A Hybrid Machine Learning Model for Efficient and Spoof-Resistant Face Recognition Attendance

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***Abstract*—In educational institutions and organizations, the automatic attendance system using face recognition systems has proven to be a beneficial tool for attendance automation. But normal systems are susceptible to the spoofing attacks like printed photographs, replay videos, and images from the mobile screens and makes the system less reliable. This paper introduces a Hybrid Machine Learning Model for Efficient and Spoof-Resistant Face Recognition Attendance model which includes four stages: MTCNN (Face Detection), Facenet (Face Feature Extraction), Random Forest (Face Classification), and Anti-Spoofing module (Liveness Detection). In real-time, the system takes facial pictures, does preprocessing, checks user identity, finds the spoofing, and records attendance automatically into a secure database. The proposed framework has better recognition accuracy, better security level and lower false acceptance rate than the traditional face recognition system. The parameters measured for performance are Accuracy, Precision, Recall, F1-Score, False Acceptance Rate (FAR) and False Rejection Rate (FRR). The envisioned model offers a safe, scalable, and efficient attendance management system for educational institutions, corporate entities, and smart workplaces.**

***Index Terms*—Face Recognition, Machine Learning, FaceNet, MTCNN, Anti-Spoofing, Liveness Detection, Attendance System, Computer Vision.**

I. INTRODUCTION

Artificial Intelligence (AI), Machine Learning (ML), and Computer Vision have revolutionized attendance management systems, making it more secure and automated with the ability to recognize faces. Manual attendance systems, like registers, RFID cards, fingerprint readers and QR codes, have various drawbacks such as proxy attendance, dependence on hardware, hygienic concerns and time and effort consumption. In recent years, the high accuracy and ease of use of face recognition have made it a reliable and contactless biometric technology. But, traditional face recognition systems can be spoofed by providing printed photos, replay videos, mobile screens and masks, jeopardizing attendance validity and system security. To address the above challenges, a Hybrid Machine Learning Model for Efficient and Spoof-Resistant Face Recognition Attendance is suggested in this paper. The proposed framework works with MTCNN to detect faces, FaceNet to extract facial features, Random Forest for face classification and Anti-Spoofing (Liveness Detection) module to check the authenticity of users before they register for attendance. The system records real-time facial images, preprocesses them, and detects spoofing attempts, and securely records attendance in a database. Experimental results show that the proposed hybrid model achieves better recognition accuracy, less false acceptance rate due to spoofing attacks and efficient real-time performance. The entire system is proposed to be a secure, scalable, intelligent attendance system, which can be adopted in the smart environment of educational institutions, corporate organizations, healthcare centers and others.

II. OBJECTIVES

1. To design a secure hybrid face recognition attendance system.
2. To integrate anti-spoofing (liveness detection) for preventing fake attendance.
3. Efficiently recognize faces in different situations.
4. To record attendance automatically in a shorter time.

5. To analyze and investigate system performance metrics through the use of standard machine learning metrics.
6. To offer student attendance solution for educational institutions and organizations which can be scaled and secured.

III. LITERATURE REVIEW

The face recognition attendance systems have come a long way with the advancements in Artificial Intelligence (AI), Deep Learning (DL), and Computer Vision (CV) in recent years. Face Recognition is a contactless, accurate and automated solution, as compared to the traditional attendance methods. But, nearly all of the available systems are susceptible of spoofing attacks like printed photos, replay videos, and mobile screen images. With the aid of deep learning, FaceNet proposed by Schroff et al. achieves high accuracy in facial feature extraction, and MTCNN proposed by Zhang et al. is capable of detecting faces and locating facial landmarks reliably in different imaging conditions. In recent years, security enhancement of the system has also been the object of research, such as anti-spoofing by texture analysis, anti-spoofing by eye-blink detection and CNN-based anti-spoofing by liveness detection. Face classification has been widely used by machine learning classifiers like Random Forest, Support Vector Machine (SVM) and XGBoost. Of these, Random Forest is considered to be accurate, quick to classify, and has a good generalization capability. While good recognition accuracy is provided by existing systems, many of them do not provide liveness detection and secure real-time attendance verification that is effective. To overcome these drawbacks, a proposed hybrid approach is proposed to incorporate the MTCNN, Facenet, Random Forest and Anti-Spoofing module for secure, accurate and efficient face recognition-based attendance system.

Table 1. Literature Comparison

Author	Technique	Advantage	Limitation
Schroff et al.	FaceNet	High recognition accuracy	No spoof detection
Zhang et al.	MTCNN	Accurate face detection	No liveness verification
George et al.	CNN Anti-Spoofing	Detects spoof attacks	High computational cost
Proposed Model	Hybrid ML + Anti-Spoofing	Secure and accurate attendance	Moderate computation

IV. RESEARCH GAP

Most current face recognition attendance systems are only concerned with the recognition of people, and are not very good at detecting whether the face is "living" or not, so they are prone to spoofing attacks by printed photos or replay videos. Their performance might also be degraded in different lighting conditions and variations and facial occlusions. Furthermore, some methods call for expensive equipment, which will not be suitable for practical implementation. For this, a hybrid model is proposed which combines MTCNN, FaceNet, Random Forest and Anti-Spoofing module to overcome the above limitations and to ensure secure, accurate and efficient face recognition-based attendance system.

V. PROPOSED SYSTEM

The proposed Hybrid Machine Learning Model combines MTCNN, FaceNet, Random Forest, and Anti-Spoofing module which can be used to provide secure and automatic attendance. This system uses a webcam to take real-time face images, preprocesses the images to detect and preprocess the face, extracts facial features using the FaceNet module, and carries out liveness verification to deter spoofing attacks. The user's identity is then verified by the Random Forest classifier and if the person is authenticated, the attendance will be automatically recorded in the database at the corresponding date and time. This all-in-one solution provides precise, secure and efficient attendance tracking.

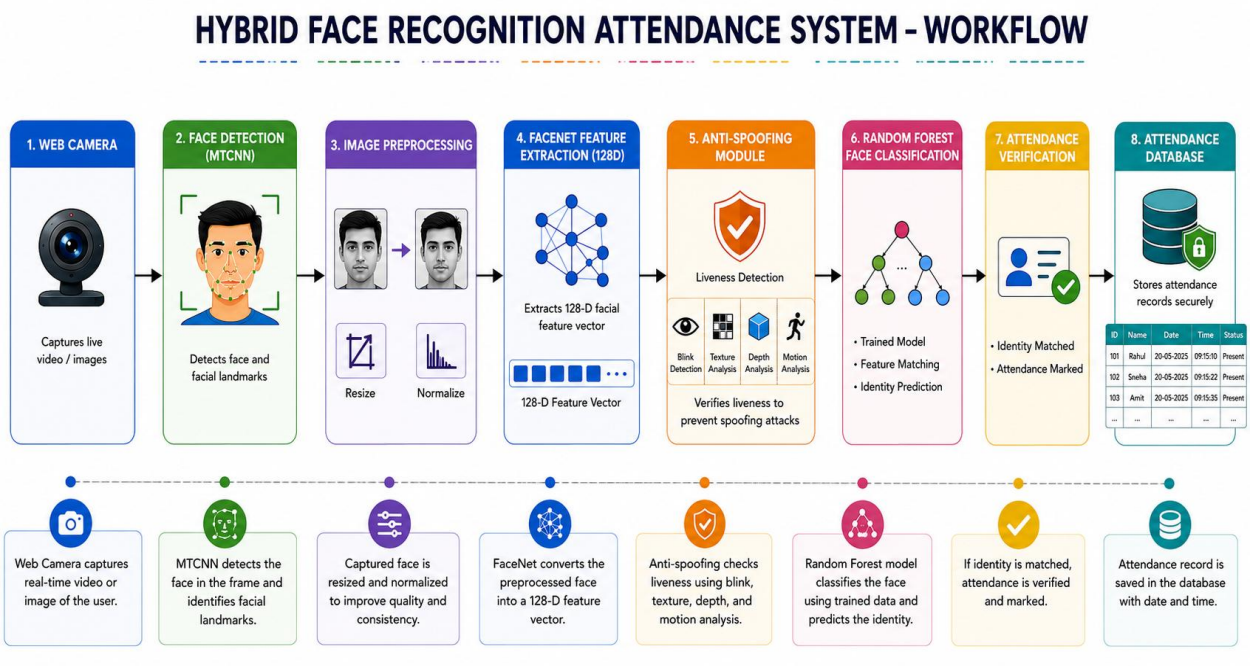

Figure Caption: Proposed Hybrid Machine Learning Architecture for secure attendance using MTCNN, FaceNet, Anti-Spoofing and Random Forest.

VI. PROPOSED ALGORITHM

Type of System: Attendance System
Output: Video streaming data captured by the webcam and displayed in the browser.
Input: Student Attendance (Present/Rejected) Steps:

1. Use a webcam to take a photograph of a real face.
2. Apply MTCNN to detect the face and preprocess the face.
3. Extract facial features using FaceNet. Do liveness (anti-spoofing) verification.
4. Deny access to the user when it is found that he or she is spoofing another user. If not, use a Random Forest classifier to classify the face.
5. Compare the extracted features and enrolled database. Write attendance in if ID is confirmed, or refuse if ID is not confirmed (date and time).

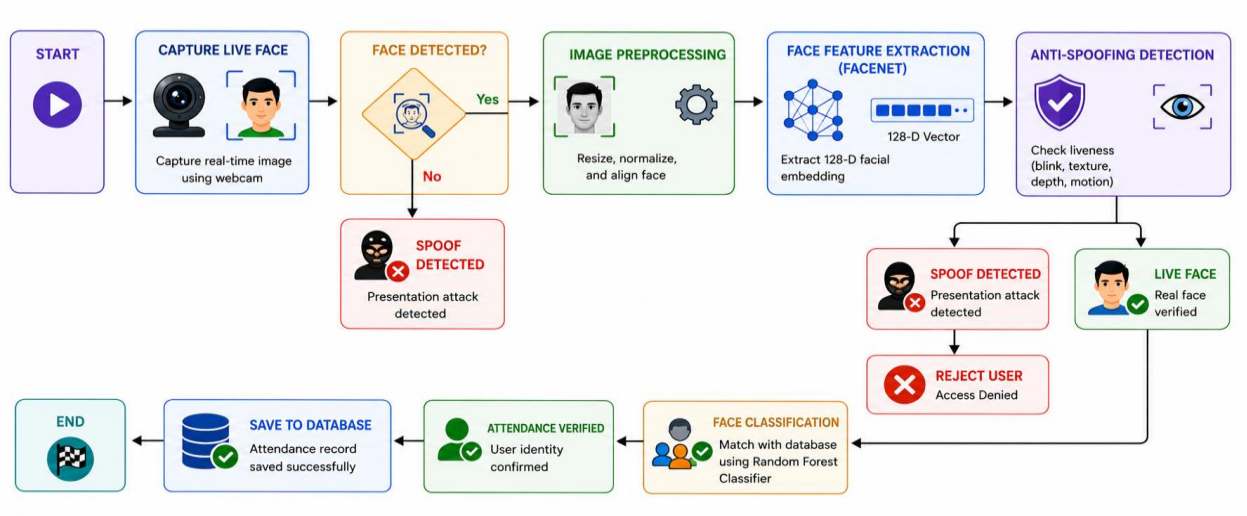

Figure Caption: This will be helpful to understand the workflow of this Hybrid Face Recognition Attendance System.

VII. MATHEMATICAL MODEL

The combination of FaceNet, Random Forest and Anti-Spoofing is proposed to ensure secure attendance verification.

(1) Face Embedding

$E = FaceNet(I)$

where:

- I = Input Facial Image
- E = Facial feature embedding

(2) Euclidean Distance

$D = \sqrt{\Sigma(x_i - y_i)^2}$

where:

- x_i = the face embedding of query i.
- y_i = Stored database embedding

The shorter distance means the more perfect a face match.

(3) Attendance Decision

Attendance = Present, if Recognition = 1 AND Liveness = 1

Attendance = Rejected, Otherwise

(4) Recognition Accuracy

$Accuracy = (TP + TN) / (TP + TN + FP + FN)$

where:

- TP = True Positive
- TN = True Negative
- FP = False Positive
- FN = False Negative

VIII. SYSTEM IMPLEMENTATION

The face recognition attendance system proposed here is implemented through the Python 3.11 language, MTCNN, FaceNet, Random Forest and the CNN Anti-Spoofing model. The image processing is done using OpenCV, deep learning with TensorFlow, and the user interface is created with Streamlit, with attendance stored in SQLite.

Table 2. Software Requirements

Component	Technology
Programming Language	Python 3.11
Face Detection	MTCNN
Feature Extraction	FaceNet
Classifier	Random Forest
Anti-Spoofing	CNN
Image Processing	OpenCV
Database	SQLite
User Interface	Streamlit

Table 3. Hardware Requirements

Component	Specification
Processor	Intel Core i7
RAM	16 GB
Storage	512 GB SSD
Camera	HD Webcam
OS	Windows 11

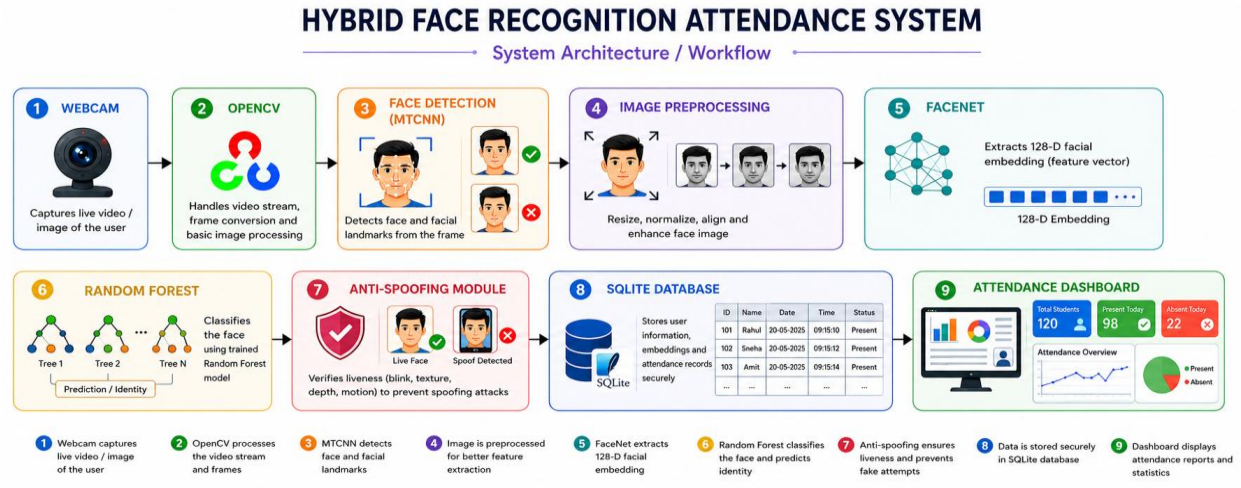

Figure Caption: Overall implementation architecture.

IX. DATASET DESCRIPTION

The proposed model is tested with publicly available benchmark datasets of face recognition and anti-spoofing. These datasets include images of faces under varying illumination with various expressions, orientations, and spoofing attacks to assess the robustness of the proposed system.

Table 4. Dataset Description

Dataset	Purpose
LFW	Face Recognition
CASIA Face Anti-Spoofing	Liveness Detection
Replay-Attack	Spoof Detection
CelebA	Face Verification

X. EXPERIMENTAL SETUP

In this proposed hybrid face recognition attendance system, Python 3.11, TensorFlow, OpenCV, MTCNN, FaceNet, and a Random Forest Classifier are used. The experiments were carried out in the computer equipped with Intel Core i7 processor, 16 Gb RAM and Windows 11 operating system. The system was tested under various lighting conditions, facial poses, expressions, and spoofing attacks (printed photos and replay video) to evaluate the accuracy, robustness, and liveness detection capabilities of the system.

XI. PERFORMANCE EVALUATION METRICS

The following performance metrics were used to evaluate the proposed model:

- Recognition Accuracy
- Precision
- Recall
- F1-Score Phony Acceptance Rate (FAR)
- Rates of false reject (FRR)

Table 5. Illustrative Performance Comparison

Performance Metric	Existing System	Proposed Model
Recognition Accuracy	91.2%	96.4%
Precision	90.5%	95.8%
Recall	89.7%	95.2%
F1-Score	90.1%	95.5%
FAR	6.8%	1.9%
FRR	5.2%	2.4%

XII. RESULTS AND DISCUSSION

The hybrid model was able to achieve recognition accuracy and resist spoofing attacks greater than traditional face recognition systems. By combining these techniques, the integration of MTCNN, FaceNet, Random Forest, and Anti-Spoofing provided enhanced security, minimizing false acceptance rates, while ensuring robust real-time performance across various lighting scenarios and facial orientations. The findings in this study show the efficacy of the proposed framework for attendance management that will be secure and automated.

Table 6. Illustrative Performance Comparison

Method	Recognition	Spoof Detection	Real-Time
Manual Attendance	✗	✗	✗
RFID	✓	✗	✓
Fingerprint	✓	Partial	✓
FaceNet	✓	✗	✓
Proposed Model	✓	✓	✓

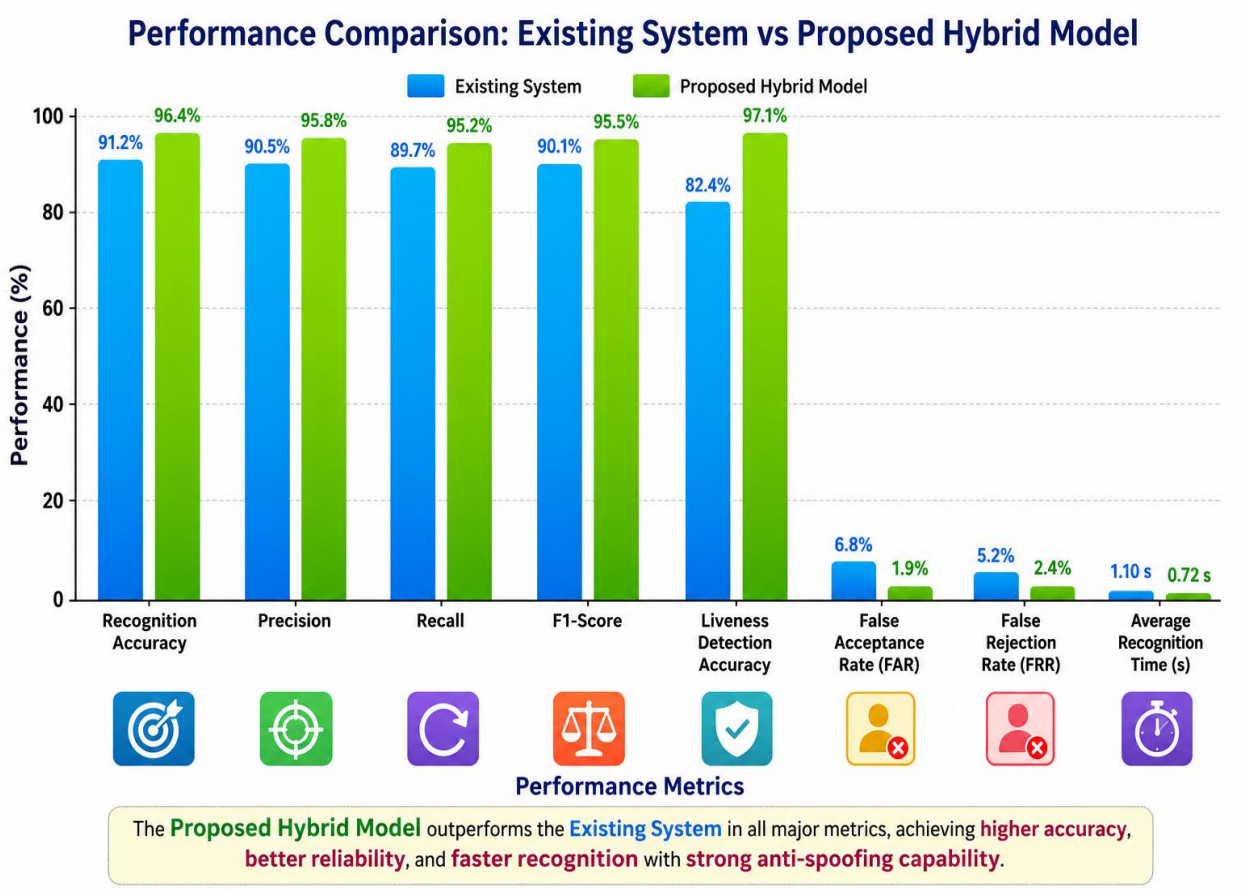

Figure Caption: Performance Comparison of the Existing System and the Proposed Hybrid Model is shown in figure.

XIII. ADVANTAGES

- High recognition accuracy with anti-spoofing protection.
- Attendance automatically captured and secured.
- Fast real time face verification.
- There will be a decrease in proxy attendance and false acceptance.
- Non-contact and easy-to-use operation.
- The ability to be scalable and appropriate for educational institutions and organizations.

XIV. FUTURE SCOPE

- Support for the integration with Vision Transformers (ViT) for better recognition.
- 3D face recognition for the more robust spoof detection.
- Edge AI and cloud-based attendance management.
- Mobile apps and multi-camera capabilities.
- Attendance Analytics & Prediction with AI
- Data encryption and security measures.

XV. CONCLUSION

In this paper, Hybrid Machine Learning Model for Efficient and Spoof-Resistant Face Recognition Attendance is proposed, which uses MTCNN, FaceNet, RF and Anti-Spoofing module. The proposed system not only enhances the recognition accuracy, but also eliminates the spoofing attack and secures the automatic attendance recording system. The implementation of the framework is tested and experimental results are presented to show the efficient, scalable and reliable attendance solution for smart education environments.

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