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The Three Dimension (3D) Spatial Urban Heritage Informatics of Malang City, Indonesia

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ABSTRACT
The spatial multimedia systems in the urban planning process is the latest innovation in urban planning and design activities. The development of this system aims to build the 3D spatial building information through online system, especially information on the spatial structuring of landscaping and historic buildings. Furthermore, this research forms the foundation for the integration of the Geographical Information System (GIS) and the Building Information System (BIM). The development of this multimedia spatial system refers to the rules of developing the Digital Platform for Urban Heritage Management. Therefore, the development of spatial multimedia systems must have completed spatial data that contains three important information, namely: the historic data layer, current data situation, and future planning data. The development of this spatial multimedia system raised Malang as the case study. The purpose of this study is developing a 3D geodatabase historical building distribution in Malang city as an effort to support information preparation of the Master Plan for Preservation of Cultural Heritage of Malang City.
Keywords: *3D, spatial information, geodatabase, building heritages, Malang City*

1. INTRODUCTION

Malang City is one of the cities in Indonesia, which has a beautiful urban landscape, which was built during the Dutch colonial period. In the latest developments, many historic buildings are poorly managed and vulnerable to eviction due to rapid development, which results from the absence of a proper data collection or documentation system. The alternative given in this research is in anticipating problems with the data collection system and documentation of historic buildings in Malang in the form of developing a Three Dimension (3D) Spatial Urban Heritage Informatics of Malang City multimedia system.

This 3D spatial multimedia system is a system package that was built-in web interface design through a javascript programming language. This system accommodates building modeling data and three-dimensional areas that make up the virtual world. The presence of 3D Virtual Reality technology will provide opportunities for developing more effective and attractive public participation in urban planning and design activities. Furthermore, in an effort to support the Indonesian Government's agenda to realize the Indonesian One Map Policy (OMP), the integration of 3D visual reality with georeferencing of objects on earth is essential. For this reason, the application of Geographic Information Systems (GIS) in managing terrestrial or spatial data and information becomes vital in spatial studies to decision making on the implementation of Good Governance.

2. THEORETICAL FRAMEWORK

2.2. A Visual Quality of Urban Space

The creation of the visual quality of urban space aims to create an image of the city. Each person has perceptions and associations, both positive and negative, on the surrounding environment and on every element in the form of an image in the neighborhood [1]. The experience of visual aesthetics in urban space is substantial in shaping the urban landscape. The role of experts in urban planning, city government and related parties in planning and design must be able to accommodate the creation of urban space that is able to guarantee the creation of a comfortable and satisfying community experience.

Each different place has a different purpose, thus demanding different environmental form characteristics [1], [2]. Understanding the diversity of values in cities that are developed and owned by people in a particular region needs to be well-identified. The process of identifying and investigating community values can be carried out by interviews, observations, and surveys, so that urban communities can express their opinions truthfully.

2.2 3D Visualization Methods and Public Participation

In order to control and evaluate the image of the city related to buildings and areas, visual evaluation and aesthetic evaluation of city space is needed that involves public participation to shape the desired city space. The involvement of the community in making urban planning decisions causes the community to feel valued and have the opportunity to participate in making environmental decisions actively and to guarantee better life, more comfortable and more satisfying city spaces.

At present, public participation activities, especially in developed countries, have abandoned traditional methods, which are usually centered on public meeting activities, where the form of communication of proposed city planning uses a two-dimensional perspective picture. Changes in the ways of public participation lead to the development of 3D visualization exploration with '3D visual reality' technology to support the planning and design of the built environment. This 3D visualization technique is able to stimulate and arouse public interest in understanding a lot in understanding the visualization of urban landscape planning on a macro or micro scale [3], [4], [5].

Various recording techniques for digital modeling of historic buildings have been carried out by researchers. Digital survey techniques to produce detailed 3D models will be interesting and useful for various purposes within the scope of cultural heritage [6]. At present, the development of image-based virtual 3D models uses three approaches, namely (1) sketch-based modeling, for example SketchUp; (2) procedural grammar-based modeling; (3) photogrammetric based modeling [7]. The use of those three 3D modeling techniques is greatly influenced by cost factors [8]. Photogrammetry technique is one of the automatic 3D reconstruction methods that is in great demand because of the availability of cheap and unpaid software [9]. The photogrammetry technique has a Structure from Motion (SfM) technique that supports the automatic photogrammetry method [9]. Agisoft Photoscan is a software with Structure from Motion (SfM) orientation [10] which gives satisfactory quality results [6]. The use of photogrammetry supported by Unmanned Aerial Vehicle (UAV) has an advantage in the high level of efficiency for high-rise building surveying [11], [12], [13].

2.3. Geographical Information System

Geographic information system (GIS) is a science-based on computer software that is used to provide digital form and analysis of the surface of the earth so as to form a precise and accurate spatial information. GIS is inseparable from the development of Information Technology (IT) [14]. Today, information technology is very advanced and developed in the presence of the internet. GIS technology integrates general data-based operations, such as queries and statistical analysis, with the unique visualization and analysis capabilities of mapping [15]. GIS technology is further a spatial database that is consistent and has good accessibility. GIS is needed because for spatial data; its handling is very hard and always changes from time to time, especially because maps and statistical data change very quickly [15].

In some situations, existing GIS software only provides one outline of problem-solving. Generally, GIS software provides a broad development environment for communicating with other application programs.

3. RESEARCH METHOD

This study aims to develop a spatial multimedia for historic building management in Malang (see Figure 1), using the 3D Spatial Urban Heritage Informatics' (3DSUHI) method, which is an integrated three-dimensional interactive spatial modeling simulation technique in the system software application. This 3DSUHI method consists of three (3) stages/ procedures, namely identification and mapping of historic building objects, the determination of the 3D modeling and visualization concept of historic building, and formulating building heritage informatics through the development of application design systems based on geographic coordinates.

The first stage is the identification and mapping of historic building objects in Malang City, which is the priority of handling data collection. This activity is carried out through the acquisition of information from the authorities and object scanning through close-range photogrammetry method supporting with Unmanned Aerial Vehicle (UAV).

The second stage is the determination of the 3D modeling and visualization concept of historic building. This phase aims to determine the 3D visualization scenario which is a guide to the concept of developing 3D simulations, which consists of 6 (stages), namely the identification stage of the historic building elements, the stage of determining the 3D object type, the 3D geometry optimization stage, the texture, and imagery mapping stage, and the 3D finalization.

The third stage is the development of application design systems based on geographic coordinates. This phase aims to build and construct spatial multimedia. The development of spatial multimedia as a support system in the urban heritage management is one of the latest developments in management planning activities related to historic building conservation and public participation activities. The use of spatial multimedia systems is intended as a medium of interaction between the concept of management planning of historic building with the community as users. Spatial multimedia is built and packaged in web interface design through web-GIS programming. The system provides geographic coordinate based 3D modeling data that acts as a virtual world. Through these virtual data, users are given the opportunity to explore space while interacting with the physical-visual elements of the virtual reality.

Figure 1 The Research Study Area

4. RESULT AND DISCUSSION

Building the 3D Spatial Urban Heritage Informatics in the context of planning sustainability and controlling urban heritage conservation, is divided into three stages:
1. Identification and Mapping of Historic Landscape;
2. Development of 3D Multimedia based on GIS;
3. Geodatabase Urban Heritage Building.

4.1. Identification and Mapping of Historic Building

Visual data mapping of historic buildings using the Unmanned Aerial Vehicle (UAV) technique in Close Range Photogrammetry. This technique used a drone mapping tool by taking photos at close range. The 3D object data acquisition used a close-range photogrammetry technique that combines the grid mission type and the circular mission type in the drone mapping technique. While the 3D mapping process from drone mapping results used a combination of photogrammetry imagery processing and 3D montage methods. The process of 3D mapping in photogrammetry software is done by dividing the stages of image matching per area to ease the 3D mapping process and to improve the accuracy of the results. While the 3D montage stage is used to combine the results of matching images from the results of the photogrammetry process with 3D modeling. The overall process of the visual data mapping of historic building objects can be seen in Figure 2.

4.2. Development of 3D Multimedia based on GIS.

The system development utilizes three application software, i.e., 3D modeling and visualization software, spatial data processing software, and web-GIS multimedia software. 3D modeling and visualization software is used to produce various types of 3D objects. Both of these data, 3D modeling and visualization, are processed in a web-GIS multimedia software. The application is able to work with 3D object, and through 3D programming. A form of graphical user interface design that combines external data, namely passive 3D simulations with interactive 3D simulations, can be developed as a prototype of an application system. This system can be published as a standalone executable or as HyperText Markup Language (HTML) files on the web.

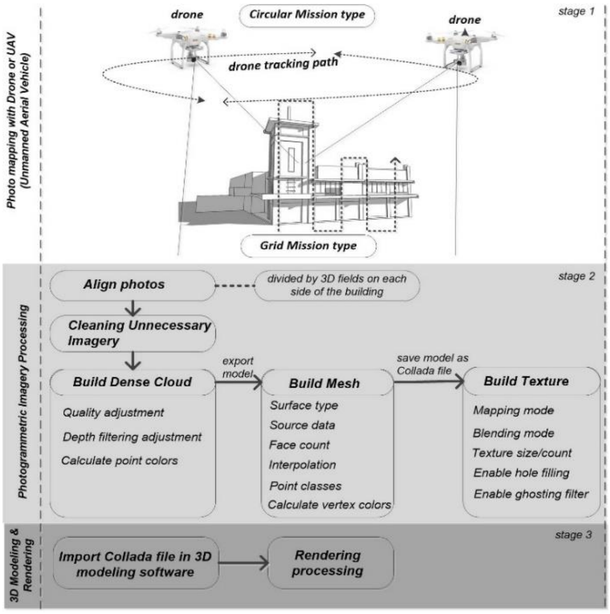

Figure 2 Visual data mapping of historic buildings

The construction of 3D objects of historic buildings in Malang city is carried out by collecting data in the field in the form of building document documents equipped with geographical coordinates in the Department of Tourism and

Culture. Furthermore, if a building image is not found, observations are made on the building with a Global Positioning Systems (GPS) and drone, then 3D displays are made through the object base of the satellite imagery platform. Furthermore, for the visualization of building faces, taking pictures with drone media with vertical movements for scanning in detail.
The results of taking the building's pictures with the drone are then orthorectified and combined with other scenes in one building. Furthermore, photos that have been built into a single building are still in the 2D form are then transferred to 3D (See Figure 3).

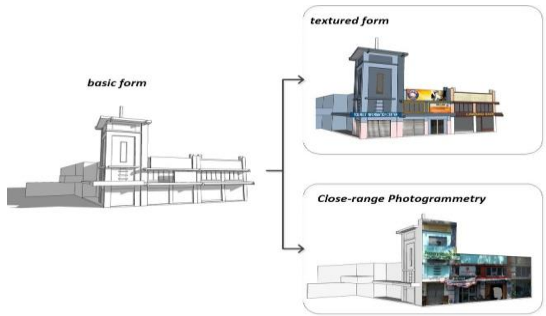

Figure 3 A coupled method of photogrammetry imagery processing and 3D montage methods

4.3. Building Urban Heritage Geodatabase.

A spatial database system is an information system that integrates a collection of earth context data that are interconnected with one another (graphic, textual and tabular) and makes it available for a variety of applications in an organization.
Spatial database management can be viewed as a collection of data that models the activities contained in the terrestrial environment of the region, city, and region. With a spatial database, changes (editing) or updating (updating) data that can be done without affecting other components in the system concerned either change in data format (conversion), file structure, or relocation of data from one device to another. The objectives of designing a spatial database system are:

1. To fulfill information containing specific user needs and their applications in spatial/earthly contexts;
2. Facilitate understanding of geographic information structures;
3. Supports processing needs and multiple object appearance (response time, processing time, and storage space).

The process of designing a spatial database system consists of six phases, namely:

4.3.1. Phase 1: Spatial data collection and analysis

Spatial data collection and analysis activities include:

1. Defining user groups and fields of application
   This activity determine the main application and user groups that will be used for the database. The main individuals in each of the user groups and application fields that have been selected are the main participants in the next steps of spatial data collection and specifications.
2. Reviewing existing documentation
   Existing documents relating to applications are studied and analyzed. Other documents (such as policies, regulations, reports) are tested and reviewed to test whether they affect the data collection and specification process.
3. Analysing the operating environment and data processing
   The current and future information is studied. This also includes an analysis of the types of transactions and the frequency of transactions and also the flow of information in the system. Input-Output data for these transactions are specified.
4. Listing the questions and interviews
   Writing responses to questions that have been collected from potential spatial database users. Group leaders (key individuals) can be interviewed so that a lot of input can be received from them by interpreting valuable information and prioritizing.

4.3.2. Phase 2: Conceptual database design

This phase has two (2) parallel activities:

1. Conceptual scheme design:
   Testing the data requirements from a database that was the result of phase 1, and produce a conceptual database scheme on the DBMS independent high-level data model such as the Enhanced Entity-Relationship (ERR) model. The data model used in the design of conceptual schemes is DBMS-independent, and the next step was to choose a DBMS to implement the design.
2. Transaction design:
   Testing database applications where needs have been analyzed in phase 1, and produce details of these transactions. The usefulness of this phase, which is processed in parallel with the conceptual scheme design phase, is to design the characteristics of database transactions that are known in an independent DBMS. These transactions will be used to process and manipulate the database at a time when the database is carried out.

4.3.3. Phase 3: Selection of DBMS

Database selection is determined by several factors, including technical, economic, and organizational political factors. Technical Factors: The existence of DBMS in carrying out its tasks such as the types of DBMS (relational, network and hierarchical) storage structures, and access points that support DBMS and users.

4.3.4. Phase 4: Logical database design

This phase is carried out by mapping the conceptual scheme and the external scheme produced in phase 2. At this phase, the conceptual scheme is transformed from the high-level data model used in phase 2 into the data model of the DBMS chosen in phase 3. Mapping can be processed in 2 levels, that is mapping an independent system and adjusting schema to specific DBMS.

4.3.5. Phase 5: Physical database design

The database design physically was the process of selecting structures and access points in database files to achieve the best performance in a variety of applications.
During this phase, specifications are designed for stored databases related to physical storage structures, record placement, and access points. Related to the internal schema, namely response time, space utility, and transaction throughput.

4.3.6. Phase 6: Implementation of a spatial database system

After the design was logically and physically completed, the researchers implemented a database system. The commands in DDL and SDL (Storage Definition Language) of the selected DBMS are compiled and used to create database schemas and (empty) database files. Now the database is loaded (united) with the data (see Figure 4). A spatial database system is a basic component of a larger geographic information system. Therefore the life cycle of spatial database applications is related to the life cycle of geographic information systems. The life cycle of a geographic information system is a macro lifecycle, while the life cycle of a database is a micro lifecycle.
After finish building the spatial database system under standalone system, the latest step was converting the 3D spatial urbah heritage information database to Web-GIS Multimedia through javascript programming language. Furthermore, for additional information, in this web, the researcher put the old Malang city map (year 1914, 1931, 1938, 1946) overlay with current situation using high resoultion satellite imagery (year 2019) for comparison. The final result can be seen in Figure 5.

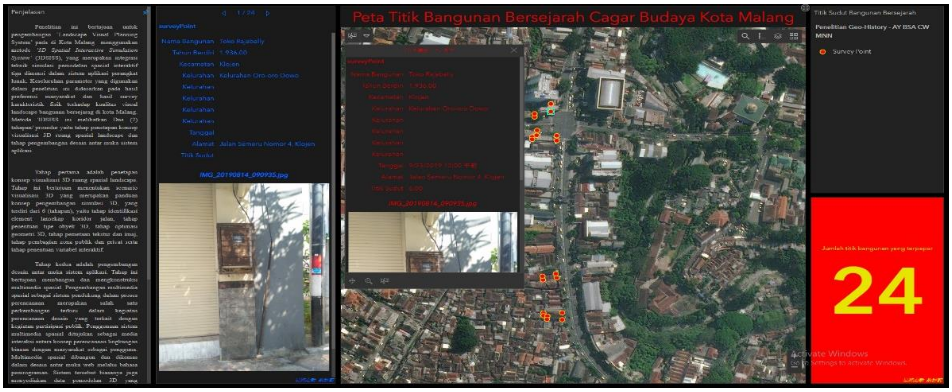

Figure 4 The application dashboard of a GIS database under standalone system

Figure 5 The Web-GIS 3D Spatial Urban Heritage Informatics (3DSUHI)

5. CONCLUSION

This study produces 4 (four) essential stages as the basis for the development of the next research stage included the grand design preparation of the spatial multimedia system development scenario, mapping of the visual characteristics of Historic Buildings in Malang City, developing 3D modeling of historic buildings in Malang City, and compiling a database of Geographical Information System (GIS) of historic buildings in Malang.

Future use of this technology is expected to be able to increase the interest and enthusiasm of the community and more significant stakeholders in community participation in every urban planning. On the other hand, to support the Indonesian Government's agenda in realizing the One Map Policy (OMP), the integration of 3D visual reality with georeferenced objects on earth is essential. For this reason, the application of Geographic Information Systems (GIS) in managing terrestrial or spatial data and information becomes vital in spatial studies to decision making on the implementation of good governance.

The development of a prototype system of the 3D Spatial Urban Heritage Informatics (3DSUHI) for historic building databases in Malang needs to be improved continuously to improve the capability of the system as one of the tools for decision making in the management planning of urban heritage.

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