Development of a Public Engagement Scenario in Metaverse Toward Maintaining the Sustainability of Valuable Historic Buildings in the Kayutangan Area, Malang, Indonesia

Herry Santosa[1(✉)], Adipandang Yudono[2], Fauzul Rizal Sutikno[2], Muhammad Satya Adhitama[1], Herman Tolle[3], and Eni Zuliana[1]

[1] Architecture Department, Faculty of Engineering, Brawijaya University, Malang, Indonesia
herrysantosa@ub.ac.id

[2] Urban Regional and Planning Department, Faculty of Engineering, Brawijaya University, Malang, Indonesia

[3] System Information Department, Faculty of Computer Science, Brawijaya University, Malang, Indonesia

Abstract. The development of immersive spatial multimedia in Metaverse Urban Historical is the latest innovation that encourages the development of Smart Governance in historic area management. This innovation carries the concept of sustainable business and tourism (green e-commerce), leading to various tourism business developments in digital innovation and supporting the green economy concept. The Metaverse technology supports asset management and historical buildings to support the historical tourism industry in Malang. This research aims to develop the Semesta Digital application (Metaverse) by creating an immersive digital experience that builds an exciting and interactive public engagement concept. This study examines the history of the Kayutangan street corridor, the first trade and service corridor built in the Dutch colonial era and gave birth to three crucial developments in Dutch East Indies architecture in Malang. The development of Metaverse in the Kayutangan street corridor aims to create historical tourism management that accommodates the wider community to enjoy an immersive digital experience by accessing and having a dialogue with the visual-spatial information of the historic area. This study results in a conceptual framework for the metaverse prototype on the Kayutangan street corridor, which focuses on four public engagement strategies, namely virtual purchases in building interiors, changing the appearance of making colors, the passage of time for historic buildings, and replacement of new buildings. The system development integrates a heuristic and features evaluation that examines aspects of the use and user experience related to user convenience and the responsiveness of user commands and describes the quality of the graphics, presence, interaction, environment, control, and hardware in the Metaverse world.

Keywords: Metaverse · Public Engagement · Immersive Digital Experiences · Urban Historic · Green e-commerce

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1 Introduction

The development of spatially immersive multimedia applications in the Metaverse Urban Historic builds on digitizing historical data information about buildings and historic areas, promoting public participation in preservation, conservation, regeneration, and promotion. Aimed, it is a form of virtual heritage tourism service. Governance for smart governance [1]. The innovative development of smart governance in historical area consolidate the concept of sustainable business and tourism (e-commerce), which develops tourism business into digital innovation (green economy), considering various social, ecological, and economic factors [2].

This study investigates the historical Kayutangan street corridor in Malang. This corridor was a Dutch colonial trade and service route and is also designated the heritage capital of Malang. The characteristic shape of buildings in the Kayutangan area is the shape of elongated buildings on the main street, which ignited the emergence of Kayutangan Heritage Tourism Village and made it one of the leading destinations for Malang Heritage Tourism in Malang. It is also proper development of the Kayutangan Heritage Tourism Village that will generate high economic income and become a source of wealth for the region [3]; with the Kayutangan Heritage Tourism Village tourism, Malang will get an idea of the amount of income generated [4]. The economic value of a building or historic area is measured through its tourism potential and the sale or rental value it holds, depending on the extent to which the building can generate profit or economic income for its owner or community [5].

The Metaverse first appeared in 1992 in a fictional story called Snow Crash, written by Neal Stephenson [6]. The literal definition of the Metaverse is a digital universe [7, 8] that combines the real and virtual worlds [9]. Understanding the Metaverse means presenting people in a way that they can communicate with others in a virtual world [10]. The Metaverse is changing the way people see everything connected to the Internet [11–14]. Metaverse technology creates embodied human representations and beings in the real and virtual worlds, interpreted in the form of avatars and holograms [6, 7, 9, 11, 15].

The Metaverse can help neurodivergence interact among people and self-develop [10]. In the Metaverse world, personal data can easily be spread if users do not respect their privacy. Still, the positive aspects of the Metaverse make it easier for people on all fronts [8]. Virtual reality (VR) can increase sports interest by providing new sports experiences and fun [11].

Metaverse development in smart cities implements intelligent metering systems, sensor networks, automated control systems, and cyber-physical systems [7, 16] planned and designed by VR [17]; government-created urban centers could be a solution for more active [18]. Metaverse developments are also taking place in the education sector [12, 14, 19–22], tourism [23–26], and online commerce [13]. Metaverse in Education uses a virtual environment with online assignment learning methods and video material delivery. This method is as effective as the face-to-face method [12]. Architecture and landscape science fields need 3D modeling visualized by a Unity Game Engine smartphone application [19]. Augmented reality (AR) helps lower-level students interact with higher-level students [20]. Pharmacy students develop a virtual tour system for different pharmacies and are introduced to different types of medicines and their uses [21]. VR

is also useful for cognitive nursing students in human anatomy and psychophysiology [14, 22] and for beginners in learning Chinese [22].

VR is a tourism promotion tool called a virtual tour. The sights are presented to the visitor at 360° and are presented virtually with historical descriptions [23]. A virtual tour can record potential disaster risks and mitigation plans, including Cryptopolsticus at the Egnatia (Italy) archaeological site, an underground tourist site [23]. A virtual tour can help you preserve historic buildings, such as a traditional Malay house built more than 100 years ago was opened to the public in a virtual tour aimed at preserving, protecting, and interpreting heritage and cultural history [24]. A perceived effect is that it can promote the dissemination of tourism information to visitors and strengthen local identity [26]. In the commercial domain, AR/VR develops customer engagement marketing that recognizes changes, developments, preferences, and customer behavior [13].

The development of AR/VR has been as crucial in virtual engineering as the early development of the Metaverse [27–29]. AR/VR technology aims to combine the virtual world developed on computers with the real world [30]. AR/VR technology enables virtual real-time interaction with the real environment [31]. VR development could be the solution for conference forums [32]. The capabilities of AR technology are more advanced than those of VR technology, as AR technology links interactions with markers or without markers [33]. AR/VR technology is used to preserve and conserve historical buildings, with HBIM models transformed into AR/VR tools [34, 35]. The use of AR is used as a virtual heritage tour application for the benefit of the social pedagogy and historical tourism industry, presenting the geographical, historical, cultural, and artistic significance of 3D building objects [36–38].

Immersive multimedia systems host 3D historic buildings forming virtual worlds, opening up opportunities for public engagement and virtual tourism development in historic buildings [39] while at the same time promoting the green economy concept for the creation of inclusive and sustainable e-commerce development. Therefore, to integrate the concept of smart governance into the era of Digital Industrial Revolution 4.0 and Society 5.0, this research attempts to develop a conceptual framework for building a metaverse prototype of the historical domain. An immersive digital experience in Kayutangan street corridor, Malang.

2 Methods

2.1 Study Area

The Kayutangan street corridor is a trade and service corridor that was first built in Malang City during the Dutch colonial era and has been designated as a Cultural Heritage area of Malang City (Fig. 1).

The Metaverse development area focuses on three spot areas on the Kayutangan street corridor, Malang City. These three areas have a strong historical history and are surrounded by buildings that play an essential role in history and our cultural heritage buildings.

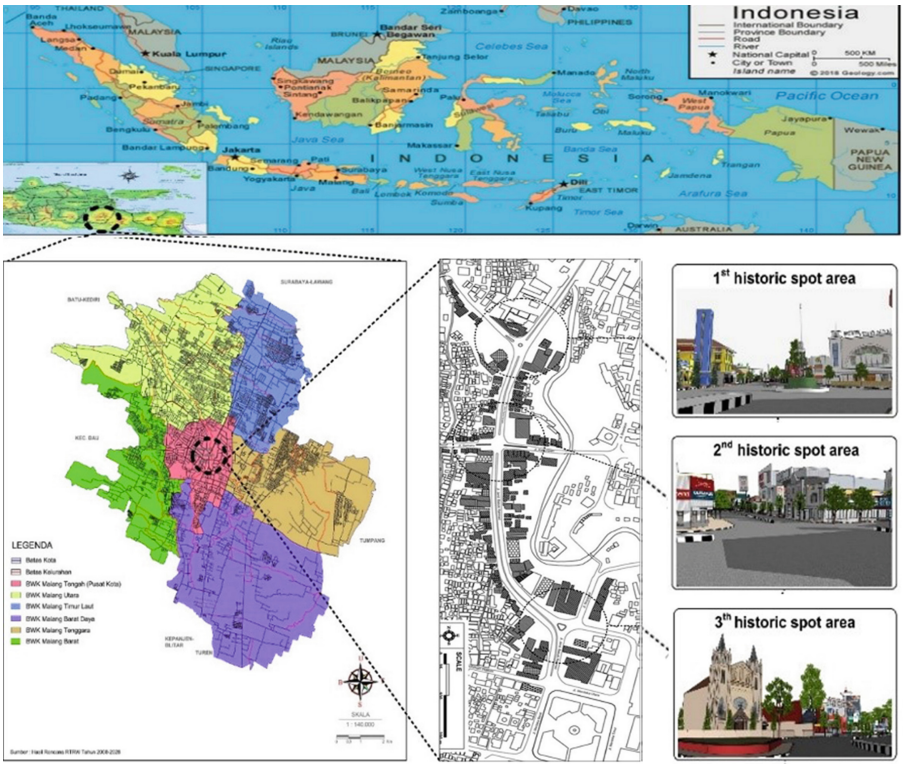

Fig. 1. Map and Three Important Spot Areas in the corridor of Jalan Kayutangan, Malang City, Indonesia

2.2 System Development Method

The method is divided into three stages: (1) visual data mining, mapping, recording, and visual reconstruction of buildings using GPS, Laser Scanning, Cameras, drones, and Adobe Photoshop. (2) The development of the Virtual Reality database is carried out by processing 3D objects of historic buildings with the help of software (SketchUp, Blender, and Adobe substance 3D). (3) Metaverse development is carried out by accommodating Immersive Digital Experiences to animation and 3D VR Historical Buildings on application systems (Blender and Unity 3D) (Fig. 2).

The applications used are Sketchup, Blender, Unity 3D, and supporting applications, namely Adobe Photoshop and Adobe Substance 3D. Visual data sources are taken with cameras, drones, and laser scanners used to record digital footage of objects (Fig. 3).

Adobe Photoshop application improves the quality of visual information in the form of materials or textures in data mining so that visual information becomes more informative and processed into 3D objects (Fig. 4).

The Sketchup application acts as a translator of visual data mining information, which is then processed into 3D objects and exported for further processing using the Blender application. The Blender application provides more detailed material and texture effects to 3D objects (Fig. 5).

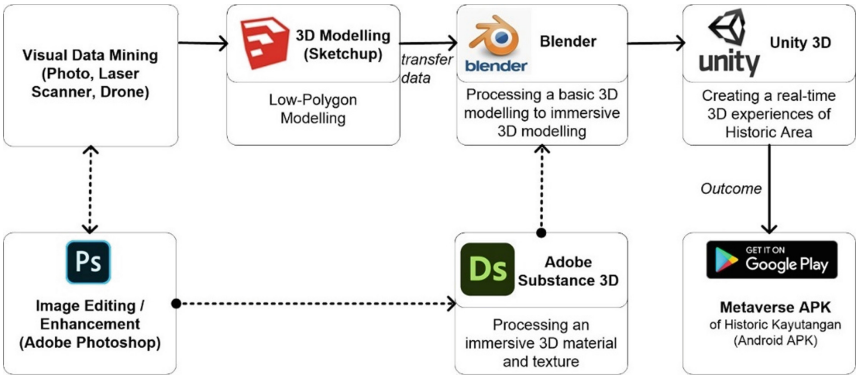

Fig. 2. Workflow system development

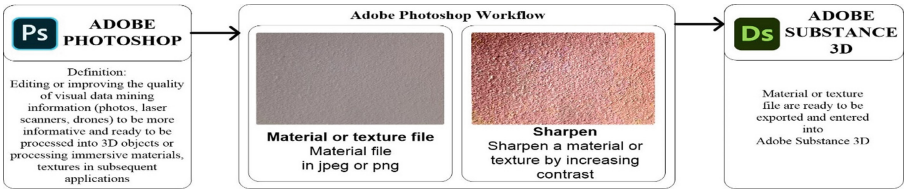

Fig. 3. Adobe Photoshop Workflow

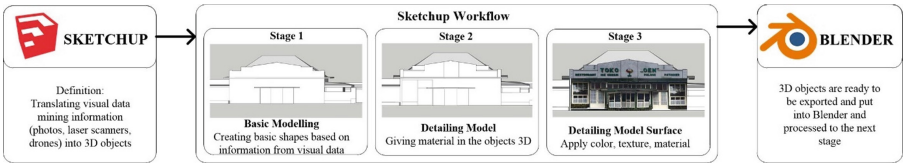

Fig. 4. Sketchup Workflow

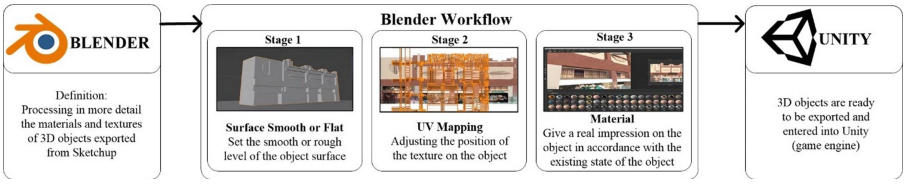

Fig. 5. Blender Workflow

The Blender application processes textures and materials on the surface of objects so that 3D objects become more accurate and closer to the original (see Fig. 6). Adobe Substance 3D is a 3D application capable of creating highly detailed materials or textures (see Fig. 7).

Fig. 6. Adobe Substance Workflow

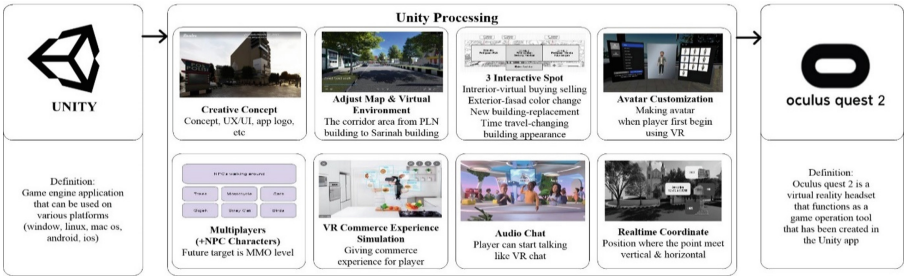

Fig. 7. Unity Processing

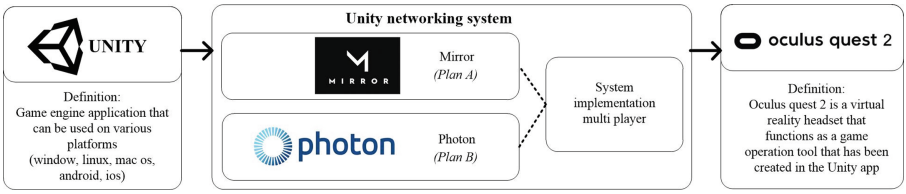

Fig. 8. Unity 3D Networking System

The Unity 3D application functions as a game engine that builds immersive experiences in the historic area of the Kayutangan corridor. The final result is a unity 3D workflow (see Fig. 8) and the Android-based Metaverse Kayutangan APK.

The Unity 3D application is a game engine that requires other applications (Mirror and Photon) to implement the player into Virtual Reality. The mirror can contain approximately hundreds of players in one virtual reality, while Photon can only have about fifty players. Both of these scenarios will be considered in terms of efficiency.

3 Results and Discussion

Metaverse develops immersive digital experiences to build a Public Engagement System with economic value. This development is a web-based spatial multimedia immersive system (online system) that produces a world prototype of the Metaverse of the Kayutangan Corridor Malang City.

The conceptual framework for the metaverse prototype in the Kayutangan street corridor focuses on four public engagement strategies: virtual buying and selling transactions in building interiors, changing of exterior building color appearance, time travel of historical buildings, and replacement of new buildings. The development scenario for the Metaverse Kayutangan prototype carries several concepts based on previous research and will then be compared with this system, as seen in Table 1.

Table 1. Comparison of Previous System and Metaverse System

3D Spatial Multimedia System			**Previous System (Literature Review)**	**Metaverse System**
General System Information	1.	Language	Not mentioned	English and Indonesia
	2.	Number of case studies	- One mock-up of the framework components [21] - One case of solving a chemical engineering problem [19] - Sixteen pharmacies [23] - One historic building [20, 25]	One corridor
	3.	Regional or case characteristics	- Education [19, 21, 23] - Historical district [20, 25]	Historical district
	4.	The complexity level of the building mass in the street corridor	- Medium [20, 21, 23, 25]	High
	5.	User response recording method	A scoring panel and a recording panel of user change results [19–21, 23, 25]	A scoring panel and a recording panel of user change result
	6.	Prerequisite	- Investigation of education system [19, 21, 23] - Investigation of public experience [20, 25]	Investigation of public preferences
Completeness of attributes	1.	Presence of guidance information	Yes [19–21, 23, 25]	Yes
	2.	Presence of a guidance map	Yes [19–21, 23, 25]	Yes
	3.	Presence of an alternative panel	Yes [19–21, 23, 25]	Yes
	4.	Presence of a scoring panel	Yes [19–21, 23, 25]	Yes
3D Visual Quality	1.	Building façade appearance	High-reality in passive 3D simulation; medium-reality in active; interactive 3D simulation	The immersive reality in interactive 3D simulation
	2.	Street Appearance		
	3.	Greenery appearance		

(*continued*)

Table 1. (*continued*)

3D Spatial Multimedia System			Previous System (Literature Review)	Metaverse System
	4.	Street amenity appearance		
	5.	Advertising appearance		
3D Simulation Technical	1.	Field of view coverage	- Spotted [19, 21] - Whole building [20, 23, 25]	Along the streetscape corridor
	2.	Degree of complexity of case exposure	- Spotted [19, 21] - Whole building [20, 23, 25]	Along the corridor and the whole building
	3.	User orientation	Focus on the spotted cases [19–21, 23, 25]	It depends on the user's observations along the corridor.
	4.	Estimated user response time	- Short time [19, 21, 23] - Long time and unpredictable [20, 25]	Long time and unpredictable
	5.	Type of motion control	Forward, backward and nodal video (360-degree rotation)	Forward, backward and nodal video (360-degree rotation)
Adjustment variables in an interactive simulation	1.	Interior	Adjustment of the building height; Adjustment of the building setback; Adjustment of the billboard; Adjustment of the streetlight & bollard; Adjustment of a tree and plants; Selection of street profile types [19–21, 23, 25]	- Virtual buying in building interior - Changing building color appearance - Time travel of history building - Replacement new building
	2.	Exterior		
	3.	streetscape		
Application system development	1.	Layout design	No [19–21, 23, 25]	a grid-based layout type
	2.	Interaction type	Direct manipulation and menu selection [19–21, 23, 25]	Direct manipulation and menu selection
	3.	Collaboration type	Basic, intermediate and advanced interactive level [19–21, 23, 25]	advanced interactive level
	4.	Type of 3D contents	Predefined walkthrough animation and Virtual Reality [19–21, 23, 25]	SketchUp, Blender, Adobe Substance 3D, Unity 3D
	5.	Type of simulation	Passive observation (animation), passive simulation, and active-interactive simulation [19–21, 23, 25]	Active-interactive simulation
Development system			- VR [20, 21, 23, 25] - AR [19]	Metaverse

Table 2. Heuristic Aspect and Feature Aspect

Heuristic Aspect	Feature Aspect
1. Natural engagement [27, 29] 2. Compatibility with the user's task and domain [27, 28] 3. The natural expression of action [28] 4. Close coordination of action and representation [27, 29] 5. Realistic feedback [28, 29] 6. Faithful viewpoints [27, 28] 7. Navigation and orientation support [27, 28] 8. Clear entry and exit points [27] 9. Consistent departures [27, 29] 10. Support for learning [27–29] 111. Clear turn-taking [27, 28] 12. Sense of presence [27, 29]	1. Graphic [27, 29] 2. Presence [27] 3. Interaction [27, 29] 4. Environment [27–29] 5. Control [27, 28] 6. Hardware [27, 29]

Table 3. Heuristics and Features Rating Scale

Score	Rating	Information
0	No problem	Everything went great. No problems happened
1	Kosmetik	Problems or glitches do not need to be fixed unless time and circumstances allow for the use of fixing the problem or disorder [27–29]
2	Minor	Problems or glitches need to be fixed, but the priority is low [27–29]
3	Major	Problems or disturbances need to be fixed and have a high priority scale [27–29]
4	Urgent	Problems or glitches fall into the urgent category and must be fixed before the metaverse product is launched [27–29]

This research tries to update the system and be more interactive with the user so that the value of the Kayutangan historical area can be adequately conveyed. VR and AR graphics are realistic and interactive, with information about the historical value of Kayutangan. User comfort is paramount in avoiding virtual reality sickness or cybersickness which causes eye fatigue, dizziness, or nausea.

The development of this system uses heuristic evaluation indicators and feature evaluation [27–29]. Heuristic evaluation evaluates the usability aspects of VR and AR, and Feature evaluation assesses the quality of metaverse graphics (see Table 2).

The purpose of the Heuristic and Feature evaluation is to find the weaknesses and strengths of the Metaverse. The rating scale for Heuristic and Feature evaluation is shown in Table 3.

The user carries out heuristic and Feature Evaluation of the Metaverse Prototype in the Historic Area of the Kayutangan Corridor to assess related aspects using a rating scale of 0 to 4. Users are also asked to provide notes or criticism and suggestions regarding

aspects in the Heuristic and Feature evaluation so that the Metaverse Prototype of The Kayutangan Corridor Historic Area can be used accordingly.

4 Conclusion

The creation of this Metaverse involves visual data mining (3D building object model mapping, recording, and reconstruction processes), virtual reality database development software (SketchUp, Blender, and Adobe Substance 3D), and metaverse environment development (immersive and real-time 3D experience generating an Android-based metaverse APK of the historic Kayutangan).

This study explores four conceptual strategies for public engagement: virtual trade transactions inside buildings, changing exterior building colors, moving historic buildings, and replacing new buildings. There are six leading indicators for metaverse development, such as the High level of complexity of building mass in street corridors, immersive 3D visual quality in 3D interactive simulations, 3D technical simulations, use of public engagement in interactive simulations (virtual purchases inside buildings, building colors appearance change, historical building time travel, new building replacement), these six key indicators make the development of the Kayutangan Metaverse prototype more worthwhile based on the comparison of previous studies. Users evaluate the Metaverse development using Heuristics and Features and then assess and provide criticism and suggestions as reference material to continue improving the quality of the Kayutangan Metaverse prototype.

The results of the development of this scenario are an essential basis for the implementation of the Metaverse Kayutangan prototype development, which will be simulated for the application of public engagement in accommodating community participation for decision-making related to the preservation of historical areas as well as adapting a green economy concept in the Kayutangan street corridor. This application system in the future will have the opportunity to increase the income of residents and regions in the historical tourism industry sector, which accommodates domestic and foreign tourists in accessing and interacting with spatial information on historical areas and buildings through Metaverse.

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