REIMAGINING BRAGA

Remodeling Bandung’s Historical Colonial Streetscape in Virtual Reality

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Abstract. This paper presents the experience of the first phase of remodeling existing historical and colonial district in Bandung, Indonesia, including existing building façade, streetscape and street furniture. Braga Street is chosen as study case because it is a well-known historical street in Bandung with art deco style buildings constructed during Dutch colonial era. By remodeling it, it could help stakeholders to evaluate existing Braga street condition, to test any modification of buildings along the street and to determine specific regulation for the street. In this case, we use Unity3D and Oculus Rift DK2 for remodeling current situation. We gathered feedback from respondents using a questionnaire given after they experienced the model in VR. Many lessons learned from modeling process and respondents’ feedback: higher frame rate to make seamless VR experience by having all components on a low poly model and provide smoother movement to prevent visual discomfort. This paper’s conclusion gives suggestions for anyone who want to start architecture modeling in virtual reality for the very first time and how to optimize it.

Keywords. Virtual reality; historical building; digital reconstruction; streetscape.
1. Introduction

Virtual Reality (VR) is a generic term for technologies that artificially create an environment that encourages human sensory organs. VR technology projects the body of a user in a three-dimensional space and causes a sense of immersion in the space by the effect of the device by wearing it on his body part with images and sounds synthesised by the computer. In another way, VR is capable of shifting the user into a different environment without physically moving him (Gutiérrez et al. 2008).

As described by Whyte (2002), VR technology can be considered as a medium that has three defining characteristics: interactive, where users can interact with any projected models; spatial, where all models are represented in three spatial dimensions; and real-time, where all feedbacks received by the users from actions that occurred are given without noticeable pause. Also, to have something that we call as virtual reality experience, there are four key elements to be achieved: a virtual world, immersion, sensory feedback and interactivity (Craig & Sherman 2003). These characteristics show the possibility to use VR technology from built environment study, specifically for architecture. VR enables architect and professionals to dive into their design more realistic and feel the spatial experience before building the design. Not only to project design that is not constructed yet, but also to remodel existing buildings or architectural elements on selected parts of the city for digital reconstruction and preservation. In further, VR technology enhances collaboration among design team members (Wang 2007), including during early design stages in architecture design (Koutsabasis et al. 2012), which can make remote co-design team possible (Dorta et al. 2011).

In this paper, we share our experience on the first phase of remodelling building façade, selected construction and streetscape along Braga street in Bandung, Indonesia using VR. The first phase includes editing method for photos of buildings and street elements along the Braga Street and transforming them into a virtual reality model. Some students and faculty members are invited to experience the VR model and share their feedback on how to improve the model, using head-mounted display (HMD) as it is the best way to present the virtual world at lifesized scale and provides depth cues with stereoscopic vision (Ries 2011). Some challenges, difficulties, and solutions also will be discussed. The research was conducted by School of Architecture Planning and Policy Development of Institut Teknologi Bandung and College of Engineering and Design of Shibaura Institute of Technology.

The area we chose as our study case is Braga Street in Bandung, Indonesia. The reason to choose the street as the study case is that Braga Street has a unique streetscape in the form of art deco style buildings that Dutch colonial government built during their colonization in Indonesia. Most of the art deco style buildings were built around 1930. On our 3D model, we decide to model two buildings with a higher level of detail. They are Gedung Gas Negara or National Gas Building and Braga Permai. Both have architecture style and significant heritage value that represents the city development during the colonial era.
2. Research Goal
The overall research goal is to propose conservation and regeneration of the historic district, and existing heritage architecture in Braga Street. We adopt VR technology and examine how to make use of it and its effectiveness in an architectural documentation. On the first phase, the goal is to develop the first VR including building mass, façade, and some street elements and then, test it by asking students and academic staffs to experience the VR model using a head-mounted display and gathers their feedback on model precision and VR experience they have.

3. Research Methodology and Tools
This research use explorative (Groat & Wang 2002) qualitative research method (Creswell 2008). The exploratory qualitative study is conducted to gather data with various information possibility and at the same time, to know factors from information obtained. We use survey technique with a questionnaire as feedback collection method, and the analysis is done by several methods such as content analysis, distribution analysis, and correspondence analysis.

Before starting the modeling, we investigated research trends on visual simulation method, specifically on VR, and summarise the direction of space and landscape research that’s already studied. We also explored Braga Street by investigated its tropical art deco style architecture, its current situation and its master plan until 2031. Hereafter, we initiate the development of VR space of Braga street and conduct a comparison experiment between the real world situation which people have experienced before and the VR space, and clarify the difference of impression between each environment with a questionnaire. By gathering feedback from the questionnaire, we can have a broad range of comments to evaluate which would give a more balanced evaluation of the model (Patel et al. 2002). In this research, we use Oculus Rift DK2 for head-mounted display, 3DS Max, SketchUp and Unity3D for 3D and VR modeling. On first phase, Unity3D is used only to prepare 3D models into VR mode. Further VR modeling using Unity3D is conducted in the next phase.

4. Modeling Process
The main data needed to start the modelling is pictures of all building elevations along Braga Street. Therefore, in the first phase, we had a survey to take photos of each building elevation on the east and the west side of Braga Street. Several tools were used, including digital camera, smartphone camera, and a tripod.

Before the survey, a briefing was conducted to divide the team members into two groups with different tasks. Each team oversaw photographing a row of buildings on each side of the road. There are two people on each team in charge of taking pictures of building elevations (one using the aid of a tripod), one person taking pictures of street furniture; one person is taking pictures of road along a sidewalk. Elevation pictures were taken in parallel and measured with water pass.
Pictures of street furniture which were taken during the survey, including chairs, bollards, lamp posts, flower tubs, street signs, and statues of the Braga letters. In this process, the team was also taking photos of the texture of the furniture. Also, the width of the pavement along Braga Street was also measured using the ceramic floor size as a reference while the Braga letter statues were documented using hand sketch method with a plan, size and height of the floor as their reference. The photographing process carried out from south to north, and it takes about three hours.

4.1. PHOTO CORRECTION

After completing the survey, the next step is photo correction. Before starting the process, all photos that have been taken had to be organized. There are two folders made which were corrected and uncorrected/raw folder. The raw folder contained all photos taken during the survey, while the corrected folder contained all photos that have been through correction process. All of them are saved in PSD and JPEG file format.

Photo correction is done by using Photoshop and briefly consisted of three main stages: perspective correction, photo cleaning (for building pictures and signpost photos which were covered with vehicles, people, trees, and street furniture), and texture extraction. At perspective correction stage, we use Transform Lens Correction feature and add some imaginary lines helping to keep the image straight. Furthermore, the photo-cleaning process is done to remove objects that block the buildings by using Stamp, cloning (copy & paste), and a little touch up (if required). Lastly, texture extraction is done to get pavement and street furniture texture.

Figure 1. Braga Street. Source: Google Maps, 2016.
4.2. 3D MODELING ON SKETCHUP

The modelling process is done with several applications as shown in figure 2. 3D modeling is done in five stages:

![SketchUp Diagram](image)

**Figure 2. 3D modeling workflow.**

- **a. Tracing**
  On tracing stage, the base model is created first to put the building models in exact position. We trace it from Google Maps images with several streets as boundaries.

- **b. Modeling**
  In this stage, the building models were created based on the base model which had been created before while the height of the models was made considering the proportion of the building’s height and width as well as considering the buildings’ proportion to Braga Street’s width.

  The modelling started with traced base model from Google Maps data that were taken on 2015. Pavement model was also based on the results of manual measurement, which was based on the pavement tile floor coverings. In exception, Gedung Gas Negara (GGN) and Braga Permai buildings that were modelled separately with higher detail.

- **c. Combining**
  The building models on the right, and the left side of Braga Street were inserted into the base model that had been made previously and using GGN model and Braga Permai model as reference. After placing building models along Braga Street, surrounding building mass models were also created to fill the void between Braga and other streets specified for the modeling. Upon completion of modeling the entire buildings along Braga Street and surrounding building mass models, then street furniture installation process was begun. After placing the street furniture, the pavement along Braga Street is also modeled and adding ceramic texture on top of the pavement design.

- **d. Texturing**
  After creating each building models, building elevation for each building is added as texture. We use building elevation photos that have been fixed previously on photo correction process. By adding photo texture, the models have to be modified again to match the height and width of the building in the photographs.

- **e. Exporting**
  Within the five stage of the modeling process, exporting to Unity 3D is done sev-
eral times to see if the modeling needs to be corrected, such as building height proportion from human eye level and checking whether buildings along Braga Street had been already modeled resembling the reality. During several trials of exporting to Unity 3D, several problems were encountered, for example, the loading time had been too long, and the process of importing into Unity 3D had become too heavy. Eventually, all the buildings in SketchUp models had to be exported to 3DS Max and then convert it into low poly line models. As for the street furniture models, they had to be remodeled in 3DS Max.

4.3. MODELLING RESULT ON UNITY3D
To create a VR space, we need to import modeling data created in SketchUp into Unity 3D. However, modeling data created in SketchUp was a high-poly model and could not be imported to Unity3D. Therefore, modeling data is remade into a low-poly model using 3DS Max. Detailed low-poly work stages are as follows.

a. **Delete Unknown Objects & Combine Some Objects**
3D model that was created in SketchUp have some unknown objects which are not displayed on the 3DS Max work area. Therefore, the unknown objects which were not supposed to be in the model are deleted. Separate objects can be combined by selecting the object that wants to be combined and convert it to an editable object.

b. **Pro Optimizer Batch Processing**
Pro Optimizer tool on 3DS Max is used to reduce the number of vertices and number of faces while maintaining the appearance of the object. Optimising the object makes it possible to lessen the amount of memory required for the scene, as well as simplifying modelling as it reduces the surface of the object. Also, the viewport display speed and rendering time are also improved. After every step had been completed, the models were exported over and over into the Unity 3D to check whether it has finally resembled the Braga Street what we know in the real world as shown in figure 3

![Figure 3. VR model of Braga Street in Unity3D.](image-url)
5. Feedback Collection

To collect the feedback on the first VR model we have created, we showed in an exhibition in March 2016 in ITB campus (figure 4) and ask visitor as a respondent to experience the model and give their feedback using survey technique in the form of a questionnaire. The questionnaire is provided after he experienced the VR space model using the head-mounted device. Respondents were asked for their experience of exploring in VR-version of Braga street (how immersive it is, nausea feeling and dizziness rate), comparing the familiarity with the real situation, comment, and feedback to the model. From 38 respondents, most respondents are college students with 68%, followed by high school students with 19% and lecturer with 14%.

![Figure 4. Students are experiencing the VR model using HMD.](image)

Questionnaire given to the respondent contains four questions that prepared qualitatively and quantitatively. Qualitative questions use open-ended structure, and quantitative questions use close-ended structure. In this paper, we are going to analyze text data from qualitative questions with the support of quantitative question result. Respondent was asked to describe their experience of exploring Braga Street as a VR model in their words. These questions were posed in the form of one open-ended question. They were also requested to rate the area familiarity, nausea feeling, and dizziness that occurred during experiencing VR model which were asked in the form of three close-ended questions.

6. Analysis and Interpretation

The first step of content analysis we do is open coding phase where we identify some keywords from text data we got from questionnaire results. Here’s an example of respondent’s answers on their opinion after experiencing Braga street as a VR model using head-mounted device,

“Exciting. The view looks almost similar to the real one, but I feel dizzy” (Student)

“It’s almost like walking on Braga street, but with a different view” (Student)

Based on those answers, some keywords are found describing their experience on exploring VR model like “exciting,” “view looks almost similar,” and “feel dizzy.” Then, axial coding is done to categorized those keywords we got from open coding phase into several categories. This phase is done to avoid a biased result. Table 1 is showing the result of axial coding process for the research.
Table 1. Axial coding result.

<table>
<thead>
<tr>
<th>No</th>
<th>Category</th>
<th>Example keywords</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Unfamiliar scene</td>
<td>Not familiar with the location it is like somewhere in Bandung</td>
</tr>
<tr>
<td>2</td>
<td>Uncomfortable</td>
<td>Too sensitive for me Feels uncomfortable with the visual</td>
</tr>
<tr>
<td>3</td>
<td>Realistic view</td>
<td>It is like walking on Braga Street Almost similar to the original</td>
</tr>
<tr>
<td>4</td>
<td>Interested with the technology</td>
<td>Impressed Want to learn more about the app</td>
</tr>
<tr>
<td>5</td>
<td>Feeling dizzy</td>
<td>Too dizzy for me Feels dizzy when I walk too fast</td>
</tr>
<tr>
<td>6</td>
<td>Excited</td>
<td>It's fun Exciting</td>
</tr>
</tbody>
</table>

After we get all categories, distribution analysis is done to analyze the frequencies from each category. Distribution analysis is also done for the rest of quantitative questions that were asked during feedback collection process. The analysis is done to get to know dominance response about their experience on exploring Braga street as a VR model.

Figure 5 shows that 20 of 38 respondents feel excited when they are experiencing Braga street as a VR space model and 10 of 38 respondents think that the VR model they saw are realistic and close to the original scene, even though there are three respondents not familiar with the scene. Around seven respondents tell us that they are interested in the VR technology after experiencing it. Fewer respondents are feeling dizzy when they are in the VR scene and even feel uncomfortable.

Based on distribution analysis on quantitative questions we asked those surveyed, as shown in figure 6 (left), 84% of respondents (3-4) are familiar with the scene they saw in the VR model. Only 17% of total respondents (1-2) are less familiar with the scene. For the nausea feeling rate, figure 6 (center) shows that 44% of total respondents (3-4) are having nausea-feeling during the experiment and 57% of those surveyed (1-2) are having less nausea-feeling. For dizziness,
figure 6 (right) shows that 68% of total respondents (3-4) are feeling dizzy during the experiment and 32% of them are feeling less dizzy.

Figure 6. Distribution analysis on area familiarity (left), on nausea feeling rate (center), on dizziness rate (right).

The last phase we are doing from analysis process for this research is to do selective coding in the form of correspondence analysis. The analysis is done to know the correspondence relation between experience on exploring Braga street as a VR model and respondents’ profession. Using this analysis, we can know what kind of experience that people will expect based on their profession. Correspondent analysis using ward hierarchical clustering can be seen in figure 7.

Figure 7. Correspondence analysis between respondent experience feedback and occupation.

We can see that most respondents who feel excited with the VR model are college students. For high school student, they are interested in the VR technology and feel that the scene is close to the real situation in Braga street, but most of them are feeling dizzy when entering the VR scene. For lecturer, they feel uncomfortable with having that kind of VR experience, and even they feel unfamiliar with the scene.

7. Conclusion

From this research, we learn on how to start architecture modeling in virtual reality for the very first time and how to optimize it. First, we need to decide which parts of buildings along the road that we want to model. Then, do the 1:1 building measurement to get the building size precisely and take lots of picture of buildings that wants to be modeled. Sometimes, the modeler needs to visit the site more
than once to take another picture or do another measurement to the building. On modeling part, it is recommended to use the latest CAD files from the government or related agency for site base model. It also makes the modeler easier to identify the buildings along the road. To create a detail, accurate and lightweight model, it is better to use professional 3D modeling software to avoid lots of triangulation in a model or even a surface and make it as light as possible.

Reflected from the model performance and questionnaire result, we can conclude that the VR model of Braga street needs to improve in several areas especially on increasing the rendering performance, better navigation and the level of details. 3D rendering performance could be enhanced by optimizing the mesh, reducing the triangulation and separating the area that should render at the same time and might increase the frame rate. The “Avatar” speed movement in VR world needs to be readjusted and to make it walk as smooth as how people walking in reality to achieve better navigation. The level of details is also needed to be increased by adding more depth and surface texture to the buildings to make the scene is more familiar to anyone to experience it on VR world. From the questionnaire, we can also conclude that most people are excited about VR technology and even interested in exploring it more especially for students. With current VR model and HMD device we use, nausea feeling and dizziness still can’t be avoided by anyone who’s experiencing VR world. VR model created in this research is a base model that can be used and improved for another future research.

References