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Facial Recognition based Smart Attendance System

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Abstract - In today's digital era, face recognition technology plays a crucial role in security, authentication, and identification, despite its lower accuracy compared to other biometrics. It presents a promising solution for attendance tracking in educational institutions and workplaces, addressing the inefficiencies of manual processes prone to proxy attendance issues. This research aims to develop a class attendance system leveraging face recognition technology. The proposed system involves database creation, face detection, recognition, and attendance updating using RetinaFace-10GF and ResNet50 models. Through real-time monitoring, attendance records are automatically compiled and accessible to faculty, offering a streamlined and automated solution that enhances accuracy and addresses the shortcomings of traditional attendance tracking methods. By integrating advanced technology with the urgent need for efficient attendance management, this research seeks to contribute to the optimization of attendance processes in various organizational settings.

Key Words: Machine Learning, Computer Vision, Face detection, Face recognition, Feature matching, Automated attendance system.

1.INTRODUCTION

In today's educational landscape, the process of manually marking attendance remains a tedious and time-consuming task for faculty members. This traditional approach not only consumes valuable class time but also introduces the possibility of errors such as proxy attendance. In response to these challenges, educational institutions have explored alternative attendance recording techniques, including Radio Frequency Identification (RFID), iris recognition, and fingerprint scanning. However, these methods often suffer from inefficiencies related to queuing and intrusive procedures.

Face recognition technology emerges as a promising solution to address the shortcomings of traditional attendance tracking methods. Unlike other biometric methods, such as iris or fingerprint recognition, face recognition offers a non-invasive and easily accessible means of identification. Moreover, it is less affected by variations in facial expressions and can efficiently perform both verification and identification tasks.

This research endeavours to harness the potential of face recognition technology to develop a smart attendance system tailored for educational environments. The proposed system aims to detect student faces from live classroom video streams, thereby streamlining the attendance tracking process and minimizing the likelihood of errors associated with manual methods. By leveraging advancements in face recognition technology and machine learning algorithms, this innovative approach seeks to enhance accuracy, efficiency, and overall classroom management.

With the increasing popularity and accessibility of face recognition technology, this paper proposes a comprehensive solution to address the evolving needs of attendance management in educational institutions. By integrating cutting-edge technology with pedagogical practices, the aim is to create a seamless and user-friendly attendance tracking system that optimizes class time and promotes academic accountability. Through this research, we seek to contribute to the ongoing discourse on leveraging technology to enhance teaching and learning experiences in the digital age.

2. LITERATURE REVIEW

The evolution of face recognition systems is evident in recent research endeavors, aiming to overcome the limitations of traditional methods that require controlled conditions. Geng underscores the necessity for face recognition under uncontrolled conditions, emphasizing the need for systems capable of operating in real-time without stringent environmental constraints. While such systems offer promise, drawbacks like single-person image input hinder their applicability in scenarios requiring rapid, multi-person detection, such as attendance systems.

Winarno introduces an anti-cheating presence system using 3WPCA-Dual Vision Face Recognition, showcasing its effectiveness with a 98% recognition rate. Leveraging stereo vision cameras and the 3WPCA method, this system enhances cheating detection in facial recognition applications, promising greater integrity in attendance monitoring and other security-sensitive contexts.

In response to the shortcomings of traditional attendance methods, recent advancements in picture-based attendance systems have emerged. These systems, as described by various authors, aim to streamline attendance tracking by capturing multiple student faces swiftly. However, ensuring continuous registration remains crucial to achieving high accuracy rates, especially in dynamic classroom environments.

Furthermore, the integration of mobile presence systems with facial recognition and NFC safety features presents a promising solution to the challenges posed by traditional attendance methods. By minimizing human errors and enhancing efficiency, these integrated systems offer a viable alternative for attendance management in educational settings.

The studies conducted by Lukas and Polamarasetty delve into the technical aspects of facial recognition, exploring techniques like DWT, DCT, and RFID integration. By combining these methodologies with advanced algorithms and hardware capabilities, researchers aim to develop robust attendance systems capable of operating seamlessly in diverse environments while ensuring accurate record-keeping and access control.

In recent years, advancements in deep learning algorithms have revolutionized the field of facial recognition. The InsightFace API, RetinaFace, and ResNet-based systems represent notable contributions in this domain. The InsightFace API, developed by Deng et al., offers state-of-the-art face recognition capabilities with high accuracy and efficiency. Its versatile architecture allows for seamless integration into various applications, including attendance systems. Similarly, RetinaFace, a face detection model developed by Deng et al., excels in detecting faces with high precision, even in challenging conditions such as occlusions and variations in pose and illumination. Furthermore, ResNet-based models have demonstrated remarkable performance in face recognition tasks, leveraging deep residual networks to extract discriminative features from facial images. By harnessing the capabilities of these advanced models, researchers aim to enhance the accuracy and reliability of attendance systems, enabling seamless integration into educational environments while minimizing administrative burdens.

3. PROPOSED SYSTEM

3.1 Underlying Machine Learning Models

The stated version of Smart Attendance System is based on the Fast Face Recognition model which is based on InsightFace API and its pretrained models powered by RetinaFace-10GF and ResNet50 models for facial detection and facial recognition respectively.

- RetinaFace-10GF: A powerful face detection model known for its accuracy and efficiency, capable of detecting faces with various poses, scales, and occlusions.

- ResNet50: A deep convolutional neural network renowned for its superior performance in image classification tasks, consisting of 50 layers and employing residual learning to address the vanishing gradient problem.

3.2 Search Algorithms

The following measures have been used for distance and similarity in the above machine learning search algorithms:

- ❖ Distance
  - Euclidean distance
  - Manhattan distance

The above measures are insensitive to outliers and high-dimensional data.

- ❖ Similarity
  - Cosine similarity

Cosine similarity is used to due to its immunity to high-dimensional data.

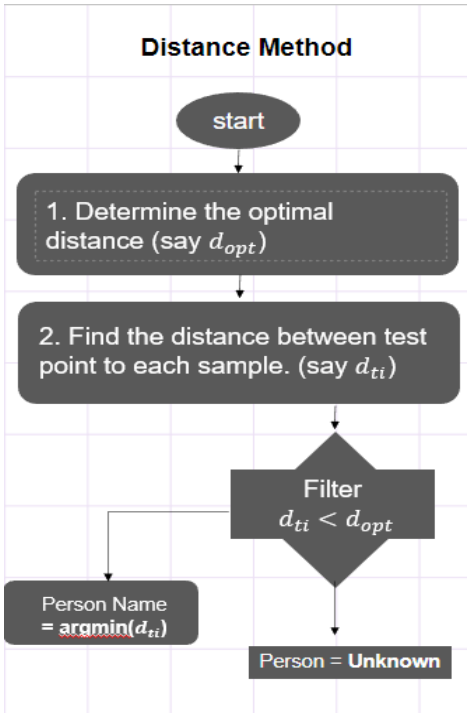

Fig 1: Distance method for face recognition.

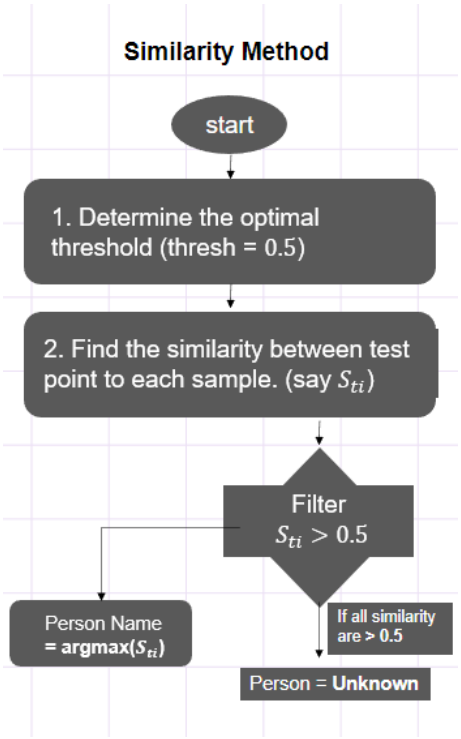

Fig 2: Similarity method for face recognition.

3.3 Dataset Creation

Capturing the dataset forms the foundational step in developing a facial recognition-based attendance system. This involves using a webcam to gather images of students. To ensure robust recognition capabilities, multiple images of each student are acquired, encompassing various facial expressions and angles. These images undergo preprocessing, which includes cropping to isolate the Region of Interest (ROI), resizing to standardized pixel dimensions, and conversion from RGB to grayscale format and conversion to an image vector which is then stored in the Redis database in folder of the user's name.

3.4 Face Detection

The system employs the Fast Face Recognition model in conjunction with OpenCV for face detection. Before use, the pre-trained classifier is used to recognize human faces effectively. The detection process involves utilizing the InsightFace API which leverages the Euclidean distance and Cosine Similarity search algorithms generating rectangles around detected faces within an image. Fine-tuning parameters buffalo_l, buffalo_m and buffalo_s optimizes the algorithm's performance for accurate face detection.

3.5 Face Recognition

Upon successful face detection, the system proceeds to face recognition. This process is divided into several steps. Initially, the dataset images are pre-processed to assign integer labels corresponding to each student's identity. Subsequently, a face recognizer employing the ResNet-50 technique is utilized. During training, image vectors are computed for each image, facilitating comparison during the recognition phase. Upon recognition, the system identifies the best-matched label associated with the recognized face, determining the corresponding student's identity.

3.6 Attendance Updation

Following face recognition, the system updates attendance records. Recognized faces are marked as present in the Redis database and an excel sheet, while absentees are listed. A detailed report of absentees is then accessible to the respective faculty members via the Streamlit WebApp. Additionally, monthly attendance sheets are provided to faculties for comprehensive record-keeping and analysis.

3.7 Clustering Method of Recommendation Systems

In addition to the core functionalities, the proposed methodology integrates a clustering method for recommendation systems, enhancing the system's versatility and utility. This entails a multi-step approach involving data collection and annotation, preprocessing, feature extraction, machine learning model development, Redis database integration, search algorithms, real-time monitoring and alerting, customization, user interface design, security and data protection measures, real-world testing and validation, and ongoing maintenance and optimization strategies. Each step contributes to the system's robustness, adaptability, and reliability in diverse educational and corporate environments.

4. SYSTEM ARCHITECTURE

The proposed Attendance System with Face Recognition, incorporating Redis database, OpenCV, machine learning, and search algorithms in Python, presents a transformative solution with numerous advantages across diverse domains. Notable benefits include enhanced accuracy through facial recognition, automation for increased efficiency, heightened security against unauthorized access, and robust data integrity provided by the Redis database. The system's customization, user-friendly interface, and reporting features make it adaptable to the unique needs of educational institutions, corporate

offices, and various businesses. Its scalability and potential for cost savings underscore its practicality for both small and large entities. The system's versatile use cases span educational institutions, corporate offices, healthcare facilities, government institutions, retail outlets, transportation, hospitality, and beyond.

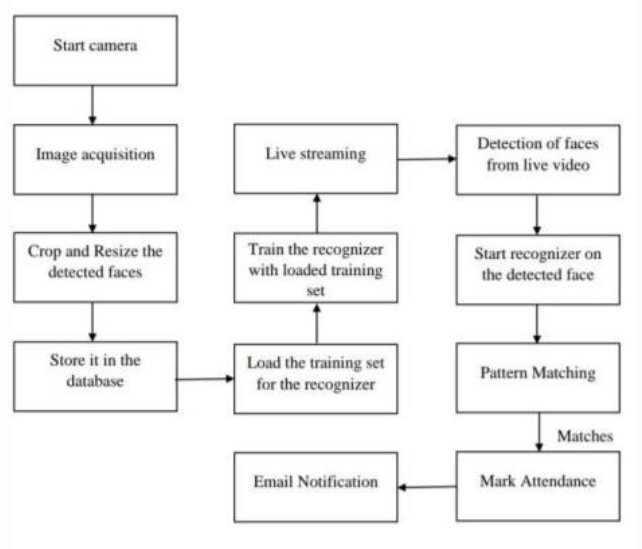

Fig 3: Smart Attendance System Flow Diagram

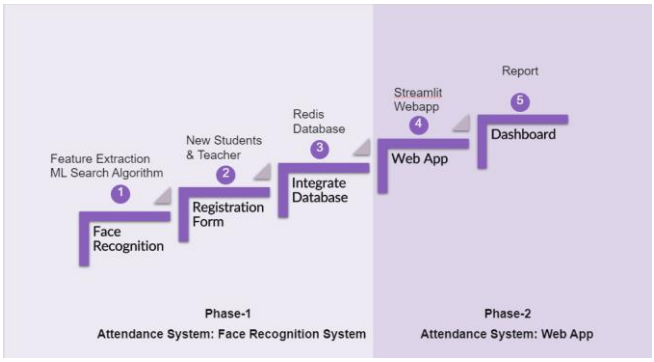

Fig 4: System Architecture

5. RESULTS AND DISCUSSION

The project's results showcase a user-friendly Graphical User Interface (GUI) that facilitates interaction with the system, offering three main options: student registration, faculty registration, and attendance marking. During student registration, users input necessary details into the provided form and click the register button, initiating the webcam to automatically capture images of faces. The system continues to collect photos until 60 samples are obtained or CTRL+Q is pressed, after which the images undergo preprocessing and are stored in the training images folder. Faculty members register with their respective course codes and email addresses, crucial for receiving absentee lists via email.

In each session, faculty enter their course code, triggering the camera to begin detection. The face recognition window displays recognized students, indicating 'unknown' for unregistered individuals. Pressing CTRL+Q updates attendance in the Excel sheet and emails absentee names to faculty members, ensuring efficient record-keeping and communication.

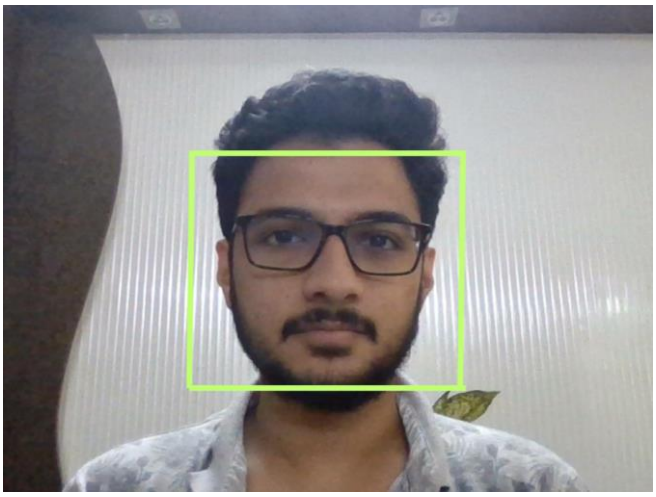

Fig 5: Bounding box for face detection.

The FastFace Recognition model flexes various benefits over the traditional attendance techniques. It requires lesser sample images of a person to train the model compared to the standard 100 to 200 images that the traditional systems would need. No model retrain is needed to introduce a new person into the system. The accuracy of the model is not affected by the addition of new people into the attendance system. Moreover, processing is faster and more efficient due to cache-based retrieval enabled by the Redis database.

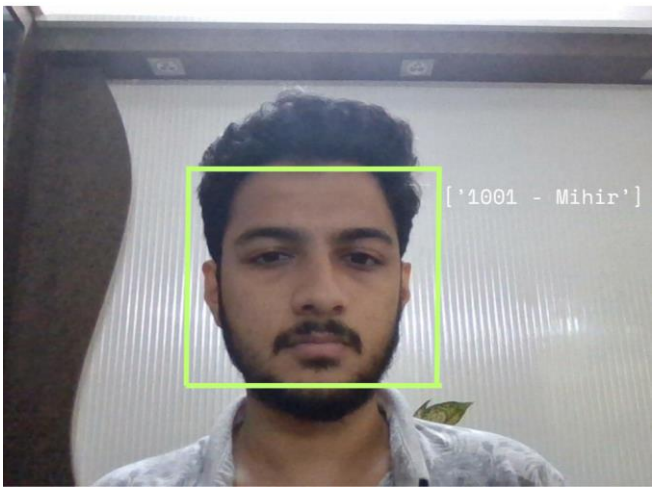

Fig 6: Face recognized.

We can see with what level of accuracy we have managed to bring to this model with the following comparative table of accuracy for different search algorithms.

Table 1: Comparison of Search Algorithms

Search Algorithm	Key Differences	Accuracy Rate
Manhattan Distance	Sum of absolute differences between corresponding coordinates	85%
Chebyshev Distance	Maximum absolute difference between corresponding coordinates	80%
Minkowski Distance	Generalization of both Manhattan and Chebyshev distances	82%
Cosine Similarity	Cosine similarity is a measure of the angle between the two non-zero vectors. Often used for high-dimensional data like facial features. Closer to 1 means more similarity.	92%

5. CONCLUSION

In conclusion, the employed method utilizing OpenCV, InsightFace and Cosine similarity for frame extraction, face recognition and face recognition to demonstrate optimal outcomes. This approach ensures superior accuracy in identifying multiple faces within a single frame while maintaining minimal response time. The primary objective of this system is to establish a robust class attendance system through the integration of facial recognition techniques. By leveraging facial IDs, the proposed system efficiently captures attendance data. Through webcam detection and facial recognition processes, it accurately identifies individuals and records their attendance. Moving forward, this system holds promise for enhancing attendance management processes with its seamless integration of facial recognition technology.

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