Facial Recognition-Based Attendance Monitoring System for Non-Teaching Employees of St. Clare College of Caloocan

Carlo Christopher Alavanza, Ariane P. Camo, Marc Josef A. Dumagpi, Paul Vincent C. Rostrata, Mhel Daniel DC. Sumugat, Prince Leandro Ira T. Tayawa

Institute of Computer Studies, St. Clare College of Caloocan, Caloocan City, Philippines

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ABSTRACT

The administrative operations of educational institutions require precise, reliable, and secure attendance tracking to maintain workforce accountability and ensure payroll integrity. Traditional manual logbook frameworks are vulnerable to transcription errors, timestamp manipulation, structural damage, and proxy attendance ("buddy punching"). This study presents the design and implementation of an offline-first, facial recognition-based attendance monitoring system optimized specifically for the 14 non-teaching employees of St. Clare College of Caloocan. The system incorporates the face-api.js library for client-side edge biometric computation, a secure PHP backend hosted via Apache, and a local MySQL infrastructure for secure record storage. Employing a mixed-methods developmental and descriptive approach, system requirements were mapped through structural interviews, direct observation, and targeted surveys with institutional staff. The application features a 5-point biometric face enrollment layout, real-time live-scanner recognition, an 11:59 PM fail-safe cutoff execution script, and a comprehensive administrative portal equipped with leave management, system audit trails, and data filtering capabilities. Empirical validation demonstrates a 90% facial recognition accuracy baseline and a sub-second processing performance profile under indoor ambient light conditions. The proposed system provides a low-cost, low-latency, and internet-independent alternative to manual mechanisms and cloud-dependent services, significantly optimizing administrative transparency and record security within resource-constrained institutional environments.

Keywords: Biometric Attendance Monitoring, face-api.js, MySQL Database, Offline-First Architecture, Non-Teaching Personnel

INTRODUCTION

Attendance monitoring serves as a foundational administrative structure within higher education institutions to preserve operational discipline, structural security, and workplace accountability. In many localized environments, non-teaching infrastructure units—including maintenance, safety, and office staff—rely heavily on paper-bound manual logbooks situated at gate entrance areas. While functional, these manual architectures introduce significant processing gaps, such as chronic queuing bottlenecks during peak arrivals, missing data inputs, layout vulnerabilities, and instances of proxy signing. These manual validation limits hinder Human Resource (HR) divisions from maintaining proper data logs, complicating payroll computation and tracking accuracy.

Although modern automated platforms utilize cloud infrastructures, these models introduce constant subscription costs, rely on external wide-area network (WAN) connectivity, and present security risks concerning personal biometric information storage. To solve these core limitations, this study presents a specialized, localized biometric attendance tracking application engineered for the non-teaching staff of St. Clare College of Caloocan. By utilizing client-side script models for facial landmark execution and keeping database updates local, the architecture establishes absolute institutional control over data stores. The primary research goals are to: (1) deploy an automated facial recognition client capable of tracking real-time arrival and departure sequences; (2) implement an isolated, offline deployment configuration independent of internet

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connectivity; (3) build a comprehensive administrative portal providing automated audit logging and leave oversight; and (4) eliminate data errors and time manipulation anomalies.

REVIEW OF RELATED LITERATURE

Automated biometric tracking architectures substantially mitigate human data entry errors while optimizing tracking speeds across complex organizational systems. Research highlights that face identification configurations offer hands-free, hygienic validation models ideal for institutional deployment environments. Perwej et al. (2024) introduced real-time identification algorithms to systematically reduce proxy logging frequencies in corporate frameworks. Similarly, Feroze (2024) emphasized that integrating edge-computed visual confirmation scripts securely bridges data logging functions directly into relational data frameworks, improving monitoring accuracy.

Deep learning techniques running within modern client browsers have mitigated historical execution constraints. Bugingo (2025) verified that pairing visual face tracking routines with deep convolutional models yields higher validation accuracy rates while enabling continuous local state processing. For regional settings, Balisi et al. (2024) verified the utility of localized web-hosted frameworks (e.g., QSUM-eASys) for establishing administrative transparency within Philippine educational networks. Additionally, Dela Cruz and Santos (2024) noted that embedding mandatory biometric background routines protects local transaction tracking while keeping operational workflows intuitive for non-technical users.

While existing literature validates the performance of biometric engines, most applications focus on broad student populations or distributed remote cloud synchronization. A notable research gap persists regarding isolated, low-cost, offline-first tracking infrastructures specifically customized for localized non-teaching institutional personnel. This study fills that gap by integrating edge-based descriptor matching, localized database handling, and institution-specific scheduling rules within a unified local server architecture.

METHODOLOGY

Research Design

This study implemented a hybrid developmental and descriptive research design framework to construct and validate the system. Developmental research methods guided the systematic programming, architectural integration, and script debugging phases of the software artifact. Concurrently, descriptive methods quantified manual operational tracking errors and evaluated user acceptance of the developed biometric platform.

Participants and Instrument

The target research cluster comprised 14 active non-teaching personnel at St. Clare College of Caloocan, isolated using purposive non-probability sampling rules to ensure all respondents interacted directly with daily attendance procedures. Data gathering relied on two structured survey questionnaires utilizing a 5-point Likert scale array to quantify existing manual vulnerabilities and evaluate initial prototype acceptance. Quantitative values were assessed using mean distribution weights, where interval bounds were computed via the standard range equation divided by target assessment categories.

System Development Approach

Software construction followed an iterative Rapid Application Development (RAD) framework, utilizing a prototyping lifecycle model during the core user design and construction loops to allow for continuous system refinements based on direct administrative feedback. This structural process consisted of four repetitive, overlapping phases:

1. Requirements Planning: Defining administrative scopes, establishing operational rules, and organizing programming configurations.

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2. User Design: Building visual HTML5/CSS3 user interfaces and mockups based on administrative feedback loops.
3. Rapid Construction: Compiling core backend PHP scripts, designing MySQL relational schemas, deploying face-api.js scripts, and refining the prototype iteratively.
4. Cutover: Executing final system validation runs, performing database optimization adjustments, and deploying the stable software build to the terminal kiosk.

Technical Stack

- User Interface Layer: HTML5, CSS3, JavaScript (client-side execution layout)
- Biometric Engine: face-api.js library running on client edge scripts
- Core Backend Routing: PHP scripting language
- Database Engine: MySQL Relational Database (XAMPP local server stack)
- Server Host Infrastructure: Apache HTTP Server running within a localized loopback connection context

System Architecture & Implementation

The platform utilizes a segmented architecture separating edge scanning interfaces, local processing routes, and internal relational database indices. The system operates across six core functional modules managed through the administrative portal and local kiosk interfaces.

Figure 1: Conceptual Framework (IPO Model)

The conceptual framework utilizes an Input-Process-Output structure to model the data dependencies of the tracking application.

[INPUT]
- Profile Information of Non-Teaching Personnel
- Facial Data (Images/Descriptors)
- System Security Credentials
- Administrative Control Parameters

[PROCESS]
- Biometric Ingestion: 5-Point facial landmark extraction via face-api.js
- Data Processing: Euclidean distance calculation for face matching
- Database Management: Local SQL transactions
- Validation Logic: 11:59 PM fail-safe cutoff script execution

[OUTPUT]
- Real-time Attendance Logs (Time-In/Out)
- Automated Leave Status Reports
- Comprehensive System Audit Trails
- Administrative Management Dashboard

Data Flow Diagram (DFD) Level 0 - Context Diagram

The data transformations and transactional pipelines between the external entities and the core system process are defined structurally below.

External Entity	Inbound Data Flow	Core System Process	Outbound Data Flow
Non-Teaching Employee	Live Facial Stream / Scan Request	FR-AMS Core Engine	Attendance Status / Match Confirmation

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System Administrator	Employee Registration / Leave Approvals	FR-AMS Core Engine	Statistical Reports / Audit Logs / Dashboards

Entity Relationship Diagram (ERD) Schema Matrix

The internal MySQL relational model structures logical dependencies across normalized tracking data tables to optimize indexing speed.

Entity Table	Primary / Foreign Key	Core Attributes Managed	Relational Structural Link
EMPLOYEES	employees_id (PK)	last_name, first_name, username, password, job_role, department, profile_pic	Parent Table (One-to-Many)
ATTENDANCE_LOG	attendance_id (PK) employee_id (FK)	log_type (In/Out), log_date, log_time, status (Present/Late)	Linked to EMPLOYEES id
LEAVE_REQUESTS	id (PK) employee_id (FK)	leave_type, start_date, end_date, reason, status	Linked to EMPLOYEES id
AUDIT_LOGS	id (PK) employee_id (FK)	admin_name, action_performed, target_object, action_date	Linked to EMPLOYEES id

Biometric Enrollment and Processing Logic

The enrollment process utilizes a 5-Point Spatial Capture Routine to extract distinct facial feature points. The application scans facial geometry from five distinct tracking fields: Upward Pitch, Downward Pitch, Left Yaw, Right Yaw, and direct Frontal view. The face-api.js engine maps 68 geometric landmark coordinates, transforming spatial profiles into a 128-float mathematical vector descriptor array. The raw photograph is discarded immediately after vector generation; only the numeric array descriptor is written to the local MySQL schema.

During daily operation, the scanner compares live faces against stored database vectors using Euclidean distance formulas. Logs are validated only when distance values fall beneath a strict threshold (Distance <= 0.4), preventing false matches and "buddy punching" proxy attempts.

Operational Logic & Automated Fail-Safes

The application enforces strict time-window parameters to standardize institutional tracking:

- Standard Attendance Window: Check-ins between 06:00 AM and 08:00 AM are logged as "Present".
- Grace Period Filter: Clearances recorded from 08:01 AM to 08:10 AM are successfully tracked but automatically flagged as "Late" in the database.
- Midnight Fail-Safe Script: To maintain database integrity, a backend trigger runs daily at 11:59 PM. Any active Time-In log missing a corresponding Time-Out record is force-closed, ensuring no transaction remains "floating" or incomplete within the database.

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Data Privacy, Ethics, and Security Protocol

Because the system operates using sensitive facial biometrics, strict data protection measures are enforced to preserve employee privacy. Prior to system ingestion, all 14 non-teaching personnel provided explicit written consent for their data usage. The system enforces an image-free privacy architecture: raw facial photographs are processed in volatile client-side memory and permanently deleted immediately after the 128-float vector descriptor array is written to the local database.

No actual imagery ever touches long-term storage or external networks. Access control is strictly maintained on the XAMPP stack local loopback connection layer via encrypted administrator credentials. Furthermore, a strict data retention and purging policy is integrated into the administrative schema; if an employee leaves the institution, their numeric vector array and credential mapping are immediately and permanently erased from the database records.

RESULTS AND DISCUSSION

Initial workflow audits involving 14 active personnel confirmed substantial tracking inefficiencies within the historical manual logbook process. Survey metrics mapped the following breakdown of pilot respondents across administrative roles:

Department Role Cluster	Total Captured Responses	Overall Distribution Percentage
Maintenance Staff	6	42.9%
Security Personnel	1	7.1%
Administrative Support Staff	7	50.0%
Total Pilot Group	14	100.0%

Pre-development evaluations showed that 100% of respondents encountered issues with manual entry errors, physical queues, and logbook damage. Following pilot deployment, empirical testing verified that the developed system successfully met all core functional requirements.

To satisfy methodological rigor, the system's baseline 90% recognition accuracy was evaluated across 70 controlled validation trials (5 distinct structural capture orientations across each of the 14 enrolled personnel). The accuracy distribution was tested across explicit physical and environmental variables:

1. Optimal Frontal View: Achieved 100% recognition efficiency under standard indoor ambient light conditions (400–500 lx).
2. Horizontal Yaw Angle (+/-15°): Maintained a stable 92.8% recognition accuracy profile.
3. Vertical Pitch Angle (+/-15° Upward/Downward): Resulted in an 85.7% validation success rate.
4. Low-Light Variations (<150 lx): Recognition performance experienced an approximate 10% operational drop, yielding an 80% baseline.
5. Structural Obscurity (Eyeglasses/Facial Hair): Verified a stable recognition rate of 91.4%.

False recognition attempts were completely mitigated by the Distance <= 0.4 Euclidean constraint limit, which consistently rejected non-matching users rather than causing misassignment errors. Sub-second match generation times eliminated gate queuing bottlenecks, and the localized dashboard automated report compilation for administrative users. By restricting data routing within a local XAMPP loopback layer, the architecture eliminated internet dependency and SaaS subscription costs while keeping student and personnel metadata securely offline.

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LIMITATIONS OF THE STUDY

While the system achieved its design goals, specific operational boundaries are acknowledged: (1) Scope Boundary: Software deployment and evaluations were restricted strictly to the 14 non-teaching personnel of St. Clare College and explicitly excluded student groups or faculty members. (2) Environmental Lighting Dependencies: System recognition drops by approximately 10% under extreme lighting variances or steep capture angles, requiring controlled ambient conditions for optimal performance. (3) Feature Omissions: The system focuses on core facial identification and attendance record management; it excludes SMS notifications, automated mask detection, or direct payroll integration. (4) Network Constraints: The system runs completely offline in a local environment, which prevents remote administrative access or offsite cloud backups.

CONCLUSION & RECOMMENDATIONS

Conclusion

The developed system provides a secure, efficient, and sophisticated biometric alternative to manual record-keeping for the non-teaching personnel at St. Clare College of Caloocan. By executing face-api.js configurations at the edge and managing records locally, the application eliminates time theft and proxy entries without introducing wide-area network vulnerabilities or recurring operational fees. The implementation of the midnight fail-safe cutoff script demonstrates how automated database rules can effectively maintain data integrity. Ultimately, this local architecture proves that resource-constrained academic institutions can achieve secure, modern administrative digital transformations using cost-effective, open-source technologies.

Recommendations

Based on the operational conclusions gathered during system evaluations, the following future engineering tracks are established: (1) Hardware Ingestion Upgrades: Integrate dedicated near-infrared (NIR) camera components or high-lumen external lighting at the gate kiosk terminal to optimize recognition accuracy in low-light conditions. (2) Database Integration Expansion: Develop a database routing channel to securely pipe verified attendance metrics directly into the college's internal payroll system for automated work-hour computation. (3) Mobile Intranet Monitoring Layer: Package an isolated mobile extension (Android/iOS) to allow administrators to monitor real-time gate logs over the secure school intranet. (4) Full Department Rollout: Standardize the system across all non-teaching sub-units of St. Clare College to establish a unified, paperless attendance infrastructure.

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