3 Dimensional Visualization for Adaptive Building Construction Masterplan in University of Darussalam Gontor Area

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Abstract. University of Darussalam Gontor (UNIDA Gontor) is one of the universities that has been developing quite significantly in Ponorogo area since 2014, especially in terms of facilities and infrastructure. Until now, UNIDA Gontor has a development master plan in physical form in the form of paper. However, there are several drawbacks to the physical prototype. First, physical documents are vulnerable to damage and loss. Second, with the condition of the campus that continues to develop, it is difficult to update the prototype in physical form. Third, physical documents cannot provide a visual representation of the buildings that have been and will be built. To overcome some of these weaknesses, it is necessary to have a solution with technology that is adaptive to needs. The purpose of this research is the design of 3-dimensional modeling of buildings in UNIDA Gontor area that can be accessed easily and dynamically. The project design is based on the steps of the waterfall model with the following stages: (1) Requirements, (2) Design (3) Implementation, (4) Verification, and (5) Maintenance. Testing is done by testing a 3-dimensional display with a 3D image viewer which shows a success rate of 90% working as expected. The test is also carried out by measuring the level of color suitability, layout and comparison of the size of the 3D media with the actual building size, implemented through distributing questionnaires to relevant parties at the university and the public gets 88% according to their wishes. The resulting media is a adaptive building asset based on 3D modeling that can be accessed easily anytime and anywhere. With various existing features, it is hoped that the resulting media can facilitate access for the community and the development activities carried out at UNIDA Gontor. The long-term benefits of this research are taken into account in the framework of the university’s development plan and its infrastructure.

Keywords: 3d Modelling, Building Master Plan, University of Darussalam Gontor

1. Introduction

In every building design, always begins with the initial planning stage by the developer, designer, or contractor. Until now, there are still many agencies and contractors who still use manual systems in designing the initial design, resulting in a 2-dimensional physical design in the form of pictorial paper or a picture. This design has drawbacks, including it requires a relatively long time and a lot of costs to manufacture, besides that the physical model is easily damaged or lost, and the document cannot provide a visual and real picture of a building. Which would be difficult for the public to understand. With the
development of technology, optimization of the 2-dimensional physical model can be done, so that it can affect many things, especially in terms of effectiveness and efficiency[1].

As one of the campuses with a fairly rapid development in the field of facilities and infrastructure, UNIDA Gontor needs dynamic building designs. A design that has a visual detail of the building and is easy to develop and update new design materials. The design is needed because a development that is quite rapid always requires renewal in the layout and design of new buildings, while the physical model of the prototype paper owned by UNIDA Gontor currently does not support the need for dynamic renewal, therefore a solution with adaptive technology is needed to compensate for the need.

A Visualization is an engineering creation of images, diagrams or animations to display some information, current design computer technology supports 3-dimensional visualization, compared to 2-dimensional objects, 3-dimensional objects have advantages in terms of visuality and image detail, this is because 3-dimensional models in addition to having x and y axes as object axles like 2-dimensional images, also have levels depth (z-axis) so that the resulting object looks more realistic and detailed[2].

Reference[3], mentioned in their research, To build a 3D model and 3D network dataset of a building, required accurate information about the shape, size and detailed specifications of the building the. Therefore, we collect images of each building to be made a 3D model, taking pictures continuously from each side of the building, even from taking aerial photographs.

Reference[4], has mentioned in their research that the result of 3D model design must be able to show good detail and have a level of reality in accordance with the original building shape, so that this 3D model can be used in later on as baseline data for restoration and reconstruction activities. In other similar research[5], it was explained in their research on the 3D visualization of mosque buildings, that the results of the 3-dimensional model were proven to be applied as additional information media and effective promotions.

The novelty in this research is the use of 3-dimensional modeling in the design of the building master plan, so it is hoped that the results of the modeling can be used to support the need for a dynamic and adaptive building layout design renewal, and can be operated easily anywhere and anytime.

2. Source and Method

2.1. Source
The data used in this research are based on paper blueprints that have previously been owned by the university. Blender is used as a 3-dimensional modeling design application for each building, Windows 10 is used as the operating system that runs the application, and 3d image viewer functions to display the modeling results that have been designed before.

2.2. Method
This research uses a research and development method in its design, following the flow of the waterfall model. In a reference[6], it is stated that the waterfall model has 5 stages, namely (1) requirements, (2) design, (3) implementation, (4) verification, (5) maintenance. We modify the flow of the waterfall model according to research needs, as seen in Table 1.

| Waterfall stages | Actions               |
|------------------|-----------------------|
| Requirement      | Interview             |
|                  | Material Collection   |
|                  | Study of literature   |
| Design           | Modeling              |
|                  | Texturing             |
| Implementation   | Rendering object      |

Table 1. Research Method Stages
Product Beta

| Verification       | Testing                      |
|--------------------|------------------------------|
|                    | Delivering product          |
|                    | and questionnaire           |

| Maintenance       | Final editing               |
|--------------------|------------------------------|
|                    | Rendering                   |
|                    | Final product               |

For the results of each of these stages will be explained in more detail in the results and discussion chapter

3. Result and Discussion

3.1. Requirement

In the initial stage, interviews were conducted with prospective users from the staff of the facilities and infrastructure section of UNIDA Gontor, aiming to identify existing problems, Table 2 shows the results of problem identification and the need for product design as a solution.

| No | Activities         | Result                                                                                                                                 |
|----|--------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| 1  | Problem identification | The blueprint masterplan building design owned by UNIDA Gontor is still in the form of paper, which is very vulnerable to damage and is considered less adaptive and dynamic for future infrastructure development needs. |
| 2  | Offered Solution    | 3 dimensional visualization for building masterplan                                                                                 |
| 3  | Design Method       | Waterfall Model                                                                                                                      |
| 4  | Technology to be used | 3 dimensional modelling                                                            |

From the results of interview, 8 buildings were determined to be made, namely the main building Unida Gontor, Markaz Shirah building, 4 student dormitories, diesel warehouse and car park. It is expected that based on the initial blueprint data, the resulting 3d modeling will be correct as needed.

![Figure 1. Umar bin khabat dormitory blueprint scan result](image-url)
The next step is material collection, which is done by taking pictures of the building from all sides, in order to get the appearance of the building that matches its original form and authentic colors. Taking pictures is also done via drones to get aerial photography, in a reference[7], it is stated that the results of aerial photographs are considered capable of providing the appearance of objects along with the whole that lies above it is more real and capable provides a wider viewing angle compared to shooting from below.

![Figure 2. Process of taking photos of the building from several sides](image)

![Figure 3. Aerial photos result taking from drone](image)

### 3.2. Design
After all material data has been collected, the next step is the design stage, which consists of modeling and texturing stages. here the whole 3-dimensional object will be designed.

#### 3.2.1. Modelling
mentioned in a similar reference[8], that modeling is a process the formation of a model according to a sketch or blueprint of the object. Digital Modeling is making a model from the real form as well as fictitious digitally using special software. In this research, 3d modeling was designed using a blender application, the blender was chosen based on its advantages that it is open source, lightweight and free, and has quite complete features in accordance with 3D modeling needs[9]. Figure 4 shows the process of modeling 3-dimensional buildings in the blender application.
3.2.2. *Texturing.* At the texturing stage, every 3-dimensional object that has been built before, is equipped with coloring in accordance with the original object, so that the object looks more real and natural and. The texturing process in a blender application can be made using existing material tools in the properties column in the blender application[10]. Figure 5 explains the texturing process in a 3-dimensional model.

![Figure 5. Texturing Stages](image)

3.3. *Implementation*

When the entire 3D object has been created, the next process is the finalization of the project, which includes the rendering stages and product launching.

3.3.1. *Rendering.* Reference[11], mentioning in their research that rendering is a conversion process from 3-dimensional objects to a ready-made image or video format (e.g., JPEG, BMP, GIF, Mpeg4 and others). More details or more the number of textures used is getting a lot of time needed in the rendering process. In this research, all 3-dimensional objects will be rendered into FBX format, the choice of FBX is due to its flexible nature, so that the rendered object can be easily displayed from various sides. Figure 6 describes the results of rendering a 3-dimensional building taken from various angles.

![Figure 6. Rendering Results](image)
3.4. Verification
At the verification stage, several tests are carried out so that the resulting product is in accordance with the needs. Table 3 describes the results of testing the color suitability level, the suitability of the 3d layout with the proper building shape.

Table 3. An example from color and layout suitability test

| No | Original Layout | 3D Modelling | Result |
|----|-----------------|--------------|--------|
| 1  | ![Original Layout Image] | ![3D Modelling Image] | Fix |
| 2  | ![Original Layout Image] | ![3D Modelling Image] | Fix |
| 3  | ![Original Layout Image] | ![3D Modelling Image] | Fix |
Further testing using the blackbox method[12], conducted with a success rate of displaying FBX files using a 3d image viewer, which showed a success rate of 90%. The failure occurred in one student dormitory object due to an input texture error, and improvements were made at the maintenance stage. Figure 7 describes the success and failure views when the object is opened using the 3d viewer application.

![Figure 7. Blackbox test result](image)

Testing was also carried out by distributing questionnaires to 7 staff of the facilities and infrastructure division of UNIDA Gontor as prospective users, getting an average score of 88.12%, so it can be said that the products produced are in accordance with user needs. Figure 8 presents the results of distributing questionnaires to prospective users.

![Figure 8. The results of distributing questionnaires](image)
3.5. Maintenance
Since this product was designed, it has been carried out twice maintenance, related to texture input errors on the model, and adding some detail objects to add to the reality of the product. The last maintenance was carried out in September 2020.

4. Conclusion
The 3-dimensional visualization product of the Darussalam Gontor University Building Master Plan, has been proven in accordance with user needs, as evidenced by the average score obtained of 88.12% on the distribution of questionnaires. 3D modeling products have also been proven in accordance with the original building model and can be used as a whole through black box testing. Hopefully this 3D material model can assist in planning the development and infrastructure at UNIDA Gontor in a more adaptive and dynamic manner and can be easily used anywhere.

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