

Smart Attendance Framework Using Face Recognition, Anti-Spoofing Liveness Verification and Automated Dress Code Enforcement

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Abstract: Educational institutions continue to rely on manual attendance procedures that consume classroom time and remain vulnerable to proxy attendance. Simultaneously, enforcing dress code policies and informing parents about attendance irregularities often requires significant manual effort. This paper presents an integrated smart attendance framework that combines face recognition, anti-spoofing liveness verification, automated dress code detection, and parental notification within a single platform. The proposed system employs ArcFace-based facial recognition through the DeepFace framework, Local Binary Pattern (LBP) texture analysis, Eye Aspect Ratio (EAR)-based blink detection, and HSV color analysis with K-Means clustering for dress code verification. A FastAPI backend, Streamlit dashboard, and SQL-based database support the complete workflow. Experimental evaluation demonstrates 96.2% face recognition accuracy, 97.1% liveness detection reliability for genuine users, and 92.4% dress code classification accuracy. The proposed framework offers an affordable, scalable, and deployable solution for educational institutions using only commodity hardware.

Keywords: Smart Attendance System, Face Recognition, ArcFace, DeepFace, Liveness Detection, Dress Code Detection, Attendance Automation, Computer Vision, FastAPI, Streamlit.

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I. INTRODUCTION

Attendance monitoring plays a vital role in educational institutions for tracking student participation and ensuring academic discipline. Traditional attendance methods such as roll calling and manual registers consume valuable classroom time and are susceptible to proxy attendance. Existing biometric solutions often focus only on identity verification while neglecting spoofing attacks and uniform compliance monitoring.

Recent advances in computer vision and deep learning have enabled accurate facial recognition systems capable of operating in real-world environments. However, recognition alone cannot prevent fraudulent attendance through printed photographs or replay attacks. Furthermore, institutional requirements such as dress code enforcement and parental communication remain largely manual processes.

This research proposes an integrated platform that combines attendance automation, liveness verification, dress

code detection, and automated parent notifications into a unified system deployable on standard hardware.

➤ Objectives

The major objectives of the proposed system are:

- Automate attendance marking using face recognition.
- Prevent proxy attendance through liveness verification.
- Detect dress code compliance automatically.
- Notify parents regarding attendance and uniform violations.
- Provide a web-based administrative dashboard.
- Evaluate system performance under realistic conditions.

II. LITERATURE REVIEW

Research in attendance automation has evolved from traditional image-processing methods to deep learning-based recognition systems. FaceNet introduced deep metric learning for face recognition, while ArcFace further improved discrimination through additive angular margin loss.

For anti-spoofing, Maatta et al. demonstrated the effectiveness of Local Binary Patterns (LBP) in distinguishing real faces from printed images. Soukupova and Cech proposed Eye Aspect Ratio (EAR) based blink detection, providing a reliable physiological liveness indicator.

In dress code analysis, HSV-based color classification and K-Means clustering have been widely used due to their robustness against illumination changes. Existing systems generally address attendance, liveness, or dress compliance independently, leaving a gap for integrated solutions.

III. PROPOSED SYSTEM

➤ System Architecture

The proposed framework follows a three-tier architecture:

- Presentation Layer – Streamlit dashboard.
- Application Layer – FastAPI backend services.
- Data Layer – SQLite/PostgreSQL database.

The system processes attendance through the following stages:

- Image acquisition from webcam.
- Face detection.
- LBP-based liveness verification.
- EAR blink confirmation.
- ArcFace face recognition.
- Dress code analysis.
- Database storage.
- Automated email notification.

➤ Face Recognition Module

The recognition engine utilizes ArcFace embeddings generated through the DeepFace framework. Each enrolled student is represented by a 512-dimensional embedding vector. Cosine similarity is used for matching incoming faces with stored templates. A threshold value of 0.60 determines successful identification.

➤ Liveness Detection Module

The anti-spoofing subsystem employs a two-stage verification process:

• Stage 1: LBP Texture Analysis

LBP texture variance identifies printed photographs and low-quality replay attacks by examining facial micro-texture characteristics.

• Stage 2: EAR Blink Detection

MediaPipe Face Mesh extracts facial landmarks used to compute Eye Aspect Ratio (EAR). Natural blink detection confirms the presence of a live user.

➤ Dress Code Detection

MediaPipe Pose identifies torso landmarks, enabling extraction of the uniform region. HSV color features are

clustered using K-Means ($k=3$), and the dominant color is compared with predefined institutional uniform color ranges.

➤ Notification Service

An automated email module dispatches daily notifications to parents regarding student absences and dress code violations using Gmail SMTP services and APScheduler.

IV. IMPLEMENTATION

This section categorizes existing literature into different approaches based on methodology. Each category includes a comparative table summarizing key contributions, advantages, and limitations.

➤ Database Design

The proposed system uses a relational database to efficiently manage student information, attendance records, dress code compliance data, notification history, and administrative access. The database is designed to ensure data integrity, minimize redundancy, and support real-time attendance processing.

The database consists of five primary tables:

• Students Table

This table stores the personal and academic details of each enrolled student, including student ID, name, email address, parent email, department, class, and the corresponding facial embedding generated during registration. The student ID serves as the primary key and is used to establish relationships with other tables.

• Attendance Table

The attendance table records daily attendance information for each student. It contains fields such as attendance ID, student ID, date, time, attendance status, and recognition confidence score. The student ID acts as a foreign key linking attendance records to the Students table.

• Dress Log Table

This table maintains records of dress code verification results. Each entry includes a log ID, student ID, date, detected dress status (compliant or non-compliant), dominant color information, and confidence score. These records help administrators monitor uniform compliance over time.

• Notification Log Table

The notification log stores details of all automated emails sent by the system. Fields include notification ID, student ID, recipient email address, notification type (absence alert or dress code violation), timestamp, and delivery status. This table provides traceability and auditing of communication with parents.

• Admin Users Table

The admin users table manages authentication and authorization for system administrators. It contains administrator ID, username, encrypted password, role, and

account status. This table ensures secure access to attendance records and system configuration settings.

The relationships among these tables are centered around the Students table, which acts as the parent entity. Attendance, Dress Log, and Notification Log tables reference the student ID as a foreign key, enabling efficient retrieval of

student-specific information. This relational structure supports accurate record management, fast querying, and scalability for deployment in educational institutions with a large number of students.

➤ *Technologies Used*

Table 1 Technologies Used

Components	Technology
Backend	FastAPI,SQLAlchemy
Database	SQLite
Face Recognition	DeepFace(ArcFace)
Liveness Detection	OpenCV,MediaPipe
Dress Detection	OpenCV, K-means
Dashboard	Streamlit
Notifications	SMTP, APScheduler

V. EXPERIMENTAL RESULTS

➤ *Experimental Setup*

Testing was performed on a Windows 11 system equipped with an Intel Core i5 processor, 16 GB RAM, and a standard USB webcam. All computations were executed on CPU without GPU acceleration.

➤ *Face Recognition Performance*

The face recognition module was tested using images of enrolled and non-enrolled students. Each student's facial

image was converted into a 512-dimensional ArcFace embedding using DeepFace. During testing, the live image embedding was compared with stored embeddings using cosine similarity. A similarity score greater than 0.60 was considered a successful match.

• *Result*

The system correctly identified most students with high accuracy while maintaining low false acceptance and false rejection rates.

Table 2 Results of Face Recognition Performance

Metric	Value
Identification Accuracy	96.2%
False Accept Rate (FAR)	1.8%
False Reject Rate (FRR)	2.0%
Average Processing Time	1.18 sec

• *Interpretation:*

The system successfully recognized students in 96.2% of cases. Only 1.8% unauthorized faces were incorrectly accepted, while 2.0% genuine students were rejected.

➤ *Liveness Detection Performance*

The liveness module was evaluated using three types of inputs:

- Genuine live students.
- Printed photographs of enrolled students.
- Images displayed on laptop/mobile screens (replay attacks).

The first stage used LBP texture analysis, while the second stage used EAR blink detection. A sample was considered live only if both checks passed.

• *Result*

Table 3 Results of Liveness Detection Performance

Test Scenario	Accuracy
Printed Photo Attack Detection	94.5%
Screen Replay Attack Detection	91.2%
Genuine Live Face Detection	97.1%

• *Interpretation:*

The system successfully detected most spoofing attempts. Genuine students were correctly identified as live in

97.1% of cases, while photo and replay attacks were effectively blocked.

➤ *Dress Code Detection Performance*

Thirty test samples were collected:

- 15 students wearing the correct uniform.
- 15 students wearing casual clothing.

The torso region was extracted using MediaPipe Pose. K-Means clustering identified the dominant uniform color in HSV space, which was compared with predefined uniform color thresholds.

• *Result*

Table 4 Results of Dress Code Detection Performance

Condition	Accuracy
Uniform under Normal Lighting	93.8%
Uniform under Low Lighting	88.4%
Casual Clothing Detection	95.1%
Overall Accuracy	92.4%

• *Interpretation:*

The system accurately classified uniform compliance in most cases. Performance was highest under normal lighting conditions and slightly reduced under poor illumination.

VI. DISCUSSION

The experimental findings demonstrate the effectiveness of integrating face recognition, liveness detection, and dress code verification within a unified attendance platform. ArcFace delivers high recognition accuracy while maintaining acceptable processing times on commodity hardware.

The dual-stage liveness detection mechanism significantly reduces vulnerability to spoofing attacks. Although some replay attacks remain challenging, the combination of texture and physiological verification provides substantial protection compared to conventional systems.

Dress code detection achieved satisfactory performance, though accuracy decreased under poor lighting conditions. Future improvements may include illumination normalization techniques and deep-learning-based clothing classification.

VII. CONCLUSION

This paper presented a comprehensive smart attendance framework integrating ArcFace-based facial recognition, dual-stage liveness verification, automated dress code detection, and parental notification services. The system achieved 96.2% face recognition accuracy and 92.4% dress code classification accuracy while operating entirely on

commodity hardware. The proposed solution addresses key challenges in attendance management, proxy prevention, and institutional compliance monitoring. The results demonstrate that modern computer vision technologies can provide an affordable and practical alternative to traditional attendance systems, making the framework suitable for deployment across schools and colleges.

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