Reconstruction of Pagaruyung Palace uses 3D Modeling Pipeline

Rani Sabtelasari, Firsov Andrey Valentinovich

Abstract: Indonesian architectural culture, which is based on local wisdom, can give meaning to human life. Architecture is a dimension of meaning that is a measure of the height of human culture. With the increasing use of 3D techniques, visualization of the introduction of architectural culture can be more easily displayed. 3D models provide a new means to visualize and introduce a design, and can even be shared to exchange design information through the internet. This article discusses the process and results of the 3D reconstruction of Indonesian traditional house attractions, namely the "Pagaruyung Palace" and their use on online sites. The wealth of the 3D model makes the structure of information better, which in turn can facilitate the preservation of a historic building, and also attract tourists when searching for and searching for information about the advantages of a tourist attraction through an online repository. Plus, the creation of 3-D animation that takes into account as much accurate information as possible and an interactive display that makes it easy to deliver information. So the narrative of tourist attractions as 3-D animation will be beneficial for cultural education and tourism.

Index Terms: 3-D Modeling, Pagaruyung Palace, Pipeline.

1. INTRODUCTION

Indonesia is an archipelago that has many unique and varied tourist objects. One of these attractions is the Pagaruyung Palace, located in West Sumatra, Indonesia. Pagaruyung Palace captures the architectural grandeur of the center of the royal government. Istano Basa, which is better known as the Pagaruyung Palace, is one of the historical legacies left from the existence of the kingdom of Pagaruyung. This kingdom is a kingdom that once ruled all the Minangkabau Realm. Even in its golden age, this kingdom had controlled the entire Central Sumatra region. The structure and construction system of Pagaruyung Palace is unique, starting from its complicated roof to its simple foundation but has a vital role for the building itself. There are 72 pillars that serve as the main buffer and 11 roofs or tops that decorate the top of this building. The entire wall of the building is decorated with colorful carved ornaments consisting of a total of 58 different motifs. However, modern elements began to influence or even reduce their existence. The generation of Indonesian people tends to narrow the architecture's uniqueness to one element, such as the shape of the roof that resembles a buffalo horn. (Dewi, 2010) This is what underlies the use of 3D model technology to disseminate information on the history of Indonesian architecture. Building the right model to simulate and present the principle of behavior is a common and important method for modern science. (Xi-Dao LUAN, 2008) The 3D results of this pagaruyung palace illustrate the added value made possible by 3D modeling, compared to traditional images or photographs. Even the structure and presentation of the latest design projects can be improved using diagrams and overlays, which utilize the results of 3D modeling efforts. In parallel, it is possible to improve information about the design by adding additional metadata to the 3D model.

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The reconstruction work is based on literature studies in the form of reasonable articles, pictures, and related videos that can test the validity of 3D model reconstruction. The collection of this document can be quite hindering, making 3d models because the information provided is usually not detailed and not accompanied by clear images. However, the basic principles of building architecture increase the level of authenticity of the reconstruction. The transformation of objects in the image can be seen in several different perspectives. The scale on the X, Y, and Z axes should be determined to facilitate the change in size. Two basic forms of modeling are automatically used to calculate solid and liquid components. Utilizing the sketch feature is used optimally to speed up, drawing some parts of the building. Pagaruyung Palace is a building that is dominated by materials from wood so that many parts of the building have similar shapes to one another. One component that has been made can be used again to arrange the other side. Simple building geometries make use of the "mirror" menu in CAD applications. Another advantage is that the building components look more real and similar to the original. This is also useful as a medium of learning, development, and preservation of a historic building in an increasingly modern era.

2 METHODOLOGY

The focus of 3D visualization of historical structures is not the stage of 3D modeling or creating stunning images but doing in-depth and systematic study of sources, correlating and assessing them, obtaining the most probable hypotheses, documenting this interpretation process in a well-structured manner and finally visualize them according to the requirements of the context in which the results of this visualization used. The methodology framework refers to the method that was applied several times during the historic reconstruction case study described by the research team from Belgium, namely:

1. Conduct archaeological surveys and investigations of building objects. The survey in this study conducted through a literature review.
2. Historical inquiry
3. Creation of "Metafile." Metafile is a tabular list or database of all resources related to research objects taken and referenced, from documents, drawings, manuscripts, and books.

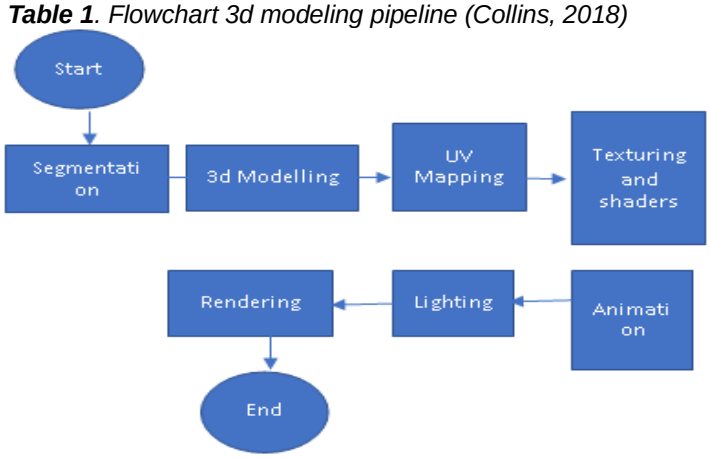
4. 3D digital modeling and interface creation (multimedia). (Han Vandevyvere, 2006)

The whole modeling process from programming to operation and maintenance must be able to cover the following main activities: modeling, product drawing, simulation, consistency checking, data extraction, visualization, and must be managed by project management. (bips, 2007)

3 RESULTS

An important objective for this case study lies in the delivery of interactive information from the historical value of traditional architecture. The digitalization of historical reconstruction allows the recreation experience of architectural artifacts for different time periods. Especially in the case of Pagaruyung Palace, where the current building is only a replica of the original building, which was burned by the Dutch in 1804. The local government rebuilt the pagaruyung palace, and its location was moved further south from the original site. So, the reconstructed 3D modeling can also be used to provide insight into the evolution of buildings or historic sites. Following are the steps in making 3D visualization of Pagaruyung Palace using pipeline modeling:

***Table 1**. Flowchart 3d modeling pipeline (Collins, 2018)*



3.1 Segmentation

The shape of the Pagaruyung Palace will be more readily understood when the archaeological building and the history of its construction are well known. Pagaruyung Palace has basic concepts such as the gadang house, the traditional house of the Minangkabau people, West Sumatra, Indonesia. The difference lies in the number of floors and building areas. Pagaruyung Palace construction is dominated by primitive models consisting of basic geometric shapes, namely: Cylinder (supporting poles), Beams (connecting wood, floors, windows, and ceilings), Triangles (roof covering) and trapezoid for walls. In addition, the roof of the building is made with a spline model because of its fairly complicated shape. It allows the creation of curved smooth surfaces. And the calculation of the slope of the roof and supporting poles.

3.2. 3D Modeling

After segmenting for structured data modeling, specific parameters of related objects are also determined, such as materials and textures. The CAD application used is Fusion 360, which is able to visualize the results of 3D modeling interactively and is able to produce a programming code that can be installed and connected directly to a website. There are several steps to improve 3D modeling, namely the following three components:

1. Modeling details of basic shapes, such as beams, columns, windows, and arches, from a small number of points measured interactively. At this stage, more use solid modeling. Solid modeling systems ensure that all surfaces meet correctly, and objects are geometrically correct. This is indeed usually used in construction, where certain parameters, measurements, and shapes are more clearly defined. Objects can also be cut open to reveal their internal features, and have mass. Which can be as if they are objects in the real world. Solid modeling can be difficult if you want to design shapes that have a lot of curves and are more natural. In this construction, the arch is found in the unique shape of the roof of the building. By modeling surfaces, vectors and tangents, manipulating shapes by "pulling and pushing" at the control points (generally where tangents intersect) with a more amorphous or liquid and natural mode shape. Surface models can be easily rotated, pulled, and bent. (Fägnell, 2018)

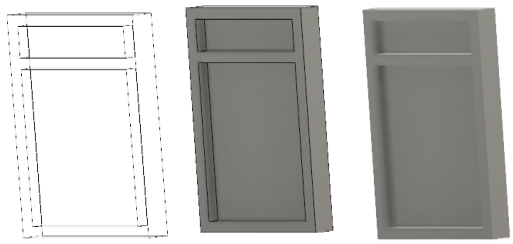


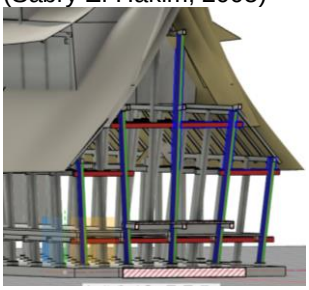
***Figure 1**. Detail window model with the basic shape of the beam*

2. Modeling with sketch will make it easier when meeting a flat model but has irregular geometry. Manually specify points or can determine points from the original image, which are then applied to the 3D Model. Determination of points originating from the original image can be more accurate than relying only on manual creation through visual observation.

***Figure 2.** Shape under the building and windows made with sketches*

3. Reuse the shape of the model in other similar parts. (Sabry El-Hakim, 2005)

(A)



(B)

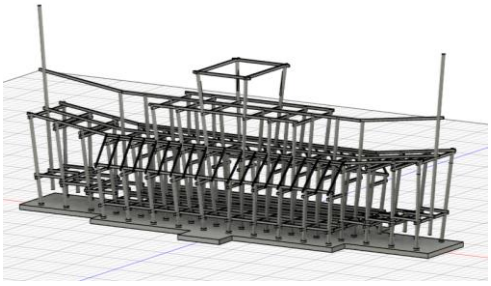
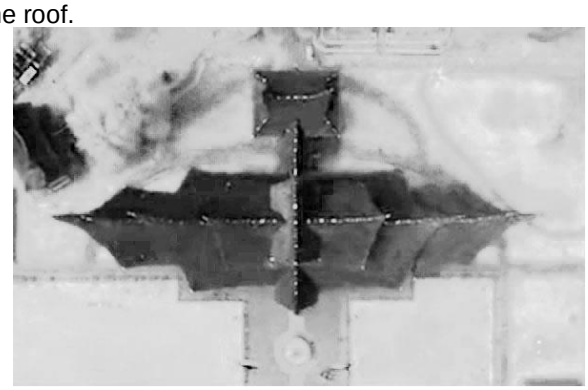


Figure 3. *(A) Building poles (B) Construction of building poles totaling 72 pieces And connecting beams having the same model.*

This digitization of Pagaruyung Palace construction resulted in an informative 3-dimensional model. Through this, 3D visualization can be seen as the function, structure, and uniqueness of the building that underlies the high creativity of past technology that originates in nature. A comparison of results from 3D modeling with original drawings of buildings is also made for the accuracy of the model. At this stage, observations are made on each side and corner of the building. This is also caused by one form of building that is the typical arch of the pagaruyung palace roof. The shape of an accurate roof is difficult to predict by just looking at the picture from one side only, so it needs to be seen from various sides. T-spline modeling makes it easy to make Pagaruyung roofs, namely the determination of the arch, depth, and position of the roof.



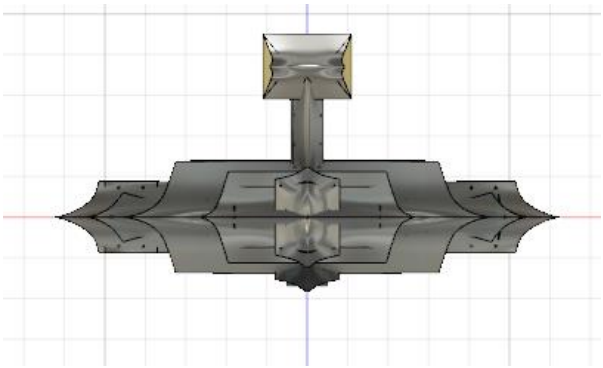


Figure 4. *Comparison of the shape of the roof from the top position of the building*

The shape of the Pagaruyung Palace roof is pointed upwards like a buffalo horn accompanied by a slope of the roof that is steep enough so that rainwater can directly fall to the ground. The supporting poles are tilted between 2-4 degrees, which serve to maintain the balance of the palace from natural disasters such as earthquakes. Poles are placed on stone slabs. The purpose of making such a foundation is to avoid cracks in building columns during an earthquake (Mukhtar M A, 2013). The mass of each floor in the pagaruyung palace is like an inverted trapezoid because the philosophy of the construction of the building is like a strong ship when adrift at sea and the connection of supporting poles are connected without nails.

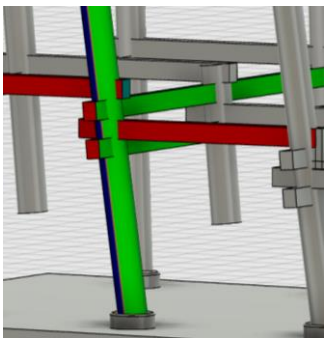


Figure 5*. All supporting poles are joined without nails*

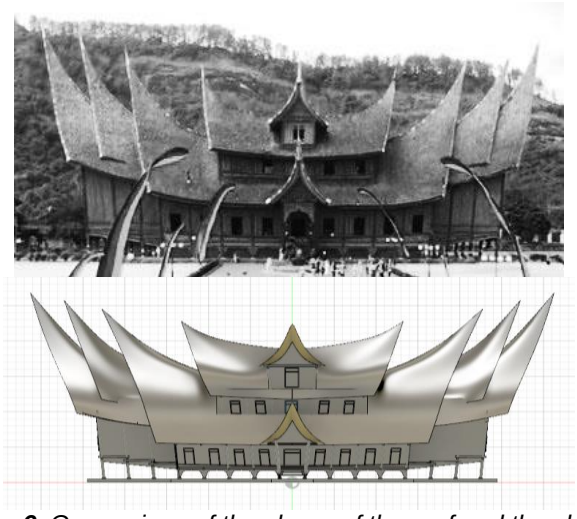


Figure 6. *Comparison of the shape of the roof and the slope of the supporting poles*

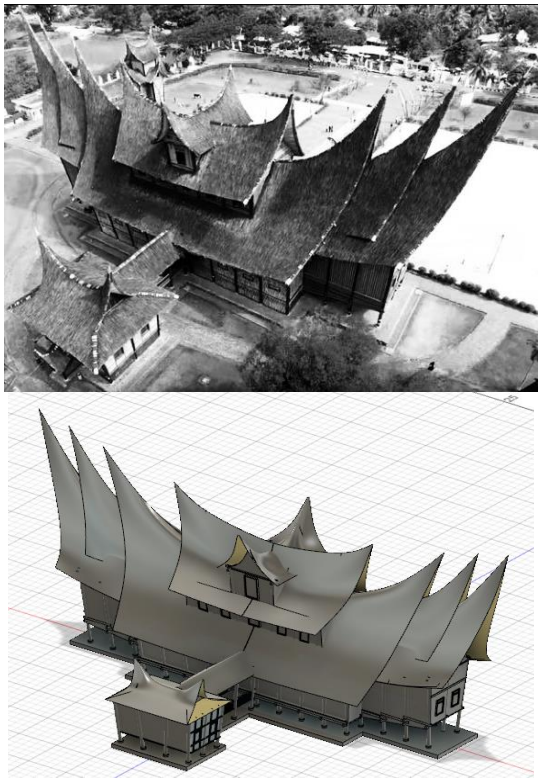
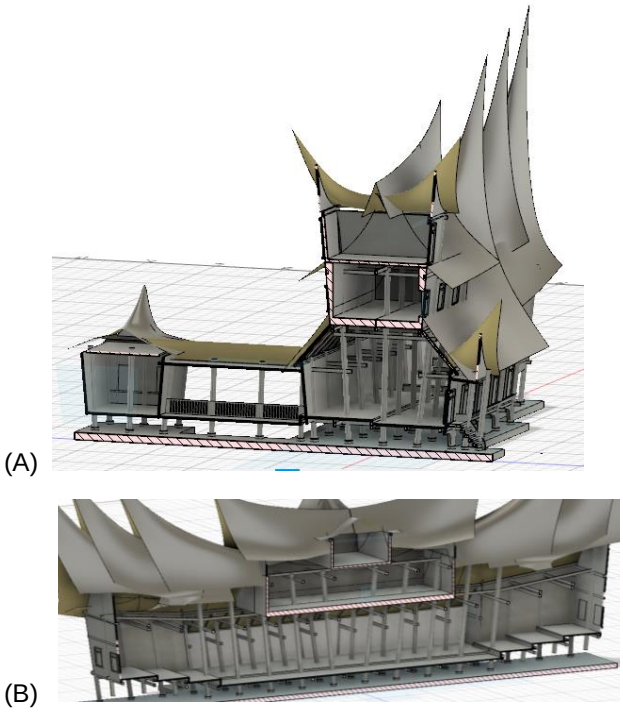


Figure 7. *Comparison of the shape of the building seen from the back side of the building*

To make the building look like the original shape, then the inside of the building is also made similar to the original building without the addition of space because each room in the pagaruyung palace is only separated by cloth in the building.



(A)

(B)

Figure 8. *(A) Details of the inner building seen with section features in the CAD application on the X axis (B) Details of the inner building seen on the Z axis*

This collection of information about the architecture of the Pagaruyung Palace is essential to be documented, and if possible, planning documents should be available at the beginning of computer-aided reconstruction work. The more high-quality archive material available, the more precise the reconstruction of the building.

3.3 UV Mapping

UV mapping is the process of projecting 2D images onto the surface of a 3D object to give shape, detail, and texture. This is achieved by placing the texture map onto the set of coordinates above the classic x, y, and z coordinates, known as U and V coordinates, which allow 3D objects to be painted so that the object's appearance becomes more similar to its original shape. In the case of Pagaruyung Palace architecture, UV Mapping can be applied to the walls and windows filled with carvings of various shapes and colors, which in total have 58 types of motifs and bamboo walls on the back of the palace. Applications for editing 2D images can be made using image editing applications, for example, Adobe Photoshop.

3.4 Texturing and shader

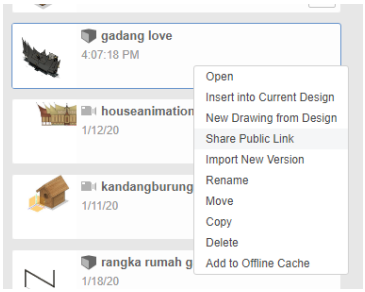
Texturing is a graphic rendering of building materials that are projected onto the geometry of building elements when photorealistic rendering is produced. The texture is a specific color on the surface of each element that matches the original material. This is applied to the model to provide real colors and details that are not boring. Shaders are the stage of giving extra detail to models that support 3D models look more authentic, such as opacity, reflectivity, depth of the building, light effects Etc.

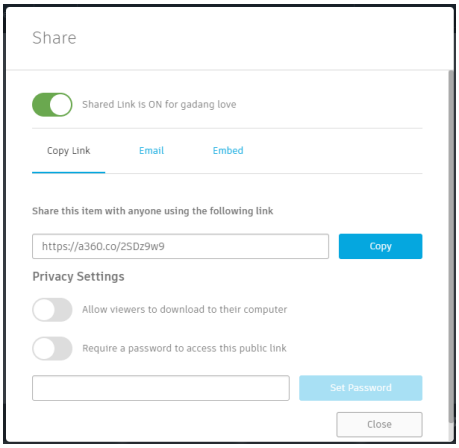
3.5 Animation and Lighting

Animation takes place before lighting because lighting and other effects take time to render, so when something that frequently changes like animation occurs, lighting will slow it down. Lighting will be influenced by models, animations, and textures that make images more real. The animation is one of the interesting ways in interactive delivery to be added to 3D visualization. Animation can be made more than one, so it can be adapted for its designation, both for education, tourism, and culture.

3.6 Rendering or Visualization

The rendering stage takes a while to render, depending on how complex the object and the scene are made. So doing it at the beginning of the process will be in vain and spend time in the process of making 3D. This is why rendering is the last step, but also one of the most satisfying steps to produce 3D visualization. Rendering produces a more realistic image. At this stage, program code is also generated for sharing data on 3D modeling results that are connected to the CAD application so that the more interactive 3D model is very dependent on the existence of CAD used at different times. After the modeling is complete, Fusion 360 provides a data sharing menu that can be done in 2 ways, namely from offline and online applications.





Public share menu Link that can be used to share data and information in the project team. (Stein, 2015) The image is a menu in an offline application, and in an online application that has an embed feature that is the application automatically generates a 3D model program code so that it can be inserted on the website. There are several interactive menus that make it easy for visitors to interact with 3D Models manually. Animated video is also displayed automatically to add its own experience in seeing objects in the form of this Pagaruyung Palace building.

Figure 9. *3D model visualization results posted on the online site.*

4 CONCLUSION

More and more fields that require and adopt 3D modeling technology as a visualization medium, not to mention the heritage of historic buildings. However, the digital reconstruction of the structure of historic buildings is something that has been studied for a long time and is something that is no longer new. This can be further developed into the field of tourism if it is packaged in an interesting way, such as AR and VR technology. There are a number of stages in 3D modeling. Collection and understanding of (Fägnell, 2018) data from various literature are needed to support the similarity of models, the character of 3D models, such as shapes, topology, and texture construction. Visual quality is also one of the main points of attention—more and more demand for 3D content with higher accuracy. So, the exploration of new methods in the form of digitalization in facilitating the preservation and delivery of cultural information and the history of Indonesian architecture should be done by relevant stakeholders. (Xi-Dao LUAN, 2008) From the results of reconstruction, using 3D modeling technology can produce an interactive replica of the building. From 3D visualization can be seen clearly the structure, philosophy, and history of Pagaruyung Palace. The use of historic architectural reconstruction techniques listed in this article has proven to be effective in facilitating the 3D modeling process. Reconstruction work must also provide a specific level of detail obtained from the process of analyzing object data in the form of art-historical findings of a building. In addition, the difficulty found in the study of literature is the accuracy of the real form of historic buildings. This condition may greatly affect the progress of the work. If done in a team, CAD applications that can share data online are needed in this work. This is to facilitate the mobilization of 3D models between the parties in charge of the process and is useful to open the way for the reconstruction of buildings that are more real and accurate information.

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