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To cite this article: Herry Santosa et al 2018 IOP Conf. Ser.: Earth Environ. Sci. 213 012003

View the article online for updates and enhancements.
3D Interactive Visualization Scenario to Improve Public Participation in the Visual Comfort Assessment for the Pedestrian in Provincial Street, Malang, Indonesia

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Abstract. The visual comfort of pedestrians in the street corridor is essential to encourage a continuously satisfying experience of a visual aesthetic leading to a better quality of urban spaces, which is significant for making cityscape, especially in the streetscape. Valuable visual attributes of the pedestrian spaces are indicated by the presence of visual comfort for pedestrians as they pass through the pedestrian space. The creation of visual comfort in the pedestrian spaces also encourages positive spaces along the road corridor, generating an excellent space utilization, which eventually led to many positive appreciations of the space environment. Creating high-quality urban places triggers a more sustainable urban development by increasing pedestrian satisfaction in visual comfort through empowering public engagement in online decision-making system. Thus, public participatory is urgently needed to evaluate the spatial and visual comfort of provincial streetscapes. The disturbance of visual comfort for pedestrians often occurs in the main road corridors, especially the provincial streets in Malang, which has a strategic location for the expansion of commercial functions. This study evaluated a visual comfort of pedestrians in the provincial streets. It employed the 3D modeling method combined with the interactive simulation through the use of a multimedia authoring platform software to develop the 3D Interactive Visualization Scenario for online participation. The result of this study was the scenario of 3D visualization interactivity development to improve the effectiveness of the decision-making system in the assessment of pedestrian visual comfort along the provincial street corridor.

Keywords: Public Engagement, Visual Comfort, Interactive Simulation, Online Decision-Making System, Provincial Street

1. Introduction
Urban spaces play a prominent role in accommodating citizen’s activities around the city, which is very important to provide safe, comfortable, and proper urban spaces for the community. Pedestrian ways alongside urban streetscapes become crucial to form urban spaces. Consequently, the visual and spatial comfort of the pedestrian way should be well-maintained to create a better quality of urban spaces, which is significant for making cityscape, especially in the streetscape. Creating high-quality urban places triggers a more sustainable urban development by increasing pedestrian satisfaction in
spatial and visual comfort and later on reducing vehicle use. The creation of good urban images will encourage people to understand and establish the valuable meaning of urban spaces [9].

Malang is one of the most significant cities in East Java Province that ever had the best urban planning among other cities in the colonial era in Indonesia. Currently, Malang has rapid growth of trade and service facilities along with an increase in the influx of immigrants, especially students who want to study in Malang. Over time, this condition led to the development of the city that has become uncontrolled with the rapid growth of buildings, citizens, and vehicles. Therefore, this situation creates the lack of control of good governance. There are five provincial streetscapes functioning as inter-city lane connecting Malang and other cities, which become the inter-city transport mobilization mode. Thus, these street corridors have become a strategic route causing the uncontrolled rapid growth of commercial area alongside the streets and lead to the occurrence of unsatisfying spatial and visual comfort for pedestrians.

The evaluation and control of the spatial and visual quality of pedestrian comfort need to perform the spatial and visual judgments process through public participatory in the decision-making process. The conventional method of public participation sorely less able to cope with the rapid development of urban space, so the community needs to gain appreciation in its involvement in urban spatial planning through easy-to-understand media with varying levels of community knowledge and skills [8]. Currently, the development of 3D computer simulation techniques has reached the level of visualization that can approach the real world. This condition encourages a change in public participation from a 2-dimensional paper-based drawing model to a 3-dimensional visualization computer-based model, which is capable of delivering high accuracy and complexity of data, present the speed of various 3D simulations, as well as the speed of design change [1,4]. Moreover, the dynamic presentations of the 3D simulation are capable of presenting the variety of future environment and can generate an active perception of space experience that is very similar to the real world [2].

In fact, the coupling method of delivering computer and Virtual Reality technology with a public assessment by the Semantic Differential method has been familiarly used to examine the quality of urban landscape comfort. Some researchers have proved that the use of a coupling method is very useful in supporting the visual and spatial streetscape quality assessment [6,8,14,19]. Moreover, the prototype development of the 3D Interactive Simulation System has been conducted in Kayutangan, a historical street corridor in Malang, through a series of continuous research stages. It involves public preference of visual quality in the historic commercial streetscape, the construction of low polygon 3D modeling, the development of 3D interactive visualization, and the development of user interface design for 3D interactivity in the virtual environment [11,12].

1.1. 3D Visualization stages
3D visualization development for the provincial streetscapes requires at least six essential stages that consist of 3D simulation scenario, data collection, 3D modeling, geometry optimization, texture application, and the entity object [12]. 3D simulation scenario is the fundamental step in preparing the basic concept of creating a 3D visualization. There is four essential consideration for constructing 3D visualization. First, the 3D simulation scenario performs estimating of the final form of 3D models provincial streetscapes, including building mass number of objects and the number of streetscape elements. Second, the concept of level of detail geometry is well into account the number of polygons in any 3D object creation models. Third, interactive concepts related to the number of entities on each 3D model object. Finally, the concept of navigation that determines the navigation control system for handling interactions on the VE. It related to the current estimate of the movement of the user views on space exploration simulation.

1.2. 3D Interactive Simulation
3D interactive simulation 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 level to interactive level in the Virtual Environment [12,18]. A passive interaction of
space assisted for the evaluation activities in a predefined animation of 3D simulation modeling. However, users do not serve the freedom to control the direction of movement, and there is a lack of interaction simulation of 3D objects [4]. 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 perform as well as an active exploration, and it should be initiated and established for built environment evaluation. On the other hand, an active interaction delivery the ability to take control of 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 [2]. Some researchers have conducted a study related to the use of 3D interactive simulation combined with the development of user interface design for building consensus through public participation [3, 5, 7, 15, 17].

1.3. 3D spatial multimedia
Recently, the development of 3D spatial multimedia as a decision-making support system in the planning process began to flourish and widely used in urban planning that associated with the public participation [16]. The use of spatial multimedia system intended as a medium of interaction between the planning concepts of the built environment with the community as a user. The development of 3D spatial multimedia system involving the scripting language to construct a 3D interactive simulation in web interface design [12]. One of the 3D spatial multimedia application authoring platforms is Adobe Director software. Adobe Director Software has Lingo script as a scripting language for 3D behavior interaction within 3D Virtual Environment. The utilization of behavioral scripts in Adobe Director Software can enrich the interactive techniques in 3D simulation and increase user participation in the utilization of the system as one tool in modeling decision-making. Moreover, the development of spatial multimedia systems inquires an understanding the strategies of good building consensus simultaneously.

2. Methods
This study is the second phase of the advancement of 3D interactive simulation construction for Landscape Visual Planning System in the streetscape in Malang, which is the continuation of the first stage research investigating people preferences through semantic differential method. This study aims to construct a 3D interactive simulation scenario of a Decision Support System for visual quality evaluation in the commercial streetscape. This study method involved three main activities based on 3D street corridor modeling development, development of three interactive levels of 3D street corridor, and development of 3D spatial multimedia scenario based on the web. This study also emphasizes the elaboration of 3D behavior script to support adequate user interactivity for empowering public engagement in online decision-making system.
2.1. Research location

The research of system development focused attention on five provincial street corridors in Malang that crossed the north area of Malang, as presented in Figure 1. These streetscape located in the strategic areas which became the prominent access connecting the north with the western region of Malang, acting as promising commercial area and an active route for trading activities and services.

2.2. Research framework

As illustrated in Figure 2, this research is in the subsequential phase of the preceding of multiple staged-projects which are addressed to construct a 3D interactive simulation decision support system in Provincial streets in Malang [13]. The previous research conducted the developing a conceptual framework of Decision Support System (DSS) for the assessment of visual and spatial comfort of the urban streetscape based on public preferences in several procedures. First, conducting a Semantic Differential method through public preferences in the provincial street corridor. Second, classifying the

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**Figure 1.** Map of the five provincial street corridors

**Figure 2.** Research framework
variables into the positive and negative zone. Third, separating the streetscape elements into primary, secondary and tertiary, based on the result of multiple linear regression analysis of the public preferences. Fourth, determining the modification type in the provincial street corridor according to the result of the determination of important variable and dominant variable level to analyze the modification criteria of each corridor. Subsequently, this study performed three crucial stages covering 3D visualization stages, 3D interactive simulation scenario, and 3D spatial multimedia scenario. These primary stages produce three interactive hierarchy level covering basic interactive, intermediate interactive, and advanced interactive [12].

3. Discussion

3.1. Development of 3D visualization stages

A 3D modeling process is the most crucial stage in the 3D visualization concepts. This stage will determine the level of detailed geometry model, and the depth of virtual reality environments. Steps to making 3D modeling consist of four types, namely modeling topographic modeling, building modeling, landscape modeling, and street furniture modeling. Each 3D object model has a degree of difficulty and different challenges and requires considerable time to complete it correctly. Optimizing the geometry is undoubtedly needed to ease the rendering process in the active rendering mode. Nonetheless, the optimizing of geometry should consider the degree of urgency of the elemental form of the building details. Eventually, the 3D visualization concepts covering five essential scenarios of 3D modeling construction to direct the development of the 3D simulation as shown in figure 3.

![Figure 3. Fiveessential scenarios of 3D modeling construction](image)

The process of 3D visualization developments requires a level of precision and high accuracy, to produce a scene that can represent the 3D urban features of excellent quality in the world of virtual reality. On another hand, it is essential to organize the number of object entity in each of the 3D objects. This setting is intended for the benefit of interactive levels in Adobe Director Software. If the level of user interaction developed through the interaction of each element in each building, then each element of the building should be broken down into some entities.

3.2. Development of 3D Interactive Simulation Scenario

![Figure 4. A scenario of 3D interactive simulation](image)
The three types of 3D simulation were categorized by the capability of the simulation to interact with the user at three levels of interaction[12], as follows:

1. **Basic interactive level**
   - The basic interactive level is the first type with less user-interactivity. The 3D simulation delivered a passive observation. It offers a walkthrough animation of various streetscape compositions, and users observed the model during the predefined animation. Users could give the assessment or scoring.

2. **Intermediate interactive level**
   - The intermediate interactive level is the second type with moderate user-interactivity. The 3D simulation performed the active-observation. It offers a VR of various streetscape compositions. Users perform a walkthrough and affect their motion in the virtual environment through navigation aids. Users could give the assessment or scoring.

3. **Advanced interactive level**
   - The advanced interactive level is the third type with high user-interactivity. The 3D simulation carried out the active-observation and 3D interactive. It offers a VR for various streetscape compositions. Users perform a walkthrough, affect their motion, and interact with 3D objects in the virtual environment through navigation aids, and some provided control panels. The user can save the results of modifications to a file for the benefit of decision-making.

### 3.3. Utilization of 3D behavior on interactive 3D simulation

Lingo is Director's scripting language which provides the capability of Adobe Director Software on the level of complexity, navigation, and a more in-depth interactive. Lingo script language is also available in the form of the instant Lingo script, or it can be obtained from commercial providers Lingo scripts, such as Chrome Lib, as well as from an independent creator Lingo script.

| Table 1. An example of 3D behavior script in advanced interactive level |
|---------------------------------------------------------------|
| **Types of 3D Behavior** | Public Zone | Private Zone |
| **Visibility behavior** | | |
| 1. showing the model | on mouseUp me (member("street0") shader("Shader1") textureList[1]) = member("street0") shader("Shader1") textureList[1] | on mouseUp me member("street0") model("Building1") visibility=#front |
| 2. hiding the model | on mouseUp me member("street0") model("Building1") visibility=#none | on mouseUp me member("street0") model("Building1") visibility=#front |
| **Scaling behavior** | | |
| 1. widening the building setback | member("Building1") worldPosition = vector(18, 100, 0) | member("Building1") worldPosition = vector(0, 0, 0) |
| 2. shorten the model | member("Building1") transform.scale(1,1,0.5) | member("Building1") transform.scale(1,1,0.5) |
| **Texturing behavior** | | |
| 1. white color | on mouseUp me member("Building1") shader("Shader") diffuse = rgb(255,255,255) | on mouseUp me member("Building1") shader("Shader") diffuse = rgb(0,0,0) |
| 2. gray color | on mouseUp me member("Building1") shader("Shader") diffuse = rgb(96,96,96) | on mouseUp me member("Building1") shader("Shader") diffuse = rgb(0,0,0) |
| 3. black color | on mouseUp me member("Building1") shader("Shader") diffuse = rgb(0,0,0) | on mouseUp me member("Building1") shader("Shader") diffuse = rgb(0,0,0) |
| **Reset model behavior** | | |
| go to frame 5 | | |
| **Save model behavior** | | |
| myFile = fileio.open("Save as file") | | |
| member("street0") model("Building1") worldPosition = member("street0") model("Building1") transform.scale(1,1,0.5) | | |

3D behavior script is the most imperative scripting language in Adobe Director Software. The script is advantageous in the development of interactive 3D simulations. Interactive simulation allows user involvement in making a change or adjustment to the model or a 3D object. At the advanced interactive
level, the 3D behavior scripting arrangement created two categories of interactive space zones, namely the public zone, and private zone (table 1). Public zone is part of the street corridor space attached to the public interest, including street, street furniture, street lighting, billboard, signboard, parks, and trees. Meanwhile, the private zone is part of the street corridor space attached to private interests, namely building the facade, building setback, building height, and commercial advertising. Furthermore, the types of 3D behavior scripting contained in the public zone consist of five types of scripting: navigation behavior, visibility behavior, scaling behavior, texturing behavior, and reset behavior models. While the 3D behavior scripting contained in the private zone includes seven types of scripting which are navigation behavior, visibility behavior, scaling behavior, position behavior, color behavior, reset behavior model, and save model behavior.

3.4. Spatial multimedia
Design scenario of the spatial multimedia conformed to the three levels of 3D interactive simulations scenario that consisted of less user-interactivity level up to high user-interactivity level. Accordingly, the concept of spatial multimedia generated three user interface design. The first type of user interface design offers three activities consisted of passive observation, selection of choices, and evaluation. A passive observation related to the viewing activity of predefined activity walkthrough animation. A selection of choices provided a panels image for selecting the type of 3D animation on a wide range of streetscape compositions. The second type offers three activities consisted of active observation, selection of choices, and evaluation. Active observation conducted an exploration activity of the 3D simulation streetscape using the navigation control. Capturing the scene conducted the recording of a picture of the scene from each 3D simulation intended as a follow-up evaluation in the future discussion. On the other hand, the third type offers three activities consisted of active observation, interaction with objects, and evaluation. 3D object interaction conducted an object editing activity through the button panels and identified by the naming of a 3D object. While the evaluation consisted of three activities, namely capturing images from the scene, saving 3D models, and scoring. Figure 5 displayed an example of a user interface design scenario at the advanced interactive level.

4. Conclusion
The advancement of a 3D interactive simulation scenario of Decision Support System (DSS) for visual quality evaluation in the provincial street corridors cover 3D visualization stages, 3D interactive simulation scenario, and 3D spatial multimedia scenario. The creation of three interactive levels ranging from less user-interactivity, medium user-interactivity to high user-interactivity aimed to accommodate the diversity of knowledge and skills of the community in the system operation and the
amount of time available to the community. This diversity of user-interactivity levels enhances active participation as well as online building consensus learning. Based on the experience in the pilot workshop of system implementation in the case of other street corridors [12], the obstacles and challenges to be aware of consist of four aspects: understanding of the system, operation of the system, quality of elements, and user interface composition design. First, a thorough and comprehensive understanding of the system requires optimal manual guidance. Second, people still feel unfamiliar and difficult in running the interactivity on the system. Third, the image used as navigational aids must have high quality. Fourth, the design of the user interface layout should be clear and easy to understand. Accordingly, the public requires sufficient adaptation to the comprehension of the system as a whole.

The outcome of this study indicates that the utilization and the development of 3D behavior scripts in Adobe Director Software can enrich the interactive techniques in 3D simulation and simultaneously capable of increasing user participation in the utilization of the system as one tool in online decision-making. In the following stage, the final authoring of the 3D Interactive Visualization Scenario for online participation stand in needsgradual tests and dissemination to establish system reliability.

5. Acknowledgments
The authors acknowledged the support from the Ministry of Research and Technology and the Higher Education Republic of Indonesia. The support is under the research grant PTUPT UB of The year 2018 Contract Number 338.123/UN10.C10/PN/2018.

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