3D Digitalization of Besakih Architectural Heritage: Documentation and Preservation

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Abstract. To be a tourist destination, an area must have three indicators: nature, culture and characteristics of its society. Bali is a tourist area that is more known due to its enchantment rather than those three indicators. Of the heritages of Bali culture well known by the enchantment is Pura - Balinese Temple. In Bali, Pura is an important component in which Bali for this is also known as a thousand-temple island as in most of each house, village, intersection, and irrigation spot, a Pura has been built. Bali has nine large Pura called as Pura Kahyangan Jagat, protecting the island from the evil spirit. Of those nine Pura is Pura Besakih – the largest Pura in Bali and becoming the tourist destination for many foreign and domestic tourists. It is one of Pura located in the slope of Mount Agung. This mount is included in the Pacific range of Ring of Fire and erupted in 1821 (but no record on this). The activity of this mount was continued in 1843 erupting again with a number of earthquakes. This eruption also produced the volcanic ash, sand and pumices. In 1963 it erupted and made a more severe damage. With those facts, the existence of Pura is found vulnerable with the natural damages. Viewed as Huluning Jagat Bali, Pura Besakih is considered a very holy and sacred place. Each of the ornaments in it is a symbol that has a meaningful and deep philosophy. However, what has been occurred with Pura Besakih as the Huluning Jagat Bali if the natural disaster has made damage? To what extent the existing books about Pura Besakih can describe the existence of Pura Besakih as the Huluning Jagat Bali? It therefore requires preservation of cultural heritage architecture of Besakih by making a 3-dimension digital documentation. This is deemed important to be done to record the genuine form and the detail size of Pura Besakih to make it enjoyable and learnt by the generation in future. The design of 3-dimension object will be made in conformity with the original form, size and texture with the purpose not only used as a preservation media but also as a media of promotion towards the cultural heritage and tourism in Indonesia particularly Bali.

1. Introduction
Bali is identical with tourism. It is the icon of Indonesian tourism. In other word, when discussing about tourism in Indonesia, Bali will always be positioned as the number one either as the excellence of tourist destination or as the reference of the model of tourism development. One of the well-known cultural heritages in Bali is Pura – an important component in this island. This is why Bali is also called as A Thousand-Pura Island in which almost in each house, village, intersection and irrigation spot, a Pura can be found. The position of Pura is determined based upon the position of Kaja-Kelod: Kaja is the direction of mount, and Kelod refers to sea.

Bali has nine large Pura called as the Pura Kahyangan Jagat. Of those nine Pura, it is Pura Besakih located in Mount Agung. Besakih is the largest Pura in Bali and it becomes the tourist destination for foreign and domestic tourists. Besakih has been developed for more than a thousand year to be the complex of 22 separated Pura. The largest and positioned in the middle is called as Pura Penataran
Agung. The complex of Pura since the fifteenth century has experienced a series of changes either in its architecture or in its ritualty.

Based on the existing fact, Indonesia is located in the Pacific Ring of Fire. Mount Agung that is included in the line of Pacific Ring of Fire has ever erupted in 1821, but there is no any documentation about it. The activity of this mount continued in 1843 in which it again erupted with a number of earthquakes. This eruption also produced the volcanic ash, sand and pumices. In 1963 it erupted and has made more severe damage. This then causes the existence of Pura Besakih prone to the natural damage. Viewed as the Huluning Jagat Bali, Pura Besakih is seen as the holy and scared place. Each of its ornaments is a symbol that has a meaningful and deep philosophy. However, what has been occurred with Pura Besakih as the Huluning Jagat Bali if the natural disaster has made any damage? To what extent the existing books about Pura Besakih can describe the existence of Pura Besakih as the Huluning Jagat Bali? For this, there is a need for the preservation of cultural heritage of Besakih architecture by making a 3D digital documentation. This is deemed important to be done to record the original form of Pura Besakih purposely to make it enjoyable and learnable by the next generation. The design of 3D object would be made in conformity with the original size, form and texture so as to be used as a media of preservation and promotion for the Balinese cultural heritage.

2. Experimental

This research cannot be apart from the previous research in terms of the research developed about the augmented reality for the documentation of cultural heritage in the architectural modeling, and cultural and artistic objects in Bali. In making the documentation of the preservation, Darmawiguna et al. proposed an application of augmented reality on the Android in which it could display a 3D object when doing a scan marker process. Darmawiguna et al. emphasized on the preservation of the cultural heritage of architectural model Kesiman et al. more emphasized, rather than architecture, on culture in this case in Tapel (mask), Balinese dances, or Barong. The result of the researches showed that the existence of the new technology utilization in the cultural preservation can more attract the user to know and preserve the Balinese cultures more. The use of technology is started with the process of making the 3D model. In the digital documentation of the cultural heritage, the accuracy in the size and the conformity in its original form of Pura Besakih are very important. Figure 1 presents the phases to be done.

![Figure 1. Research Flow](image)

1. The first step of this research was to identify the problems based on the Literature Review that has been done. In addition, this phase determined the techniques or procedures that can be used to solve the identified problems. 2. Data Gathering, this phase is the phase of preparing the blueprint distribution prior to taking the photograph or data in field. This was done to share the result of the photograph capturing to be grouped well when used as the reference later. Also the photograph capturing was done for the front view and side view of each building in Pura Besakih. 3. Data Grouping, This is the phase of structuring and grouping the photographs/images in the process of searching in making 3D modelling. In this phase, the result of the front view, side view and back view of the building images would be sorted. This was important to be done as the name of raw files of the camera was still in the standard format. Hence, it is important to do renaming and grouping the folder based upon the blueprint that has been made in the first phase. 4. In 3D modeling of the building, a
number of simple numbers was done using the front view and side view of photographs to be used as a reference. In making 3D model, a number of simple spots were used to reduce the size when used in the application of virtual reality. 5. Texturing, in this phase, the texturing on the 3D building object that has been made was done. In its process, the steps included the distribution of seam, uv mapping, uv unwrap, etc.

3. Result and Discussion

Figure 2 shows the entire blueprint of the Penataran Agung of Pura Besakih. This mapping was done to ease in sorting the results of front view and side view photograph captures. The numbering was done for each building with the format of the first number indicating the building group and the second number indicating the number of building. Those two numbers were separated by the limiting point. In this phase, 9 blueprints were successfully made based upon the level in the Penataran Agung Pura Besakih.

Based on the result of the phase in mapping the blueprint of Penataran Agung pura Besakih, it was continued by taking the picture in order in accordance with the number that has been given on the blueprint. Figure 3 shows one of buildings from the front view and there is a person standing carrying a stick and a piece of paper. If we see the stick more deeply, there is a line with two types of color: red and blue. The red line is in the size of 10cm while the blue line is 50cm. The stick was used as the reference to determine the size of the building. On the other hand, there is the number of 3.1 on the paper carried in which it means that the building is in group 3 and the building is number 1. In the implementation phase the collection of the photograph in the front view, side view and back view was done from 49 buildings either in the form of Pelinggih building or in other buildings. The total of photographs obtained either from the front view and side view and texture was 458.
Data grouping is the phase of managing and grouping the photographs/images into the folders to make it better organized and it can make it simple in the searching process in making the 3D model. This phase also dealt with the sorting of the front view, side view and back view of the photographs. It is deemed essential to be done as the names of raw file of the camera were still in the standard format as seen in Figure 4. Therefore, there was a need for the renaming and the grouping of the folders based on the blueprint that has been made in the first phase.

![Figure 4. Raw File of Front Side View Photo](image1.png)

![Figure 5. Modeling & Texturing Process](image2.png)

![Figure 6. 3D Model Final Result](image3.png)
3D modelling is a phase of making the 3D objects of 49 buildings and pelinggih in Pura Besakih. The 3D object made used few vertexes to make the application of blender was not so heavy in the rendering process. The use of modifier in the form of mirror was also so helpful in making this 3D object. Using the mirror, we simply need to make ¼ of 3D model of the building and later the mirror was given to the X and Y axes but this was only applied for the building that has symmetric form in its four parts.

After 49 of 3D model of buildings and pelinggih in Pura Besakih was completed to be made, the next phase was to give the materials and texture on the 3D objects. This was done to make the object made would have the texture resembling with the original object. The distribution of texturing was started from giving the materials and stuck on one object. Later, the unwrapping process was done to the 3D object into the planar form. Figure 4 and 5 show the process and the result of the texturing.

4. Conclusion and Future work
In this research, the view digital photographs have been collected and used as the reference of 3D model of Pura Besakih. The total photographs captured were 458. In the first phase, 9 blueprints of map based on the level in Penataran Agung Pura Besakih were successfully made. Later, in the implementation phase, the collection of photographs or image from the front view, side view and back view was successfully done from 49 buildings either in the form of pelinggih or other buildings. In addition, the rename of photograph files was done to make them suitable with the blueprint that has been made and they were then grouped into the folders to make the searching and making of the 3D model more simple. In the last phase, digitalization of 49 building in the Penataran Agung Pura Besakih was made in the form of 3D model resembling with the original size, form and texture. The further development of this research is in the digitalization of 3D dimension of the buildings in the area of Pura Pedharma in Pura Besakih.

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