A 3D GIS mapping for landscape geovisualisation and park management: A case study in Kuala Keniam Station, Taman Negara Malaysia

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Abstract. The Kuala Keniam Research Station in Taman Negara has experienced severe damages to large flood and therefore this station spatial visualization and database management need to be enhanced appropriately. A meticulous park information system is required for assisting staff and users to manage the spatial park entities in an identifiable ecotourism mapping. This pilot study was proposed to develop a 3D GIS visualisation for the park and landscape management using software development life cycle (SDLC) and several 3D software. Findings from the local user requirements showed that 100% agreed for developing an interactive 3D mapping in the study area. The developed mapping has demonstrated its capabilities in modelling 3D park mapping and constructing a geopark database such as updating functions of park’s attributes, park animation and visualisation, and other basic functions of a common park system. An experienced staff from the Department of Wildlife and National Parks Peninsular Malaysia (PERHILITAN) has been also interviewed with a testing form to evaluate the mapping’s capabilities and this evaluator was satisfied with all elements and functions developed in the digital map, but the interactivity of the map need to be improved for an advanced geoanalysis of the park.

1. Introduction

Park is a tract of land often including lawns, woodland and pasture to attract the public in a country and used as a game perverse and for recreation, a piece of ground in or near a city or town kept for ornament and recreation, and an area maintained in its natural state as a public property [1]. Parks serve people by providing preservation and protection of natural and cultural resources and providing opportunities for recreational use and resources and for leisure, outdoor recreation and outdoor living in natural surroundings. Parks are invaluable elements of our environment and landscape.

According to [8], Park is land reserved as a public park for recreational activities and leisure-themed entertainment with focus based on design and culture, entertainment and education. [2] explained recreational parks that have been built and used by the public should be maintained to ensure the function and purpose of providing facilities are maintained and not harmful to consumers. In addition, maintenance is required to ensure that all available facilities are durable and always safe and attractive. The life of a facility is also dependent on the way and frequency of maintenance [2]. [9] stated that Kuala Keniam Research Station have experienced severe damages to large flood on the east coast in year 2014 and three years ago this research station could not be used for safety reasons.
Kuala Keniam has an ecotourism potential due to its flora and fauna attraction and researcher exploration in this country. A good park mapping and 3D view are essential elements to be implemented in this station in order to visualise and manage the spatial park datasets appropriately as conducted at other countries specifically for visual interest of visitors [24] and spatial orientation interpretation [25]. However, [10] who was the contractor hired to manage the park at Kuala Keniam Research Station, said that updating information on the park and facility management records need to be done manually in park management since this Research Station does not have currently a digital information for park and facility. Lack of comprehensive information on the internet can give unfavourable effects in ecotourism for this area. [3] defined virtual reality (VR) presentation as a computer-generated experience that submerges the common user to the point in which he believes that he is in another world, place or space. VR can also defined as a special kind of simulation designed to convince users to a great extent that they are not actually within a computer simulated environment; but a 3D computer-generated representation of a scene or object that gives the user a sense of reality and obeys laws of physics. Interactive 3D maps give users the ability to see the environment, surrounding building and facility.

An interactive mapping enables user to easily click on a visualized structure to repair the building and facility to perform data management and manipulation of park. GIS acts as a prepared collection of computer hardware, software, geographic data and personnel designed to efficiently capture, store, update, manipulate, analyse and display many forms of geographically referenced information [11]. Thus, [4] stated that the implementation of a web-based GIS could provide interactive mapping and spatial analysis capabilities for enhancing public participation and collaboration in decision-making processes.

The proposed system is to develop an interactive 3D mapping for the park management system at UiTM PERHILITAN research station. Using an interactive 3D map is a relevant way to use in a park management system as it helps to simplify processes and makes it easier for user to update record for park management at Kuala Keniam Research Station. The objectives of the study are: i) to determine user requirements and the 3D software capabilities for a proposed 3D park mapping at Kuala Keniam, ii) to develop a 3D map for park inventory databases at Kuala Keniam, and iii) to evaluate the capabilities of proposed 3D park mapping at Kuala Keniam.

2. Review on Park and Amenities Mapping System

2.1. Park administration and management

The administration in managing recreational park services focuses on relationships and processes in carrying out operations efficiently based on the objectives set by an organization. In the administrative process, it will involve the use of resources within the organization, especially to employees as well as other materials or tools to achieve specified management goals. In addition, maintenance is required to ensure that all available facilities are durable and always safe and attractive. The life of a facility is also dependent on the way and frequency of maintenance [2]. Maintenance includes building maintenance work and structure, the cleanliness of the area, and the care of the trees in the recreational park area.

Maintenance is defined as a combination of technical and administrative-related efforts to maintain the original condition of a facility or maintain it to ensure it can function properly as it should [2]. For that purpose, the maintenance needs to be properly managed and planned. Good maintenance should have a systematic planning. Thus, maintenance planning as a manageable arrangement which encompasses what will happen in the future as well as its regulatory measures and the use of records to certify future. [13] formulated the management of area and landscape maintenance which involve the process of designing objectives, planning operations, implementing plans and monitoring the execution of activities as well as requiring different planning if there is difficulty in implementing them.

2.2. Three-D mapping and geographical information system

Three dimensions (3D) which are usually abbreviated as 3D is a form that has a length, width and height [5]. This term is widely used in the arts, animation, computer and mathematics. It can be concluded that a three-dimensional object is an object of a particular shape that has length, width and height. Currently, three-dimensional objects can be formed in real or virtual environments that cannot be touched directly. Three-dimensional map adopts the applicable term of the object in three dimensions. Where the spatial
information and elements are displayed with the three-dimensional shape both in real and virtual environments. With a predetermined scale, the information contained in the three-dimensional map is displayed with due consideration to the conditions and real circumstances of the place and location or geospatial information.

Geographical information system (GIS) is a computer-based system that is specially designed to support the acquisition, storage, processing, analysing and displaying of spatial data. The analysed data consist of spatial and attributes data. The database is the core to any GIS implementation no matter what type of GIS software is used. Database is important for the ease of user requirement and provide precise analysis result to the user. However, there are many notions about geographical information system either in terms of definition, components, capabilities and applications.

Geospatial-based system can be defined in many ways as there are different approaches and diverse user’s field. [6] has proposed a general definition of GIS as a unique spatial data that can be linked to a geographic map. GIS can be a database and information, and method to connect both databases and information that is related with park and facility management system. 3D is three-dimensional, a real-world object in a map or scene, with elevation values (Z-values) stored within the feature’s geometry [12]. The program called ESRI 3D Analyst is an extension to ArcGIS, which was developed to provide a seamless extension of the GIS to support fully interactive 3D visualization.

The function of 3D in GIS is to make analysis about height of some features that cannot be done by using 2D methods. The data are needed to create 3D model is z (height) and coordinates of a feature. The most popular tools in 3D technique are visualizing, managing, creating, and sharing in 3D GIS context that can be combined with various geomatic techniques such as photogrammetry [17], laser scanning [18], LiDAR remote sensing [20][21] and geospatial databases [22][23]. Previous studies have shown that the technologies of GIS can be applied in park and landscape planning and management through a public participation geographic information system (PPGIS) [14] and GIS-based suitability analysis [15][16][19].

3. Data and Method
In this study, software development life cycle (SDLC) waterfall model is used as a guideline to develop an interactive 3D map for park management system in Kuala Keniam Research Station. The cycle includes user requirement, system design and development and system testing. All the phases in this modelling cycle must be completed step-by-step and moving to the next phase only when its preceding phase is completely done [7]. The following explanation helps to get an overall process on how to create an interactive 3D mapping in the study area

3.1. Data collection
Related information in the study were conducted via internet, books, articles, interview, observation and questionnaire with persons involved in making demands for this product. Software development life cycle (SDLC) is also used as a guideline to develop proposed 3D map for park management system in Research Station Kuala Keniam. SDLC Waterfall model was used because all the phases must be completed step-by-step and moving to the next phase only when its preceding phase is completely done.

This can convince user and help them in the management of park and amenity systematically and all related thing to do can be done successfully. Interview and questionnaire were conducted among selected respondent people in the study area in obtaining information that are needed. Last step is to identify the related software and hardware that were used to develop this study.

3.2. System development and implementation
In design phase, the features are described in more detail with the operations that are going to be used in the study. First design of system is designing flowchart of the system. Last phase in design is designing the storyboard which is explained about the interface of the 3D map by showing related spatial park elements that will be added when developing process. Software needed for this project are available for download and can be installed from the internet including SketchUp, Unity3D and SQLite. After the installation of Unity3D, Unity3D provides script editor called Microsoft Visual Studio for building
database. Then the analysis, system design, implementation, testing and evaluation were carried out for system application by using waterfall model.

4. Result and Discussion
This study highlights three outcomes for showing the capabilities of 3D GIS mapping for park and facility management in Kuala Keniam, including the local feedbacks on the proposed system and current problems of the park administration services, the functionality and the usefulness of the proposed mapping system and its performance capabilities in real sites.

4.1. The user requirements study on the proposed 3D GIS mapping
A survey has been conducted and 11 respondents were given the feedbacks, consisting of 9.9% (1 person) of the respondents who work as the contractor, 45% (5 persons) of the respondent from the PERHILITAN staff and 45% (5 persons) of the respondents consisting of residents around Kuala Keniam. The questionnaire was divided into two categories that are focusing on existing method and proposed system. Based on the observations and questionnaires upon the existing method used in study area nowadays prove that there are functions in the existing method that need to be enhanced towards a better park mapping and management system. Therefore, Figure 1 shows most respondents with the percentage of 27% satisfied with the existing method, but the percentage for respondent that were very satisfied with the existing method still low as 10%. While 63% of the respondents also not satisfied with the existing method.

![Figure 1. Evaluation of the existing park mapping system used in Taman Negara](image)

Regard with park presentation, it is identified that the development of 3D based system are useful to manage the information of park and facility in spatial and digital since majority of respondent strongly agree for development of 3D based system and its functions. Figure 2 indicates survey conducted for suggestions of 3D geospatial element or function in the proposed system. Park map in a 3D view will improve the current system that it has never been developed in the study area. 3D Park Map are useful for park management. 73% of respondent also strongly agree with the proposed functions and then others (27%) of respondent are also agree with that functions. For the proposed database management system for park and facility were also agreed by 91% of respondents and the others (9%) are in uncertain situations about the function that is proposed in the proposed system. The implementation of an interactive 3D map in this study is very useful to users. It is advisable to transform the existing system in study area to an interactive map because make it easy to maintain and manage of the park and facility.
Figure 2. Proposed 3D GIS elements and functions in the existing system used in Taman Negara

4.2. System development and applications

Figure 3 shows the flowchart of the 3D map that explain overall starting and ending of system work, while Figure 4 illustrates the overall view of the study area in 3D map. 3D map of the park displays features consist of sky view, wind, waterbodies, building and land/surfaces areas. This interactive 3D mapping is useful to contractor in park management system because when users click at 3D building, the Updating UI is displayed for updating of park and facility in study area.

A database for spatial data and non-spatial storage and records for the building and facility of the park management system that have successfully produced. By producing this database, it can replace the previous system that used for the recording the inventory assets data more effective and regulated nicely. Moreover, the process of updating data also can be used easier and faster. The database construction was created in 4 tables consist of activities table, building tables, facility tables and routines table. This database construction is very important for activities update of park management. Creating a Database by using the SQLite and this platform is easy to connect the database on Unity3D because the SQLite have provided the plugin in Unity3D.

This database was developed to help contractor update and submit the reporting of park management in Kuala Keniam Research Station. Generally, this system starts with the user choosing or click the building in the park. Then, the updated UI appears, and the user can tick if any facility was repaired and the user click save button. After clicking save button, the data of repaired for facility was submitted into the database project. The system also offers for updating data in the database project.
Figure 3. Flow chart of 3D park GIS mapping and management system in Kuala Keniam Station

Figure 4. Proposed 3D park GIS elements and functions in the existing system of Kuala Keniam Station
4.3. Mapping system testing and evaluation
A survey has been conducted to identify the functionality and the satisfaction of user when trying this virtual 3D mapping system in a real site as shown in Figure 5. As a preliminary study, an experienced PERHILITAN staff is selected to evaluate the proposed system. The respondents tested 5 elements provided in the system. The user was satisfied with all element and functionally of this prototype system since it is easy to understand, and user-friendly platform as displayed in Figure 6. This exploratory study could increase the effectiveness and the functionality of existing park management in study area. In future, adding other feature in the existing system toward increasing the interactivity of the proposed system and making it can be a very significant system in real applications.

Figure 5. Transforming 2D map of Kuala Keniam station into a 3D virtual mapping using Unity3D

Figure 6. Respondent feedbacks on the proposed 3D mapping in Kuala Keniam

5. Conclusion
A 3D GIS park mapping has been developed in Kuala Keniam, Taman Negara based on the local user requirement. This proposed interactive mapping has also databases of the parks that can manage data, keep updating data and avoid data redundancy. This interactive GIS mapping can facilitate the contractor to manage datasets of the parks systematically. The proposed mapping has a better presentation than previous mapping because the manual and traditional 2D method has been presented into a digital or 3D
visualization method. In order to successfully complete this exploratory study, selection of advanced 3D tools need to take into consideration towards developing an integrated 3D photorealistic presentation and geospatial analysis in Kuala Keniam Station.

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