

3D Spatial Development of Historic Urban Landscape to Promote a Historical Spatial Data System

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Abstract

Spatial experience in historical street corridors is essential to encourage a continuously satisfying experience of a historical aesthetic leading to a better quality of the historic urban landscape, which is significant for making precious memory of the city's history. 3D spatial formation along the historic street corridor fosters the generation of historical memory of the urban space. Both tangible and intangible aspects attached to the historic street corridors' spatial configuration have significant meaning that forms the integrity of the valuable historical urban space. The research area is in Kayutangan street as one of the historical street corridors in Malang City, East Java, Indonesia. The study aims to develop the historical spatial data system of the Kayutangan corridor to construct an online digital spatial database and enforce it as a policy decision reference by the government in managing the urban development in historical areas, especially in the Kayutangan street corridors. The 3D spatial development of historic urban landscape performed the combination of 3D modeling software, 3D visualization software, and 3D spatial multimedia application authoring platforms. The collaboration of three systems generated three spatial data types, namely a 3D spatial-passive observation data, a 3D spatial-active observation data, and 3D spatial-interactive simulation data. As a result, this study produces 3D spatial multimedia contained the 3D spatial of historical data of Kayutangan streetscape, which performs as a historical spatial data system to reference the smart development of cultural tourism and heritage cities in Malang.

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Keywords

Urban Modeling; Historic Streetscape; Historical Spatial Data; Online-Spatial Multimedia; Kayutangan Street

1. Introduction

The aesthetic experience is commonly defined as the experience of a human being to the environment that gives a sense of pleasure, desire, life value, and meaning. A cultural context and human locality are born to build a specific characteristic that will provide identifiers for every human experience. Awareness and aesthetic taste will be dependent on human memory traces in the aesthetic experience. According to Leder *et al.* (2004), aesthetic processing relies on some implicit memory effects, and the results of this do not have to become conscious to affect aesthetic processing.

On the other hand, historic streetscape as one of the valuable parts of urban spaces becomes a space medium that is responsive to the heritage values existing in human beings with the perception values generated by urban space formation. Well-designed historic streetscapes contribute to the visual quality and livability of the communities. Historic streetscapes make a significant contribution to the urban character and overall legibility of settlements since

they are the primary way to travel through and experience different areas. The historic streetscapes must create a suitable environment for people to visit and gather to be the center of urban image.

In order to encourage the improvement of the good governance framework and support the 2011 UNESCO plan, the essential steps of the Historic Urban Landscape approach are recommended to the member countries and relevant local authorities. So, one of the critical consensuses that need to be examined is the importance of building appropriate partnerships and local management frameworks in identifying buildings and conserved landscapes and developing conservation control mechanisms to coordinate various activities between different public and private actors. Furthermore, the development of a multimedia spatial system is very much needed. It will refer to the rules of developing digital platforms to manage urban heritage (Digital Platform for Urban Heritage Management). Therefore, the spatial multimedia system development requires spatial data containing three crucial information, namely historical layer data, present situation data, and future planning data, as supporting materials.

Malang is one of the historic cities in Indonesia, with many beautiful urban landscapes built during the Dutch colonial period. One of the city's beautiful historical landscapes in Malang is the Kayutangan Street corridor. This study aims to construct the 3D historical spatial data system for the Kayutangan Street corridor in Malang, Indonesia.

2. Literature review

2.1. Site history and background

Malang earned the nickname *Parijs van Oost-Java* because the city's beauty is like the city of "Paris" in the east of Java. Moreover, Malang also earned the nickname *Zwitserland van Java* because of its city's beauty, surrounded by mountains and neat city layout, matching the Swiss country in Europe.

In the early development, the Kayutangan region in the Dutch colonial era, around the 1900s, the Kayutangan region was intended as a trading area. Around the 1960-1970s, the shopping area of Kayutangan became a lively trade center in the Malang city, through a diversity of commercial operations, i.e., general trade function, office, movie theaters, clothing stores, grocery, and others. At first, the Kayutangan area was reserved for Europeans. The building's characteristic shape in the Kayutangan region is an elongated-shaped building on an extensive streetside, cube-shaped, and has a small street or alley to the rear for easy oversee the surrounding environment. The natives used the building's arrangement as a place to lean back in the crowded mall, looking for opportunities to get closer to the business as an employee working at Kayutangan street. The Europeans living in the streetside of the Kayutangan area required business opportunities as the employee at Kayutangan street. The condition was eventually changed as well as a place to live. In recent days, trade and services still dominate the building functions along the Kayutangan street corridor. The trade function totaled 50%, whereas the function of services totaled 48% (Santosa et al., 2013). The trading function is dominated by banking, restaurants and cafes, travel and tour agencies, clothing stores, groceries, and motorcycle dealers and services (see Figure 1.).

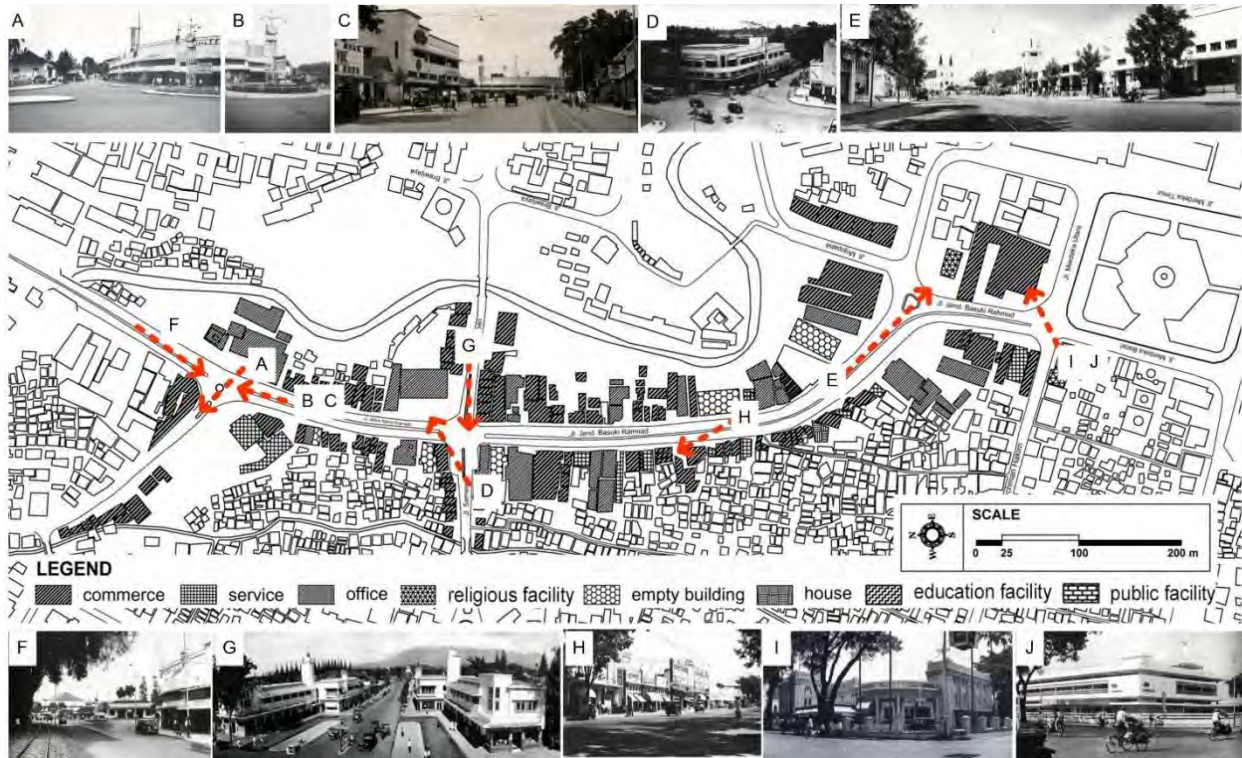


Figure 1. The historic urban landscape in Kayutangan Street

The characteristics of the building facade in Kayutangan street is mostly a legacy of the Dutch colonial architecture. According to Soehargo (1996), the development of Dutch colonial architecture in Malang city, especially in Kayutangan Street, is closely related to the development of the colonial in the Dutch Indies at that time. There are three periods of development classification: the development of colonial architecture in the 19th century (1850-1900), the development of early colonial architecture in the 20th century (1900-1915), and the development of colonial architecture 1916 – 1940. Dutch colonial architectural style developed in this period, the Indische Empire style, was taken from a French architectural style, i.e., Empire Style. This style extends to all levels of society, applied to residential buildings and in public buildings. The Indies Empire Style characteristic is as follows: full symmetry shaped of the floor plan, thick walls, high ceilings, and marble floors. Colonial architecture that spread in 1900-1915 is an architecture style of early modern colonial, in which a building floor plan still has a stable pattern of symmetry. Their Architectural elements are commonly used in the Netherlands in many buildings. The architectural elements often used in many building design cases were building detail and tower (Soehargo, 1996). Meanwhile, the Colonial Architecture style developed in 1915-1940 has thoroughly modern architecture named *Nieuwe Bouwen*, which has characteristics: the use of a variety flat-shaped on the building roof, flat roof, horizontal gevel, the volume of a cube-shaped building, and white painted.

The beauty of the Kayutangan road corridor's historic landscape is a valuable historic asset to be preserved. Kayutangan street corridor is strived to become a historic urban landscape that can become one of the tourism destinations of Malang heritage tourism and bring historic spatial experience. On the other hand, spatial experience in historical street corridors is essential to encourage a continuously satisfying experience of a historical aesthetic leading to a better quality of the historic urban landscape, which is significant for making precious memory of the city's history. 3D spatial formation along the historic street corridor fosters the generation of historical memory of the urban space. Both tangible and intangible aspects attached to the historic street corridors' spatial configuration have significant meaning that forms the integrity of the valuable historical urban space.

2.2. Related previous studies

There are various methods used to build historical spatial data in many studies, such as physical data recording using Photogrammetry (Demetrescu et al., 2020; Aicardi et al., 2018; Andrés et al., 2012), 3D modeling development (Demetrescu et al., 2020; Georgoula et al., 2013; Alsadik et al., 2013), Heritage Building Interaction Modeling

(HBIM) (Khodeir et al., 2016), and virtual tour (Jacobson et al., 2009; Mah et al., 2019; Napolitano et al., 2018). On the other hand, the process of historical spatial data making required at least six essential stages that consist of 3D visualization scenario, data collection, 3D modeling, geometry optimization, texture application, and the entity object (Santosa et al., 2014). 3D visualization scenario is the fundamental stages in preparing the basic concept of creating a visualization type. There are four essential considerations for constructing 3D visualization, as follows: estimation of the final form of 3D models historic streetscapes, detailing the level of geometry model polygon which affects the amount of digital data, type of interactive visualization of the historic 3D spatial data object needed, and the navigation method that determines the navigation control system for handling interactions on the Virtual Environment. These considerations will determine the strategy of presenting a form of historical exploration of spatial data to users.

The development of digital data visualization that can be accessed by the wider community also leads to the development of interactive 3D spatial data visualization techniques. 3D interactive visualization development as a tool in the decision-making process in urban visual landscape planning demands the importance of observation and navigation activities in the passive-interaction level to active-interaction level in the Virtual Environment (Santosa et al., 2014; Wu et al., 2010). Gaps in the level of interactivity in the visualization of historical spatial data systems aim to accommodate various levels of the importance of data system access while accommodating the diversity of knowledge and people's ability to understand spatial data technology. The passive interaction level aims to bring passive observation that directs users to a predefined 3D visualization animation and may be perfectly adequate for virtual tourism experiences. At the same time, the active interaction level delivers the ability to take control of the navigation of a virtual model that might lead to a deeper and richer understanding of the modeled space, since people tend to experience the real world through self-determined movement through it (Santosa et al., 2014).

On the other hand, some researchers have conducted studies related to the use of 3D interactive visualization combined with the development of user interface design as spatial multimedia for building consensus through public participation (Honjo & Lim, 2001; Kawakami & Shen, 2006; Koga et al., 2008; Shen & Kawakami, 2010; Takiguchi et al., 2003). There are various techniques used to develop spatial multimedia, such as web multimedia development (Doyle et al., 1998; Orland et al., 2001), interaction in the virtual environment (Howard & Gaborit, 2007; Ibanez & Delgado-Mata, 2011), navigation technique setting on the web (Martens & Antonenko, 2012; Burigat & Chittaro, 2007; Conniff et al., 2010; Laing et al., 2007), and simulation technique on the web (Dykes, 2000; Parush & Berman, 2004; Marini et al., 1997; Huang & Claramunt, 2004; Munzer et al., 2009).

Recently, the development of 3D historical spatial data as a digital database and even for the decision-making support system in the planning process began to flourish and was widely used in urban planning (Burigat & Chittaro, 2007). The use of a digital spatial data system in a multimedia manner is intended as a medium of interaction between the conservation management of the historic urban landscape by the government and the community. Moreover, developing a 3D spatial data system involves the scripting language to construct a 3D interactive visualization in web interface design (Santosa et al., 2014).

3. Methodology

As shown in Figure 2, the location of the study illustrates the area of Kayutangan starting from the Oro-Oro Dowo T-junction in front of the National Electric Company to the south, which is precisely in the north of Malang city square.

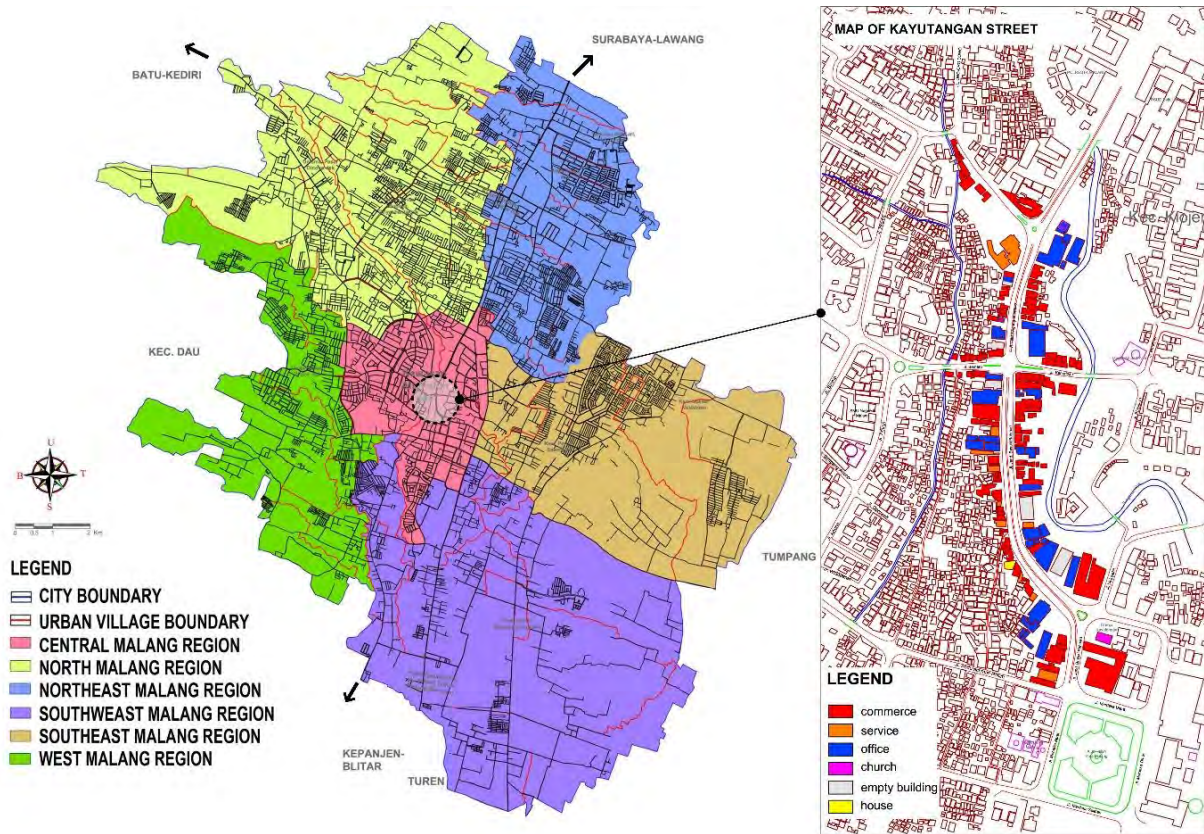


Figure 2. Map of the research location in Kayutangan Street

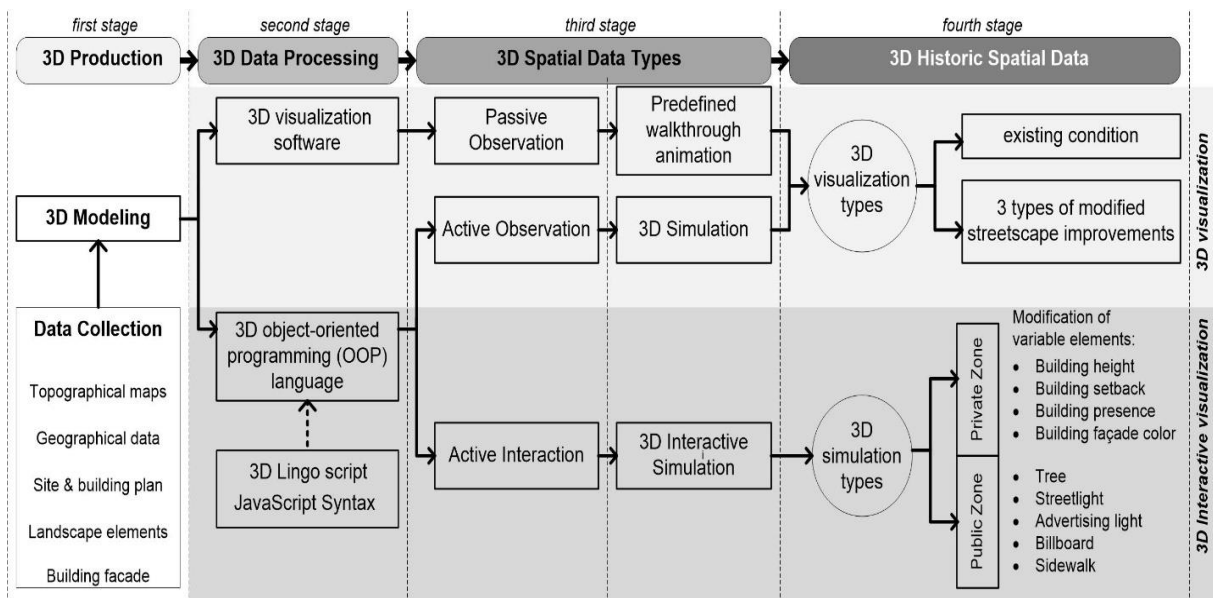


Figure 3. The development framework of a 3D historical spatial data system

The research focuses on developing the online digital data visualization system to promote a spatial multimedia system of the historic urban landscape to boost public engagement on a sense of belonging to the historic city space. This study method involves four primary stages consisting of the production of 3D historic street corridor modeling, the processing of 3D modeling data that collaborates with the 3D visualization software and 3D object-oriented programming (OOP) language, the production of 3D spatial data types, and the development of 3D spatial multimedia of historical spatial data types consisting of predefined 3D visualization and 3D interactive visualization (see Figure 3.)

3.1. The 3D modeling of a historic street corridor

The technical process of the visualization stage of making a 3D modeling of a historic street corridor requires a relatively long step. Manufacture stages depending on the complexity and diversity of 3D models that must be arranged. In principle, four elements must be arranged in a 3D visualization composed of topography elements, building elements, landscape elements, and environmental settings. The wider the area of 3D visualization objects, the more involved the work will be, which takes more time and considerable effort.

The making process of landscape 3D modeling of a historical corridor on Kayutangan Street begins with the preparation of modeling scenarios based on the ultimate goal of the expected visualization form. 3D modeling is a fundamental stage that determines the level of detail of the object geometry that will be presented later on in the visualization. This stage also affects the 3D digital data load that will be generated, which indirectly affects the development of multimedia system application models that will be created. Making 3D models on a reasonably broad corridor scale requires a 3D modeling strategy that is lightweight and easy to run in online applications. The 3D modeling stage also requires an extended time depending on the number of objects and elements that must be made in a single corridor. Therefore, the strategy used is to divide the 3D modeling of the Kayutangan road corridor into three sections of the road corridor. Each element's modeling technique in the road corridor uses a low polygon technique and optimizes an image-based approach. Thus, it needs to set the level of detail of building objects and other road corridor elements that are quite optimal. The spatial data visualization results will still have a representative level of precision and accuracy to be presented in the virtual environment. On the other hand, it is essential to set the number of object entities and the types of elements in each 3D object for visualization purposes at the level of active observation and active interaction.

At the stage of acquisition of object data in the field uses the close-range photogrammetry technique combining grid mission type and circular mission type on drone mapping techniques (see Figure 4). Simultaneously, the 3D mapping process from drone mapping results uses a combination of image matching and 3D montage methods. The process of 3D mapping in photogrammetry software is done by dividing the stages of image matching per area to lighten the 3D mapping process and improve the results' accuracy. While the 3D montage stage is used to combine image matching results from the results of the photogrammetry process with 3D modeling (see Figure 5.)

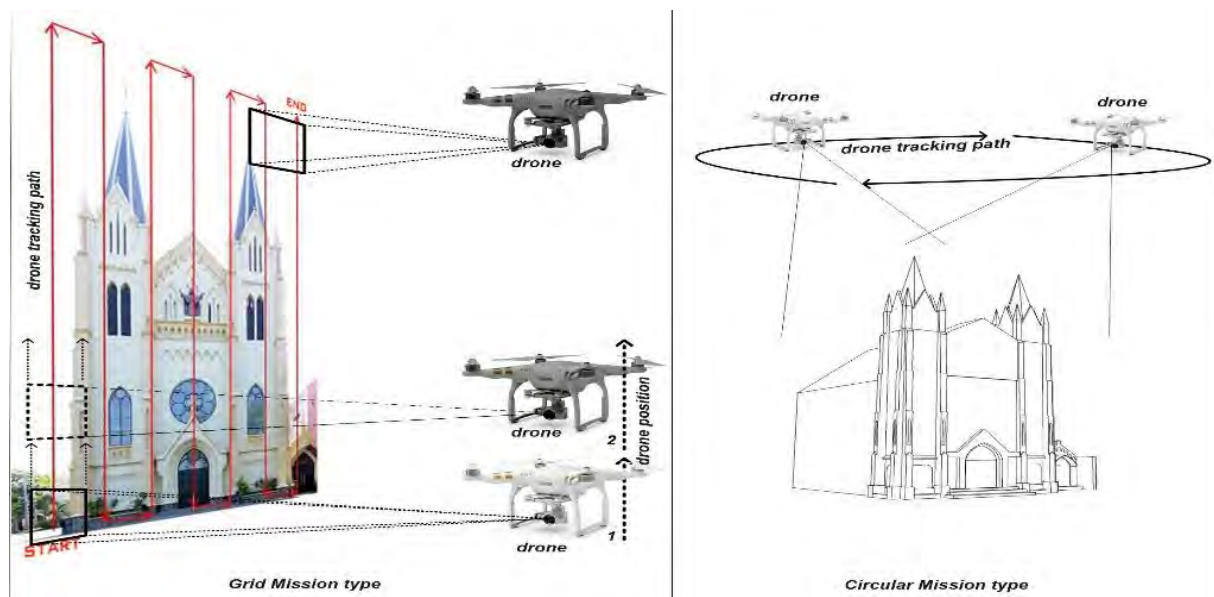


Figure 4. The data acquisition of 3D historical data using a drone (UAV)

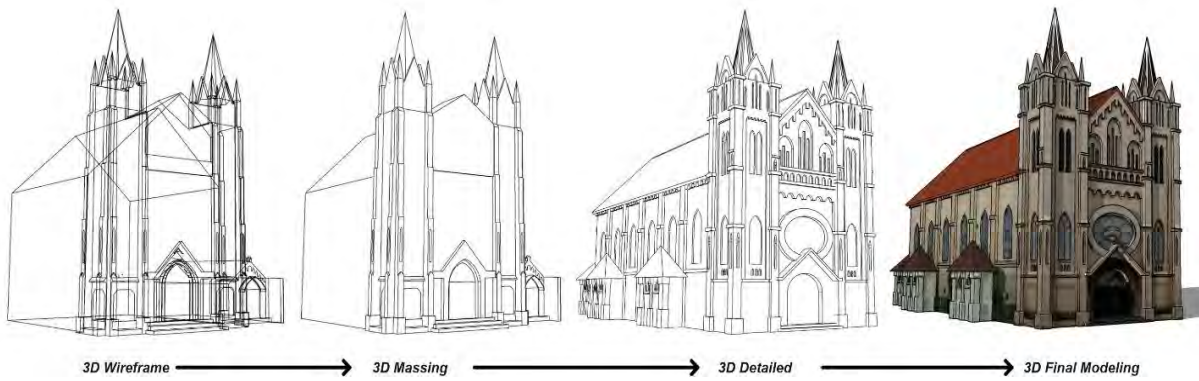


Figure 5. The production stage of 3D historic building modeling in Kayutangan Street

3.2. The processing of 3D modeling data

The final process of 3D modeling produces 3D modeling data in three types (see Figure 6.). The first type is 3D modeling data, where all elements of the street corridor are integrated into a unified spatial data unit in a single corridor. This type of data is exported to the 3D visualization software application for predefined walkthrough animation (passive observation), which is the visualization content at the necessary level of user interactivity on the system. The second type is 3D modeling data that is divided into each entity element of the road corridor object. Each of these 3D object element entities is incorporated into a multimedia application authoring platform to embed the 3D object programming language to produce two types of interactivity levels produced, namely active observation and active interaction. Visualization of the active observation type produces a 3D simulation product of the Kayutangan road corridor in the virtual environment, giving users access to conducting 3D spatial exploration.

Moreover, the visualization of the active interaction type results in a 3D interactive simulation product of the Kayutangan road corridor in a virtual environment, which gives users access to being able to perform 3D spatial exploration and perform modification interaction on 3D objects along the road corridor. Active interaction also means that the user has control to direct the movement simulation (active navigation) and the interaction of 3D objects in the world of 3D models (Virtual Environment). The ability to take control of a virtual model's navigation might lead to a deeper and richer understanding of the modeled space since people tend to experience the real world through self-determined movement through it.

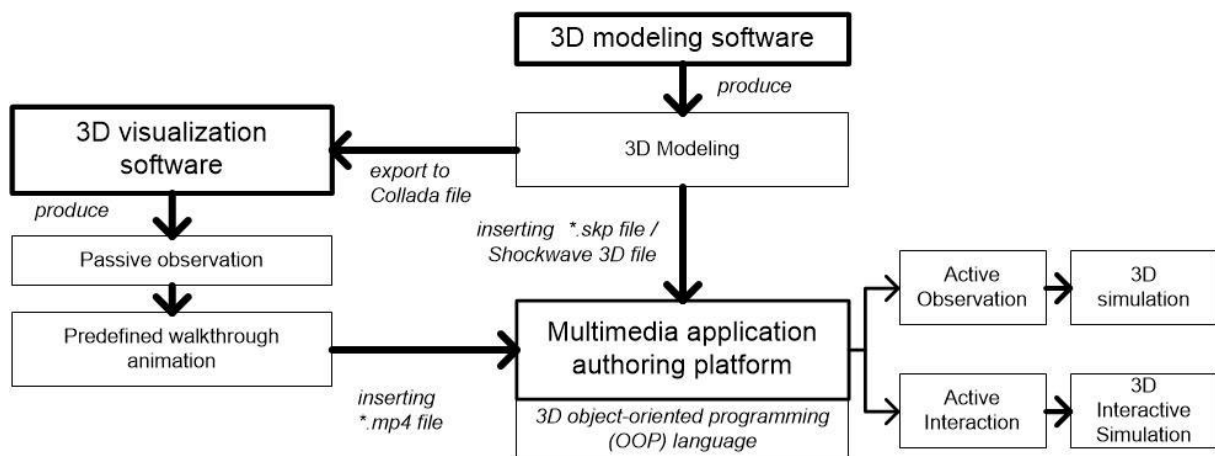


Figure 6. The collaboration of three application software in the 3D data processing

4. Result

4.1. Types of 3D historical spatial data

The development of an interactive leveling scenario of the historical spatial data system is based on the fact that the community has a different level of knowledge and understanding of interactive simulation systems in the Virtual Environment. This leveling is based on the fundamental consideration that every human being has seven different

intellectual abilities: intelligence figures, verbal understanding, perceptual speed, inductive reasoning, deductive reasoning, spatial visualization, and memory. This scenario also aimed to create a gradual learning concept for people to utilize the spatial data system for historic urban landscape conservation. Thus, the community is allowed to use the system that can be easily adjusted to each understanding level.

3D modeling data processing results deliver three types of 3D historical spatial data covering 3D spatial-passive observation data, 3D spatial-active observation data, and 3D spatial-interactive simulation data. All the 3D modeling data processing results are composed in a User Interface Design (UID) programmed with a multimedia application authoring platform. There are several essential components embedded in the UID of each type, namely the instruction map per section of the Kayutangan road corridor, the control panel for modification and selection, 3D spatial visualization content, and application system operating instructions. The specification of each 3D historical spatial data type is as follows.

First, The 3D spatial-passive observation data is historical spatial data in the form of predefined walkthrough animation. The development of predefined walkthrough animation is required to provide an overview of the three-dimensional space corresponding to the sight of the human eye. Visualization through the walkthrough animation requires a high-quality 3D object modeling and a representative finishing capable of approaching the real condition. Users can only observe the spatial visualization of the Kayutangan corridor by running the mp4 data file that has been provided. The User Interface Design (UID) in this spatial multimedia has also been equipped with a panel feature for animation operations along with four alternative animation options, which include an animation of the existing conditions of Kayutangan streetscape and three options for viewing an animation of design modifications of Kayutangan streetscape corridor. The form of spatial multimedia design in this data type can be seen in Figure 7.

Second, The 3D spatial-active observation data is historical spatial data in the form of a virtual environment (VE) simulation. Users can perform the spatial exploration of the Kayutangan corridor freely with the help of active navigation. This form of active navigation is in the form of a walkthrough exploration and view a motion along the street corridor in each section of Kayutangan Street with the directional arrow keys on the computer keyboard. This navigation system uses 3D programming languages provided in a multimedia application authoring platform. User Interface Design (UID) in this spatial multimedia has also been equipped with a selection panel feature of streetscape modification in each section of Kayutangan Street. The form of spatial multimedia design in this data type can be seen in Figure 8.

Third, The 3D spatial-interactive simulation data is historical spatial data, which is also in the form of a virtual environment (VE) simulation but has a higher interactivity capability for 3D data objects. The most important key in developing application systems-based interactivity is to provide convenience to the user in the access, manipulation, and navigation through the content material. Besides being able to conduct the spatial exploration of Kayutangan corridors freely with the help of active navigation, users also have the opportunity to interact with 3D spatial data on each element of the Kayutangan corridor. The types of interactions offered are separated into two zones: the free zone and the private zone. The public-zone is an open space area between rows of buildings along the Kayutangan road corridor. The private-zone is a building area located along the Kayutangan corridor. The UID for each zone is created separately so that the number of panel features is not too complicated and reduces the application system's workload. The interactivity system was also built using 3D programming languages provided in a multimedia application authoring platform. The User Interface Design (UID) in the multimedia spatial built-in the two corridor space zones has also been equipped with features to modify each element of the road corridor. The form of spatial multimedia design in this data type can be seen in Figure 9.

Active navigation is better than passive observation, and an active interaction much better than just active navigation. A passive observation does appear to be sufficient for creating a sense of place and maybe perfectly adequate for virtual tourism experiences. The method of an active interaction performs as well as an active exploration, and it should be initiated and established for built environment evaluation. The user interface design of active interaction should accommodate the active exploration in a virtual learning environment gradually. The user is recommended to have plenty of exercises to ensure public engagement successfully utilizing the system.



Figure 7. The development of 3D spatial-passive observation data



Figure 8. The development of 3D spatial-active observation data

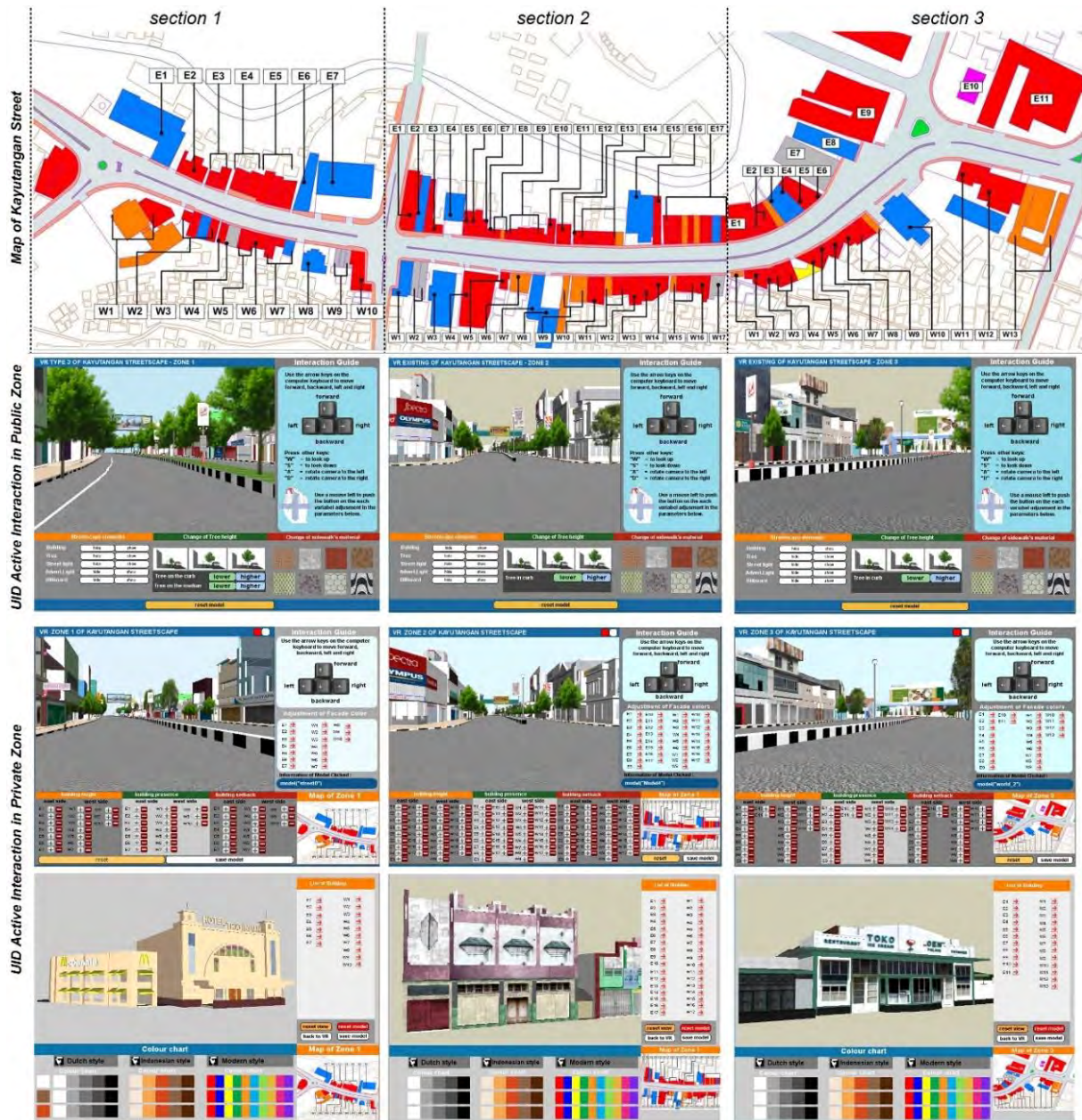


Figure 9. The development of 3D spatial-interactive simulation data

4.2. The 3D spatial multimedia of historical spatial data

The development of online spatial multimedia involves the design of an appropriate user interface. The user interface should be designed by taking into account various characteristics of users or the public to be involved in online public engagement. Ease of people's understanding of the user interface design, greatly influenced by the quality and accuracy of the interface design in understanding the community's customs and culture. Ease of people accessing the system is part of a familiarization aspect.

Moreover, the online system development's failure is associated with public access to the system, frequently caused by unsuccessful interface design to the use of cultural symbols or applying the targeted community. Excellent consideration of cultural factors can improve the interaction web site usage better. Therefore, the user interface design for the benefit of the development of the historical spatial data system should consider cultural symbols that are familiar to the target communities.

The development of online spatial multimedia involves the planning and designing a suitable and appropriate Graphical User Interface (GUI). Graphical User Interface (GUI) uses multimedia elements (such as images, sound, video) to interact with users. GUIs provide benefits such as quickly learned by users that experience in using a

computer is relatively minimal. On the other hand, the objective of designing a spatial multimedia system is to communicate user interface system features that are available to allow users to understand and be able to use the system. In this case, the most potent use of language is to help the understanding because language is the second oldest gesture communication tool used by people to communicate daily. Designing the GUI is also related to the use of color. Effective use of color can make the user interface of spatial data systems more effective. Color can help users understand particular meanings and complete the application system appear more aesthetically pleasing and refined.

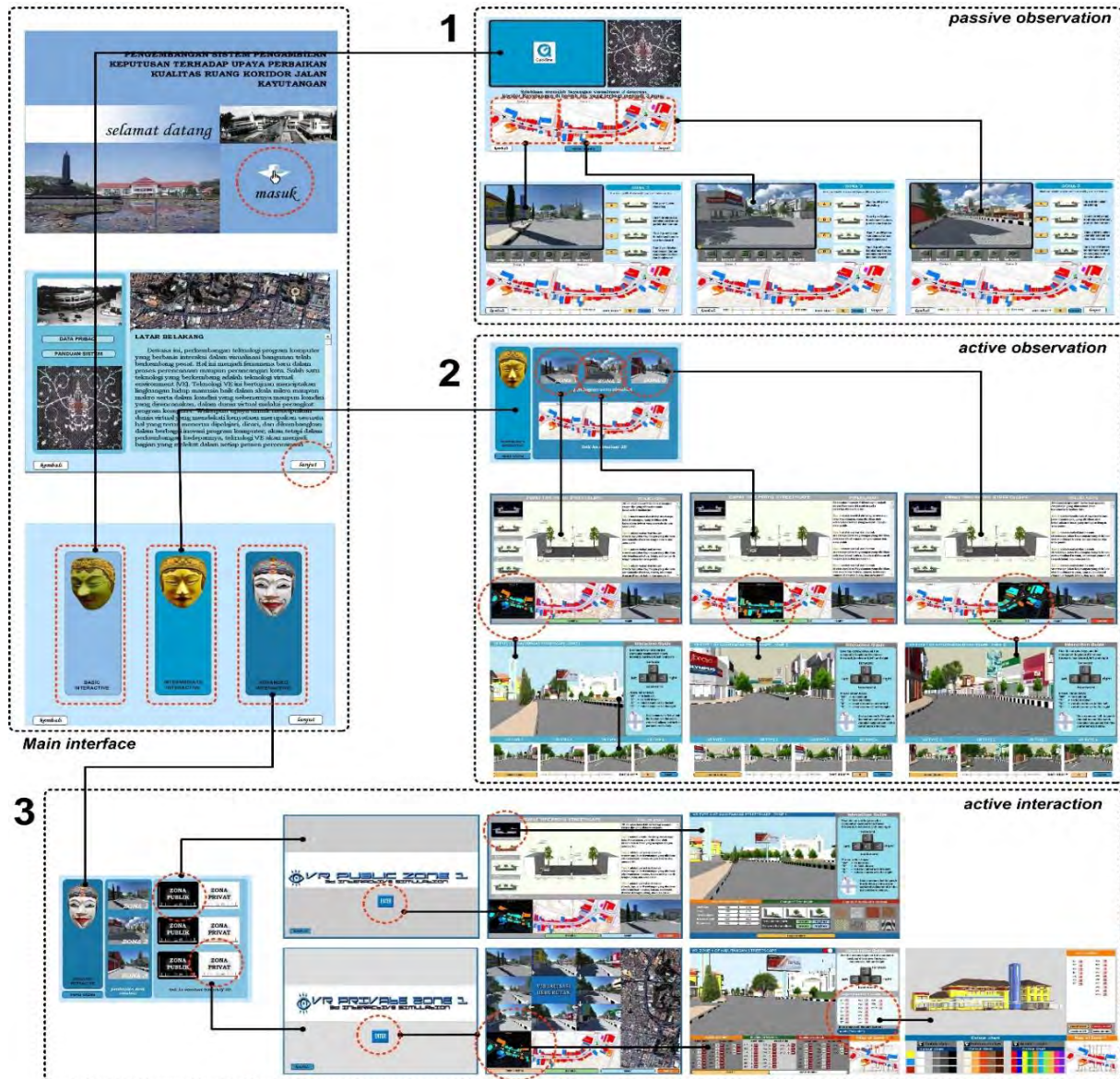


Figure 10. The overall UID development of historical spatial data in the spatial multimedia system

Overall, historical spatial data is developed from three types of 3D historical spatial data consisting of 3D spatial-passive observation data, 3D spatial-active observation data, and 3D spatial-interactive simulation data. A single Graphical User Interface (GUI) is designed to accommodate a spatial multimedia package of the historical spatial data system in the Kayutangan Street corridor (see Figure 10.). The user interface design organization is divided into four types, namely UID main interface, UID passive observation, UID active observation, and UID active interaction. The UID main interface is divided into three user interfaces, which include the opening user interface, the Kayutangan Street corridor historical information data user interface, as well as the user interface of a gateway to each of the three types of historical spatial data systems. The composition of the main user interface design also incorporates elements of cultural symbols and identity and historical landmark symbols of the city of Malang to increase appreciation and awareness of the community towards Malang's cultural heritage and building aspects of familiarization of the application system.

5. Conclusion

In summary, this paper's outcome is the online historical spatial data system development of the 3D historic urban landscape for the community. This study emphasizes the four essential stages of 3D historical spatial data making that consist of 3D historic street corridor modeling production. First, the processing of 3D modeling data that collaborates with the 3D visualization software and 3D object-oriented programming (OOP) language. Second, the construction of 3D spatial data types. Third, the development of 3D spatial multimedia of historical spatial data types consisting of predefined 3D visualization and 3D interactive visualization. The process of data acquisition of a historic building and overall historic landscape component requires drone equipment (also known as Unoccupied Aerial Vehicle (UAV)) to enhance the accuracy and precision of 3D spatial data. The use of 3D drone mapping and UAV photogrammetry for large scale buildings and areas requires a lot of photo data recording and a burdensome 3D mapping process. Therefore, using a 3D mapping method is divided per field object on photogrammetry software to lighten the 3D mapping process and improve the accuracy of the results.

This study also emphasizes developing a historic 3D spatial data system that presents three types of data visualization that are capable of supporting the interactivity level of spatial data delivery. These strategies cover 3D spatial-passive observation data, 3D spatial-active observation data, and 3D spatial-interactive simulation data. Therefore, it recommends employing a collaboration of four software applications to produce the development of 3D spatial data of historic urban landscape, i.e., 3D modeling software, 3D visualization software, photogrammetry software, and 3D spatial multimedia application authoring platforms.

For further research, a combination of close-range photogrammetry methods with grid and circular mission methods in historic buildings needs to be tested in various cases in order to produce a more effective and better 3D mapping, especially in areas of buildings with lacking sufficient space for drone mapping. On the other hand, the low cost and effective technique to produce 3D mapping data of a single building or small area can be recommended using a combination of close-range photogrammetry methods and 3D montage techniques. Hence, the development of the historical spatial data system is still a prototype application and requires advanced development and application enhancements and online delivery system testing.

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