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DEVELOPMENT OF A WEB-BASED GIS APPLICATION FOR POLITEKNIK UNGKU OMAR USING QGIS AND LEAFLET

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ABSTRACT

Politeknik Ungku Omar (PUO) accommodates a diverse population of visitors for academic and administrative purposes. The lack of an interactive, web-based platform for accessing spatial information has limited efficient navigation and access to location-based data within the campus. Conventional systems remain static, fragmented, and less user-friendly. To address this gap, this study develops a web-based Geographic Information System (GIS) for the PUO campus, employing open-source tools for spatial and non-spatial data preparation, with Leaflet.js for web deployment. The project involves the acquisition of geospatial data from drone imagery and institutional records. An orthomosaic map was generated and digitized in QGIS to extract essential campus features, including academic blocks, administrative offices, student facilities, roads, and utilities. These datasets were exported and integrated into a Leaflet-based application to create an interactive, dynamic campus map. The system offers user-friendly features such as zooming, panning, clickable icons, pop-up information windows, and layer toggling, enabling efficient access to detailed information on campus facilities. This platform significantly enhances navigation for students, staff, and visitors unfamiliar with the campus. Accessible through standard web browsers, it presents a cost-effective and scalable solution. Furthermore, the system promotes spatial literacy, digital transformation, and improved campus management within PUO.

1. Introduction

Geographic Information Systems (GIS) are essential tools that support spatial decision-making and planning across various fields, including urban development, environmental monitoring, and educational infrastructure management. In the context of academic institutions, GIS can significantly enhance spatial awareness, resource allocation, and navigational assistance for students, staff, and visitors (Lin & Li, 2018; Taddesse & Tofu, 2025). The evolution of web-based GIS platforms has further extended the reach of spatial tools, allowing users to access interactive maps from any location using standard web browsers. This platform becomes a powerful tool that enables users to perform complex geospatial analyses and collaborate remotely (Netek et al., 2023) . Technologies such as JavaScript, Hypertext Markup Language (HTML), and Cascading Style Sheets (CSS) are commonly integrated with GIS to create interactive and efficient web-based mapping solutions.

Open-source GIS platforms, particularly QGIS and Leaflet.js, offer a cost-effective and flexible alternative to proprietary systems. QGIS is a powerful desktop GIS software that supports advanced spatial data processing, while Leaflet.js is a lightweight JavaScript library for rendering interactive web maps. According to Duarte et al. (2021), Leaflet is recognized as one of the most popular Web mapping libraries, offering a well-documented and user-friendly API, supported by extensive tutorials, which facilitates the development of dynamic and accessible web maps. The integration with cloud services and utilizing advanced analytical techniques enables the development of fully functional Web GIS applications that are visually informative and scalable (Vinueza-Martinez et al., 2024). As a result, the need for expensive licenses was eliminated, promoting wider adoption, especially in institutions with limited budgets. Despite their benefits, many campuses still rely on static or print-based maps, which offer minimal interactivity and lack real-time features. This often poses challenges for new students and visitors, as traditional maps fail to provide precise spatial cues or building-specific information.

At Politeknik Ungku Omar, there is currently no integrated system designed to support location searching within the campus. Consequently, students, staff, and visitors primarily rely on external tools such as Google Maps or seek assistance from others to navigate and identify locations around the campus. This situation reveals a gap in the institution's spatial information infrastructure that could be addressed to enhance wayfinding and overall campus navigation. Therefore, there is a demanding need for a digital solution that combines spatial accuracy with user-friendly interfaces accessible through common devices such as smartphones and laptops. This project involves the development of a Web-based GIS application for Politeknik Ungku Omar (PUO). The application employs QGIS software for spatial data preparation and Leaflet.js for web-based mapping functionalities. The system incorporates digitized spatial layers representing academic blocks, administrative units, student facilities, and pathways, supplemented with attribute data and interactive clickable features.
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2. Methodology

The development of the web-based GIS application for Politeknik Ungku Omar (PUO) was structured into several key phases. This flow shows the step-by-step process, starting from requirement analysis and data collection, to creating an interactive web-based map that users can access through a browser, as shown in Figure 1.

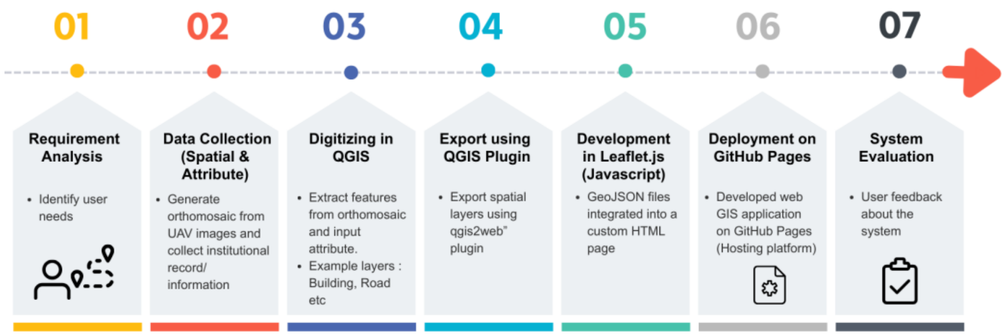

Figure 1. Workflow for GIS-Based Campus Mapping System Development.

2.1 Requirement Analysis

Initially, a requirements analysis was conducted to identify user needs by interviewing security personnel and distributing a questionnaire via Google Forms to first-semester students enrolled in the Diploma in Geomatics program at the Civil Engineering Department, Session 1 2024/2025, Politeknik Ungku Omar. The total number of respondents was 63. The questionnaire was developed to understand the existing navigation methods used by students and to gather their specific requirements and expectations for an enhanced location-search system. The data collected provided important insights that helped define both the particular functions the GIS should include and the overall qualities or standards it should meet to address users' needs effectively.

In order to locate locations on campus, the majority of the participants (70%) depend on asking other people for guidance, while smaller numbers use signboards (19%), apps such as Google Maps (8%), or other methods (3%). However, 57% reported still facing difficulties with chosen methods, which indicates that the existing approaches are not fully effective. Finding campus locations is still challenging, majority of the respondents still need more help, which emphasises the need for improved navigation support. Strong support was also shown for the creation of a dedicated location search application, with most respondents agreeing or strongly agreeing to its development. Suggestions for improvement included providing detailed campus maps, developing a user-friendly app, installing clearer and larger signboards, setting up directories across campus, and giving maps to new students to ease their navigation.

2.2 Data Collection via UAV

The subsequent phase involved collecting spatial data using unmanned aerial vehicle (UAV) imagery, which provided a comprehensive and high-resolution visual overview of the PUO campus. Aerial images, captured via drone and processed using Agisoft software to generate an orthomosaic, served as the foundational base map for the project. This generated output was imported into QGIS as a georeferenced GeoTIFF base layer for digitizing campus features. Meanwhile, attribute data were carefully selected to capture relevant information about campus features, including buildings, pathways, parking lots, and facilities. Examples of attribute fields include feature names, types or categories, and area.

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2.3 Digitizing in QGIS

Once the base map was accurately georeferenced, the next step involved digitizing desired features visible on the campus, such as academic buildings, administrative blocks, pathways, and student facilities. In the QGIS software, vector layers were created to represent each of these categories. Each feature was manually traced using the digitizing tool, resulting in the creation of polygon, line, and point geometries. Attribute data were then assigned to each feature. For example, building polygons were tagged with details such as the building name and image. This data was stored in an attribute table linked to the spatial features, enabling rich, descriptive content to be displayed in the web application as depicted in Figure 2.

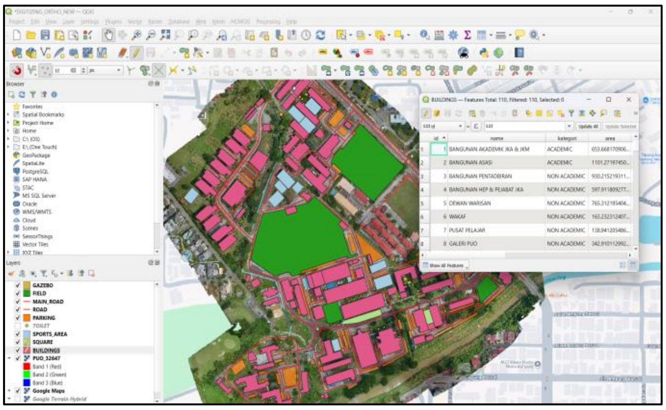

Figure 2. Digitizing process in QGIS software.

2.4 Export Using QGIS Plugin

Upon completion of the digitization process, the spatial layers were prepared for web deployment. The "qgis2web" plugin in QGIS was utilized to export the map into a web-ready format. This plugin allows users to convert map projects into HTML, JavaScript, and GeoJSON files that are compatible with web mapping libraries such as Leaflet. The layers in shapefile format were converted to GeoJSON format, a JavaScript object that contains geographic data, and added to the web map application. During export, the plugin preserves symbology, pop-up configurations, and layer controls. This approach significantly reduces development time while ensuring that the web application maintains the visual consistency and user interface characteristics of the original QGIS project.

2.5 Development in Leaflet. js

This phase involves the web interface development using Leaflet.js, a lightweight JavaScript library for interactive maps. The GeoJSON files exported from QGIS were integrated into a custom HTML page. Figure 3 shows a JavaScript code snippet written for a Leaflet web mapping application. The Leaflet framework was used to load map layers, manage zoom controls, and add user interactions. Clickable features allowed users to view pop-up windows containing the attribute data previously entered in QGIS. Additionally, users can locate specific buildings or facilities through search functionality in the web interface.

```javascript
const openStreetMap = L.tileLayer('https://{s}.tile.openstreetmap.org/{z}/{x}/{y}.png', {
  maxNativeZoom: 19, maxZoom: 23,
  attribution: '© OpenStreetMap contributors'
}).addTo(map);

const satellite = L.tileLayer('https://services.arcgisonline.com/arcgis/rest/services/World_Imagery/MapServer/tile/{z}/{y}/{x}', {
  attribution: 'Tiles © Esri',
  minZoom: 1,
  maxNativeZoom: 19, maxZoom: 23
});

const baseMaps = {
  "OpenStreetMap": openStreetMap,
  "Satelit (ESRI)": satellite
};

const layerGroup = L.layerGroup().addTo(map);
const fullFeatures = [];
const layerStore = {};
const overlayMaps = {};
```

Figure 3. JavaScript code snippet written for a Leaflet web mapping application.

2.6 Deployment on GitHub pages

The stage involves deploying the developed web GIS application on GitHub Pages, providing a reliable and accessible platform for hosting the project. The entire project, comprising source code, GeoJSON spatial data, HTML files, and supporting documentation, was uploaded to GitHub Pages. The users can access the website through a GitHub.io subdomain URL. This deployment enables effective version control, collaborative development, and continuous updates, ensuring that the application remains current and accessible to users. Figure 4 shows the GitHub Pages settings interface for publishing a website directly from a GitHub repository.

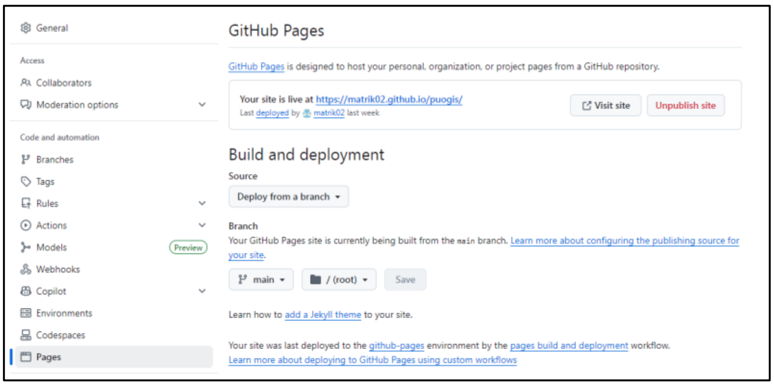

Figure 4. Build and Deployment configuration in GitHub Pages Section.

2.7 System Evaluation

The system evaluation focused on four key aspects: usability, functionality, performance, and overall satisfaction. A five-point Likert scale (ranging from strongly agree to strongly disagree) was employed to measure respondents' perceptions. The evaluation was conducted with the same group of respondents from the requirement analysis stage, namely Semester 3 Diploma in Geomatics students, Session 1 2024/2025. Data was collected online through Google Forms to ensure accessibility and convenience. Table 1 shows the mean score ranges and their corresponding interpretations for Likert-scale evaluation. It is based on the scoring method from Landell (1997) and Mohd Najib (1994).

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Table 1. The Mean score and interpretation

Mean Score	Interpretation
1.00 – 2.33	Low
2.34 – 3.67	Neutral
3.68 – 5.00	High

3. Results

3.1 Web GIS Application Interface

The image in Figure 5 shows the main interface of a web-based Geographic Information System (GIS) application specifically developed for the campus of Politeknik Ungku Omar. This interface serves as an interactive campus map, providing users with a variety of spatial tools and information layers to enhance navigation, spatial analysis, and campus management. It demonstrates how modern GIS technology can be tailored to meet the specific needs of educational institutions, improving both operational efficiency and user experience. The developed application displays a campus map with interactive icons representing various buildings and facilities. When users click on an icon, a pop-up window shows details such as building name, department, and function. The platform features a responsive, browser-accessible interface that enables users to explore and search for specific campus buildings.

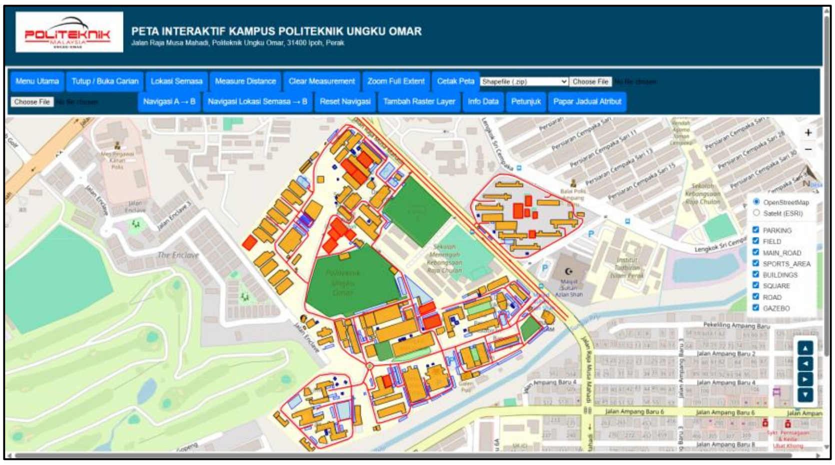

Figure 5. Web-Based Interface

3.2 Building Search Functionality

A key feature of the web-based GIS platform is its building search functionality, which enables users to locate specific buildings within the campus map interface. Users interact with this feature by typing a building's name or identifier into a search box, such as "Block Bangunan HEP & JKA," which immediately highlights and zooms to the corresponding building's location on the map, as shown in Figure 6. This interactive capability significantly enhances the user experience, especially for new students, campus visitors, or staff unfamiliar with the layout, by reducing the time and effort required to find desired locations.

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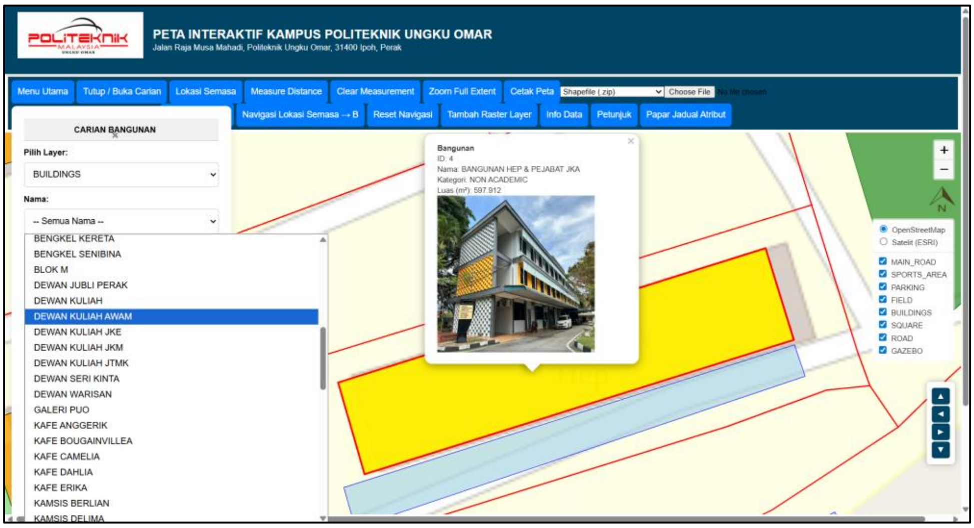

Figure 6. Search Functionality tools in the application.

3.3 Accessibility and Scalability

The application is accessible via standard web browsers without the need for additional software installation. It is designed to be user-friendly, functioning seamlessly across various devices such as smartphones and laptops, thereby facilitating effortless campus navigation for all users. This accessibility and ease of use contribute to the system's scalability, enabling it to accommodate an increasing number of users and larger datasets. Consequently, the platform possesses the potential for future expansion to other campuses.

3.4 Educational and Managerial Implications

This system not only help users in navigating the campus but also introduces GIS and digital cartography concepts to PUO students and staff. The findings also reveal that the educational implications of the web-based campus map lie in its ability to enhance learning and teaching by enabling students and faculty to locate facilities easily, gain a clearer understanding of the campus layout, and integrate GIS technology into their academic activities. Meanwhile, the managerial implications underscore how the system aids campus administrators in optimizing maintenance planning, resource management, and emergency response. These implications highlight the system's significant contribution to both educational advancement and efficient campus management.

3.5 Navigation Functionality

One of the key features of the Web GIS application is the navigation functionality, which allows users to identify and follow a route from one location to another within the Politeknik Ungku Omar campus. Users can select start and end points—such as "A → B"—based on building names or IDs, and the system will generate a visual route on the map using highlighted lines, as depicted in Figure 7. Distance, time, and navigational information was displayed in a pop-up window on the right side of the display. On the other hand, users can also navigate from their current location to a desired destination (point B). These features enhance the user

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experience by supporting intuitive campus navigation, particularly beneficial for new students, staff, and visitors. The implementation uses Leaflet.js for real-time rendering, ensuring that the navigation is responsive, interactive, and accessible on any browser without the need for additional software installation.

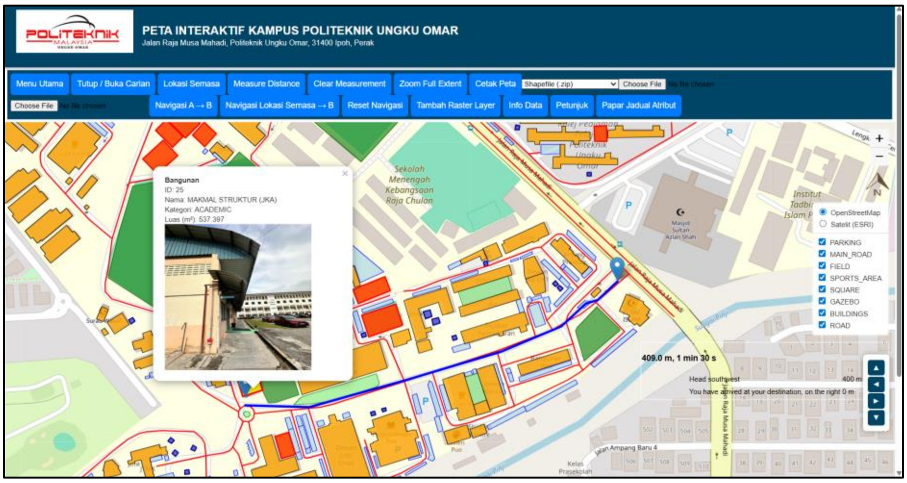

Figure 7. Navigation Functionality tools in the application.

3.6 System Evaluation

The evaluation results indicated positive user responses across all four key aspects: usability, functionality, performance, and overall satisfaction, as shows in Table 2. System usability recorded a mean score of 4.32, reflecting that users found the platform easy to use and navigate. Functionality achieved a slightly higher score of 4.37, suggesting that the system's features effectively met user needs. System performance obtained a mean of 4.21, demonstrating reliable operation and responsiveness. Overall satisfaction received the highest score of 4.43, indicating strong approval and acceptance of the system.

Table 2. The respondent's feedback about the system development

Item	N	Mean	Std	Interpretation
System Usability	52	4.32	0.85	High
System Functionality	52	4.37	0.81	High
System Performance	52	4.21	0.94	High
Overall Satisfaction	52	4.43	0.73	High

4. Discussion & Recommendations

One of the most significant advantages highlighted in this project is the effective use of open-source technologies in building a fully functional Web GIS application. The development of a web-based GIS platform for Politeknik Ungku Omar (PUO) effectively addresses the critical need for an interactive and accessible spatial information system on campus. The QGIS platform facilitated efficient spatial data processing and digitization, while Leaflet.js enabled responsive and interactive web-based deployment accessible through any modern browser. This combination supports long-term sustainability and encourages continuous improvement without dependence on proprietary vendors. The project illustrates how open-source solutions can make GIS tools more accessible in educational environments, supporting broader goals of digital transformation and spatial literacy. This approach also provided greater flexibility in customizing map features and functionalities according to institutional needs.

However, several challenges and limitations arose during the development process. Reliance on manual digitization may lead to inaccuracies or delays in updating spatial data. To extend the current study, future research should investigate the adoption of geospatial artificial intelligence (GeoAI) technology for automatic feature extraction in spatial data management (Kausika & Altena, 2025). By leveraging deep learning and AI models trained on extensive geospatial imagery such as satellite, UAV, and mobile mapping data. GeoAI can accurately and efficiently identify, classify, and delineate spatial features such as buildings, roads, vegetation, and infrastructure (Li & Hsu, 2022). This approach reduces dependence on manual digitization, minimizes human error, and enhances overall data quality and processing speed.

Additionally, exploring the use of indoor positioning systems (IPS) can help overcome navigation difficulties inside complex buildings (Deiva Nayagam et al., 2023), which is an important area yet to be addressed in campus wayfinding solutions. Moreover, applying machine learning techniques to analyze user behavior and improve route recommendations may increase the system's intelligence and ease of use. Furthermore, user feedback should be further utilized to guide the development of essential system features, such as personalized navigation, accessibility for individuals with disabilities, and multilingual support to serve a diverse campus population. Future research should also evaluate the system's long-term impact on campus navigation and user satisfaction, thereby identifying areas for refinement and informing its potential adaptation in other educational institutions. In addition, subsequent work should integrate broader geospatial datasets, including utility networks and detailed building information, together with BIM technology to generate intelligent 3D models that capture both the physical and functional characteristics of facilities."

5. Conclusion

In conclusion, the development of a web-based Geographic Information System (GIS) for Politeknik Ungku Omar effectively addresses the current challenges of campus navigation by creating an interactive and easily accessible spatial information platform. Utilizing open-source tools and Leaflet.js, the system integrates comprehensive spatial data into a user-friendly web application, enhancing wayfinding for students, staff, and visitors. This initiative not only improves operational efficiency and user experience but also exemplifies the potential of open-source GIS technologies in advancing digital transformation within educational institutions. The project thus contributes significantly to the institution's goals of improving campus management and promoting spatial literacy.

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