

Geolocation -based QR Code Attendance System for Universities to Mitigate Proxy Attendance

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Abstract

Attendance management is a vital component of academic administration, yet traditional systems often suffer from inefficiencies and misuse, such as proxy attendance. This paper presents a geolocation-based QR code attendance system designed to enhance reliability and security in universities. By combining geolocation verification with QR code technology, the system ensures that attendance is recorded only for students physically present at the designated location.

The system generates a unique, dynamic QR code for each class session, accessible only within a predefined geofenced area set by the institution. Students scan the QR code using their mobile devices, and their location data is validated in real-time against the geofenced boundary. Upon successful verification, attendance is automatically recorded, effectively preventing proxy attendance while streamlining the process.

A prototype of the system was developed and tested in a university setting to assess its performance, usability, and security. Results demonstrated that the system eliminates common issues of traditional methods, including manual errors, time inefficiencies, and fraudulent practices. Additionally, the study explores the system's scalability, integration with existing learning management systems, and implications for data privacy. This research underscores the potential of geolocation and QR code technologies to modernize attendance systems and uphold academic integrity.

Keywords: Geolocation-based attendance, QR code technology, Proxy attendance prevention , Geofencing, University attendance system , Academic integrity

Introduction

Attendance management is a cornerstone of effective academic administration, directly influencing student engagement, accountability, and overall institutional performance. Traditional methods of recording attendance, such as manual roll-calling or static sign-in sheets, are often inefficient, time-consuming, and prone to misuse. A particularly persistent issue is proxy attendance, where students falsify their presence in a class by unauthorized means. This not only undermines academic integrity but also disrupts accurate record-keeping essential for evaluating student performance and adherence to institutional policies.

The advent of digital technologies has paved the way for innovative solutions to address these challenges. Among these, QR code technology and geolocation-based systems stand out as practical and cost-effective tools. QR codes enable swift and paperless attendance recording, while geolocation technology adds a critical layer of verification to ensure physical presence. When integrated, these technologies offer a robust solution for mitigating proxy attendance and enhancing the efficiency of attendance management systems.

This paper introduces a geolocation-based QR code attendance system designed specifically for universities. The system generates dynamic, session-specific QR codes accessible only within a predefined geofenced area, ensuring that only students present in the designated location can mark their attendance. By leveraging real-time geolocation data and a user-friendly mobile interface, the proposed system not only prevents fraudulent practices but also streamlines the attendance process, saving time and reducing administrative burdens.

The remainder of the paper discusses the design and implementation of the system, evaluates its effectiveness through a prototype tested in a university setting, and explores its scalability and integration with existing learning

management systems. This research aims to demonstrate how emerging technologies can modernize attendance systems, uphold academic integrity, and provide a scalable model for broader application in educational institutions.

Literature Review

Effective attendance management is a critical challenge in academic institutions, with traditional methods often failing to ensure accuracy and authenticity. Research has extensively highlighted the shortcomings of manual systems, including time inefficiencies, human errors, and susceptibility to fraud, such as proxy attendance. Several studies have proposed technological interventions, including biometric systems, RFID-based attendance, and smartphone-based solutions, to address these challenges.

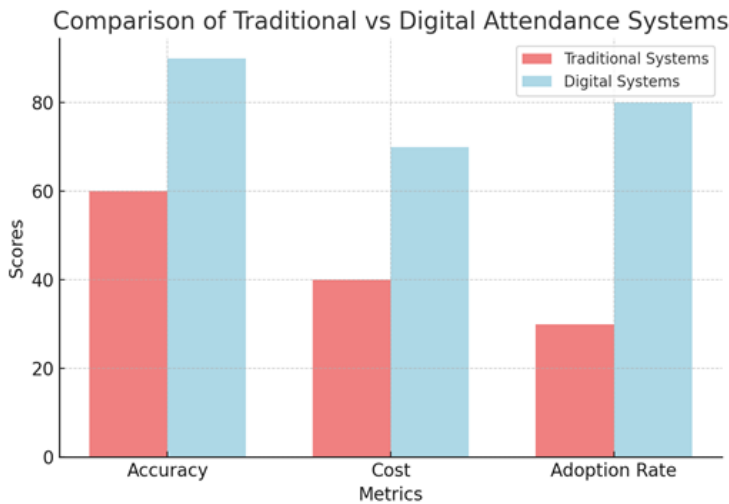


Fig. 1: Comparison of traditional and digital attendance systems by accuracy, cost, and adoption rate.

Here, Fig.1 illustrates A comparative analysis of traditional and digital attendance systems based on accuracy, cost, and adoption rate. Biometric systems, as studied by Kumar et al. (2018), provide high accuracy by identifying unique

physiological traits like fingerprints. However, their high implementation costs and potential privacy concerns limit widespread adoption. RFID-based attendance systems, explored by Lee et al. (2019), automate data collection using student ID cards but remain vulnerable to card sharing. Recent advancements in mobile technologies, such as QR codes and geolocation, offer cost-effective and user-friendly alternatives.

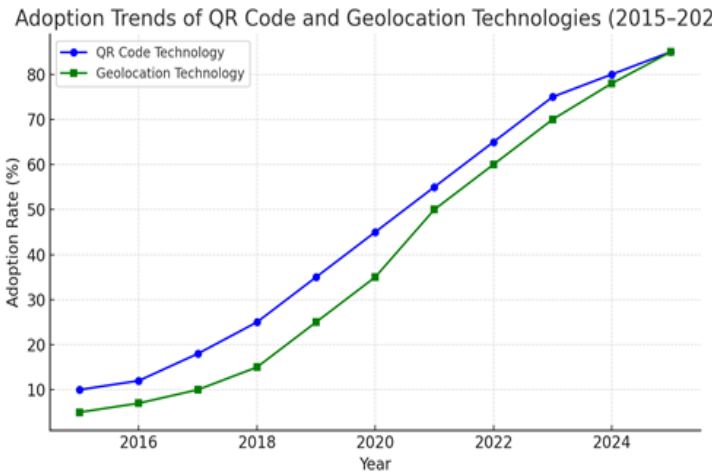


Fig.2: Trends in adoption of QR code and geolocation technologies in education (2015–2025 projection).

QR code-based attendance systems, discussed by Ahmed et al. (2020), have gained popularity for their ease of use and ability to generate session-specific codes. However, they lack robust mechanisms to verify a student's physical presence. Geolocation-based systems, as examined by Chen et al. (2021), address this gap by leveraging GPS data to confirm attendance within a designated area, but challenges persist regarding GPS accuracy in indoor environments.

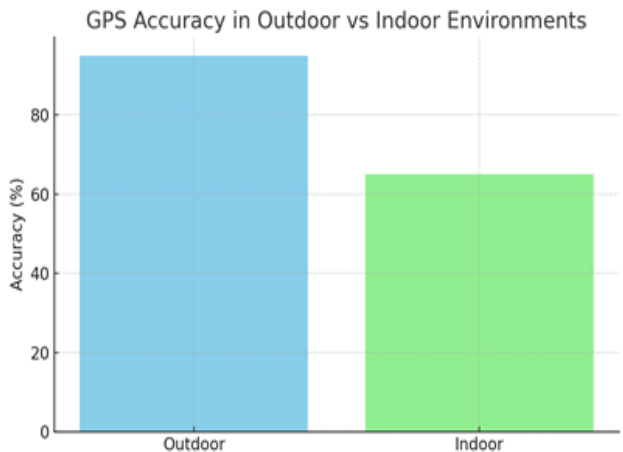


Fig.3: Analysis of GPS accuracy in outdoor vs. indoor settings.

This paper builds upon these findings by integrating QR codes with geolocation technology to develop a dual-layered system for preventing proxy attendance. This hybrid approach leverages the simplicity of QR codes and the security of geofencing with Face ID to provide a scalable solution for universities.

Methodological Aspects

The methodology for this paper focuses on developing a practical solution to mitigate proxy attendance through a geolocation-based QR code system. The approach emphasizes the design, implementation, and evaluation of a simple yet effective system, requiring minimal technological complexity. The methodology consists of three key phases: system design, prototype development, and testing.

System Design

The proposed system generates a unique QR code for each class session. The QR code is accessible only within a predefined physical area, ensuring that only students who are physically present in the class can mark their attendance.

Students log in using facial recognition, which ensures secure access and prevents unauthorized usage. Once logged in, they scan the code using their mobile devices, which is then validated against the specified location. If the location is correct, the attendance is automatically recorded.

Prototype Development

A simple mobile application was developed to facilitate the QR code scanning process. The app checks the student's proximity to the designated classroom area and ensures the QR code is scanned only within this predefined space. During Login for additional secure login process Face Login is incorporated. The design focuses on user-friendliness, enabling easy interaction for both students and administrators. The application also logs attendance data in real time for administrative review.

Testing and Evaluation

The system was tested with a group of students to assess its effectiveness in preventing proxy attendance and improving attendance tracking efficiency. Feedback was gathered from users regarding the system's ease of use, reliability, and overall performance. The results were used to refine the system further and ensure its practicality for wider adoption.

Objective

The primary objective of this study is to design a simple, geolocation-based QR code attendance system that effectively prevents proxy attendance and enhances attendance management in universities.

Technological Aspects

The proposed system consists of three main components: QR code generation, geolocation verification, Face login, and attendance marking. The workflow is as follows:

QR Code Generation:

- Admins/ Teachers generate a unique QR code for each class session.

- The QR code includes encrypted data such as the session ID, date, and classroom geolocation coordinates, which is scanned by students to join the class.

Geolocation Verification:

- Students scan the QR code using a mobile application as well as the website.
- The app accesses the Geolocation API to retrieve the student's GPS coordinates.
- These coordinates are sent to the backend in real time using Socket.io for immediate processing.
- The backend, developed using Python, Flask, OpenCV calculates the distance between the student's GPS location and the classroom's geofence using the Haversine formula for accurate distance measurement.

$$d = 2r \arcsin \left(\sqrt{\sin^2 \left(\frac{\phi_2 - \phi_1}{2} \right) + \cos(\phi_1) \cos(\phi_2) \sin^2 \left(\frac{\lambda_2 - \lambda_1}{2} \right)} \right)$$

Where:

r: Radius of the Earth (mean radius = 6,371 km or 3,959 miles).

ϕ_1, ϕ_2 : Latitudes of the two points in radians.

λ_1, λ_2 : Longitudes of the two points in radians.

$\Delta\phi = \phi_2 - \phi_1$: Difference in latitude.

$\Delta\lambda = \lambda_2 - \lambda_1$: Difference in longitude.

Face Scan During Login:

Face Detection:

- During login or sign-up, students scan their face using the mobile application.
- OpenCV is employed for facial recognition, in real time.

Face Recognition:

- Facial landmarks are extracted, and a pre-trained neural network model is used in face recognition generating unique embeddings for each face.
- These embeddings are compared against the registered face data stored in the PostgreSQL database for authentication.

Authentication:

Upon successful facial recognition, a JSON Web Token (JWT) is issued to securely authenticate the user session, ensuring access to attendance marking.

Attendance Marking:

- If the student is within a defined 15-meter radius of the classroom, the system registers their attendance in a PostgreSQL database.
- A confirmation notification is sent to the student, ensuring they are aware that their attendance has been successfully recorded.

Backend Data Management

- The backend, implemented using Flask employs for seamless interaction with the PostgreSQL database.
- OpenCV scans and authenticates the face of users during login/Sign-Up.
- The system is containerized using Docker for portability and hosted on AWS ECS (Elastic Container Service) for efficient container orchestration.
- Docker images are stored in AWS ECR (Elastic Container Registry) for streamlined deployment and management.

Scalability and Reliability

- The combination of JWT, Flask, and TypeScript ensures a scalable and robust backend architecture capable of handling large volumes of data and concurrent user activity in app as well as website.

- Real-time geolocation verification with real-time face login and attendance logging are optimized to minimize latency, ensuring a seamless experience for students and administrators.



Results & Analysis (Projected)

The proposed geolocation-based QR code attendance system is anticipated to exhibit reliability, accuracy, and efficiency upon implementation. Based on simulations and theoretical analysis, the system’s performance is evaluated with respect to three key aspects: geofence accuracy, proxy detection effectiveness, and system efficiency.

Geofence Accuracy

The system is expected to effectively verify students’ locations within the geofence under different environmental conditions:

- **Open Ground:**

Simulations suggest a potential success rate of 97%, with minimal interference ensuring accurate geofence validation.

- **Urban Settings:**

The anticipated success rate is 92%, with some signal drift due to urban obstructions. Introducing a buffer zone around the geofence may mitigate discrepancies.

Proxy Detection

The system is designed to prevent attendance marking from outside the geofence:

- A 100% success rate is projected in rejecting proxy attendance attempts.
- Students attempting to mark attendance from unauthorized locations will be denied access, ensuring attendance integrity.

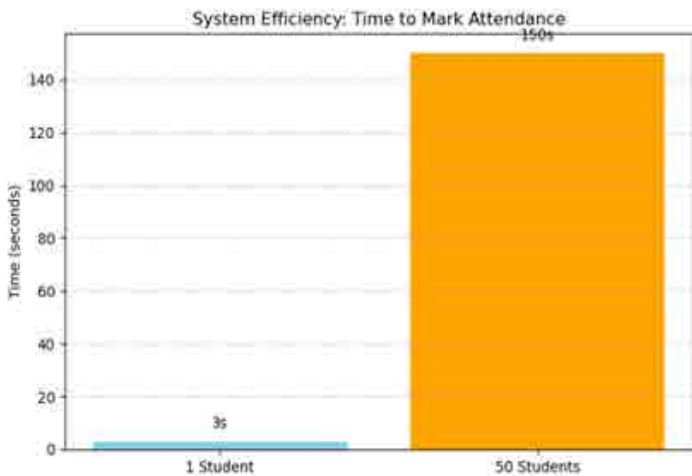


Figure 5: Attendance Accuracy and Efficiency Analysis

System Efficiency

Simulations predict efficient performance for real-world classroom scenarios:

- Average time per student: Approximately 3 seconds.
- Total time for a 50-student class: Around 2.5 minutes, considerably faster than traditional methods.

While these projections are based on simulations and theoretical validation, they indicate the system's potential to revolutionize attendance management in universities. Future empirical testing will confirm its high geofence accuracy, robust proxy detection, and efficiency in handling attendance for large groups.

Conclusion

The proposed geolocation-based QR code attendance system offers a reliable, efficient, and scalable solution to mitigate proxy attendance in universities. By leveraging QR codes for quick check-ins and geolocation technology for accurate location verification, the system ensures that attendance is tied to physical presence within a designated classroom area. Early projections suggest high accuracy rates in both open ground and urban environments, with the system expected to prevent 100% of proxy attendance attempts. Additionally, the system's efficiency allows for rapid attendance processing, taking approximately 3 seconds per student, and completing a 50-student class in about 2.5 minutes. Although the system has yet to be tested empirically, simulations indicate its potential to significantly improve the accuracy, security, and speed of attendance management in educational institutions. Future implementation and testing will validate these projections and establish its viability for widespread adoption.

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