VIRTUAL REALITY HERITAGE MODELLING WITH CONTOUR-BASED AND REGION-BASED SHAPE REPRESENTATION TECHNIQUES: A CASE STUDY ON APHRODISIAS SEBASTEION PROPYLON

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ABSTRACT

Virtual Reality (VR) is a new medium for creating three-dimensional representations for architectural fields. It is possible to create digital models with VR through bodily movements. Users can feel the presence by being-in-the-virtual-world with the design product which can be a building or part of a building. Thus, VR becomes a tool for understanding the shape and scale of architectural elements. Reconstructions of a damaged heritage site is a long process, so before that, the representations (drawings, digital and physical models) are using for describing the area. This also creates an understanding of the space, so people can perceive the whole heritage area through models and drawings. Producing digital and physical models get their basis from shape representation techniques. This study aims to create an understanding of a heritage modeling process by using contour-based and region-based shape representation techniques in the virtual environment. The subjects are assembling the heritage parts together by using the VR headset in order to build what they saw on the pictures of the heritage site. 10 architects participated in the study. They divided into two groups to construct the architectural parts which are modeled with these two different techniques. The first 5 people used region-based model parts to assemble the Aphrodisias Sebasteion Propylon, the other 5 people used the contour-based model parts for the same area. Their moves and assembling methods are determined.

Keywords: Virtual reality, virtual modelling, presence, shape representation, Aphrodisias

INTRODUCTION

Cultural heritage is a participatory construction of a community. It is a representation of a common culture through its methods and materials. It is the image of the mutual experiences of a society. Tilden stated that interpretation of heritage is an educational activity to explain meanings and relationships of daily activity through the use of objects, by first-hand experience, also usage of illustrative media (Tilden, 1977). She explained that it is more than communicating through descriptive information (Tilden, 1977). Conserving a heritage site has

the importance to create and enhance the sense of belonging for that society. Reconstructions are one important way of preserving ad interpreting through heritage sites. According to the long processes of the reconstructions, representations (drawings, digital and physical models) are using for describing the area and space usage to create an awareness of the space. These representations are the documentation, the way of preservation of the site and creating an understanding of the area. De Luca et al. explains that the three-dimensional digital model becomes a documentation of the current state of a historical place and resources of analyses on the historical evolution of the building (De Luca et al., 2011).

Bailenson et al. cited that William Gibson (Neuromancer [1984] book writer) defined virtual reality (VR) as "a consensual hallucination", an environment where technology prevents the physical world stimulants and creates its own sensory inputs to stimulate the user (Bailenson et al., 2003). According to Baudrillard "Simulation is no longer that of a territory, a referential being or a substance. It is the generation by models of a real without origin or reality: a hyperreal." (Baudrillard, 2011). This hyperreal world includes the individual as *Dasein* which is defined by the Heidegger as "being-in-the-world" (Ökten, 2011). As Bolt explains, modern "human" has become the decisive center of reality with technology and sees the world as something independent of itself (Bolt, 2013). While human is defined as being cared for by the existing, this situation changes with the modern age and human becomes the spectator (Bolt, 2013). The spectator human is the one who builds his own reality, and this helps him develop methods of understanding his own world. The spectator human is in physical reality and forms the image of the world by the relationship of the world with himself. From this point of view, the presence in virtual environment is described by Coyne as 'being-in-the-virtual-world' which is also interpreted as virtual *dasein* (Coyne, 1994). Virtual environments as new mediums for reconstructing and perceiving a heritage site creates the virtual presence for virtual *dasein* and give the opportunity to experience the digital model of it.

Virtual environments (which is VR for this study) are the platforms where all the design moves and space perception can be observed and measured with three-dimensional features of the technology. The physical reality can be reconstructed and simulate with the VR technology.

The architects and the students participate in the process on that point. This study discusses the designers as virtual dasein and understanding their modeling moves for VR reconstruction of heritage with the different representation techniques is the methodology of the research. According to Filippi et al., shape-based design activities include the designers' direct interaction with the shapes surround interactive approximation to create innovative solutions (Filippi & Barattin, 2019). VR medium becomes the place to using shape-based design activity and modeling the heritage with shape representation techniques. Virtual dasein which is also described as the user can make the heritage reconstruction model and perceive it through experience in the environment by using bodily movements.
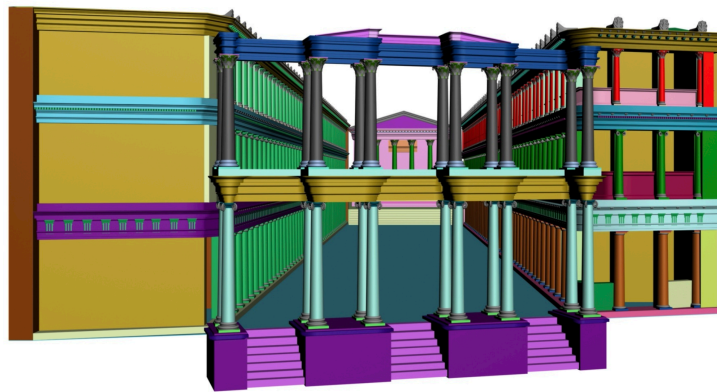

Figure 1. Aphrodisias Sebasteion Propylon Model (Öztürk, 2011).

According to De Luca et al. there were five key concepts as dominant surface, transition, plans of construction, repetition, and mouldings to understand the geometrical nature of heritage (De Luca et al., 2007). These concepts create the basis of the model template of the Aphrodisias Sebasteion Propylon. Detecting the dominant surfaces and modeling them, then transitions and plans of constructions are made. After all repetitions on columns are made by multiplying on an axis. Producing digital models is also supported by shape representation techniques which are contour-based and region-based representations (Zhang & Lu, 2004). This classification gets its basis on the shape features. Therefore, if the shape feature is created by being extracted from the contour only means the contour-based representation or it is constructed by extracted from the whole shape region creates the region-based representation (Zhang & Lu, 2004). The contour-based technique is divided into two as the continuous approach which does not divide the shape into sub-parts and the discrete

approach which breaks the shape boundary into segments called primitives using a particular criterion (Zhang & Lu, 2004). In region-based techniques, all the area within a shape region is taken into account to obtain the shape representation, rather than only use boundary information as in contour-based methods (Zhang & Lu, 2004). The global approach will be applied to these techniques. While a contour-based global approach is focused on "perimeter", for region-based the global approach is "area" (Zhang & Lu, 2004).
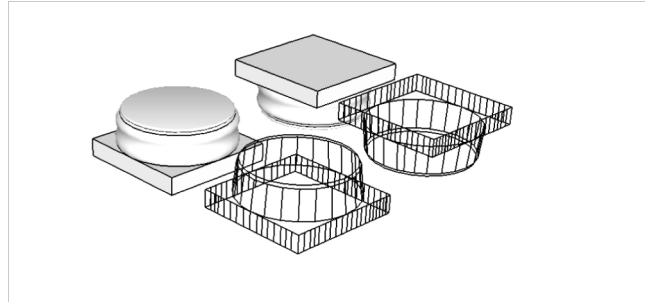

Figure 2. Contour-Based and Region-Based Model Parts.

Sebasteion Propylon of Aphrodisias which is located at Denizli province Turkey is the chosen heritage site of this study (Fig.1) It is damaged and cannot be visually understandable with its current condition. The reconstruction model will be the reference image of the research (Öztürk,2011) (Fig. 1). The study is based on assembling the propylon columns in the virtual reality environment. The first group is used the contour-based model parts to assembly, while the second group is used the region-based model parts (Fig. 2).

Figure 3. Region-based model as a pilot study.

The completion tool is drawing with VR Sketch which is the Sketchup virtual reality plugin. Applying the shape representation techniques while modeling the building is the methodology of this study. The user will draw the parts with both contour-based and region-based methodologies (Fig. 3). There will be two models in VR according to this situation. The movements of the user are recorded as a video and cartesian plane data. After that, the data is analyzed to reveal the advantages and disadvantages of VR modeling based on shape representation techniques.

METHODOLOGY

Virtual reality gives the opportunity to 360-degree bodily movement and 6DoF [six degrees of freedom] point of view which means that the user can move body and head in the virtual environment. It creates advantages to see through the model and perceive the 1/1 scale. HTC Vive Head Mounted Display [HMD] is one of the tools for experiencing VR as a room-scale installation (Fig. 4). The room scale HMD is installed at 2,5 m. x 2,5 m.

Virtual Dasein can move and feel the presence in this virtual environment. Even if it has still difficulties in using a big goggle that sometimes creates motion sickness, there are lots of advantages such as bodily movements and perceiving space as the real world. Therefore, perceiving the three-dimensional world includes similar features with the real world. Modeling in VR is a new concept and this study aims to understand VR heritage modeling.
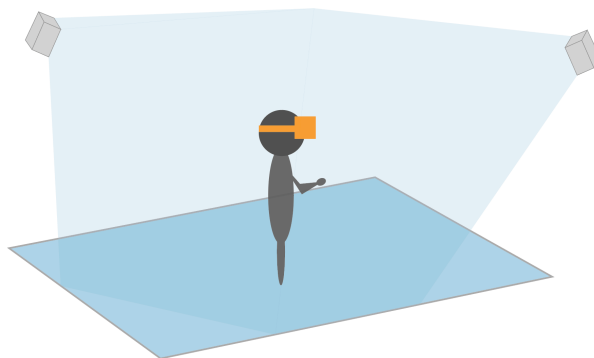

Figure 4. HTC Vive Head Mounted Display Room Scale Installation

Applying the contour-based and region-based shape representation techniques to the digital model of the Aphrodisias Sebasteion Propylon in VR is the first step of this study (Fig. 7). The Sketchup models were uploaded to HTC Vive HMD through VRSketch plugin. After that, the users are looked at the finished pictures of the model (Ozturk,2011) (Fig. 5). The users had 5 minutes to finish the model. The 10 architecture professionals have participated in the modeling study. 5 of them used the contour-based parts to assemble the propylon. The other 5 used the region-based parts. The users assembled the contour-based and region-based parts by using HTC Vive HMD triggers. According to this, when the experiment is finished there will be two heritage models in VR which are contour-based and region-based. Is there any difference between these shape representation techniques is one of the main problems.
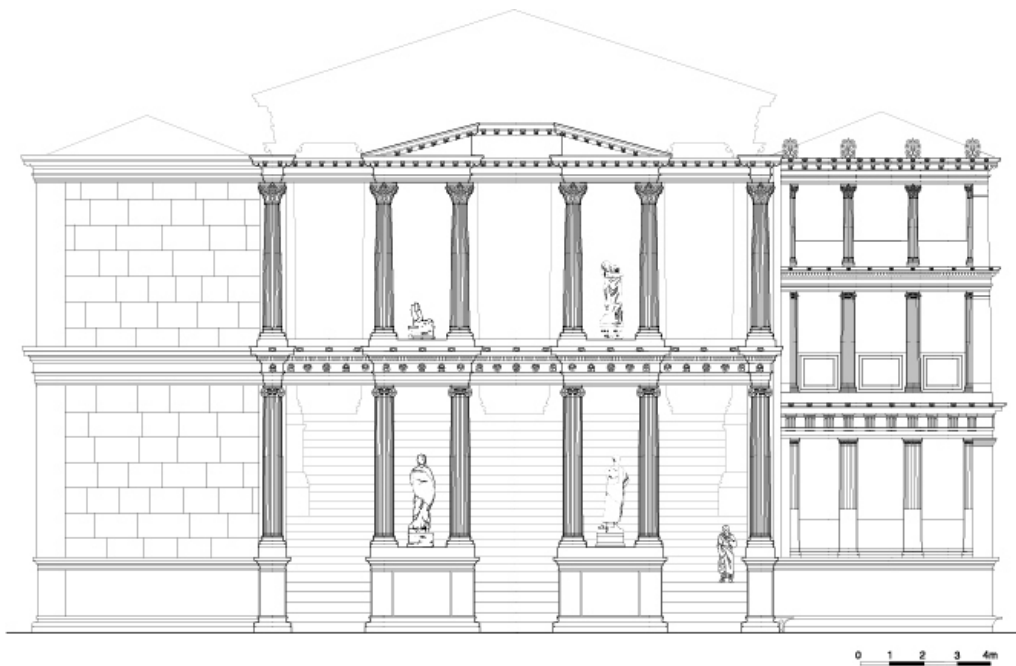

Figure 5. Aphrodisias Sebastion Proplyon Drawing (Ozturk,2011)

The movements of the user for both modeling processes are recorded as a video and cartesian plane data (X, Y, Z and Euler Angles for each second) (Fig. 4). The videos are analyzed for the forwards and backwards of the modeling process. While forwards are marked as advantages of the methodology, backwards are marked as the difficulties or disadvantages of the technique. It is also researched how many moves does the user do during modeling

according to analyzed videos. After that, they participated in the interviews for the VR modeling experience.
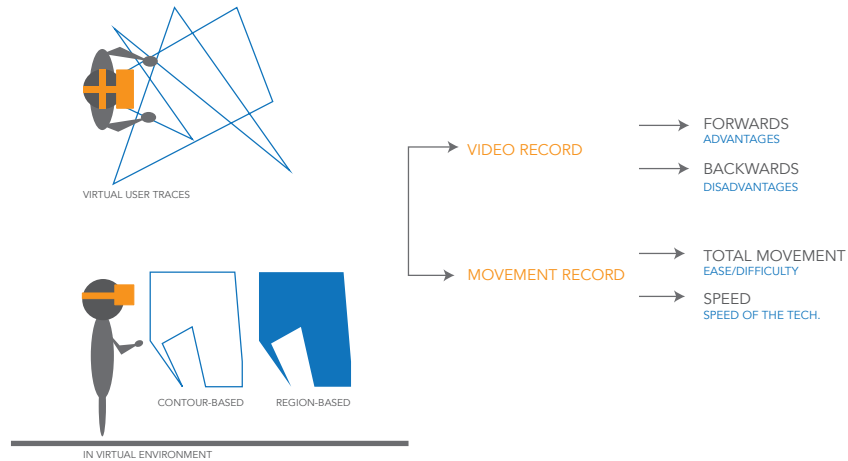

Figure 6. Virtual Movements and Recordings

The 5 minutes modeling time is an important restraint of the study. Therefore, the users are trained to comprehend the VR modeling tools which are "copy, move, and scale" for this study. Every user has used the commands in VR for 5 minutes to become familiar with the tools. So, the study procedure was built as training the user for the commands, showing the propylon model photographs to the user then giving them the related parts (contour-based or region-based). Then they had 5 minutes to finish the model. Their video recordings are analyzed to detect moves, ease, and difficulties.

MODELING WITH VIRTUAL REALITY PILOT STUDY

The study is designed as understanding the contour-based and region-based shape representation techniques in the VR heritage modeling process and also it is researched that are they differentiate while assembling the heritage parts in VR. The chosen heritage was Aphrodisias Ancient Site and the modeled part was the Sebasteion Building Propylon. The photos of models are used for the assembling procedure. Then the two different shape representation techniques are focused on modeling methodology. The first technique is

contour-based shape representation and the second one is region-based shape representation. The Sebasteion is decomposed as parts of its shapes with two techniques (Fig. 8). The base, column, and capital were used for dividing the Propylon. The user had 5 minutes to construct the models for each technique. During the experiment, the data collection phase started. The user movements recorded from the virtual environment as video. They also answered the questions about their moves after finishing the model. The tools for the experiment are installed (HTC Vive HMD, Google Sketchup with VR Sketch plugin) and the model parts were imported to the VR HMD. Also, OBS Video Recorder (screen recording from VR) was used as the data collection tool.
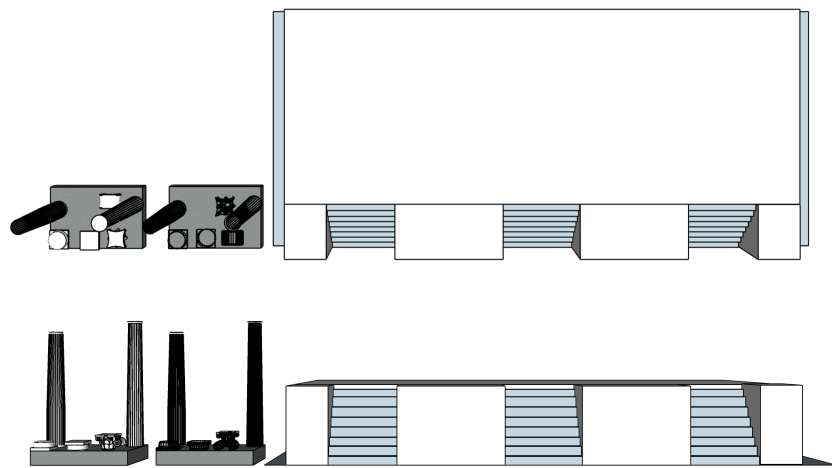

Figure 7. Plan and Front Elevation of Contour-Based and Region-Based Model Parts

All these hardware and software are installed for the study. 10 design field participators divided into two groups to modeling contour-based (5 people) and region-based (5 people) heritage parts. Sebasteion Propylon of Aphrodisias model had shown them before the VR modeling. They looked and memorized the arrangement of the columns. They have 5 min. to assemble the column parts and place them to the right locations. During the study, the user movements are collected with the software. The video explains modeling moves forwards and backwards.

First, 5 users had assembled the contour-based model parts. The first user has assembled the columns with the capital and the base and grouped them. After that, he multiplied the groups to settle the columns (Fig. 9). Then he multiplied the group (8,9,10,11,12) At 10th move, the

user has created two copy then he moved for the last elements. 12 moves used for assembling the model. He stated that seeing through the contour-based model makes the assemble precision better with the opportunity to perceive all the sides simultaneously while modeling. He learned the Sebasteion Propylon of Aphrodisias with the understanding of the joints of the parts. Another contour-based user placed the bases on every point. Then he placed columns at every point. In the end, the corinth caps are placed one by one. There is no grouping action. 36 moves to assembly the model.
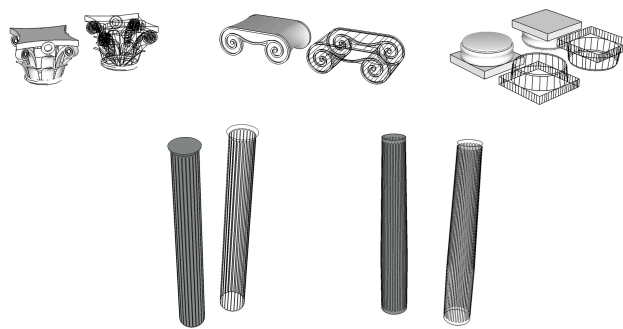

Figure 8. Aphrodisias Sebasteion Propylon Contour-Based / Region-Based Parts

The second 5 users assembled the region-based model parts. The first user has assembled the columns with the capital and the base and grouped them. After that, she multiplied the groups to settle the columns one by one to the places. She missed the first placement. She finished modeling through 12 moves (Fig. 10). She stated that, She learned both the propylon and the column types. She understands the joints but cannot match them properly because of the triggers. She did not see the empty base plate. Seeing through different scales by using one gesture creates a better learning experience than any other representation medium.
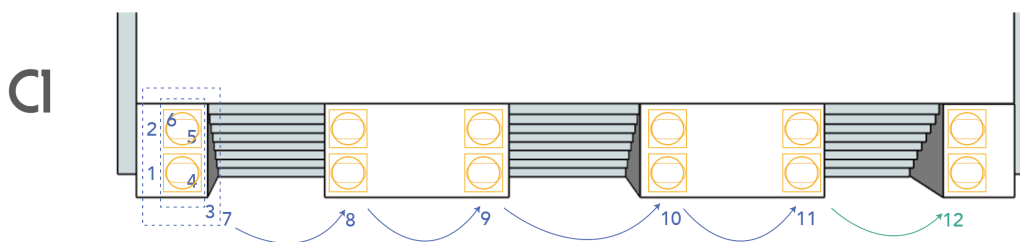

Figure 9. First contour-based model user moves

In the end, the contour-based parts are assembled to create the contour-based reconstruction. There are some difficulties for the contour-based system such as overlapping the edges of the contours, seeing the correct point to merge the parts. Also, the region-based system has its own disadvantages as it cannot see through the regions to perceive the model three-dimensional or move around to overlap the parts.
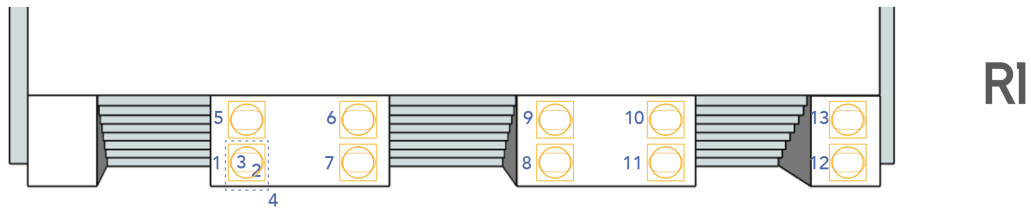

Figure 10. First region-based model user moves

All users moves were analyzed and it became clear that average move count is 12 for assembling the model parts in both technique (Appendix A). Most of the users cannot remember the correct column cap.

CONCLUSIONS

The differences between contour-based and region-based modeling in VR have been detected that while region-based model becomes a dominant surface while modeling, contour-based parts cannot be perceived as a whole surface with some scales such as 1/1. A region-based model becomes a dominant surface while modeling. Contour-based parts cannot be perceived as a whole surface with some scales such as 1/1.

While the region-based model users are stated that, they can perceive the model as a whole and everything is clear. The contour-based model users stated that it can be understandable but they cannot be completely sure that parts are matched correctly. But, every user tried to grab the parts as using their hands, their gesture is not like using a computer mouse. This created a problem with placing the parts correctly. The contour-based users need to hold from a contour line and the region-based users need to hold from a surface that will overlap

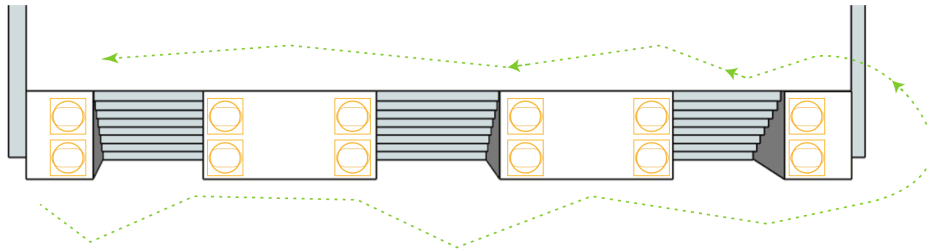the other surface. though the users did not hold from there, they grabbed randomly and tried to overlap.

Figure 11. Most of the users tend to walk around the model

All of the subjects are used their body movements while placing the model parts that some of them stroll behind the backline columns to place them (Fig. 11). Every subject is used scale transitions from 1/1 to 1/20. Therefore, opportunities such as bodily movements, 6DoF (six degrees of freedom) are important features for scale transition and modeling process.

In the end, virtual reality assembling is an experimental heritage perceiving and learning process. Even if there is no correlation between memory (which refers to remembering the arrangement and the type of the column) and the technique, being-in the virtual model world is an important factor for remembering and learning the parts and the whole.

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APPENDIX A-