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SMART ATTENDENCE SYSTEM USING BIOMETRIC AUTHENTICATION BASED ON REAL-TIME FACE RECOGNITION.

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Abstract: **The human face stands as a pivotal aspect of identification, uniquely distinguishing individuals. Leveraging facial characteristics as biometric data, a face recognition system can be deployed. Attendance marking remains a pivotal yet demanding task within organizational frameworks. Traditional methods prove cumbersome and intricate. This paper presents an approach utilizing the Open-Source Computer Vision Library (OpenCV) for face recognition. Integrated with a camera, the model captures input images, encodes and identifies faces, and marks attendance within spreadsheets. Haar Cascade Feature extraction algorithms facilitate feature extraction, while face recognition employs CNN deep learning algorithms. Incorporating cutting-edge technology, this system streamlines attendance tracking processes, enhancing efficiency and accuracy. Embracing the complexities of facial recognition, it offers a seamless solution for organizational needs. We use the concepts of artificial intelligence to monitor student attendance like capturing the motion pictures of the student when present in class to analyze the student data how much time student present in the class.**

Index Terms **- Face recognition, Biometric authentication, OpenCV, Attendance marking, Haar Cascade, CNN deep learning.**

I. INTRODUCTION

The field of biometrics revolves around identifying individuals based on their unique physical or behavioral traits. These traits encompass a range of characteristics, including movements, signatures, keyboard dynamics, fingerprints, faces, hands, iris patterns, and hand geometry. In a typical biometric system, specialized sensors capture these traits, and identity verification occurs by comparing this data to stored information in a database. The human face holds significant importance as a primary means of identification and communication worldwide. Its distinct features make facial recognition feasible in practical applications. While humans easily distinguish individuals based on facial characteristics such as color, nose shape, eye structure, and ears, computers face challenges in analyzing such data. Thus, computer vision technology becomes instrumental in recognizing human features accurately.

In recent years, face recognition techniques have undergone significant advancements due to the availability of various biometric methods. However, implementing face recognition systems on a large scale poses challenges. Variations in facial expressions, lighting conditions, facial styles, image resolutions, sensor devices, and viewing distances add complexity to system implementation. Multiple algorithms have been developed for face recognition, each with its strengths and capabilities. Currently, two primary approaches dominate face recognition methods. The first relies on local facial features, such as eyes, nose, and color, for identification. The second approach utilizes the entire face for recognition, offering a more comprehensive approach to identity verification. Deep learning, a subset of machine learning, utilizes deep neural networks to extract intricate representations from data. These networks, comprising multiple layers, have revolutionized various fields, including computer vision and natural language processing. In face recognition, deep learning algorithms analyze facial features across multiple layers, allowing for highly accurate identification. By leveraging representation learning, deep learning models can discern complex patterns in facial data, enabling robust recognition even in challenging conditions.

II. PROBLEM STATEMENT AND OBJECTIVE

Problem Statement

Manual attendance systems are plagued by buddy-punching and time-theft. Since the data is entered manually, it can easily be manipulated. The employee may provide inaccurate information for extra income, resulting in less productivity and increased costs. In traditional classroom environment, students' attendance management is one of the key factors to analyze the students' learning process and also to keep track of other factors like discipline, engagement and leads to effective learning and increase the success

rate. There are several works in attendance management system to overcome the difficulties faced in a traditional classroom environment by using finger print, RFID, iris, wireless and face recognition-based methods. Also, there are many face detection-based attendance management systems available in which they place a camera in a classroom, capture the image/video, recognize the students using face detection techniques.

Objectives

The main aim of this paper is to make automatic attendance system using camera. In this proposed system, the manual errors will be avoided. We can save the teaching time and we can avoid the waiting time of students. Finally, it will provide the accurate attendance for the students.

- To reduce attendance taking time
- To avoid intervention of learning process.
- To reduce the manual errors.

III. LITERATURE REVIEW

In 2023, Abhishek Kumar Singh, Sumit Kumar, Bhavesh Kumar, Dr. Alok Singh Chauhan [1] proposed "Face Recognition Using Machine Learning". This paper outlines the typical process of face recognition: data collection, preprocessing, feature extraction, and model training, comparing traditional methods like Eigenfaces and LBP with modern deep learning approaches such as CNNs and GANs. Variations in illumination, pose, occlusions, and expressions are some of the challenges in face recognition. The paper highlights advancements like deep learning models, cross-domain models, and 3D face recognition.

In 2023, Sindura Rajendra Dasi, Ekta Shantaram Gujar, Abdul Samad M I Ansari, Prof. Yaminee Patil [2] proposed, "Real-time Attendance Monitoring System using Machine Learning and Blockchain". This paper studies the development of a real-time attendance monitoring system using facial recognition integrated with blockchain technology. Facial recognition using OpenCV and the Haar cascade algorithm provides accurate detection and identification of students, addressing inefficiencies and inaccuracies in traditional attendance methods. The system uses blockchain for secure, immutable storage of attendance data, enhancing transparency and reducing the risk of manipulation. The integration of these technologies aims to create an automated, reliable, and tamper-proof attendance monitoring system.

In 2022, Lamis Ghoualmi, Mohamed El Amine Benkechkache [3] proposed "Feature Selection Based on Machine Learning Algorithms: A Weighted Score Feature Importance Approach for Facial Authentication". This paper explores advancements in facial biometric authentication through a novel feature selection method leveraging machine learning and genetic algorithms (GA). It reviews various machine learning techniques for the future importance, including mutual information, random forest, decision tree, chi-square, low variance, and support vector machine, highlighting their roles in enhancing facial recognition accuracy. This paper outlines the typical process of face recognition: data collection, preprocessing, feature extraction, and model training, comparing traditional methods like Eigenfaces and LBP with modern deep learning approaches such as CNNs and GANs. The proposed method, combining machine learning-based feature importance scores using a genetic algorithm, shows improved accuracy (from 93.5% to 95.62%) and reduced feature size (from 4096 to 964).

In 2021, Sahajpreet Singh, Sai Chandra Kumar C, Saksham Garg, Yash Giri, Manoj Kumar [4] proposed, "Efficient Face Identification and Authentication Tool for Biometric Attendance System". This paper highlights face identification for a attendance system which is mainly focuses on LBPH algorithm. LBPH (Local Binary Pattern Histogram) is popular method used in computer vision for face recognition. It includes LBP calculations, Divide image into cells, Histogram concentration, Feature Vector Construction, and Comparison using histogram Distance. It concludes digitization of educational and industrial organization towards biometric attendance system in upcoming years. So that chances human error, false attendance, complication in retrieving the data, etc. will be decreases.

In 2020, Ankur Sikarwar, Himachal Chandra, Indradeo Ram [5] proposed, "Real-time Biometric Verification and Management System Using Face Embeddings". The paper discusses an advanced biometric verification system using face recognition technology. They propose an end-to-end pipeline utilizing deep learning models—Zero-DCE for low-light image enhancement, MTCNN for face detection, and FaceNet for face recognition—aimed at achieving near real-time performance and high accuracy. The system's key features include biometric verification, attendance management, and user registration and deletion, with a user-friendly interface developed using Kivy. Testing on the Faces94 and Grimace datasets from the University of Essex demonstrates the system's robustness, achieving an overall accuracy of 96.76%, surpassing existing methods.

IV. METHODOLOGY

- **HARR Cascade Face Detection:**

Haar Cascade is a machine learning object detection algorithm used to identify objects in an image or video and based on the concept of features proposed by Paul Viola and Michael Jones in their paper "Rapid Object Detection using a Boosted Cascade of Simple Features" in 2001.It is a machine learning based approach where a cascade function is trained from a lot of positive and negative images. It is then used to detect objects in other images.

The algorithm has four stages:

1. Haar Feature Selection
2. Creating Integral Images

3. Adaboost Training
4. Cascading Classifiers

It is well known for being able to detect faces and body parts in an image, but can be trained to identify almost any object.

Fig 1,2: Examples of HARR Cascade algorithm

❖ **CNN Classification**

CNN model at present, the typical architecture of neural network is divided into the following categories: LeNet5, AlexNet, ZF Net, GooLeNet, and VGGNet, the following will LeNet5 architecture for a detailed analysis. LeNet5 is a CNN classic structure that existed long ago, and it is mainly used in the recognition of handwritten fonts. It contains a total of seven layers of structure, except for the input layer, each of the other has training parameters, and each layer contains a plurality of Feature Maps, we can extract the input features through a convolution kernel.

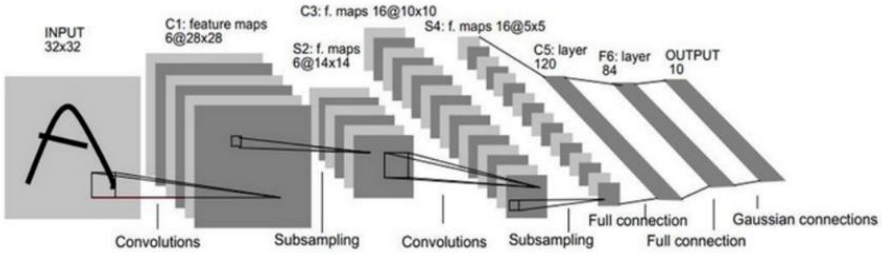

Fig 3: CNN Architecture (LeNet5)

System Architecture:

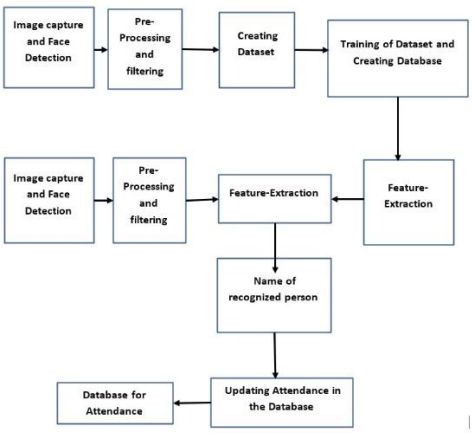

Fig 4: System Architecture

Systems design is the process of defining the architecture, components, modules, interfaces, and data for a system to satisfy specified requirements. design is one of the most important phases of software development process. The purpose of the design is to plan the solution of a problem specified by the requirement documentation. The design of the system is perhaps the most critical factor affecting the quality of the software. We present an AI based attendance detection system It contains two phases First Training phase. In this phase students' images will be captured and detected face using Haar features. then converted to gray in preprocessing and stored in dataset folder, System use the dataset images to train the model using CNN algorithm and saved the training model. In the second phase students' images will be captured in real time and detected face using Haar features. then converted to gray in preprocessing, then system loads the CNN algorithm to recognize. If registered students are available in the current frame mark as present else absent. Save the generated attendance in the system.

Sequence, Class, and Use case diagrams:

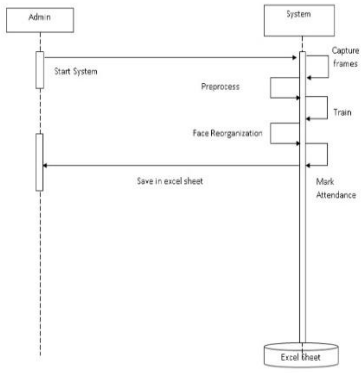

Fig 5: Sequence Diagram

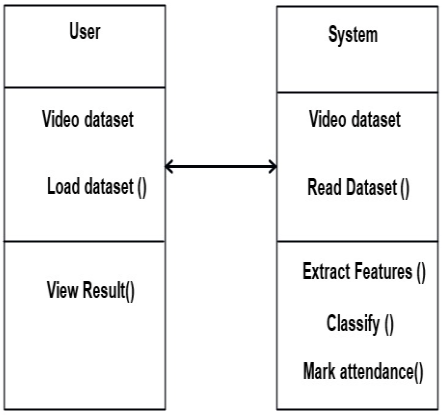

Fig 6: Class Diagram

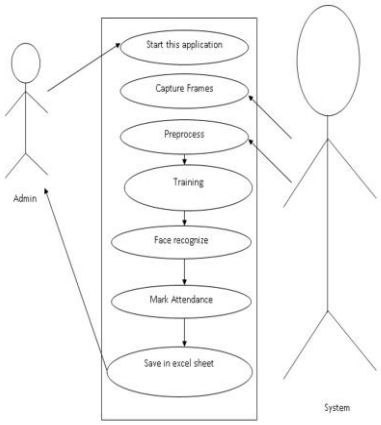

Fig 7: Use Case Diagram

In software engineering, the Unified Modeling Language (UML) provides several diagram types to describe different aspects of a system. A class diagram is a type of static structure diagram that illustrates the system's structure by showing the system's classes, their attributes, operations (or methods), and the relationships among the classes, thereby indicating which class contains specific information. A sequence diagram, another UML construct, is an interaction diagram that shows how processes operate with one another and in what order, detailing the interactions as a Message Sequence Chart. These diagrams are also known as event diagrams, event scenarios, or timing diagrams. Additionally, a use case diagram is a type of behavioral diagram created from use-case analysis, designed to present a graphical overview of the system's functionality in terms of actors, their goals (represented as use cases), and any dependencies between those use cases. The primary purpose of a use case diagram is to show which system functions are performed for which actor, clearly depicting the roles of the actors within the system.

V. IMPLIMENTATION

We are implementing using following modules.

1) **Image Capturing:** Proposed System of a rotating HD camera, placed in the classroom to capture all the students. From these captured image frames, the students' faces are detected using OpenCV face detection technique.

2) Training Phase: The number of students detected depends on the seating arrangement of the students in the classroom. Fig1 contains frontal and occlude faces and Fig2 contains frontal, tilted and occlude faces. The proposed face detection technique can detect all faces presents in Fig1 and Fig-2 with the rate of 100% accuracy. From detected faces, we identified the students using face recognition algorithm, for Frame-1 the correctness of true identification rate is 100% while for Frame-2 it is 90%. The accuracy of student recognition can be improved by using more images of each student in the training phase.

Fig 8,9: Training data

3) Face Recognition: We proposed face detection technique by incorporating Haar cascade classifier and CNN techniques. This technique does not play out any sub-sampling, but it optimizes over all sub-windows. This method is much accurate to detect all varied faces positioned frontal, tilted up/right/left/down and occluded faces with 99.69% accuracy. Following figure shows some samples of detected face using proposed method.

Fig 10: Sample of detected face in different pose

4) **Experimental Setup:** In this experiment we used OpenCV using Cascade model, the hardware platform is 64-bit operating system and Linux 16.4, processor 2.5 GHz, Memory 8 GB and 16 MP HD. The setup was tested in a real classroom that contains 20 students with all variation of poses. We tested the proposed face detection method and existing face detection techniques using the benchmark dataset (FDDB). This dataset contains images of human faces in multiple poses. Out of 3500 of FDDB images, Haar Cascade Classifiers technique detects the face with an accuracy of 94.71%.

VI. CONCLUSION

The Smart Attendance System using Biometric Authentication based on Real-time Face Recognition offers an efficient solution to attendance management, overcoming the limitations of traditional methods. Leveraging facial recognition technology and deep learning algorithms, the system ensures accurate identification of individuals, minimizing errors and manipulation. By integrating OpenCV and Haar Cascade Feature extraction algorithms, it achieves robust performance in detecting facial features under various conditions. With rotating HD cameras for image capturing and a training phase for face recognition, the system provides real-time attendance marking with high accuracy. Overall, it offers a reliable, user-friendly solution for attendance tracking, enhancing productivity and accountability in educational and organizational settings.

VII. REFERENCES

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