay has the little information about model and be placed on the top right corner of the mobile device screen. The music for the models is chosen to emphasis the culture and the ancient time of the model. The view of the application in a desktop is shown in Figure 14.

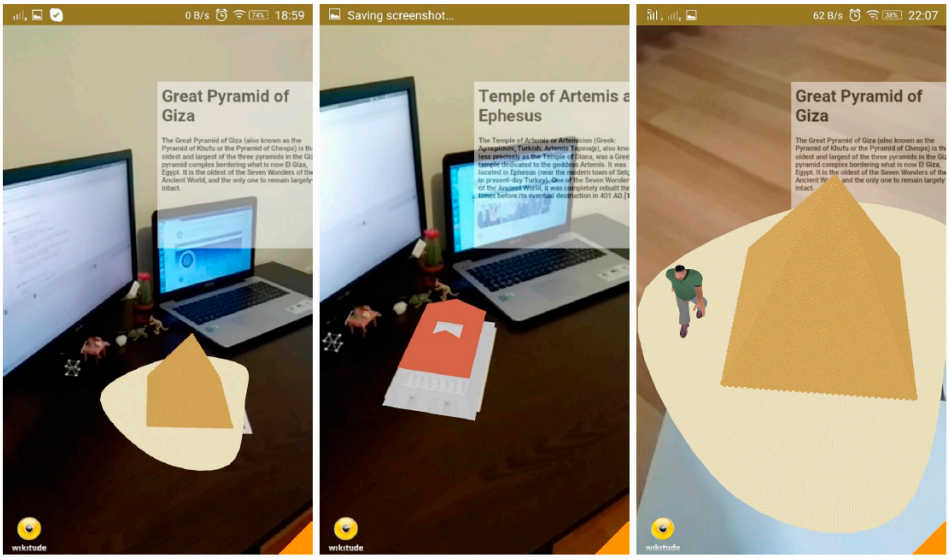

Figure 14: The results of the application

Conclusions and Future Study

The application and the models which was developed in this study are expected to help the students and teachers to enhance the learning experience in the context of cultural heritage. The study and its usage in the education is expected to prove that AR should help the education to understand the topics easily, effectively and interactively. The application was designed user-friendly to be easy-to-use and reach more students as possible. Another view of the development of the application is that it could motivate the development of applications in other fields of education to increase the use of the AR in education. The developed application helps to obtain information about the ancient wonders of the World and its properties. There are limited number of people who exactly knows their countries history and the common history of the World. It is expected that the ap-

plication presented here can be presented to different countries' historical information in different language settings as another type of expansion in the education. That will allow the people to get knowledge about their countries or the information which they are interested in. The application, in its current form, offers six of the Seven Wonders of the World. Remaining model were not currently being created and added to the application. Detailed runtime tests are also to be conducted with full feature set. The application and the education method presented in the here should also be tested in the schools. Future work will involve contains modeling of those wonders and put into the application with full of descriptive information. The AR world which was created in this paper has limited options to teach the models such that texts, sounds and characters. In the future, we are planning to combine the animated AR agent which helps to teach the models to the students with artificial intelligence. The character will have speech and maybe speech recognition features to answer the questions coming from the students.

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