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GeoAttend: A Modern Attendance Tracking System Utilizing GPS Geofencing and AI Cloud Vision

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Abstract

Traditional manual attendance systems in educational and corporate institutions are highly susceptible to time fraud, human error and administrative inefficiencies. To mitigate issues such as buddy punching, this study develops GeoAttend, a modernised mobile and web-based attendance management system. Developed utilizing the Agile methodology, the application integrates HTML5 Geolocation for precise GPS geofencing and the Anthropic Claude Vision API for AI-powered facial liveness detection. All 14-unit tests passed successfully, validating GPS boundary logic, location spoofing detection, and AI confidence threshold gating. User Acceptance Testing (UAT) conducted with five end-users yielded a 100% maximum rating for both ease of understanding and system response time, with GPS location verification and live photo capture consistently rated 4 or 5 out of 5. Furthermore, 80% of respondents awarded the highest score for proxy attendance reduction, while 100% expressed full satisfaction with overall system performance. In conclusion, GeoAttend has the potential to significantly reduce proxy attendance, providing administrators with a secure, real-time, and digitised platform that significantly enhances workforce accountability, data integrity, and overall operational transparency.

1. Introduction

The reliance on traditional manual attendance systems, such as mechanical punch cards and paper-based logbooks, remains a significant operational bottleneck for many modern educational institutions [1], [2]. These archaic, trust-based methods are highly susceptible to human error, time fraud and buddy punching which severely compromises data integrity and staff accountability [3]. Furthermore, the inability to verify the real-time physical presence of distributed personnel such as security guards and cleaners creates immense administrative inefficiencies and unreliable record-keeping [4], [5].

To address these critical vulnerabilities, this study introduces GeoAttend, a modernized digital attendance tracking system. GeoAttend replaces manual processes with a robust dual-authentication mechanism, integrating precise GPS geofencing to validate user location and live photo capture to prevent image spoofing. By providing empirical, real-time proof of staff presence, this system aims to definitively eliminate proxy attendance, streamline administrative reporting, and foster a highly secure, transparent, and accountable organizational ecosystem. While existing digital attendance systems utilize basic GPS or photo capture, recent

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studies indicate they remain highly vulnerable to sophisticated location spoofing and static image bypasses [6]. Although contemporary frameworks have begun exploring camera-based anti-spoofing to eliminate fraudulent check-ins [6], a significant research gap persists in deploying these technologies into a unified, cost-effective platform. GeoAttend bridges this gap by combining dynamic GPS geofencing with AI-driven heuristic liveness detection to verify both exact location and true physical presence simultaneously.

1.1 Problem Statement

Sekolah Kebangsaan Temenggong Ibrahim Penggaram (SKTIP) currently relies on traditional punch cards and paper-based logbooks to record staff attendance. Based on preliminary investigations, including interviews with school administrators and direct observations of daily clock-in procedures, it was identified that these manual methods are susceptible to time fraud, proxy attendance (buddy punching), human error, and inaccurate record keeping due to the absence of reliable identity and location verification [4]. Furthermore, the existing system does not enable administrators to verify the real-time presence of security guards and cleaning staff, resulting in reduced workforce accountability and limited operational transparency [7]. The manual attendance process also increases administrative workload through repetitive data entry and report preparation, often producing unreliable attendance records that hinder effective decision-making [3]. Therefore, there is a need for a secure and automated attendance management system that integrates location verification and identity authentication to improve data integrity, operational efficiency, and workforce accountability.

1.2 Objectives

This study aims to develop and evaluate GeoAttend, a secure mobile attendance management system for educational institutions. The specific objectives are to design and develop a mobile attendance application that replaces conventional attendance recording through digital clock-in and clock-out using GPS verification and mandatory live photo capture. Next objective is to implement a dual-authentication mechanism integrating GPS geofencing and AI-powered facial liveness detection to verify users' physical presence and identity while preventing proxy attendance and photo spoofing. Lastly, the project aims to evaluate the functionality, effectiveness, and usability of the proposed system through comprehensive unit testing and User Acceptance Testing (UAT) based on system accuracy, operational efficiency, and user satisfaction.

1.3 GPS Verification

GPS technology is widely used in location-based systems to obtain accurate user coordinates for verification purposes [7]. Studies show that geolocation services, including those implemented through web and mobile technologies such as the HTML5 Geolocation API, are commonly integrated into attendance applications to ensure that check-ins are performed only within authorized locations [8]. GPS verification helps reduce attendance fraud by confirming the physical presence of users at designated areas. In addition, camera functionalities supported by modern platforms allow image capture for identity verification or documentation of attendance-related evidence. The integration of GPS verification and image- based validation enhances the reliability and security of digital attendance systems such as GeoAttend, which depend on real-time location and visual proof for accurate attendance recording.

1.4 Live Photo Capture

Most modern attendance systems also have another layer of verification through live photo capture to increase authenticity and decrease attendance fraud. GeoAttend takes this further by extending the standard live photo capture with an AI-powered liveness detection system that leverages the Anthropic Claude Vision API (claude-sonnet-4- 20250514) [9]. School staff take a selfie when clocking in or out and sends the image to the AI model for analysis. The model does five verification checks to verify if the image is a real person or a spoofed photo, single face, face clearly visible, sufficient lighting, looking at camera, and liveness detection. The AI returns a confidence score between 0.0 and 1.0, and the process is only approved when the result is passed and the confidence score meets or exceeds the minimum threshold of 0.75 [9].

1.5 Related Works

To provide a clearer overview of the existing attendance systems and the proposed GeoAttend system, a comparison of the related works is presented in Table 1. The comparison focuses on the technologies and key features adopted by each system.

Table 1 *Comparison of related attendance system*

Related Works/ Aspects	MySyarikat [10]	UTP Attendance	GeoAttend

		System [1]	
Technology Used	Mobile attendance relies on login-based attendance submission	University mobile system using live photo capture and designated location verification	Mobile app, GPS and cloud synchronization
Evidence of Attendance	Relies on user credential and server timestamp only	Requires live photo capture verified against fixed campus coordinates.	GPS geofencing and live photo capture.
Cost	Utilizes existing employee devices	Utilizes students' smart- phones	Uses mobile devices and cloud services
Data Storage	Centralized database linked to HR records	University itself managed database	Cloud database, accessible real time
Security	Secured through authentication	Identity verification through live photo and location control	Location, image with digital logs
Maintenance	Maintenance handled by system administrators	Software maintenance handled by university IT department	Software updates and minimal hardware
Reporting Capability	Attendance summaries and HR related reports	Attendance reports accessible to lecturers and administrators	Automated reports, exportable, real-time dashboards

Based on Table 1, GeoAttend demonstrates several advantages over existing attendance systems such as MySyarikat and the UTP Attendance System. While MySyarikat primarily relies on user credentials and server timestamps, and the UTP system focuses on fixed campus locations with live photo verification, GeoAttend integrates GPS geofencing, live photo capture, and cloud-based data synchronization to provide more evidence and secure attendance verification.

Furthermore, its flexible attendance location configuration and real-time reporting capabilities make it more adaptable to modern educational and organizational environments. Overall, the comparison indicates that GeoAttend is well-suited for contemporary attendance management by offering enhanced security, flexibility, and administrative efficiency supported by mobile and cloud technologies.

2. Methodology

The development of GeoAttend was guided by the Agile Software Development Model. This method was selected because it breaks the project into smaller, manageable iterative phases known as sprints. This approach allows for continuous testing and adaptation, ensuring that critical features like the GPS validation and camera integration were functional before moving to the next phase [11].

2.1 System Architecture and Technologies

GeoAttend utilizes dual-interface architecture consisting of a mobile application for staff and a web-based dashboard for administrators. The mobile client was developed utilizing the Flutter framework to ensure a responsive, cross-platform user experience. Conversely, the administrative web dashboard is constructed using standard web technologies (HTML, CSS, and JavaScript) to guarantee cross-browser compatibility and seamless data management for ICT personnel.

For data storage, the system employs a centralised MySQL database to reliably handle structured attendance records. Backend communication and server-side operations are securely mediated through PHP and Node.js scripts, which serve as the bridge connecting both the mobile and web interfaces to the database [7], [12]. Furthermore, a critical component of the system's security architecture is the integration of the Anthropic

Claude Vision API. Accessed securely via the backend scripts, this AI model (specifically claude-sonnet-4) executes the heuristic facial liveness detection and visual assessment feature, ensuring the submitted image is a live capture rather than performing biometric identity recognition against a database and was selected for its optimal balance of vision accuracy [13]. The system architecture diagram shown in Fig. 1.

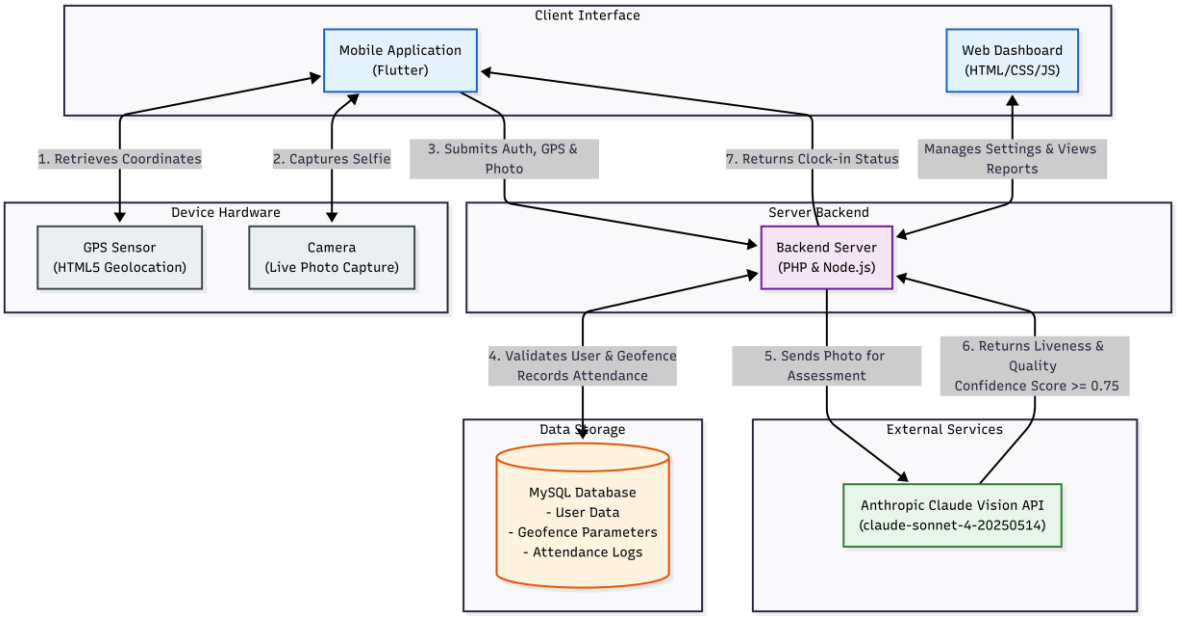


Fig. 1 *System architecture diagram*

2.2 Requirement Analysis

The requirement analysis phase was fundamental in defining the specific criteria necessary for GeoAttend to achieve its operational goals. Functional requirements focused on the core capabilities the system needed to execute, such as secure user authentication, precise GPS-based geofence validation and real-time facial liveness detection. Conversely, non-functional requirements were established to ensure the system maintained high standards of reliability, rapid response times for API communications and secure data handling [14]. Ultimately ensuring the final product effectively addressed the administrative challenges at Sekolah Kebangsaan Temenggong Ibrahim Penggaram (SKTIP).

2.3 System Design

Following the requirement analysis, the system design phase established the structural blueprint of the application. This involved the design of a centralized relational database schema to securely manage user profiles, geofence parameters and timestamped attendance logs. Furthermore, system interaction flows were mapped out to optimise the communication sequence between the mobile client, the backend servers and the external AI Vision API. Finally, high-fidelity user interface (UI) prototypes were developed to guarantee an intuitive, minimalist and ergonomically sound experience for both the school staff logging their attendance and the administrators managing the dashboard, as illustrated in Fig. 2.

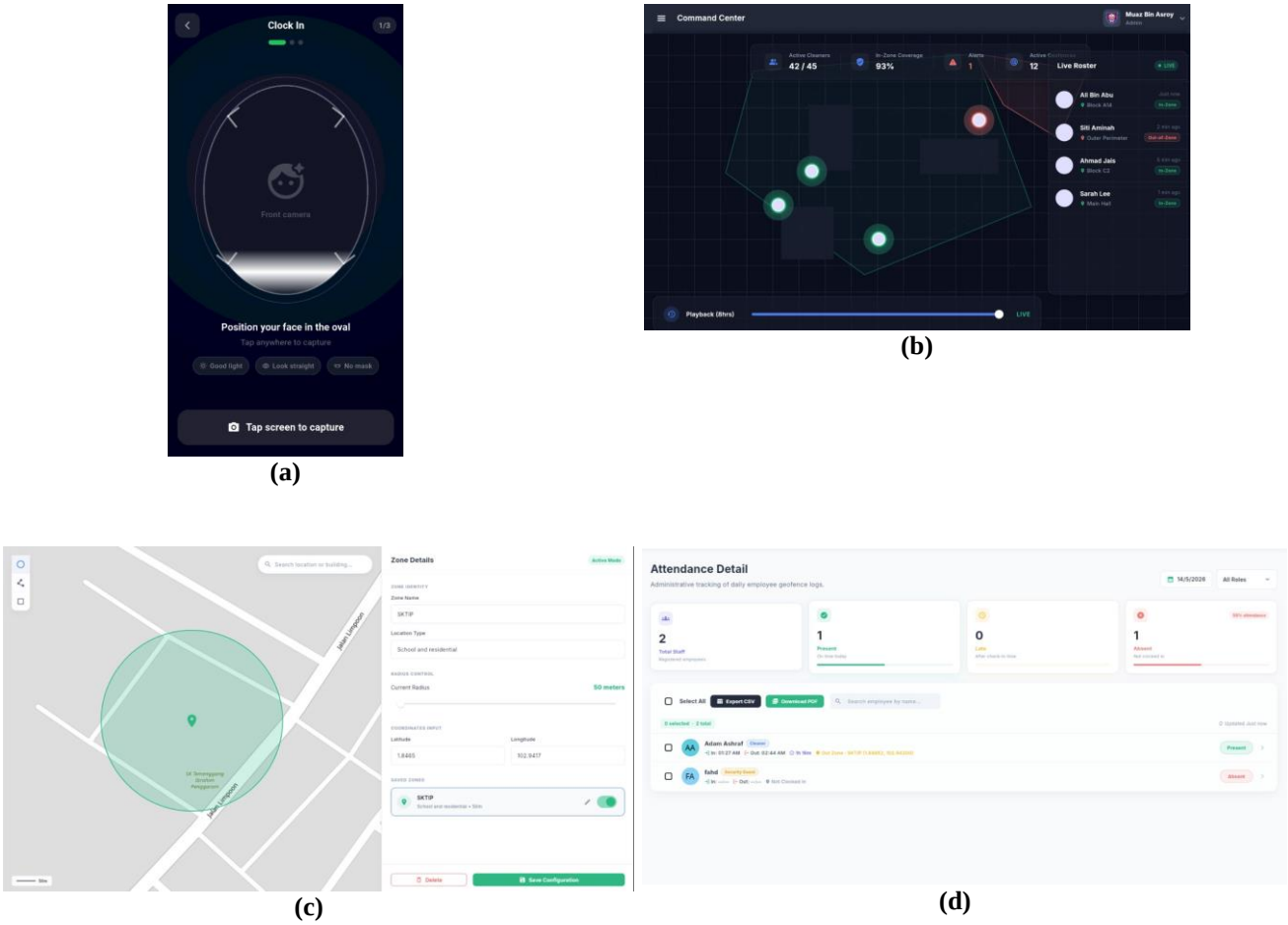


Fig. 2 *GeoAttend mobile and web user interface (a) face capture; (b) live tracking; (c) Geofence configuration; (d) attendance detail*

2.4 Testing and Evaluation

To validate the system's reliability, a comprehensive multi-tiered testing strategy was executed. System testing commenced with unit tests to validate the core business logic using the Flutter Test framework. A total of 14 unit tests were conducted targeting two primary services: the GeofenceService class (evaluating GPS accuracy thresholds, zone boundary creation, and location spoofing detection) and the FaceVerificationService class (evaluating AI confidence threshold gates and failure handling). Following the successful passage of all unit tests, integrated testing was performed to verify end-to-end functionality, ensuring correct login authentication, smooth live photo capture, and accurate timestamp synchronization.

Subsequently, User Acceptance Testing (UAT) was conducted with selected school staff and administrators to evaluate the application's real-world usability, functionality, and effectiveness. The primary data collection instrument was a structured online questionnaire distributed via Google Forms, supplemented by direct observations and brief interviews to gain deeper qualitative insights. The specific questions utilised for this evaluation are categorized and listed in Table 2.

Table 2 *User Acceptance Testing (UAT) questionnaire*

Usability & Interface	System Functionality
1. Is the GeoAttend application easy for you to understand?	1. Does GPS location verification accurately detect your location during clock-in and clock-out?
2. Is the response time of the system during attendance recording satisfactory?	2. Does the live photo capture feature function smoothly without errors?
System Effectiveness	User Feedback

1. Does the application help reduce attendance-related issues such as proxy attendance	1. What difficulties did you face while using the GeoAttend application?
2. Are you satisfied with the overall performance of the GeoAttend system?	2. What improvements would you suggest to enhance the GeoAttend system?

3. Results and Findings

This section presents the outcomes of the system evaluation phase, comprising system testing results, quantitative UAT findings, and qualitative administrator feedback

3.1 System Testing Result

Initial system testing focused on the reliability of the dual-authentication module, specifically the GPS geofencing and live photo capture features. Testing confirmed that the application accurately detects the user's location within the predefined school parameters and successfully restricts gallery access to enforce real-time photo capture. A total of 14-unit tests were conducted using the Flutter Test framework, targeting the GeofenceService and FaceVerificationService classes as shown in Table 3.

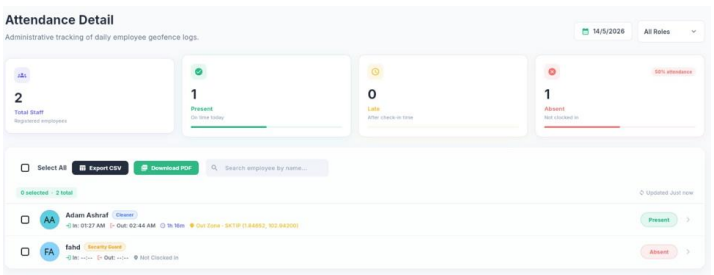
Table 3 *Summary of unit testing scenarios*

Service Tested	Test Scenario	Expected Result	Actual Result
GeofenceService	User clocks in within defined GPS boundaries	Success (Coordinates accepted)	Passed
GeofenceService	User clocks in outside defined GPS boundaries	Failure (Out of bounds error)	Passed
GeofenceService	User attempts GPS location spoofing via third-party app	Failure (Spoofing detected)	Passed
FaceVerificationService	Live photo meets AI threshold (≥ 0.75)	Success (Liveness confirmed)	Passed
FaceVerificationService	Photo submitted is a picture of a screen	Failure (Confidence < 0.75)	Passed
FaceVerificationService	Multiple faces detected in photo	Failure (Single face required)	Passed
FaceVerificationService	API communication timeout or failure	Failure (Graceful error handling)	Passed

All tests passed successfully, validating GPS boundary logic, location spoofing detection, AI confidence threshold gating, and error handling, with the successful attendance log reflected on both the mobile and web dashboard as shown in Fig. 3.



(a)



(b)

Fig. 3 *Successful attendance log (a) mobile clock in; (b) attendance web dashboard*

3.2 User Acceptance Testing (UAT) Results

To evaluate system usability and effectiveness, a User Acceptance Testing (UAT) phase was conducted with five targeted end-users (comprising three teaching staff, one security guard, and one ICT administrator). This purposeful sampling was selected to represent the primary user roles in a preliminary pilot study. However, this small sample size is acknowledged as a limitation of the current evaluation, and the reported percentages should be interpreted within the context of this initial pilot group. As illustrated in Fig. 4, the results yielded a 100% maximum rating (5/5) for both ease of understanding and response time. Core functionalities also demonstrated high reliability, with all users rating GPS location verification and live photo capture positively at scores of 4 or 5 out of 5. Furthermore, the system proved effective in addressing traditional attendance vulnerabilities, with 80% of respondents giving the highest rating for proxy attendance reduction, and 100% expressing full satisfaction with overall system performance.

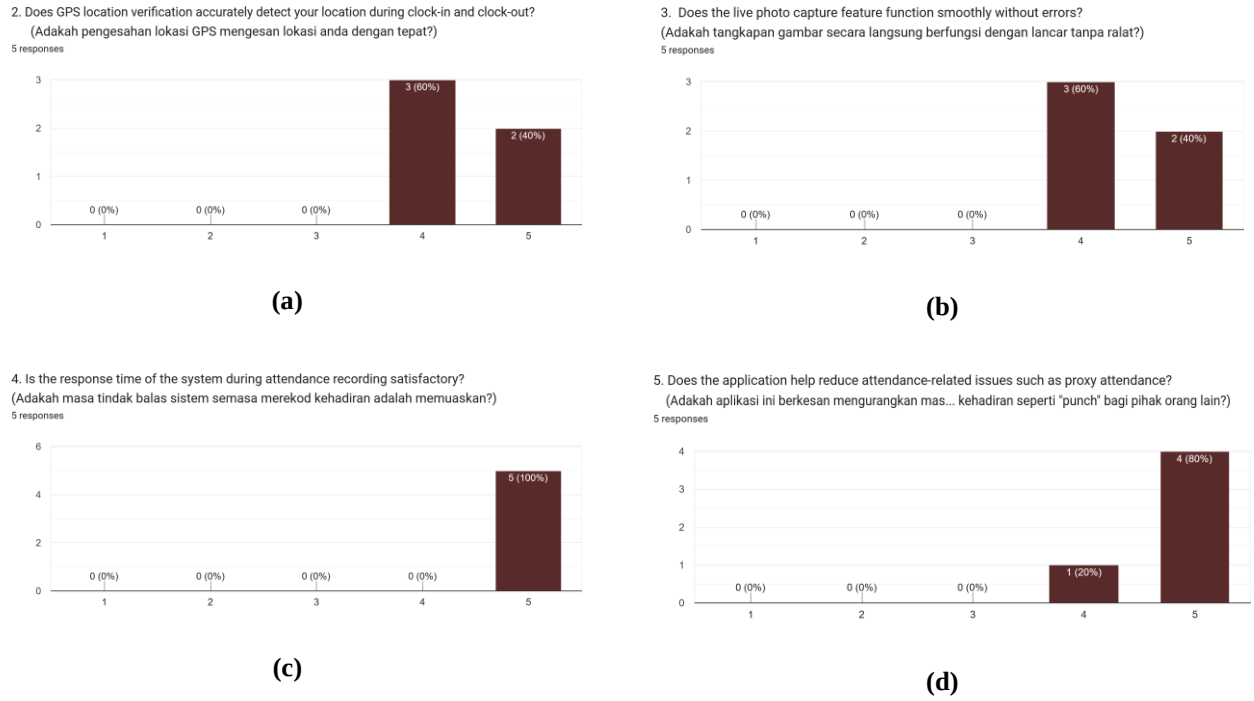


Fig. 4 *Testing results (a) location verification; (b) photo capture feature; (c) response time satisfaction; (d) reduction of attendance issues*

3.3 Qualitative Findings

Qualitative evaluation of the web dashboard was conducted via a structured interview with the ICT administrator during the UAT phase. Feedback confirmed the dashboard interface as highly intuitive and sufficient for daily staff monitoring. The leave approval workflow, including review of uploaded supporting documents, was reported to function without bottlenecks. Two key limitations were identified: backend scalability under a significantly larger workforce remains untested, and continuous live GPS tracking causes high battery consumption on staff devices, which was mitigated by recommending fully charged devices or power banks prior to each shift.

4. Conclusion

This study successfully designed, developed and evaluated GeoAttend, a modernised digital attendance management system built to address the critical vulnerabilities of traditional manual systems at SKTIP. The system achieves its primary objective by implementing a robust dual-authentication mechanism, GPS geofencing and AI-powered live photo capture via the Anthropic Claude Vision API that provides empirical, real-time proof of staff physical presence, helping to effectively reduce proxy attendance and time fraud. All 14 unit tests passed successfully and UAT results confirmed high system usability, with 100% of end-users rating overall performance satisfaction at the maximum score of 5 out of 5. The administrative dashboard was further

validated through a direct interview, confirming its effectiveness in streamlining attendance monitoring, leave approvals and data reporting for ICT personnel.

Nevertheless, two key limitations were identified during the evaluation phase. First, the system's backend scalability under a significantly larger workforce remains untested, as the current deployment was optimised for a small user base. Second, continuous live GPS tracking was observed to cause high battery consumption on staff mobile devices, requiring proactive power management as a temporary mitigation. Future work should address these limitations by implementing adaptive location polling to reduce battery usage, integrating AI-based anomaly detection into the dashboard to automatically flag irregular attendance patterns, and extending full cross-platform support to IOS devices by leveraging the existing Flutter codebase. Overall, GeoAttend establishes a secure, transparent, and scalable foundation for digital workforce management in modern educational institutions.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Adam Ashraf, Muaz;* ***data collection:*** *Muaz, Muhammad Ihsan, Adam Ashraf;* ***analysis and interpretation of results:*** *Adam Ashraf, Muaz, Muhammad Ihsan;* ***draft manuscript preparation****: Muhammad Ihsan, Mizani Mohamad Madon. All authors reviewed the results and approved the final version of the manuscript.*

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