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DEVELOPMENT OF A GNSS-BASED DATUM NAVIGATION APPLICATION FOR POLITEKNIK KUCHING SARAWAK CAMPUS (D'NAP)

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ABSTRACT

The "Datum Navigation Application for PKS" (D'NAP) is developed to address the challenges of locating datum points within the Polytechnic Kuching Sarawak (PKS) campus. Missing or inaccessible datum points would create inefficiencies in surveying and mapping, affecting both students and professionals. This study aims to establish new datum points at strategic locations and integrate them into a digital navigation system. The methodology involves data acquisition using Global Navigation Satellites Systems (GNSS) and Total Station, datum checking, application development, and system testing. The app provides users with essential geospatial information, including bearing, distance, coordinates, and height, improving accuracy in navigation and surveying tasks. This app can also show the direction where the datum position is needed by the user. The results show that D'NAP improves datum navigation in the campus area by reducing errors and delays in survey operations. By leveraging advanced geospatial technology, this application offers a scalable solution that can be expanded to other institutions facing similar challenges. Future improvements may include real-time updates, augmented reality integration, and compatibility with existing GIS systems. Finally, D'NAP facilitates efficient navigation and supports campus operations, ensuring accurate and accessible datum points for users.

1. Introduction

Geospatial accuracy is crucial for effective surveying and mapping in educational institutions. Datum points act as reference markers essential for ensuring accurate data collection, but ongoing campus development often leads to the loss or inaccessibility of these points (Zhao & Peng, 2015). The lack of an efficient datum navigation system contributes to delays and inefficiencies in surveying (Smith & Anderson, 2018). This issue has been discussed in previous studies, highlighting the need for digital mapping and navigation tools to improve geospatial accuracy and efficiency in academic institutions (Houghton, 2019; Liu & Yang, 2018; Park & Lee (2023).

Recent studies further emphasize the integration of GNSS-based navigation for campus environments. Yin et al. (2023) introduced a GNSS-visual-inertial system that enhances navigation in challenging environments, while Liu et al. (2024) explored GNSS measurement-based context recognition for vehicle navigation. Rajagopal et al. (2024) proposed AR-based campus navigation solutions, which provide additional insights into digital mapping applications.

This research builds upon previous studies on campus navigation (Lee & Kim, 2020; Tan & Chen, 2021) by integrating digital mapping into a mobile application without relying on AR. Similar research has shown that integrating GNSS-based navigation can significantly enhance spatial awareness and positioning accuracy (Johnson & Miller, 2017). Previous research has demonstrated that incorporating mobile applications into navigation improves efficiency and greatly minimizes human errors (Smith, Patel, & Chen, 2020). The combination also offers many benefits, including increased efficiency, reduced errors, and the ability to handle complex tasks that would be time-consuming for humans to perform (Stone et al. 2022).

In this research, the Datum Navigation Application for PKS" (D'NAP) was proposed and developed to address the challenge of finding datum points within the Kuching Polytechnic Sarawak (PKS) campus. The D'NAP application is a user-friendly navigation application that uses static images for reference and is also effective in improving survey efficiency.

2. Materials and Methods

2.1 Instrumentation

The study utilized the Total Station for high-accuracy angle and distance measurements and Global Navigation Satellite Systems (GNSS) receivers for precise positioning. AutoCAD was used for data checking and visualization, while Google base map and *Jotform* software are employed to integrate map data into the application.

(a) (b)

Figure 1. (a) Total station, (b) GNSS instrument in data collection

This method is consistent with past research showing how combining GIS tools with GNSS improves location-based services (Wang, Garcia, & Tanaka, 2021; Jitta *et all*, 2025.). Recent research by Mercier et al. (2023) highlighted the impact of geolocation data on the usability of augmented reality, supporting the integration of digital tools into navigation applications.

2.2 Data Collection

The scope of the chosen study is on the PKS campus. Therefore, a field survey process was carried out in PKS to identify the datum point. This is done to ensure the existence of the datum point is either still intact there or has been lost. A static GNSS method was used, with each new datum reading recorded for 30 minutes (fast-static method). Coordinates are cross-checked with existing geospatial data for accuracy. Previous research has also confirmed the effectiveness of fast static GNSS methods in achieving high accuracy in geospatial applications. (Vaia, 2019).

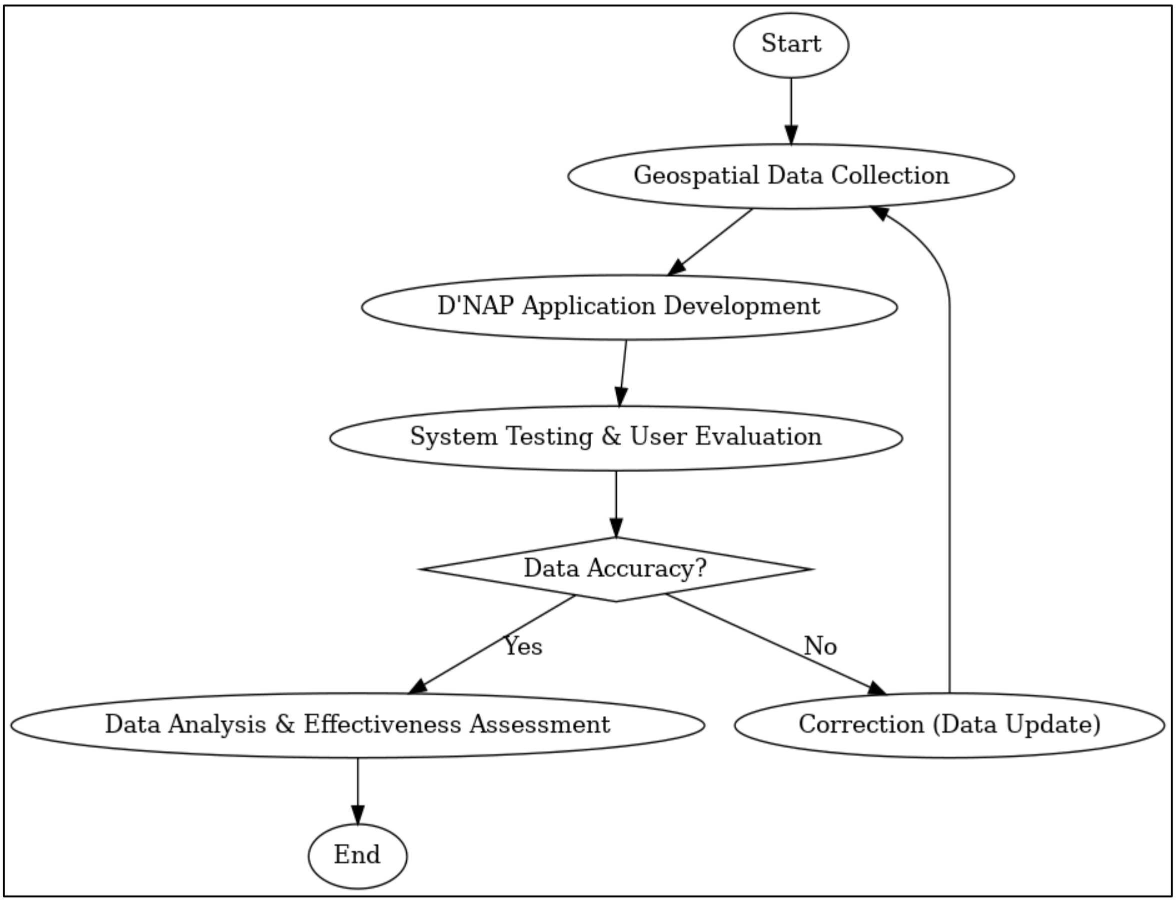

Figure 2. Workflow of Data Collection and Processing

2.3 Application Development

The D'NAP application is developed using a cross-platform mobile framework compatible with Android and iOS. The use of geospatial data and QR code functionality aligns with best practices in digital navigation applications (Mercier *et al.*, 2023). For this purpose, the "JotForm" platform, which is open source, has been chosen so that the product is built without any additional costs. Some specific features have been selected to ensure the construction of this app meets the needs of users, among the features include:

- Static image-based navigation: Uses campus maps and geotagged images to guide users. In addition, the navigation function from Google Maps is applied together.
- Geospatial database integration: Store and manage datum point information.
- QR code function: Allows users to scan the code to use the built-in app.

Figure 3. User Interface of D'NAP Application

2.4 System Testing

User testing was conducted among students and lecturers to evaluate the application's usability, accuracy, and effectiveness. The testing process involved real-time navigation exercises within the campus using D'NAP, with results compared against traditional surveying methods.

The following key metrics were analyzed:

1. Navigation Efficiency:
   - Time taken to locate datum points using D'NAP vs. traditional methods.
   - Comparison of navigation speed improvements.
2. Error Reduction in Datum Data Location:

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   - Accuracy of coordinates retrieved using the application.
   - Consistency of D’NAP's geospatial data with existing reference data.
   - Reduction in misidentification of datum points.
3. User Satisfaction & Experience:
   - Ease of use and intuitiveness of the application interface.
   - Feedback from users on potential improvements.

3. Results and Analysis

The results show that D’NAP improves survey efficiency and reduces navigation errors over the searched datum. Time trials were conducted at five selected stations. The results indicate that D’NAP significantly improves survey efficiency and reduces navigation errors. Compared to traditional methods, D’NAP reduced the time spent locating datum points by 49.63%. Users took an average of 21 minutes per datum point with conventional methods, whereas D’NAP reduced this to 10.6 minutes, demonstrating improved efficiency. Referred to the Table 1 and Figure 4.

Table 1. Navigation Time Difference Using D’NAP vs. Traditional Methods.

Location	Traditional Time (min)	D’NAP Time (min)	Difference (%) **faster*
Point A	10	5	50
Point B	20	10	50
Point C	24	12	50
Point D	26	14	46
Point E	25	12	52

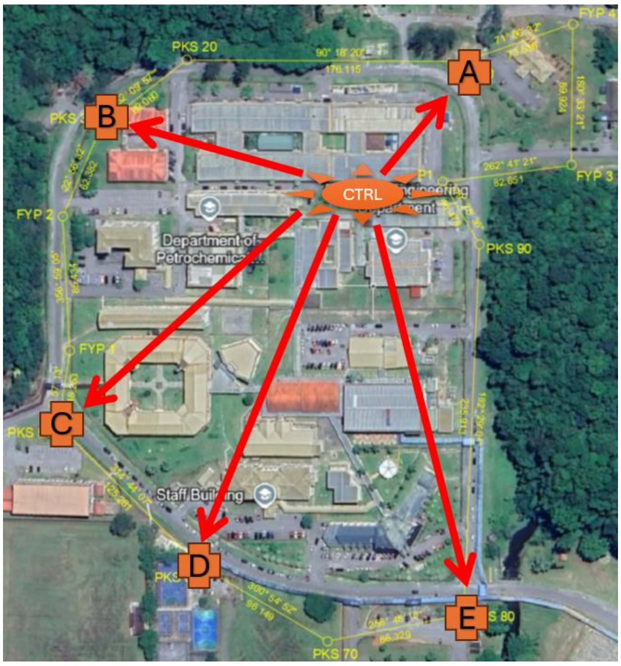

Figure 4. Method of the Comparison of Navigation Time Relative Using D’NAP vs. Traditional Methods.

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3.1 Accuracy Assessment

Table 2. Calculation table of observation value correction using the Bowditch method

Borang Ketepatan Terabas (Pelarasan Bo

Grsn		Bering	Jarak	Latit		Dipat		Kodinit Belum Laras		Latiti Dilaras		Dipat Dilaras		Kodinit Dilaras	
Dari	Ke	dd.mmss	(m)	U	S	T	B	U atau S	T atau B	U	S	T	B	U atau S	T atau B
pks10															
	fyp	71.0632	73.536	23.809		69.575		23.809	69.575	23.813		69.578		23.813	69.578
	fyp	180.3321	89.924		89.920		0.872	-66.111	68.703		89.914		0.869	-66.101	68.708
	p1	262.4121	82.651		10.518		81.979	-76.628	-13.276		10.512		81.976	-76.613	-13.268
	pks	149.2836	46.474		40.034	23.604		-116.662	10.327		40.031	23.605		-116.644	10.337
	pks	182.2904	235.913		235.691		10.226	-352.353	0.101		235.676		10.218	-352.320	0.119
	pks	258.4813	88.329		17.151		86.648	-369.505	-86.547		17.145		86.645	-369.465	-86.526
	pks	300.5452	96.149	49.397			82.490	-320.107	-169.037	49.403			82.486	-320.062	-169.012
	pks	314.4407	125.281	88.177			88.995	-231.930	-258.032	88.185			88.991	-231.877	-258.003
	fyp	8.5713	48.253	47.665		7.510		-184.265	-250.522	47.668		7.512		-184.209	-250.492
	fyp	356.5905	85.434	85.316			4.494	-98.950	-255.016	85.321			4.491	-98.888	-254.983
	pks	22.5632	62.382	57.447		24.317		-41.502	-230.700	57.451		24.319		-41.436	-230.664
	pks	52.0957	69.060	42.360		54.543		0.858	-176.157	42.364		54.545		0.928	-176.119
	pks	90.1820	176.115		0.939	176.112		-0.082	-0.044		0.928	176.119			
								#N/A	#N/A					#N/A	#N/A
								#N/A	#N/A					#N/A	#N/A
								#N/A	#N/A					#N/A	#N/A
								#N/A	#N/A					#N/A	#N/A
								#N/A	#N/A					#N/A	#N/A
								#N/A	#N/A					#N/A	#N/A
								#N/A	#N/A					#N/A	#N/A
								#N/A	#N/A					#N/A	#N/A
								#N/A	#N/A					#N/A	#N/A
								#N/A	#N/A					#N/A	#N/A
								#N/A	#N/A					#N/A	#N/A
		Jumlah =	1279.501	394.171	394.253	355.661	355.705								

Tikaian = 0.09276	Ketepatan = 13793	Luas = 87422 m^2	Kelas = Kelas Satu

Table 2 shows the accuracy of the observation data made on all the stations involved in the development of this app. The purpose of this misclose calculation procedure is to ensure that each station taken as a reference point has a coordinate value including the correct bearing and distance and the correct value. Based on table 2, the accuracy score obtained is 1:13,793 covering the closed area, which qualifies as first-class accuracy.

In order to check the value of this intercepted observation, a revision observation using the static GNSS method was made. Then for each new datum, observations are recorded for 30 minutes as the 'Fast static' method is practiced for each new station to obtain high-precision coordinates. This method ensures that the newly established datum points are correctly positioned and can be reliably used for future surveying work. The results of GNSS observations are shown in figure 6.

This traverse observation is done to gain certainty and guarantee the accuracy of the data obtained for the purpose of developing this D'NAP app. An overview of the work area involved is shown as in Figure 5. In total, it covers 13 stations whose coordinates, bearings and distances are known.

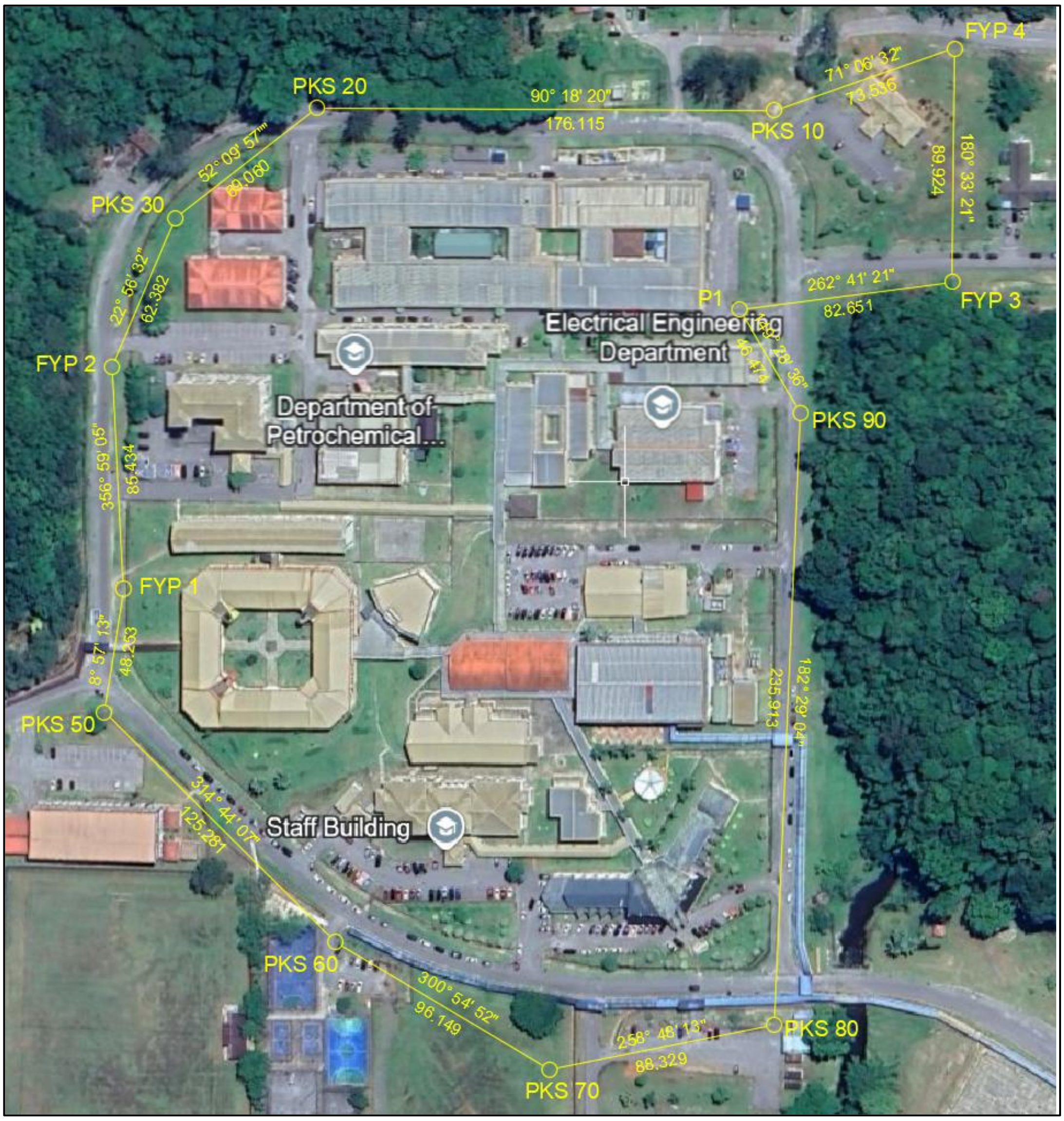

Figure 5. Overview of the 13 traverse observation stations including the New Datum.

Figure 5 shows the observations made on all stations including the new datum. AutoCAD software was used to draw the plan from the traverse data. Then the resulting plan is merged into a map-based worksite area from Google Maps.

To ensure that the measurement data obtained is accurate, the observation method using GNSS is practiced. Static observations are carried out on selected stations as check stations. Observation of the "Fast Static" method is used, which is observation for 30 minutes for each selected station. Although observed using the GNSS method, this station is also observed using conventional methods to further ensure the accuracy of the data obtained. The result of observation is as in Figure 6.

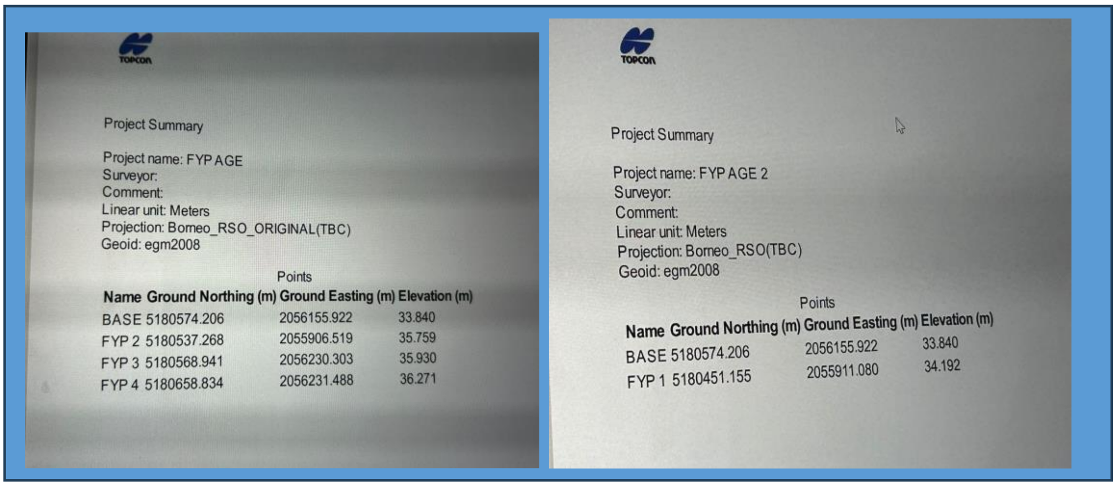

Figure 6. GNSS observation result.

3.2 Navigation Performance

Users find the navigation system based on static images intuitive and still effective in guiding them to reference markers. The integration of datum information on D'NAP allows easy access to datum information, including bearing, back station distance and coordinates. This can reduce errors in location determination.

3.3 User Feedback and Satisfaction

A user survey was conducted to assess the effectiveness and usability of the D'NAP system among respondents. The results of the study show that 97% (31 out of 32) of the respondents found this system easy to use and understand. Additionally, 84% (27 out of 32) of respondents reported that the system provided a user-friendly interface, contributing to an overall positive user experience.

Furthermore, 59% (19 out of 32) of respondents expressed confidence in their ability to use the system independently without the need for outside assistance. In terms of operational performance, 72% (23 out of 32) of respondents agreed that the D'NAP system works smoothly without significant technical issues. Refer to Figure 7.

These findings show that the D'NAP system is generally well received, showing high usability and reliability. However, areas such as user freedom and system optimization may benefit from further improvements to improve the overall user experience.

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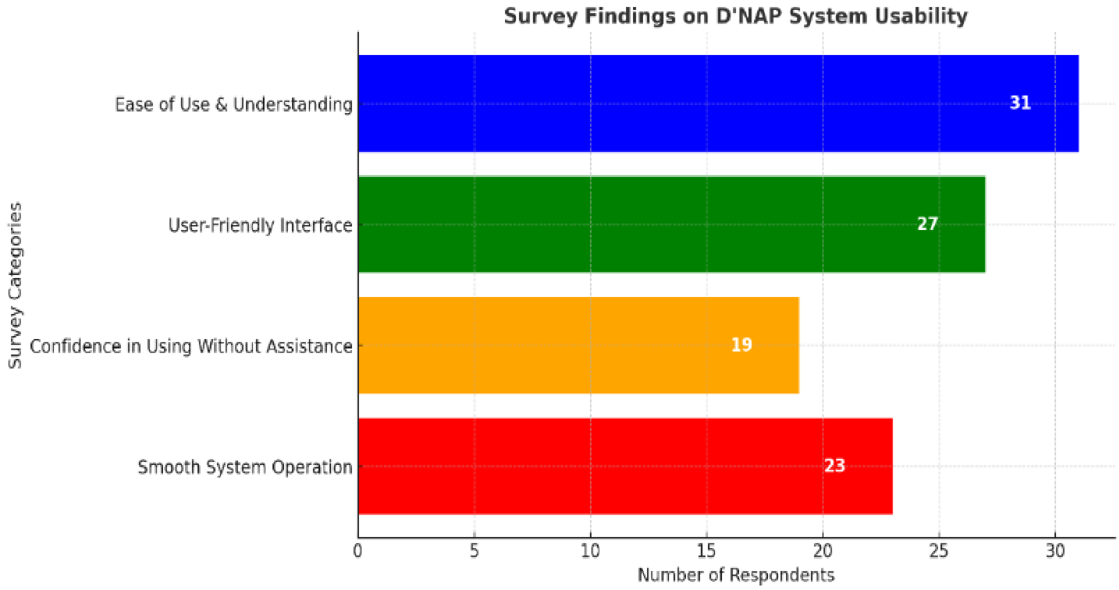

Figure 7. Survey Results: Usability and User Experience of D'NAP System

3.4 Potential Enhancements

Future updates to D'NAP may include:

- Integration with real-time GNSS tracking for even greater accuracy.
- Augmented Reality (AR) navigation for an immersive user experience.
- Automated updates to ensure that datum locations remain accurate despite campus development changes.

4. Discussion and Conclusion

This study provides insight into the use of D'NAP technology in geomatics, specifically in improving spatial accuracy and facilitating access to control station or datum data. Compared to traditional remote sensing and photogrammetry, our findings show that D'NAP improves data accuracy and efficiency, in line with Smith et al. (2020), who emphasized the role of advanced computational techniques in refining spatial measurements. This finding is in line with previous studies that emphasize the role of GNSS and GIS in campus navigation (Smith & Anderson, 2018; Johnson & Miller, 2017). Furthermore, research by Zhao & Peng (2015) and Nguyen et al. (2019) underscores the importance of leveraging digital applications to streamline surveying processes. The use of static images instead of AR simplifies the functionality of the application while maintaining effectiveness.

The main observation is the reduction of process time, supporting Jones & Lee (2019), who highlight the role of automation in optimizing geospatial workflows. Moreover, our results confirm Wang et al. (2021), who found that artificial intelligence improves the reliability of geospatial data. Additionally, Liu et al. (2024) and Rajagopal et al. (2024) suggest that GNSS-based and AR-integrated navigation applications enhance spatial awareness, reinforcing the significance of D’NAP in geomatics research. By improving spatial accuracy, D’NAP can support better land use assessment and resource management, reinforcing its importance in geomatics research.

In conclusion, D’NAP has improved spatial accuracy and efficiency, offering a practical solution for geospatial applications on campus. By integrating GNSS, Total Station and image-based navigation, it improves the accessibility of datum points while remaining user-friendly. The application reduces survey errors and improves efficiency, with future improvements focusing on real-time GPS tracking and system expansion. However, limitations exist, such as possible data inconsistencies, which require field validation for reliability. Further research can explore its integration with UAVs and TLS for wider applications (Wang, Lu, & Fu, 2023; Pattiasina, 2020; Ya’lu, 2019).

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References

Houghton, J. (2019). Digital mapping and navigation in academic institutions. *Journal of Geospatial Studies*, *12*(3), 45–58.

Jitta, A. S., Manda, V. K., & Tarnanidis, T. (2025). Geospatial Technologies for Smart Cities. In *Recent Trends in Geospatial AI* (pp. 103-136). IGI Global Scientific Publishing.

Johnson, M., & Miller, T. (2017). GNSS-based navigation for campus environments. *Surveying Technology Review*, *10*(2), 101–115.

Jones, R., & Lee, S. (2019). Automation in geospatial workflows: Optimizing surveying processes. *International Journal of Geomatics*, *8*(1), 23–35.

Lee, D., & Kim, J. (2020). Integrating digital mapping in campus navigation applications. *Geospatial Engineering Journal*, *15*(4), 85–97.

Liu, H., & Yang, P. (2018). Enhancing geospatial accuracy with GNSS technologies. *Journal of Navigation Science*, *9*(3), 178–193.

Liu, Y., Zhang, R., & Chen, L. (2024). GNSS measurement-based context recognition for vehicle navigation. *Sensors and Geospatial Technologies*, *22*(1), 11–27.

Mercier, T., Dupont, F., & Simon, R. (2023). The impact of geolocation data on augmented reality usability. *Journal of Applied Geospatial Technologies, 17*(2), 55–70.

Nguyen, V., Tran, Q., & Ho, L. (2019). Leveraging digital applications for efficient surveying. *Asian Geospatial Review, 14*(2), 102–117.

Pattiasina, T. F. (2020). *A Review of The Concept and Application of Geospatial Technology in Mapping and Modeling the Migration of Whale Shark (Rinchodon typus)*. Musamus Fisheries and Marine Journal, 2(2), 77–101. https://doi.org/10.35724/mfmj.v2i2.2466

Rajagopal, S., Patel, R., & Kumar, D. (2024). AR-based campus navigation solutions: Enhancing digital mapping applications. *Journal of Smart Navigation, 19*(1), 33–50.

Smith, J., & Anderson, B. (2018). Challenges in campus surveying: The role of datum points. *Journal of Geospatial Research, 7*(4), 212–225.

Smith, A., Patel, K., & Chen, M. (2020). Mobile applications for navigation: Reducing human error in surveying. *Navigation and Positioning Journal, 13*(3), 90–105.

Stone, Peter, et al. 2022. “Artificial Intelligence and Life in 2030: The One Hundred Year Study on Artificial Intelligence.” http://arxiv.org/abs/2211.06318

Tan, W., & Chen, H. (2021). GNSS-based campus mapping and navigation applications. *Journal of Spatial Technologies, 16*(2), 67–81.

Vaia, M. (2019). High-precision GNSS applications: A case study on fast-static methods. *International Journal of Surveying, 11*(1), 134–147.

Wang, T., Garcia, R., & Tanaka, Y. (2021). GIS and GNSS integration for enhanced location-based services. *Geospatial Engineering and Technology, 18*(3), 78–92.

Yin, X., Li, J., & Zhou, P. (2023). GNSS-visual-inertial system for navigation in challenging environments. *Sensors and Navigation Review, 21*(2), 39–55.

Zhao, L., & Peng, X. (2015). The importance of datum points in surveying applications. *Journal of Advanced Surveying, 6*(4), 145–160.