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MAPPING OF MANADO STATE POLYTECHNIC CAMPUS AREA WITH WEB-BASED GEOGRAPHIC INFORMATION SYSTEM (GIS): A SMALL UNMANNED AERIAL VEHICLE (SUAV) APPLICATION

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ABSTRACT

Technology is continuously developing, especially in mapping and information technology. Geographic Information System (GIS) is a system used to collect, store, analyze, and display geographic data. Geographic data is information about location or geography, such as maps, satellite imagery, digital elevation models, or data associated with a particular location. This study aims to produce a web-based GIS map by visualizing spatial data containing each room's location, parking area, and landscape in the Manado State Polytechnic campus area. The method used in this study was to collect location data using a Small Unmanned Aerial Vehicle (SUAV) to take aerial photos, Ground Control Point (GCP), and tagging photos. Data processing uses Agisoft Metashape Software to combine all aerial photographs to become an exclusive photo and ArcGIS for programming. The result is creating a digital map that makes it easy for users to get the position of buildings with a visual display along with the information contained therein.

Keywords: mapping, GIS, Manado state polytechnic, SUAV.

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INTRODUCTION

Technological developments in construction are very rapid, especially in mapping science. Mapping is measuring and recording data about an area or a particular area to make an accurate and detailed map of the shape, size, and position of an object or feature. The Manado State Polytechnic Campus is a higher education institution with various buildings and infrastructure supporting lectures. The availability of digital maps will make it easier for people to find information and the location of buildings or places they are going to. Jebur (2021) stated that GIS techniques are helpful for various applications such as Education, Medicine, Tourism and Archeology, Urban Planning, Temperature, Water Harvesting, Change Detection, and Business. The main benefits of GIS technology are increasing productivity and fast transformation. Handayanto *et al*. (2015) described that Geographic Information Systems (GIS) are the most effective resource for choosing the optimum location since they make it easy to organize spatial data. Azmil *et al*. (2015) added that the map's geographic feature information, such as route length and estimated arrival time, will be helpful in emergency operations. According to Singh *et al*. (2012), there is a growing need for web-based GIS for easy and fast dissemination, sharing, display, and processing of spatial information, which helps in decision-making for various natural resource-based applications. GIS and various web technologies can be efficiently combined for free, open, and easy spatial information sharing. Sandinska (2016) said that GIS web applications could be widely used and help in many fields, such as military defense, environmental conservation, tourism development, disaster management, and education. On the application side, the main goal of future development is for a GIS WEB application to include complex functionality to be featured in public information services, citizen engagement events, and operational decision support. Geofana (2021) described statistical and spatial data processes using a GIS network analysis approach in producing coverage figures for each health facility and compared them with applicable service coverage standards and thresholds.

Jacob *et al*. (2021) integrated a drone with the ArcGIS geoprocessing neural network application tool in a web-configurable smartphone application in real time to determine eco-geographical locations and bodies of water that are among the typical breeding grounds for Anopheles mosquitoes. Plata *et al*. (2022) developed a Drone-Based Geographic Information System (GIS) Mapping of Cassava Pythoplasma Disease (CPD) for Agriculture, which is an effective and innovative tool for detecting CPD to prevent the spread of the disease. Kotovs and Zacepins (2023) analyzed an interactive map application based on a geographic information system developed to support beekeeping activities. The interactive map includes flowering calendars, weather information, and vegetation information and can link hives to remote monitoring system data observations. Rozi and Zulfikar (2021) stated that mapping mangoes in crisis areas using a web-based GIS application makes it easier for people to find locations and data related to mangoes. This application can be accessed on computers, laptops, and smartphones because it is based on a dynamic website. Conventional Geographic Information Systems (GIS) and spatial mapping techniques are methods for achieving several outcomes in complex forest areas. However, it is crucial to involve local communities in the GIS approach and spatial mapping (Sidiq, 2021). According to Hamza

and Chmit (2022), Geographic Information Systems (GIS) have an essential role in managing and planning electricity distribution to increase the capacity and output of electricity and gas companies.

Akanbi and Agunbiade (2013) stated that effective use of web-based geographic information systems could only be realized by representing the world in its original appearance, where spatial object attribute data is integrated with spatial objects and available to users on the web, using Google API and Google Earth API which integrated can be used for comprehensive web-based 3D city models. Mazhindu and Madamombe (2022) acknowledged that Web-GIS was developed to manage road infrastructure assets such as road signs, bridges, animal networks, and rest areas. Web-GIS has made it possible to visualize scattered data into a single platform, filter assets according to their condition and visualize them, and measure the distance from any asset to the nearest departmental camp. Mushonga *et al*. (2017) stated that they produced a web-based GIS that can be used to collect data from health facilities and, in turn, provide this data to public health administrators to support decision-making, also focusing on creating portals for public interaction with health facility spatial information.

Hazrin *et al*. (2014) developed a programmable web mapping system using ArcGIS Server. The web mapping application allows users to use a GIS database with information facilities, services, and service providers without having in-depth knowledge of GIS or GIS software. Ahasan *et al*. (2022) stated that using spatial analysis and GIS can significantly improve understanding of pandemics and address underserved demographic groups and communities. Based on Bhandari *et al*. (2016), Web GIS can easily be used to display spatial information worldwide and can be accessed by all users via the Internet. Desert information systems generated using GIS techniques and remote sensing have been used to display and view through Geo- and web servers. Singh *et al*. (2012) claimed that to make the implementation, operation, and maintenance of spatial information via the web cost-effective, a cheaper but feature-rich alternative to commercial software that can be fulfilled by Open Source GIS software is needed. Yuhendra (2016) described that web-based GIS (also called internet GIS or online GIS) is a network-based geographic information service that utilizes wired and wireless Internet to access geographic information and analysis tools in providing GIS services. The database and the application allow various users to access information quickly and efficiently. Masudara *et al*. (2015) said that Geographic Information Systems are needed, especially for finding housing locations. With the GIS, the community can more easily and quickly obtain housing information.

A 3-dimensional digital tourist map equipped with spatial information from objects is crucial to help tourists get to the place quickly. Putri *et al*. (2017) mentioned that one method of mapping in tourist areas is photogrammetry using the UAV (Unmanned Aerial Vehicle). Based on Budiharto *et al*. (2021), research is conducted using drones and developing 3D models using photogrammetry and situation mapping using Geographic Information Systems. Drones can reach a wider area with adequate power support, making them suitable for mapping activities. Cilek *et al*. (2020) described that UAVs provide promising opportunities to create high-resolution and precise images, making 3-D mapping easier. The use of UAVs is suitable for area studies with different area sizes. The resulting data can improve the design and planning process and increase interaction and cooperation in the planning process using GIS.

RESEARCH METHOD

The study was conducted to obtain the required data and information. The data needed are campus geographic information, aerial photo surveys, tagging photo data taken directly in the field, and coordinate data of points on the earth's surface. The digital map-making method uses a web-based Geographic Information System. The results of aerial photos are sourced from shooting with the DJI Mavic Pro 2 Drone, with Emlid Reach RS2 Geodetic GPS for taking Ground Control Point (GCP) coordinates. All aerial photographs are merged into one complete photo using Agisoft Metashape and ArcGIS for program creation.

The location used for this study was carried out within the Manado State Polytechnic campus area. Figure-1 below is the area where the study was conducted.

Figure-1. Study area (source: Google Earth).

RESULTS AND DISCUSSIONS

After the benchmarking stage, then take the GCP coordinates. The method used for recording is NTRIP – RTK (Network Transport RTCM via Internet Protocol - Real Time Kinematic). This method is used to observe positions in real time or record coordinates directly in the field.

Mapping using drones to get a map of the location that is the object of study. Double Grid (3D Mapping) in the Pix4D Capture application is an option for flight missions if the mapping area is square and some

particular objects or buildings stand out and display them in 3D. Area of Interest (AoI) in 3D Mapping displays buildings or objects in 3D, making the grid more comprehensive than AoI to minimize errors during further processing.

Figure-2. Double grid (3D mapping) display.

Making GCPs for Field Tie Points

The GCP coordinates from the Geodetic GPS recording consist of 5 (five) points corrected via CORS BIG (Continuous Operating Reference Station Badan Informasi Geografis - Geographic Information Agency) coordinates. Table-1 shows the GCP coordinates.

Table-1. The GCP coordinates.

Point	E	N	Z
GCP01	709598.943	167871.546	116.699
GCP02	709890.365	168076.260	135.503
GCP03	709727.367	168021.297	128.543
GCP04	709767.311	168021.297	136.368
GCP05	709990.872	168021.297	136.368

Accuracy Test Error Analysis

Error analysis of the accuracy of horizontal and vertical earth tie points to orthophoto obtained horizontal GCP accuracy values of 0.04 m and 0.004 m vertical. Table 2 shows the results of the horizontal and vertical accuracy analysis.

Table-2. Horizontal and vertical accuracy test results.

Accuracy	Test Result	Accuracy on Map Scale 1: 1000		
	CE 90 and LE 90	Class 1	Class 2	Class 3
Horizontal Vertical	0.04 0.004	0.3 0.2	0.6 0.3	0.9 0.4

Source of 1:1000 Scale Map Accuracy: Regulation of the Geospatial Information Agency No. 6, 2018

Georeferencing Analysis

Figure-3. Georeferencing result display.

After all aerial photographs have been entered into the Agisoft Metashape software, markers, and GCP coordinates are also entered to start error analysis. The following table 3 shows the total georeferencing error. The error value was found during the georeferencing process of 3.8607 cm.

Table-3. Total georeferencing error.

Point	X error (cm)	Y error (cm)	Z error (cm)	Total (cm)
GCP01	-1.7867	-1.5092	-0.1233	2.3420
GCP02	-1.1841	2.9426	0.4469	3.2032
GCP03	-0.1384	-0.7107	-0.4272	0.8407
GCP04	6.6880	-0.0532	-0.3759	6.6988
GCP05	-3.5692	-0.6725	-0.0722	3.6327
Total	3.5237	1.5425	0.3298	3.8607

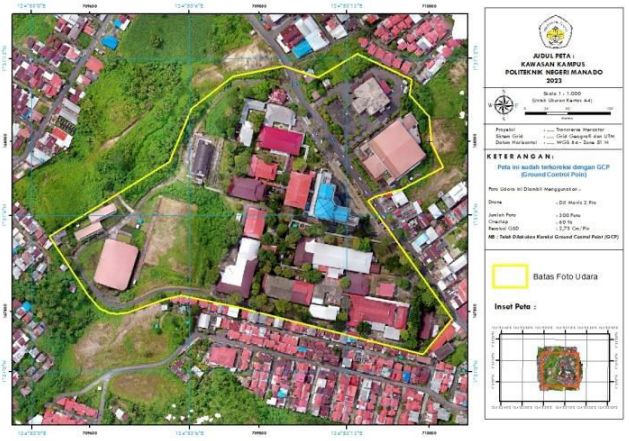

Figure-4. The digital map of the Manado State Polytechnic campus.

Geographic Information System

There are four central driving systems on this Geographic Information System built on a web-based: pedestrian line, vehicle line, destination point, and areas.

Pedestrian lines function to transport objects from one place to another. It helps GIS users navigate safely

and efficiently through pedestrian areas, such as sidewalks, walkways, or notable pedestrian routes. Pedestrian lines indicate paths or recommended routes for pedestrians within campuses.

Figure-5. Pedestrian line.

The vehicle line on the campus digital map shows the path or route for motorized vehicles. It covers the streets and the most efficient routes to reach specific locations within the campus. The vehicle line functions to deliver objects according to the traffic routes that are made.

Figure-6. Vehicle line.

The destination point in a web-based Geographic Information System (GIS) is the location or place the user wants to reach or go to by the user. The destination point serves as the leading destination of each object.

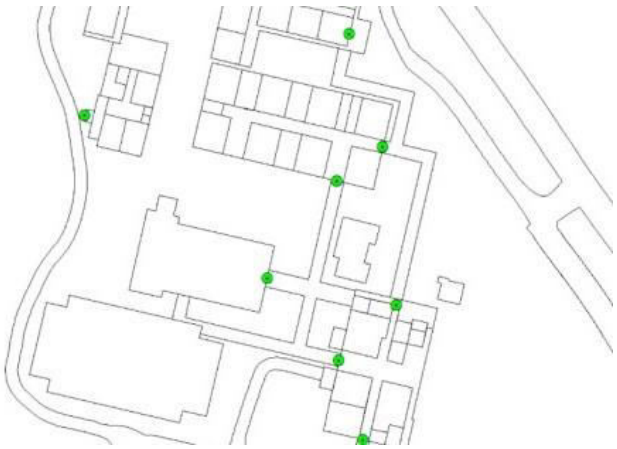

Figure-7. Destination points.

The area on the campus digital map is a geographical area that includes various entities or features within the campus environment. The area serves to direct objects to the nearest line or point. Areas can include buildings, facilities, parks, courts, and other special zones on campus.

Figure-8. Area.

The main display of digital maps in a web-based GIS provides users with quick and intuitive access to information relevant to the campus environment. The following is the prominent display of digital map data.

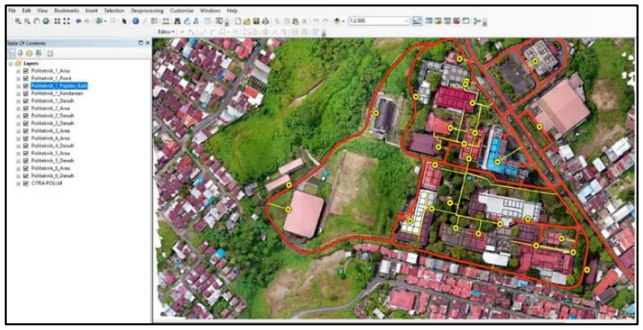

Figure-9. Distribution of choice layers.

Figure-10 shows the location of the buildings in the area and provides information about the distance from each building to a certain point or area.

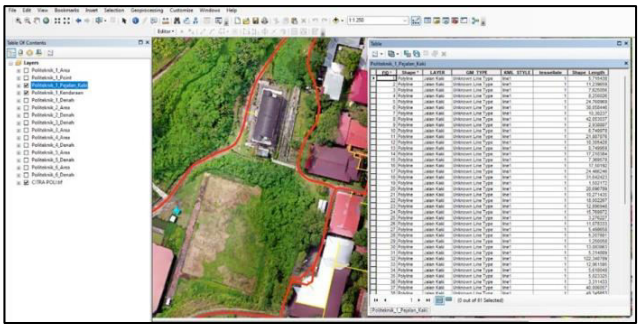

Figure-10. The distance to each building.

Figure-11 displays the pop-up of the building and field. This feature provides additional display information about an object or location on a digital map and interactively provides additional information.

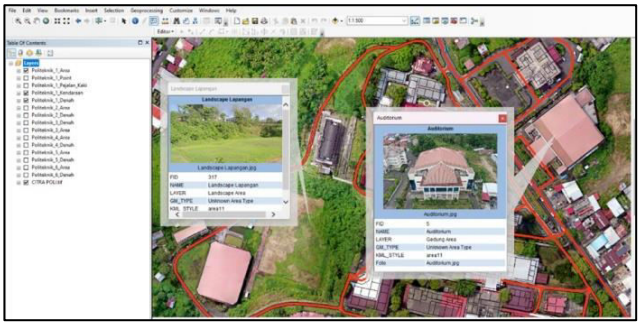

Figure-11. The pop-up of the auditorium and playing field.

Figure-12 displays a pop-up of the 2nd floor of a building equipped with information about the area or room on that floor. There is a view of the 2nd floor, which includes details of the rooms, corridors, and other elements. It provides more detailed and contextual information about the area to users who access the map and can help users gain more insight into the functions and services on that floor.

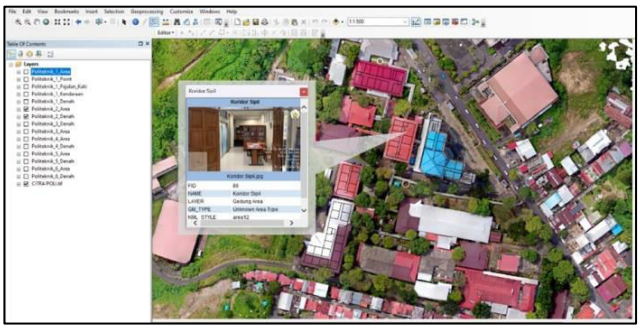

Figure-12. The pop-up of the 2nd-floor area.

A pop-up on GIS is a view that appears when the user clicks over an object or a particular location on the digital map. When a user interacts with a GIS map using a pop-up, information relevant to that object or location will appear as a small window or dialog box. Pop-up photos provide further visualization of objects or locations on the map, helping to understand and recognize places better. The pop-up contains additional information about a particular object.

CONCLUSIONS

A web-based GIS of the Manado State Polytechnic area map was built by determining GCP and photogrammetry using drones and taking tagging photos, followed by data processing and making digital maps in ArcGIS. Mapping the Geographic Information System that was built, can provide convenience to each user in finding information about the geographical location of the Manado State Polytechnic campus, along with the condition of existing buildings and facilities. Serves as a basis if development planning will be done in the campus area. This web-based digital map service is still being developed by adding features that will make it easier for people to get the information they need.

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