3D Campus Map Towards Sustainable Development and Infrastructure Management In UPNM

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Abstract. 3D technology is used in GIS maps to create descriptive graphics that accurately depict the size of real-world items. In a wide variety of various areas, 3D models aid in appearance and survey. For example, 3D maps may depict the height of a building or a mountain in addition to its location. 3D tools must be utilized in conjunction with 2D GIS and then visualized in a 3D environment. The current UPNM campus map accessible to students and staff is not sufficiently helpful and hardly identified its whereabouts. This project was undertaken to develop a web-based 3D campus map and analyze specifically the campus's area zoning. This study uses a personal computer with Esri CityEngine software to develop the 3D campus map and ArcGIS Online to publish the web-based 3D campus map. The data was acquired by downloading the base map of UPNM from OpenStreetMap (OSM). Completion of data processing results in a web-based 3D UPNM campus map with area zoning. The finding shows that the 3D map, using the Geographical Information System (GIS) platform, is more informative and attractive than the 2D map due to the attribute and spatial data. In addition, the capabilities of the 3D map to visualize and show the campus area and area zoning in the map can be managed according to the structural information. All in all, it can be concluded that this web-based 3D map contributes towards the sustainability of the UPNM infrastructure and campus while facilitating campus maintenance and rehabilitation.

1. Introduction
Historically, people acquire information about old and new places, from cave paintings to ancient maps. A map symbolizes a location containing information that indicates precise locations, distance from two points, shapes, and sizes of a site. There are many levels of map dimension, including a 3D map. A 3D map has the same sense of distance, depth, and height as a 2D map. Presently, a map is still important as new generations travel worldwide, learning about new places in their lives. Digital maps to depict the physical world are no longer new as they continue in the fourth industrial revolution. 2D maps cannot now satisfy people's growing demand for urban management, but a 3D map is an excellent substitute for that. 3D maps also provide clear visibility in all relevant areas by representing objects in a 3D context, particularly the Geographic Information System (GIS).

This study develops a 3D campus map for sustainable development and infrastructure management at Universiti Pertahanan Nasional Malaysia (UPNM). The reasoning behind the selection of the study area is due to the data needed to produce a functional, informative 3-dimensional web-
based map that holds the entire topography, geographical and physical features, and information about UPNM. People, especially visitors, have difficulty getting information about UPNM. The explanation is that the UPNM map that holds information about the campus is not available both on the internet and on the official website of the UPNM. It will significantly help raise knowledge of UPNM among students and staff by classifying campus areas into other regions. It will also make zoning campus areas easier for future planning and growth, maintenance, and restoration.

There are two objectives of this study. The first objective is to develop a 3D web-based campus map of UPNM. The second objective is to analyze specifically the area zoning of UPNM. Several past studies have been referred to the area zoning of UPNM to create a proper and up-to-standard zoning analysis. Referring to past studies contributes significantly to the decision-making for zones’ color and the zones’ categories.

2. Literature Review

The use of Geographical Information System (GIS) has also been in top demand. According to Anh et al. [1], 3D Geographic Information Systems currently play a significant role in many areas of study and development, such as environmental monitoring, location and routing, urban management, and tourism. 3D GIS is a state-of-the-art technology, a three-dimensional geographic information system that aims to introduce reality to objects with spatial information enhancement, while standard GIS is only two-dimensional. 3D GIS can be described as a map representing, in three dimensions, geographical objects such as a house, road, and tree by form, texture, ratio, a position as theirs. 3D GIS provides an overview of different areas for defining practical approaches to addressing urban issues affecting many aspects, such as society and the climate.

The technological demand is lately considered, the wide use of GIS, multimedia technology, and various applications cannot be denied. The above-listed technologies incorporate the dynamic 3D GIS interface. The Cloud GIS solution and public visualization of 3D GIS are accessible to decision-makers and planners in the region by implementing a GIS. Data on a building, the building type, the building name, portion, street name, the style of building, the height, the land use, parcel and field view can easily be obtained by the public and planners. Besides that, 3D GIS visualization can be used to imagine the effects of urban planning proposals as well as planned land use and zoning reforms in city planners, architects, urban planners, and land use planners or to forecast the outcome of intelligent growth strategies to achieve sustainable development in cities [2].

A map can be produced in many ways, traditionally by drawing up and using the modern application. OpenStreetMap (OSM) is an international initiative aimed at creating a free, editable world map. The geodata behind the map is regarded as the critical development of the project. OSM has evolved and expanded in many parts of the world due to shortcomings in the use and availability of map data and the advent of inexpensive satellite navigation devices. The image-based method of creating virtual 3D of any educational campus is straightforward, and this method is also very suitable for urban 3D modeling. The principal benefits of this approach are expenditure and time [3]. As for Over et al. [4], the OSM project offers a wide variety of data and continuously expands the standard feature set. The OSM was designed to create free maps generated by users. A numerous different web application shows the ability to do much more than just map rendering. Partially, height information is available, which enables virtual City Models to be created. All other information from the OSM system is processed separately and updated daily or weekly except for land-use areas, streets, and rail networks part of the integrated DEM.

According to Corrigan [5], the Esri CityEngine software is an innovative 3D modeling technology that enables the production of vast, interactive, and immersive urban settings in a fraction of the time required by traditional modeling methods. The Esri CityEngine modeling program can fully use existing GIS data and combine other models designed to quickly and batch 3D modeling on the internal and external parts of buildings to increase the performance of 3D modeling [6]. Cities built by Esri CityEngine may be based on real-world GIS information or display a fictional city of the past, the present, and the future [7].
3. Methodology

The methodology of this study can be categorized into five phases. Phase 1 involves a preliminary study. Phase 2 is the study preparation, where the site and equipment are selected and the software is installed. In Phase 3, data acquisition covered the study area from border to border without leaving any important data in the study area. Phase 4 sees data processing where the base map of the study area is downloaded from OpenStreetMap (OSM), and the attribute and spatial data is managed in the Esri CityEngine 2019.0. After that, zone classification is done. Lastly, Phase 5 is data analysis and results. Figure 1 below visualizes the methodology of this study.

![Methodology of the Study](image)

**Figure 1: Methodology of the Study**

3.1. Preliminary Study

Preliminary research was conducted to review the current existing map utilized for a long time, find, and assess the software required to meet the project objectives. The current UPNM campus map, which students, staff, and visitors utilize, is insufficiently effective, and its location has not been identified. UPNM also retains the previous campus map in a conventional 2D layout, which is inconvenient for users. Furthermore, the current UPNM map with campus data is not accessible through the internet or the official UPNM website. As a consequence, individuals, especially visitors, have difficulty finding information about UPNM. Users today want a more dynamic and immersive map experience, preferably a 3D map. ESRI CityEngine 2019.0 and ArcGIS Online were used to develop a web-based 3D UPNM campus map and area zoning for software assessment.

3.2. Preparation of Study

The site location is the campus area of UPNM in Kem Sungai Besi, 20 km from Kuala Lumpur's central capital. It is the home to students that consists of cadet officers and civilian students. The location is inside the Royal Military Camp, Sungai Besi, and is bounded by the Royal Military College. Figure 2 illustrates an overview of the study area.
After assessing various hardware according to the recommended specifications of Esri CityEngine 2019.0, it was recognized that the MSI GP72M 72REX Leopard Pro laptop has the nearest performance specifications to that of the recommended specifications. System verification was needed before installing Esri CityEngine 2019.0 to ensure the system met all the minimum system requirements. Authorization was required on all of Esri’s platforms before usage. With the presence of the concurrent license of Esri CityEngine 2019.0, ArcGIS License Manager was installed and used to verify the concurrent license. The user status was checked and had administrator privileges.

3.3. Data Acquisition
Data collection covered UPNM from border to border, leaving no important data in the study area. When all data from the study area is included and no important data is left out, the findings of this research may be considerably more accurate and precise. Data is collected by identifying the whole chosen region of UPNM and obtaining the base map from OSM.

3.4. Data Processing
A base map serves as a reference map on which data from different layers is overlaid and displayed. Various function, raster, or web layers may shape an individual base map. They form the basis of the maps as well as provide background for the work. The easiest way of getting a base map was via OSM. OSM is an international initiative aimed at creating a free, editable world map. In this study, a base map was acquired from OSM via Esri CityEngine 2019.0. By using CityEngine 2019.0, OSM can be obtained. Figure 3 shows various methods for obtaining OSM while using CityEngine 2019.0.
The methods for managing the attributes and spatial data started with extrusion of 3D models and the Level of Detail (LOD). 3D modeling or extrusion modeling operates in the same way as box modeling, where the modeler constructs the model to a specific design using the design template and then reverts straight and applies all the information. The methods to manage the extrusion of 3D models together with LOD 3 and zone classification are clarified as follows in Figure 4.

**Figure 3:** Ways to obtain OSM using CityEngine 2019.0

**Figure 4:** Manage the extrusion of 3D models
4. Results and Discussion

4.1. Capabilities of 3D web-based Campus Map of UPNM

After the processed attribute and spatial data have been managed and then developed into 3D models, all models are selected to be exported as a CityEngine Web Scene file (.3ws). Then, the .3ws file is shared as CityEngine Web Scene Package, which is then published into cloud-based via ArcGIS Online. 3D web-based campus map of UPNM is finally accessible to all targeted users.

Figure 5 shows the actual view and interface of the web-based 3D campus map of UPNM with the area zoning feature incorporated within the map. Few other features and capabilities of the web-based 3D campus map, such as Layer Tab, Search Tab, Settings Tab, Information Tab, and Comment Tab.

The Setting tab shown in Figure 6 allows the user to adjust the sunlight timeline using the drag slider. The preferences for the time zone and the month also can be changed. In this tab also are the Shadowing functions, which are Direct Shadow and Diffuse Shadow. The user can adjust these parameters according to their needs to satisfy their desire. After setting out their desire, the user can Screenshot the web-based 3D campus map according to the preferred size. With the Sunlight and Shadowing capabilities, the user, especially the management of UPNM, can do the shadow analysis. This analysis can be performed on the web-based 3D campus map models, which plays an important part in the decision-making when planning new construction, maintenance, or renovation of buildings in the campus area. These capabilities contribute to more sustainable development and management of infrastructure in the campus of UPNM itself.
Figure 6: Setting Tab

Figure 7 shows the variation of a screen capture from ArcGIS Online, which displays the publicly accessible 3D web-based campus map of UPNM.

![Screen capture of ArcGIS Online](image)

- **a)** View from the main gate of UPNM
- **b)** Bird’s eye view of
- **c)** View from Akademi Latihan Ketenteraan

**Figure 7:** Variation of a screen capture of the 3D Web-based Campus Map of UPNM
4.2. Area Zoning Analysis

Area zoning is the practice of separating the land into separate areas for specific uses. Zoning of the areas helps to identify areas and helps to protect and maintain the environment. Area Zoning was done by referring to the National Geospatial Information Symposium as the guideline. Figure 8 shows the variation of a screen capture of the area zoning of the 3D web-based campus map of UPNM from ArcGIS Online, which displays the categorized zones of area and lands. Area zoning analysis is also publicly accessible from the same 3D web-based campus map of UPNM. However, it is more efficiently used by a technical user such as UPNM Development and Maintenance Department staff or top management in UPNM to growth strategies for achieving sustainable development in UPNM.

![Area zoning analysis viewed in 3D](image1)

![Area zoning analysis viewed from above](image2)

![Area zoning legend](image3)

**Figure 8**: Variation of a screen capture of the Area Zoning Analysis

Based on the analysis in Figure 9, there are a few findings of the area zoning of the UPNM campus area. First of all, the commercial areas, including important places such as restaurants and convenience shops, are just 4% of the total campus area, whereas the institution and public utilities are 36% and the residential areas are 29%. Nevertheless, the percentage of the transportation hub, which is only 2%, is enough to provide the demands of transport in the campus area and cope with the increasing population density in the UPNM and ALK, especially around the campus area due to the policy and the walking distance between student residences and their respective faculties and classes.
5. Conclusion
A 3D web-based campus map of UPNM complete with area zoning features is produced and published in ArcGIS Online. The free-to-access 3D web-based campus map will replace the unconventional old-fashioned 2D campus map of UPNM. This map will also ease UPNM management, provide sustainability for future campus planning and development, and increase the safety and security of staff, students, and visitors. As a suggestion, the management of UPNM can provide the official website of UPNM with this 3D campus map as it is the best platform to reach their staff, students, and visitors. This 3D UPNM campus map also can be upgraded further. For future improvements of this 3D UPNM campus map, future studies could propose a higher Level of Details and a slider function in the ArcGIS Online, or even a navigation assist. With all these findings, such as the development of a web-based 3D UPNM campus map and area zoning of the campus area, it is guaranteed that this 3D UPNM campus map can benefit towards the sustainable development and management of infrastructure of UPNM, in addition to easing the staff, students, visitors and the management of UPNM. This study is the first step in laying the groundwork for a smart campus used by users such as students, staff, and management in the future.

References
[1] Anh, P., Chuc, M. D., Hung, B. Q., & Thanh, N. T. N. (2017). Development of virtual campus using GIS data and 3D GIS technology: A case study for Vietnam national university, Hanoi. Proceedings - 2017 9th International Conference on Knowledge and Systems Engineering, KSE 2017, 2017-January, 281–286. https://doi.org/10.1109/KSE.2017.8119472
[2] Samad, A. M., Hussein, S. M., Karnadi, M. S., Bohari, S. N., Suldi, A. M., & Maarof, I. (2012). Web GIS solution and 3D visualization towards sustainability of Georgetown as a world heritage site. Proceedings - 2012 IEEE 8th International Colloquium on Signal Processing and Its Applications, CSPA 2012, 210–215. https://doi.org/10.1109/CSPA.2012.6194720
[3] Singh, S. P., Jain, K., & Mandla, V. R. (2014). Image based Virtual 3D Campus modeling by using CityEngine. In American Journal of Engineering Science and Technology Research (Vol. 2, Issue 1). www.ajestr.com
[4] Over, M., Schilling, A., Neubauer, S., & Zipf, A. (2010). Generating web-based 3D City Models from OpenStreetMap: The current situation in Germany. Computers, Environment and Urban Systems, 34(6), 496–507. https://doi.org/10.1016/j.compenvurbys.2010.05.001
[5] Corrigan, F. (2020). 12 Best Photogrammetry Software For 3D Mapping Using Drones –
DroneZon. https://www.dronezon.com/learn-about-drones-quadcopters/drone-3d-mapping-photogrammetry-software-for-survey-gis-models/

[6] Jia, G., & Liao, K. (2017). 3D modeling based on CityEngine. AIP Conference Proceedings, 1820, 50001. https://doi.org/10.1063/1.4977305

[7] Esri. (2018). Advanced 3D City Design Software | ArcGIS CityEngine. https://www.esri.com/en-us/arcgis/products/arcgis-cityengine/overview