Virtual Reality Application of Interactive Interior The Development Study for Computer and Android Smartphones

Hendro Trieddiantoro Putro[1], Luhur Sapto Pamungkas[2], Suparno Sastra[3], Murwantoro Panghargyo[4], Endang Setyawati[5], Endah Tisnawati[6]

[1,2,3,4,5,6] Program Studi Arsitektur, Fakultas Sains dan Teknologi, Universitas Teknologi Yogyakarta
Jalan Glagahsari No.63 Umbulharjo Kampus 2 UTY, Yogyakarta, Indonesia

Article Info

ABSTRACT

This research describes the process, obstacles, and results in making a Virtual Reality Application of interactive interior using Unity 3D. In this research, we propose a VR application that supports interaction and VR views between users and the digital environment using computers and android smartphones. The study has three stages, namely input, process, and output. C# script was developed for user interaction with the digital environment. The user can interact in a small interior room with digital objects such as moving around, changing furniture color, and switching the light on or off. The research successfully created a virtual reality application using Unity3D for computers and android smartphones. This study clearly describes the step of making virtual reality applications and the problems encountered during the process—also, a more stabilized method for developing the interactive user feature. Moreover, the research brings another opportunity for VR application development that focuses on other VR development factors such as immersion, imagination, and insight.

Corresponding Author:

Hendro Trieddiantoro Putro,
Program Studi Arsitektur, Fakultas Sains dan Teknologi, Universitas Teknologi Yogyakarta,
Jalan Glagahsari No.63 Umbulharjo Kampus 2 UTY, Yogyakarta, Indonesia
Email: hendro.trieddiantoro@gmail.com

1. INTRODUCTION

There are specific visualization techniques; the most straightforward, such as 3D animation with a static view, has no interactivity between the user and the digital environment. The advanced type is an interactive visualization created using a game engine called Virtual Reality. Virtual Reality is sometimes called Virtual Environments [1]. VR is already used in architecture and design as an approach to be a medium and supporting tool in interior design. Virtual Reality is a medium by which humans can share ideas and experiences. VR is a computer-generated digital environment that interactively engages users [2].

Moreover, interactive Virtual Reality will help interior designers to get another perspective, such as a way to get more iteration and direct review from user interaction such as architecture students for spatial understanding [3]. In developing VR, applications use the technology of the game engine. Through a game engine like Unity3D, it is possible to create a realistic interactive environment of the interior [4]. Unity3D is a cross-platform game engine freely available for educational and research purposes. There are three primary types of VR categories. Those are non-immersive, immersive, and semi-immersive [5].

Immersion, interaction, imagination, and insight are keywords in the development of Virtual Reality applications [6]. The immersion factor is about the visual experience given to users. Immersive is to assure a great connection between believable and interaction that comes from immersion and presence, a sense of being here. Conceivable and imagination is a factor given to virtual reality applications; the purpose is to impact the user and aim to solve problems or convey specific ideas. At the same time, insight provides a deep understanding to groups of users and researchers.

Interaction in VR is about human interaction with a computer or application. Interaction is a factor that focuses on creating an interactive and explorable digital environment. Also, VR should embrace the same complexity and detail as the real world, such as interacting with the elements in the computer-generated world [7]. Furthermore, Straaten defines the interaction in a virtual environment in four components: purpose, participant, medium, and content [8]. Objectives relate to the goal of the VR application, and the participant is the user involved. Medium is the hardware or mediating technology that will connect the user to a digital environment, such as a head-mounted display, game pad, mouse, haptic gloves, etc. At the same time, the content consists of digital objects. The purpose of VR will affect the degree of interactivity in the digital environment [9]. According to Steuer, interactivity in VR is composed of three-element elements: speed, range, and mapping [10]. Rate relates to response time in the digital environment, which considers responding to user action as quickly as possible. The range is the degree of digital object that a user in the digital domain can manipulate. The more digital the user can interact with, the higher the degree of interactivity. While mapping relates to the interconnection between the action of the user and the action in the digital environment. Mapping will define the type of controllers that will use to interact with the digital environment and the specific hardware used to create an action, such as a mouse, head-mounted display, game pad, etc.

There is also plenty of Virtual Reality interactive research and project, such as various development of VR platforms such as single or multi-user using Web VR [11]. VR can also be used for visualizing the future of a city [12], a new method for digital heritage that preserves cultural and historical studies digitally [13] [14], interior decorating [15], and also study the usability of smartphones for Virtual Reality [16]. The design and implementation of Virtual Reality should have a friendly user interface [17]. The interaction capacity in Virtual Reality should be designed, for example, how the user can move around and interact with the digital environment [18]. Also, a good VR app should add the relevant voice, text, and image to give users a more in-depth understanding [19]. The efficacy of VR was well demonstrated for commercial and industrial development [20] and also useful for education, such as for architecture students to learn architectural space [3]. Designing as an activity involves decision-making based on solving spatial problems and generating new opportunities [21]. Virtual Reality also helps develop new opportunities in interior design, such as replicating real-size rooms into a digital environment [22]. Patera added that color in interior spaces evokes specific emotions. Students can better understand the effect of color in an actual or more extensive area, particularly in a digital environment with the user in it. However, the intent was to allow students to experience their own color choices in a digital environment of the actual sized room, not focusing on producing highly realistic rendering. According to Sneha [23], VR applications will save cost, resources, and workforce by substituting wasted money by building a sample room with a digital environment. However, to our knowledge, no studies have described the distinctive process of creating a VR application of interactive interior that focuses on user interaction that runs for computers and android smartphones and also analyzes and explains the problem.

Hence, the development of virtual reality applications is essential to discuss and clearly describe, such as focusing on creating the user interaction with the digital environment for computers and android smartphones. This research objective will investigate the distinctive process of building a VR application using Unity3D for single users for computers and smartphones that support VR views. In addition, we will develop a C# scripting language consisting of interactive methods for computer and android smartphone users to specific digital objects. The digital environment can be explored through a head-mounted display and manipulated through actions on the keyboard or gamepad. The method is left-clicking the mouse for the computer and using the timer method to interact with digital objects on the android smartphone using a head-mounted display. The purpose is to create the experience of a real-sized room and enable color iteration on a specific thing in the digital environment, such as changing the material color of the furniture and allowing the lighting for a better visual of the interior. At the end of this research, we will test VR applications on computers and android smartphones, then analyze and describe the report. This research benefits education, especially digital architecture, research, and technology development. This research will be an initiator project of a primary user interaction development in VR application for interior study. This research will also be a descriptive sample of the VR development process for computer and Android smartphones developed using Unity3D. The different focuses can create the degree of user interaction related to medium technology and other VR development factors. This research will be an example of investigating the process and problem encountered during the VR development using Unity3D and also brings up an optimized C# script method for a better solution.

2.   RESEARCH METHOD

The application uses Unity3D 2018.3.14f1. Unity3D is a cross-platform game engine freely available for educational and research purposes. Campbell explains in his thesis that unity3D and unreal engines are the two best software for developing VR applications [24]. Moreover, several 3D CAAD software can be used to make a 3D model, such as 3D Studio Max, Maya, Sketchup, etc. [4]. We use unity3D because this game engine is suited to our development purposes, considering the cross-platform output such as computer and smartphone android. Unity3D has various build setting; as shown in the figure below also need to choose the platform before the VR application development begin. A game production idea or workflow is known as a pipeline by performing several tasks sequentially, such as the concept phase, starting with the game concept, then explicit content, and implementation [25].
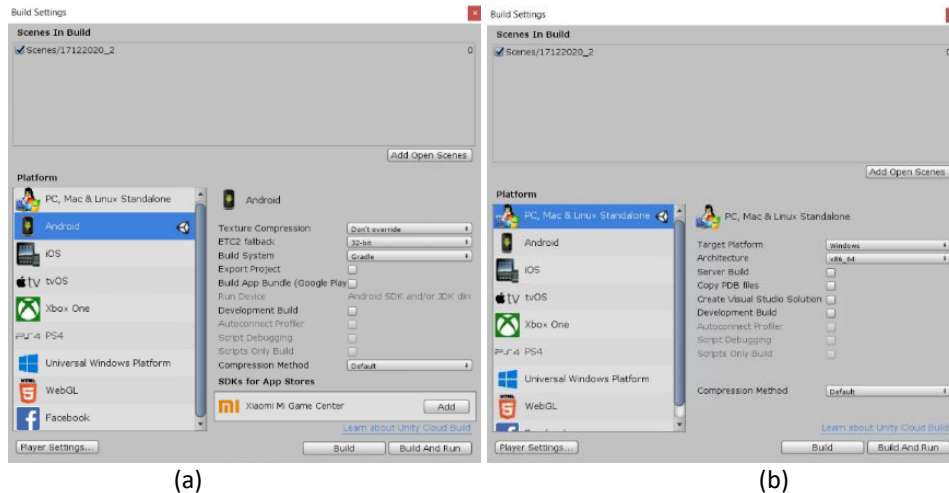

(a)   (b)

Figure 1 and 2. Build Setting in Unity3D

(a)   Build Setting for Android, (b) Build Setting for PC

The development of the VR application in this research is grouped into three stages, as shown in the figure below, namely input, process, and output. Input is the process of creating the 3D model of an interior. The 3D model for an interior used in this research was developed from [BFW]ArchViz Interior Apartment Vol.01. A 3D model was downloaded from the Unity asset store. The 3D model described already includes furniture and material [26]. Also, the low poly 3D object model will be good for optimized or customized [27]. It uses soft poly mesh in games and high poly for animated movies [25].
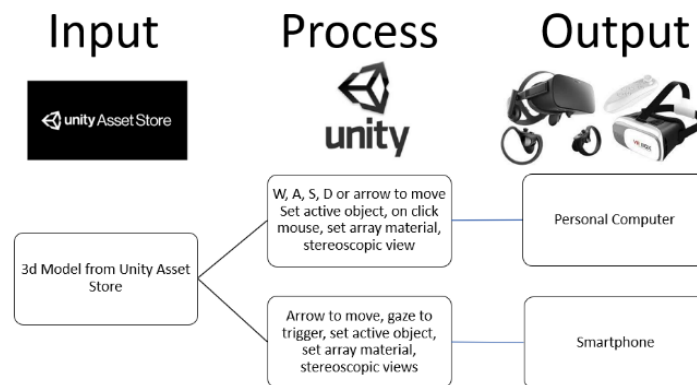

Figure 3. Research Workflow

The next step is developing the scripting interaction and behavior—developing the scripting interaction process using Unity3D script editor or Microsoft visual studio. The C# scripts language is to exchange the user to the digital environment such as moving the camera, iteration of furniture material color and lighting visual also put gravity and controlling moving camera speed [19]. The output is the final VR application planned to run on multiple platforms, like a personal computer and Android smartphone. The Virtual Reality interaction is designed for a head-mounted display such as Oculus and VR Box, a keyboard or gamepad, and a computer mouse. Google VR SDK is also used to develop the VR application, especially for Android smartphones. It consists of several C# scripts that can be created for user interaction in a digital environment using an android smartphone.
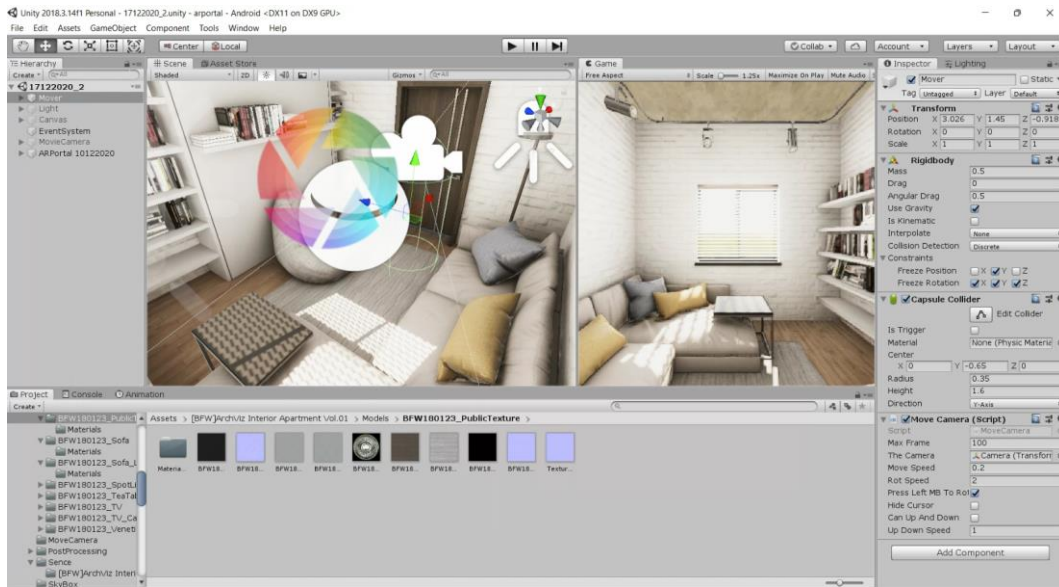

Figure 4. Unity3D Game Engine Screen

The last stage is the output; this stage consists of the building process on the targeted platform and initial app testing on personal computers and android smartphones. It uses a minimum computer specification for developing and testing a virtual reality application with Unity3D, such as CPU, VGA, and RAM [19]. This minimum computer requirement is related to preventing user motion sickness and delay that caused lagging when the app runs. The recommended android smartphone API level is 19, or an Android device that runs Android 4.4 Kitkat. It is the minimum requirement for running a VR application for Android smartphones or hardware that uses cardboard VR. The software requirement for google VR development is Unity3D 2018 or newer [28].

3.   RESULTS AND DISCUSSION

The input stage develops a fully 3D model of a small room interior with furniture and a set of material colors, as seen in the figure below. The interior is a small room of a 9-meter square with a sofa set with a pillow and table, a lazy sofa, a bookshelf, a lamp, and a carpet. A small window on one side of the room gives daylighting visual into the room. The application's main menu consists of an option for users to get information about the app and exit the app. The figure below shows detailed information about the VR app.

There is 3 type of light used in this 3D model, directional type light for creating sunlight, spotlight for stand lamp, and baked area light for creating the atmosphere of the day scene. There is also one camera with a C# script, so the user can interact with every object included in this small room, such as changing the furniture's color and turning the lamp light on or off.

(a)
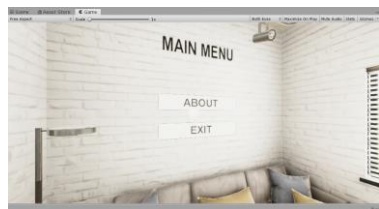
(b)   (c)

Figure 5. Developed 3D model
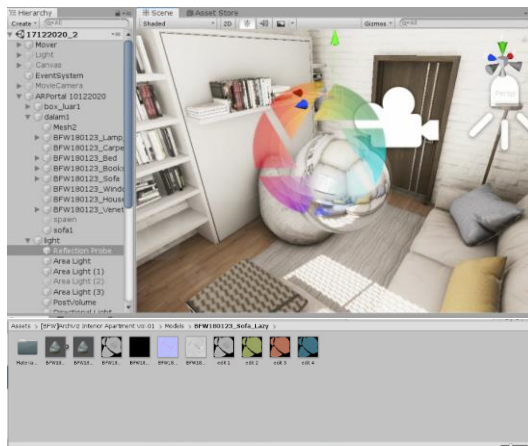
(a) 3D model, (b) Main Menu, (c) About

Figure 6. Set of materials color for furniture iteration and scene of 3D Model in Unity3D

The interaction stage produced a user interface and several input key methods that trigger an action, such as using a keyboard or gamepad for moving around in digital environments. The moving camera script is developed for computer and smartphone applications whenever an input key is detected. It will transform the camera into a new position according to the legend pressed, such as W or up arrow, S or down arrow, D or right arrow, and A or left hand. In addition, it can also set the parameters of the moving and rotating speed. Moreover, there is also a feature for computer users using mouse left click to rotate, hide the cursor, and freely move up and down without gravity included.
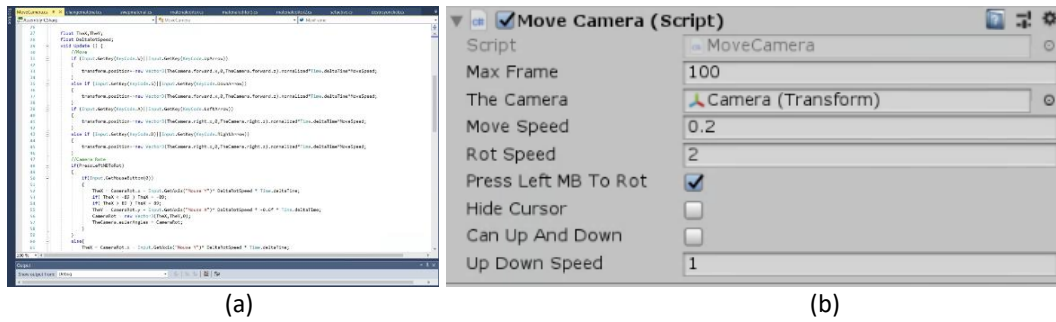
Figure 7. Move Camera Script for Computer VR application,

(a) Move Camera Script developed, (b) Move Camera interface

We developed a trigger method for user interaction called the GVR button for the user to interact with digital objects, such as gazing ray cast on digital things that work as pointers using VR head-mounted display for android smartphones. The script works as a substitute for the mouse click on an android smartphone; instead of using a mouse click, they need to gaze at a digital object and wait a specific time to trigger an action. Furthermore, it can set the total time for gazing and distance of ray for a particular activity. We set the parameter 2 seconds to create a complete circle at the full-timer, as seen in the figure below.
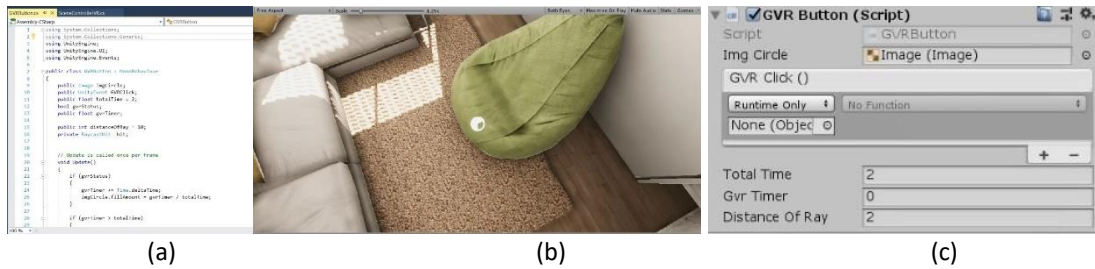

Figure 8. GVR Button Script for Android VR Application,

(a) GVR Script developed, (b) Gaze time, (c) GVR button interface

From initial testing of user interaction, we found that there still needs an optimization about switching the object material or texture that using trigger method such as gamepad or mouse left clicking on the targeted object. After several trials, we are not recommending using the method of setting active things true or false for iterating the furniture. It will gradually decrease the frame per second and cause lagging of the virtual environment. So, an optimization for the method is required. The phase for optimization or creating a smoother object to create less lagging when changing object material is a standard process in developing VR apps [29].
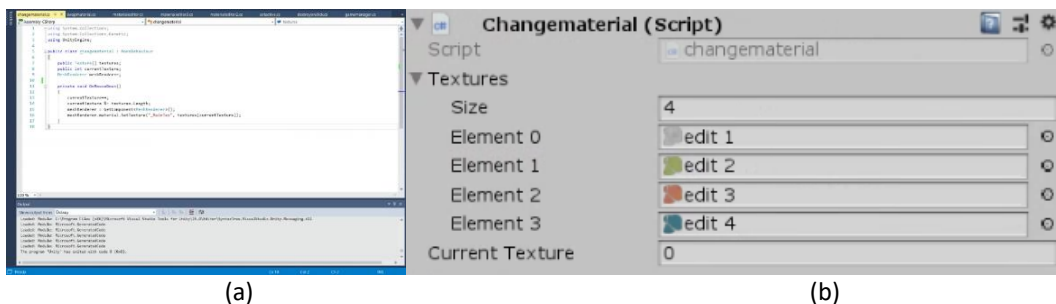

Figure 9. Change the Color of furniture Script for VR application

(a) Move Camera Script developed, (b) Move Camera interface

Interior design is about mixing and matching colors [30]. Implementation of colors will affect the user, such as culture, psychology, and art. To mix and match the furniture's color, we try to swap object material using albedo texture on standard material stored manually using the array method as seen in the figure above. First, we make a set of furniture color materials from the 3D model input stage. Then we used it as action triggered interaction. The 3D object texture switched sequentially based on a list of surfaces every time it started with the left mouse clicked on the object and the pointer gazing at the object using VR head-mounted display for a smartphone. It is a current, reliable method for the optimization process of iterating the furniture color.
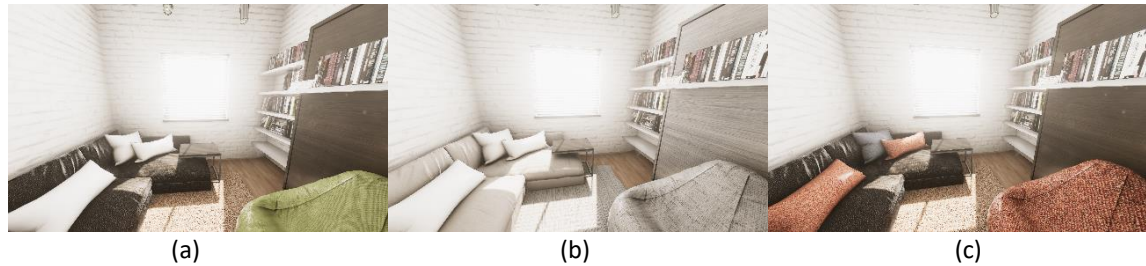

(a)   (b)   (c)

Figure 10. Iteration of Furniture Color

(a) Iteration 1, (b) Iteration 2, (c) Iteration 3

The computer specification for this research is CPU i7-3770, GPU Nvidia GTX 560, and RAM 12GB. Also, the android smartphone for app test uses a Pocophone F1, which had Android 8.1 Oreo for OS with 6GB RAM. In addition, there is various hardware for running a VR application for a computer, such as Oculus Rift for head-mounted devices and VR Box for android smartphones. The Oculus Rift is a headset package consisting of a gamepad used for gaming purposes; it has a position tracking system and two paired lenses to view two 2D images as one 3D image [31].
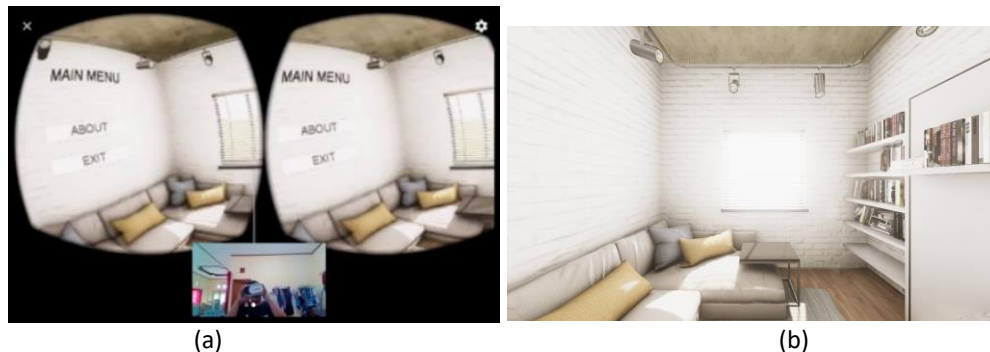

(a)   (b)

Figure 11. VR App Testing

(a) App Running on Smartphone, (b) App Running on Computer

VR Application tested with a computer and an android smartphone was recorded. The application is running smoothly on personal computers. There is no problem shown on opening the app, and the user interaction worked well with no delay or lag. However, it showed a lagging issue when testing the VR application with the smartphone Pocophone F1. There is a delay every time the user tries to turn around to another angle with VR Box head-mounted device. Arguably, latency or delay are common problems for VR applications, especially smartphones [32]. The problem happened because the model's polygon exceeded the smartphone's limited processing power and caused excess RAM usage. The artists must define maximum polygons, keeping the number and detail of polygons as low as possible [25]. The overextended box collider was another problem that occurred when testing the application. It makes the trigger input of the 3D model area overlap. The user must calibrate the box collider area to make interaction with digital objects work well. Conversely, the testing went well in exchange for switching on or off the lamp for both platforms. There is no delay or latency on this specific testing.

(a)   (b)

Figure 12. VR App Initial Testing

(a) Switch the Lamp On, (b) Switch the Lamp Off

4. CONCLUSION

The research successfully created a virtual reality application using Unity3D for computers and Android smartphones. This study clearly describes the step of making virtual reality applications and the problems encountered during the process. Creating VR applications in Unity3D, such as input, process, and output is the primary key to developing VR applications. The planned output platform of the intended VR application will define the process, such as the building setting in Unity3D, and the software that influences the programming language, such as C#. The C# script developed for user interaction for computers and android smartphones in this research is right on target. It allows users free access to move around and interact with an object in a digital environment. For example, the furniture color iteration using the VR application will enable users to explore various alternatives for mixing and matching colors. This degree of freedom in this VR application is helpful for architecture education, especially for interior studies focusing on color and sense of place.

Furthermore, the VR application runs smoothly on personal computers but not on Android smartphones and happened because the model's polygon exceeded the limited processing power of Android smartphones and caused excess RAM use. There is much room for improvement, especially for user interaction that uses more advanced hardware such as haptic gloves or gesture methods and developing multi-user interaction. The problem occurred from a large box collider that made several 3D objects overlap. The research brings another opportunity for VR application development, focusing on factors such as immersion, imagination, and insight and utilizing Building Information Modeling in 3D model development for VR application for specific teaching, training, and research purposes. This research describes the distinctive process of making a VR application for computers and android smartphones. The input process, such as making an efficient 3D model for VR application and the efficacy of VR application for an architecture student to understand scale and color effects in the digital environment, will be one of the focuses of the subsequent research.

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BIOGRAPHIES OF AUTHORS

Hendro Trieddiantoro Putro	Hendro Trieddiantoro Putro is a researcher focusing on digital architecture and computational design. His latest research utilizes BIM, Virtual Reality and Augmented Reality in digital heritage and architecture design. He is a lecturer in the bachelor of architecture study program at the University of Technology Yogyakarta. He joined a team teaching at the design studio, building technology, building physics, and bioclimatic architecture. He holds a bachelor's and master's degree from Gadjah Mada University. His thesis explores the spatial perception in architecture at Ando's The Church of Light using Virtual Reality.
Luhur Sapto Pamungkas	Luhur Sapto Pamungkas is a researcher focusing on digital architecture and green building. He has a specialty as Greenship Professional with Green Building Council Indonesia. He is a lecturer in the bachelor of architecture study program at the University of Technology Yogyakarta. He joined a team teaching at the design studio, building technology, investment and real estate. He holds a bachelor's and master's degree from Gadjah Mada University. He is a Ph.D. Candidate from Gadjah Mada University. His thesis discusses spatial and typology related to green building assessment.
Suparno Sastra	Suparno is a researcher who focuses on facade aesthetics and residential typology. His latest research is about the typology of changes in the function of village houses due to the construction of a development center. He is a lecturer in the undergraduate architecture study program at the University of Technology Yogyakarta. He joined a team teaching the courses Architectural Design Studio, Building Technology, Investment and Real Estate, and Structure and Construction. He holds bachelor's and master's degrees from Gadjah Mada University. His thesis explores the Aesthetic Forms of Real Estate Housing Facades in Yogyakarta.
Murwantoro Panghargiyo	Murwantoro Panghargiyo is a researcher focusing on Building Science, especially Building Energy. His latest research explains thermal and daylighting performance in Kampus 3 University Technology of Yogyakarta. He is a lecturer in the bachelor of architecture study program at the University of Technology Yogyakarta. He joined a team teaching at the design studio, architecture building science, and building structure. He holds a bachelor's and a master's degree from Gadjah Mada University. His thesis explores the depth of shading devices in thermal and daylighting performance in Jakarta.
Endang Setyawati	Endang Setyawati is a researcher focusing on the typology morphology of heritage buildings and cultural heritage. Her latest research is about the Pathok Negoro Mosques as the form of territorial defense region of Mataram Kingdom of Islam Java in Jogjakarta. She is a lecturer in the bachelor of architecture study program at the University of Technology Yogyakarta. She joined a team teaching at the design studio, architecture history, and building structure. She holds a doctoral degree from Diponegoro University. Her doctoral thesis explains the Form, Function, and Architectural Meaning of Pathok Negoro Mosque in Defense of the Yogyakarta Sultanate.
Endah Tisnawati	Endah Tisnawati is a researcher and lecturer living in Yogyakarta. She specializes in urban kampung spatial studies, heritage conservation, and architectural design. Tisnawati has spent almost 15 years in urban kampung empowerment programs and heritage conservation activities in Yogyakarta and Indonesia. Her thesis focuses on spatial settlement changes in urban kampung around educational facilities in downtown Yogyakarta City.