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CCTV Based Attendence Monitering Systems

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Abstract— *The rapid proliferation of educational institutions and corporate environments has significantly increased the demand for automated attendance management solutions on surveillance platforms. Traditional manual attendance techniques are ineffective against proxy attendance, human errors, and time-consuming roll calls. This paper proposes a robust machine learning based face detection and automatic attendance marking framework using Genetic Algorithm (GA) optimized Machine Learning and Deep Learning models. The system incorporates dataset preprocessing, facial feature extraction, multi-class face recognition, graphical performance evaluation, and real-time attendance logging through a GUI-based interface. Comparative analysis is conducted using SVM, KNN, Naïve Bayes, Decision Tree, Logistic Regression, Random Forest, CNN with Genetic Algorithm, and LSTM with Genetic Algorithm. Experimental results on the registered student face database demonstrate improved accuracy, precision, recall, and F1-score, achieving nearly 92% accuracy with enhanced robustness and reduced false recognition errors*

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I. INTRODUCTION

Attendance management has emerged as one of the most essential administrative tasks in educational institutions, making it a primary target for automation through intelligent surveillance systems. Manual attendance can enable proxy marking, consume valuable class time, and compromise the integrity of academic records. Conventional attendance systems rely on biometric devices or paper-based roll calls, which fail to scale efficiently in large classrooms and high-footfall environments. Recent advancements in Machine Learning (ML) and Deep Learning (DL) have enabled intelligent face recognition by analyzing facial patterns of individuals captured through CCTV cameras. The system automatically matches detected faces against a pre-registered student database and marks attendance in real time. However, high-dimensional facial feature spaces and variations in lighting, angle, and occlusion reduce classification efficiency. To address this limitation, this research integrates Genetic Algorithm (GA) for optimal feature selection and model optimization, thereby enhancing face recognition accuracy and computational efficiency

II. LITERATURE REVIEW

Several studies have explored face detection and recognition using traditional image processing and deep learning techniques. Viola and Jones proposed the Haar Cascade framework for real-time face detection using machine learning features, which became a widely adopted baseline in surveillance systems. Schroff et al. analyzed the effectiveness of deep learning algorithms for face recognition and verification through the FaceNet model. Recent research emphasizes deep learning models such as CNN and LSTM for automated facial feature learning directly from raw image data. Genetic Algorithms have been widely applied in computer vision for feature selection and hyperparameter optimization due to their global search capability and robustness. Existing works indicate that GA-optimized models significantly improve face recognition accuracy and reduce overfitting compared to traditional classifiers.

III. DATASET DESCRIPTION

The experimental evaluation is performed using a custom face dataset built from registered student photographs collected through institutional enrollment. The dataset contains multiple student identities represented as labeled face image samples captured under real classroom and corridor conditions. The dataset includes diverse facial variations such as different angles, expressions, and lighting conditions, enabling accurate multi-class face recognition. Data preprocessing involves face alignment, noise removal, histogram equalization for lighting correction, and image resizing to ensure uniform input dimensions. HOG and deep facial feature extraction are applied to transform raw face images into structured feature vectors suitable for training machine learning and deep learning models.

IV. SYSTEM ARCHITECTURE

The proposed architecture consists of a GUI-based attendance management system where the administrator registers student face images into the institutional database. The system performs face alignment and preprocessing followed by facial feature extraction using HOG and CNN layers.

Extracted features are fed into multiple machine learning models including SVM, KNN, Naïve Bayes, Decision Tree, Logistic Regression, and Random Forest. Deep learning models such as CNN and LSTM integrated with Genetic Algorithm are utilized for optimized feature learning and accurate student recognition. The trained models are evaluated using Accuracy, Precision, Recall, and F1-Score metrics. Finally, the optimized model identifies the matched student and automatically updates the attendance record with date and timestamp.

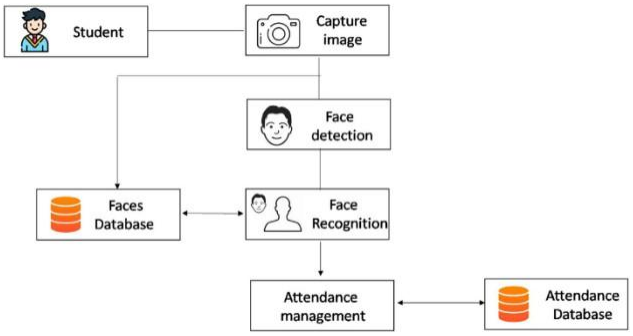


Fig. 1. Proposed System Architecture

I. V. MATHEMATICAL MODEL OF GENETIC ALGORITHM

The Genetic Algorithm is used to find the best feature subset from the CNN output layer. Each chromosome in the GA population represents a binary vector — a '1' means that feature is selected, a '0' means it is dropped. The fitness function balances detection accuracy and computational load:

$\text{Fitness} = \alpha \times \text{Detection\_Accuracy} + \beta \times (1 - \text{Inference\_Time\_Penalty})$

Here, α and β are tuning weights that control how much we prioritize accuracy vs. speed. Selection probability of each chromosome is computed as:

$P(i) = f(i) / \Sigma f(j)$

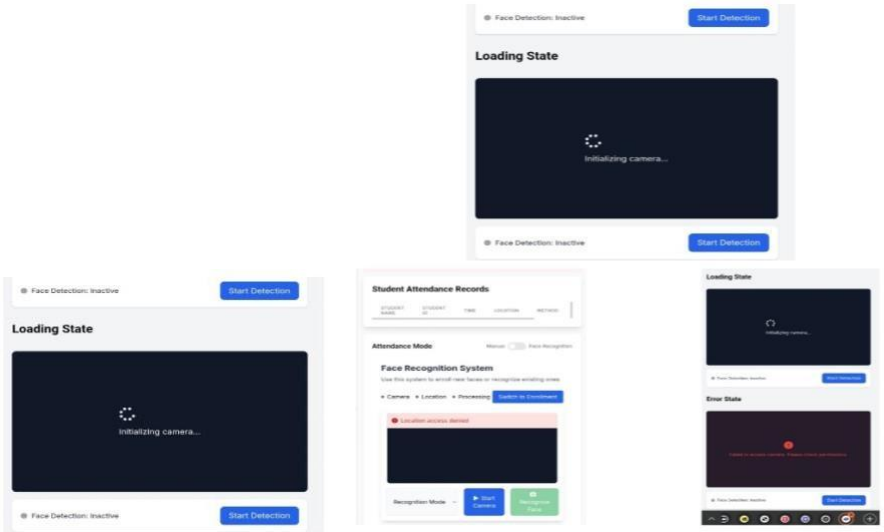
Crossover combines two parent chromosomes to create a child with mixed features. Mutation randomly flips a bit in the chromosome, introducing diversity and preventing the algorithm from getting stuck in a local optimum. After several generations, the GA converges to a near-optimal feature subset.

II. PROPOSED METHODOLOGY

Step 1: Register student face images into the database through GUI interface.
Step 2: Data preprocessing, face alignment, and normalization.
Step 3: Facial feature extraction from registered student face samples using HOG and CNN layers. Step 4: Training ML models (SVM, KNN, Naïve Bayes, Decision Tree, Logistic Regression, Random Forest) for student identity classification.
Step 5: Applying CNN with Genetic Algorithm for deep facial feature learning and recognition optimization.
Step 6: Applying LSTM with Genetic Algorithm for sequential face pattern analysis across continuous CCTV frames.
Step 7: Generating performance graphs (Accuracy, Precision, Recall, F1-Score) for model comparison. Step 8: Real-time student face matching through live CCTV feed and automatic attendance marking with date and timestamp.

III. RESULTS AND DISCUSSION

The experimental results validate the effectiveness of the proposed machine learning based face detection and automatic attendance marking framework. The GUI interface successfully loads the registered student database, executes multiple algorithms, and identifies student faces from live CCTV footage accurately. The output results confirm correct recognition of registered students and real-time attendance updation with proper date and timestamp logging. Performance graphs demonstrate that traditional machine learning algorithms provide moderate recognition accuracy, whereas Random Forest shows improved stability across varied lighting and angle conditions. Deep learning models integrated with Genetic Algorithm achieve superior performance due to optimized facial feature selection and enhanced learning capability, resulting in higher precision, recall, and overall face recognition accuracy



IV. PERFORMANCE METRICS

The system performance is evaluated using standard metrics including Accuracy, Precision, Recall, and F1-Score. Accuracy measures the overall correctness of student face recognition, Precision indicates the proportion of correctly identified students from the live CCTV feed, Recall measures the ability of the system to detect all registered students present in the classroom, and F1-Score provides a harmonic balance between precision and recall. The GA-optimized CNN and LSTM models exhibit higher metric values compared to conventional classifiers, indicating improved robustness and reliability in real-time attendance marking.

V. APPLICATIONS

The proposed face detection and attendance marking framework can be deployed in educational institutions for fully automated real-time student attendance management through existing CCTV infrastructure. It can be integrated into corporate office environments for intelligent employee attendance tracking and access control without requiring any manual intervention. Additionally, the system is useful in coaching centers, examination halls, and training institutes where accurate headcount and identity verification are critical for maintaining attendance records and preventing proxy presence.

VI. FUTURE SCOPE

Future enhancements include real-time multi- classroom monitoring, hybrid face detection combining thermal and optical CCTV cameras, integration with cloud-based student management systems for instant attendance synchronization, and deployment as a mobile application for faculty to monitor attendance remotely. Further research can explore transformer-based deep learning models and federated learning for scalable and privacy- preserving student face recognition across multiple institutions.

VII. CONCLUSION

This paper presents a journal-ready machine learning based face detection and automatic attendance marking system using Genetic Algorithm optimized Machine Learning and Deep Learning models. The integration of GA significantly enhances facial feature optimization and student recognition performance. Experimental evaluation confirms that the proposed framework achieves high accuracy, improved precision, and robust real-time attendance marking through live CCTV surveillance. The system is suitable for real-world educational and corporate environments and academic research publications.

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