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Review JoOSD

Facial Biometrics Driven Attendance Automation Solution Using LBPH Algorithm

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Abstract

In today's educational landscape, managing attendance remains a central administrative task, often conducted manually on paper, consuming valuable time for educators. This project proposes a solution utilizing facial recognition technology to streamline the attendance process, thereby saving time and maintaining accurate student records. The objective is to develop an automated attendance system that is minimally intrusive, cost-effective, and highly efficient, leveraging computer vision techniques and algorithms like local binary patterns (LBP) implemented in Python. OpenCV libraries offer comprehensive functionality for operations such as face detection, training, and testing, facilitating seamless integration into the system. The process involves two key components: face detection and face recognition. Initially, face detection identifies and captures the facial features of students, storing this data in a dataset. Subsequently, during attendance sessions, the system compares captured images with those in the dataset. Upon a match, attendance is automatically recorded, associating the student's presence with the date and time in a CSV file. By harnessing the power of facial recognition technology and advanced algorithms, this project aims to revolutionize attendance management in educational institutions, offering a faster, more accurate, and convenient alternative to traditional methods.

Keywords: Local binary pattern (LBP), OpenCV (open-source computer vision library), CSV (comma-separated values), Python, attendance automation

INTRODUCTION

In the contemporary age of automation, significant strides in science and technology have revolutionized labor efficiency and accuracy, enhancing the overall quality of life. Among these advancements, the automated attendance system stands out as a pivotal innovation in the realm of automation, supplanting traditional attendance tracking methods.

Automated attendance systems typically utilize biometric, smart card, or web-based technologies and are extensively employed across various organizational settings. Traditional methods of attendance marking, notorious for their time-consuming nature, tend to become increasingly intricate with larger group sizes. In contrast, automated systems offer notable advantages, including time savings and enhanced security measures, effectively curbing instances of fraudulent attendance done by any unknown person.

An attendance management system, leveraging biometric features such as facial recognition, typically encompasses stages such as image acquisition, database development, face detection, pre-processing, feature extraction, and classification, culminating in post-processing procedures. This paper delves into a comprehensive

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literature review, detailed elucidation of each stage within the proposed model, analysis of findings, conclusive remarks, and avenues for future enhancements.

Attendance management and monitoring are crucial functions within any organization. A facial recognition–based automatic attendance system mimics the traditional attendance process but with minimal human intervention. Previous techniques often struggled with data storage and the detection of multiple faces or variations. The proposed system aims to address these shortcomings by incorporating features such as face detection, feature extraction, and detailed student data storage.

The system employs techniques like image contrast enhancement, integral images, color feature analysis, and cascading classifiers for robust feature detection. Leveraging features such as edge detection, color analysis, and local binary patterns (LBPs) ensure high accuracy. The project undergoes rigorous testing with a variety of test cases, assessing performance in different lighting conditions, facial expressions, backgrounds, and partial face scenarios.

While the system initially caters to one registered student at a time, it has the capacity to store details for multiple students. Testing encompasses varying light conditions, facial expressions, backgrounds, and partial face scenarios to ensure comprehensive functionality and accuracy.

LITERATURE REVIEW

In 2017, Okokpujie et al. [1] introduced a face recognition attendance system with GSM notification. This system employs the Viola-Jones algorithm to detect faces. Additionally, the Fisher faces algorithm is utilized to generate patterns from the identified faces, and these patterns are then transformed into templates that are stored in a database. The system utilizes the OpenCV library and a software development kit (SDK) to develop the graphical user interface.

In another study, D’Souza et al. [2] present an automated attendance marking and management system based on facial recognition. This innovative system automates the process of recording student attendance through camera capture within the classroom. Employing the histogram algorithm, the system facilitates face identification by converting facial images into matrix format. Histograms play a crucial role in accurately recognizing individual faces within the image. Consequently, this system effectively addresses the issue of time-consuming attendance management.

Nandhini et al. [3] presented an attendance system relying on face recognition technology in 2019. This system operates by capturing video footage of students, converting it into individual frames, and subsequently storing these frames in a database. The implementation utilizes the convolutional neural network (CNN) algorithm for face detection, enhancing both the accuracy and speed of the system's performance.

In 2019, Sawhney et al. [4] introduced a real-time smart attendance management system utilizing face recognition techniques. This system employs face detection and recognition methods utilizing CNN and principal component analysis (PCA). It incorporates two cameras: one positioned at the classroom entrance for face detection and recognition, and another inside the classroom to monitor proxy attendance.

Vardharajan et al. [5] presented an automatic attendance management system utilizing face recognition. This system utilizes the Eigenfaces and Eigenweight method for face detection. The camera captures images, and the system subsequently crops student faces, associating them with the student database.

In 2017, Poornima et al. [6] presented an attendance management system using facial recognition with audio output and gender classification. This system employs the Viola-Jones algorithm and PCA for face recognition. Additionally, it includes a gender classification module and a voice conversion module. Following face detection and recognition, the system utilizes the Microsoft Speech API (application programming interface) to announce the names of absent students, serving as a cross-check mechanism.

In 2018, Salim et al. [7] introduced a class attendance management system using face recognition. This system is built on Raspberry Pi, and it captures images by facing the camera. The face recognition process is implemented using the binary patterns algorithm LBPs. The Raspberry Pi is programmed to handle this face recognition functionality as part of the overall attendance management system.

In a scholarly work in 2018, Shrivastava et al. [8] unveiled an automated attendance system centered on face recognition and gender classification. This innovative system harnesses the power of the Haar-Cascade method, LBPH (local binary pattern histogram) algorithm, and an LDA (linear discriminant analysis) model to achieve its objectives.

In 2017, Katara et al. [9] presented an attendance system utilizing face recognition and class monitoring. This paper introduces the utilization of Raspberry Pi, an embedded computing device. OpenCV library is employed for both the facial recognition algorithm and class monitoring functionalities. The system integrates a webcam connected to the Raspberry Pi and a database linked to the device.

METHODOLOGY

Digital Image Processing

Digital image processing refers to manipulating digital images using computational techniques. Its applications are primarily driven by three main objectives:

1. Enhancing visual information for improved human perception.
2. Enabling image processing for autonomous machine systems.
3. Facilitating efficient storage and transmission of image data.

Steps in Digital Image Processing

1. *Image Acquisition*: Capturing images using sensors and converting their analog signals into digital form.
2. *Preprocessing*: Improving image quality through operations such as filtering and contrast enhancement.
3. *Segmentation*: Dividing images into meaningful regions or objects.
4. *Description/Feature Selection*: Extracting pertinent features from image objects for further computational analysis.
5. *Recognition and Interpretation*: Assigning labels to objects based on their descriptors, followed by deriving meaning from the labelled objects.
6. *Knowledge Base*: Employing stored knowledge to enhance processing efficiency and facilitate interaction between processing modules.

Face Detection

Face detection involves identifying and locating faces within images or videos, regardless of their position, size, orientation, age, or facial expression. It aims to operate independently of extraneous factors such as lighting conditions and image content. Many contemporary algorithms utilize the Viola-Jones object detection framework, which relies on Haar cascades for effective face detection.

Face Recognition

Face recognition addresses the challenge of identifying faces depicted in images despite variations in illumination, pose, and other factors. In advanced applications, the technology extends its capabilities to precisely determine the identity of the detected face, providing information about whose face it is.

Face recognition is essentially the process of recognizing a detected face and determining whether it is a known or unknown face. In more sophisticated scenarios, it goes a step further by accurately identifying and attributing the detected face to a specific individual.

Block Diagram of System

The proposed system is built on the foundation of face recognition. When a student comes in front of the camera module, their image is captured and subjected to recognition with validation. Upon successful recognition and validation, the system automatically marks the student's attendance. For interaction, users are provided with a login interface. If the login is successful, the system displays the home page. The overall structure of the automatic attendance system is illustrated in the block diagram shown in Figure 1. The components and functioning of the system are explained further in the system block diagram.

Capturing the Image

The camera, positioned at the classroom entrance, captures high-quality images of students' faces, initiating the face detection process.

Face Detection

The system employs face detection to identify and locate student faces within the captured images. The Haar cascade classifier is utilized to detect faces, providing information about their positions and sizes.

Image Preprocessing

To enhance image quality, preprocessing is performed. The input image undergoes grayscale conversion using a color-to-gray image conversion technique.

Training Set

Faces slated for recognition are compared with similar faces in a training set. This set serves as a reference for the algorithm, indicating which individual a recognized face belongs to. During recognition, the algorithm utilizes the training set.

Face Recognition

The core functionality lies in face recognition, an automatic process that identifies and verifies individuals based on images and videos from the camera.

Attendance Marker

Successful face recognition triggers the attendance marking process. If a recognized face corresponds to a face in the specific date folder, the associated student is marked as present. Conversely, students who are not recognized are marked as absent. This method effectively generates a list of present students for that class session.

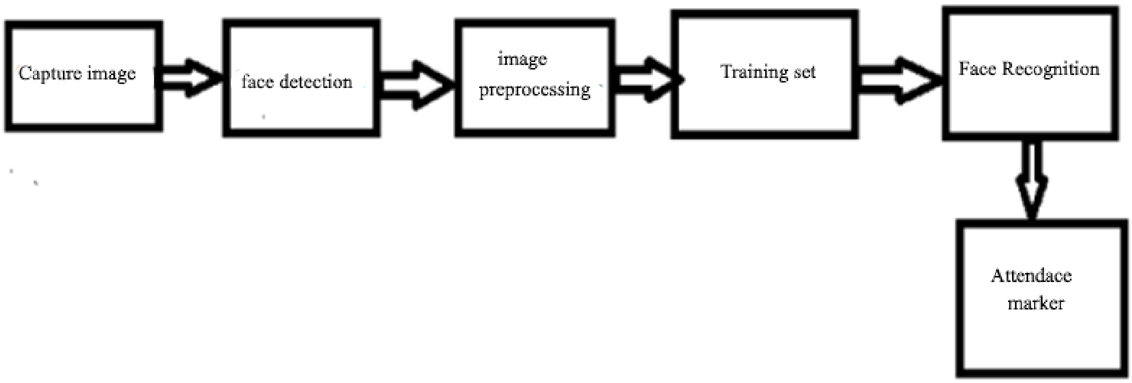

Figure 1. Proposed block diagram.

Face Detection Using Harr Cascade

Paul Viola and Michael Jones introduced an effective object detection method known as the Haar cascade classifier, which is based on machine learning. This method employs a cascade approach, where analysis is conducted on both positive and negative images. The resulting classifier is then utilized to detect objects in other images.

For effective face detection, the algorithm relies on a substantial dataset of positive and negative face images. Haar cascade features play a crucial role in this process, examining different aspects within the images. Each operation involves analyzing a 24 × 24 window of the image, calculating the difference between the sum of white region pixels and the sum of black region pixels. This computation results in an integer value, which is instrumental in determining the validation of the corresponding feature.

Face Recognition Using Local Binary Pattern Histogram

In this algorithm, when given an input image, a new histogram is generated, and it is compared with other generated histograms. The comparison aims to find the best match histogram, and the associated label of that histogram is returned. For face recognition using histograms, a 3 × 3 window moves across the image. At each position, the center pixel is compared with its neighboring pixels. A binary pattern is created where 1 denotes that the intensity value of the neighboring pixel is less than or equal to the center pixel, and 0 denotes otherwise. This process is repeated for the entire image, resulting in a list of local binary patterns corresponding to different areas of the image. For example, the pattern "11000011" is local to a specific region of the image. The recognition process generates a list of these local binary patterns for the entire image.

The LBPH algorithm operates in five steps:

Parameters

LBPH utilizes four parameters:

- *Radius:* Determines the radius around the central pixel to build the circular local binary pattern, typically set to 1.
- *Neighbors:* Specifies the number of sample points used to construct the circular local binary pattern. Increasing sample points results in higher computational costs, usually set to 8.
- *Grid X:* Defines the number of cells in the horizontal direction, influencing the granularity of the grid and the resulting feature vector's dimensionality, typically set to 8.
- *Grid Y:* Determines the number of cells in the vertical direction, influencing the grid's granularity and resulting in a higher-dimensional feature vector. Typically set to 8.

Training the Algorithm

Initially, the algorithm requires training. This involves utilizing a dataset containing facial images of individuals to be recognized. Each image is associated with an ID (such as a number or the person's name) for identification purposes. Images of the same individual should share the same ID. Once the training dataset is prepared, the LBPH computational process can be outlined [10].

Applying the LBP Operation

The first computational step of LBPH involves generating an intermediate image that effectively captures facial characteristics from the original image. This is achieved through a sliding window approach, guided by the specified radius and neighbor parameters. Figure 2 shows this procedure.

Histogram Extraction

Following the previous step, the generated image is divided into multiple grids using the Grid X and Grid Y parameters. Each grid serves as a basis for extracting histograms, as depicted in Figure 3.

Performing Face Recognition

At this stage, the algorithm has been trained. Each histogram corresponds to an image within the training dataset. When presented with a new input image, the algorithm repeats the previous steps to generate a histogram representing the image. Various methods exist to compare histograms, such as calculating the distance between two histograms using metrics like Euclidean distance, chi-square, or absolute value. For this instance, we opt for the Euclidean distance, a commonly used metric, formulated as:

$$D = \sqrt{\sum_{i=1}^{n}(hist1_i - hist2_i)^2}$$

System Order of Flow and Status

1. *Capture Image:* Capture the input image.
2. *Convert to Greyscale:* Convert the color image to greyscale.
3. *Face Detection:* Use Haar cascade classifier for face detection.
4. *Face Recognition:* Implement face recognition using local binary pattern histogram.
5. *Matching:* Match the detected face with trained ones.
6. *Check Student:* If the student is recognized.
7. *Attendance Marking:* If recognized, mark attendance as "PRESENT" in the datasheet.
8. *Absent Marking:* If not recognized, mark attendance as "ABSENT" in the datasheet.
9. *Generate Report:* Generate a report.
10. *Update Attendance:* Update the attendance records.

RESULTS

Face recognition technology has been employed to develop an attendance tracking system, particularly in a classroom setting. When consistent conditions such as lighting, face distance, and facial expression are maintained during image acquisition, the accuracy of face recognition reaches approximately 95%. Feedback from students indicates satisfaction with the functionality and efficiency of the system as shown in Figures 4 to 8.

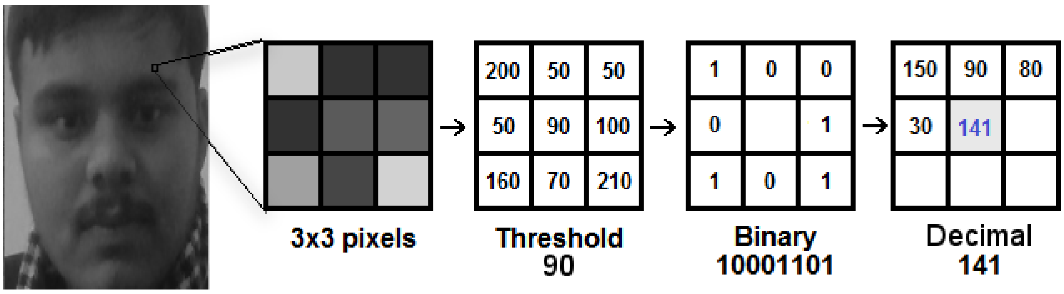

Figure 2. Performing local binary pattern (LBP) operation.

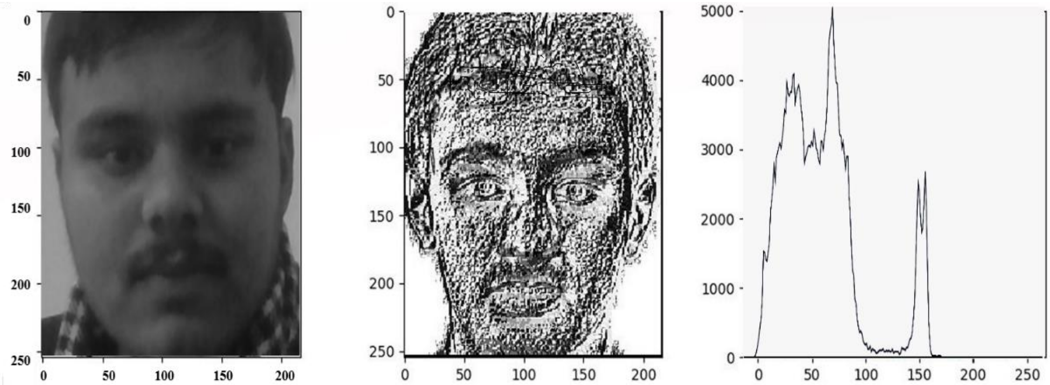

Figure 3. Extracting histogram.

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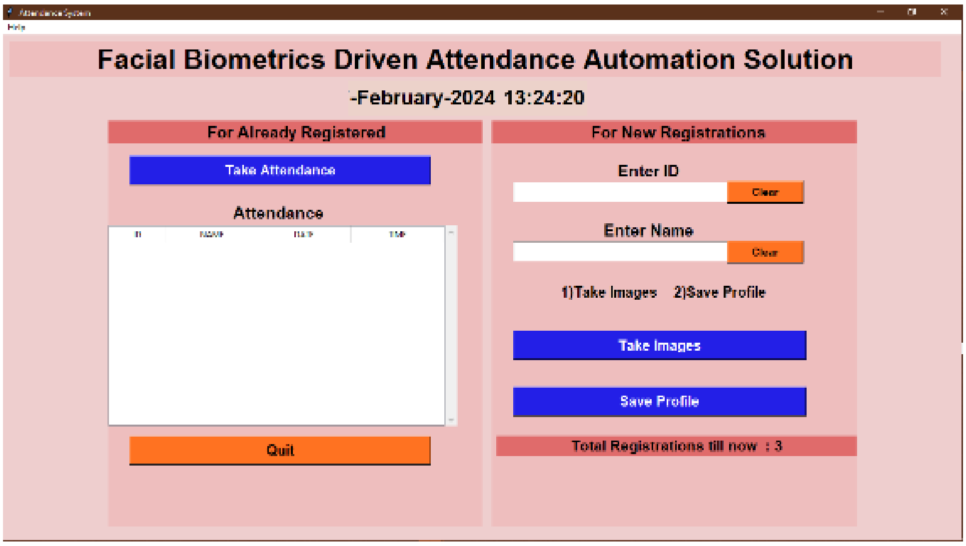

Figure 4. Home screen.

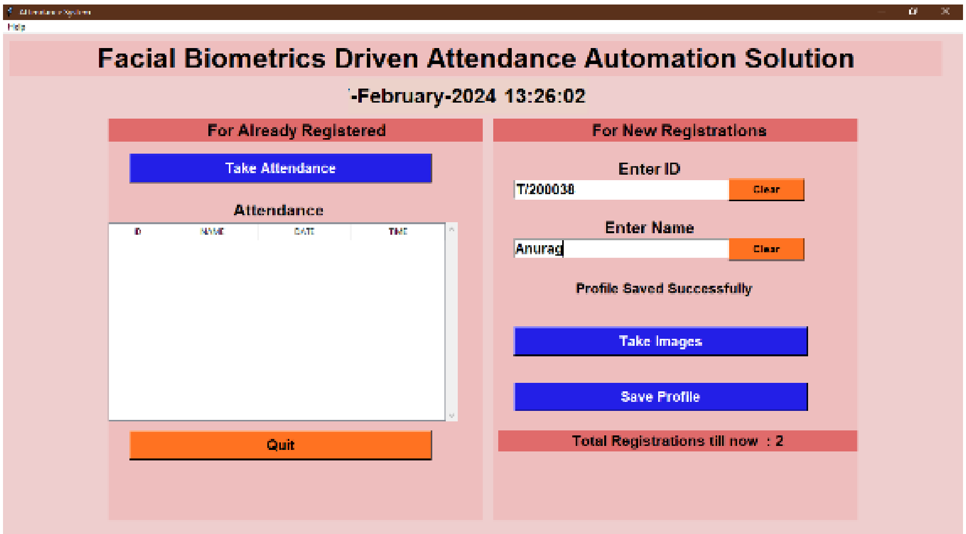

Figure 5. Entering user details.

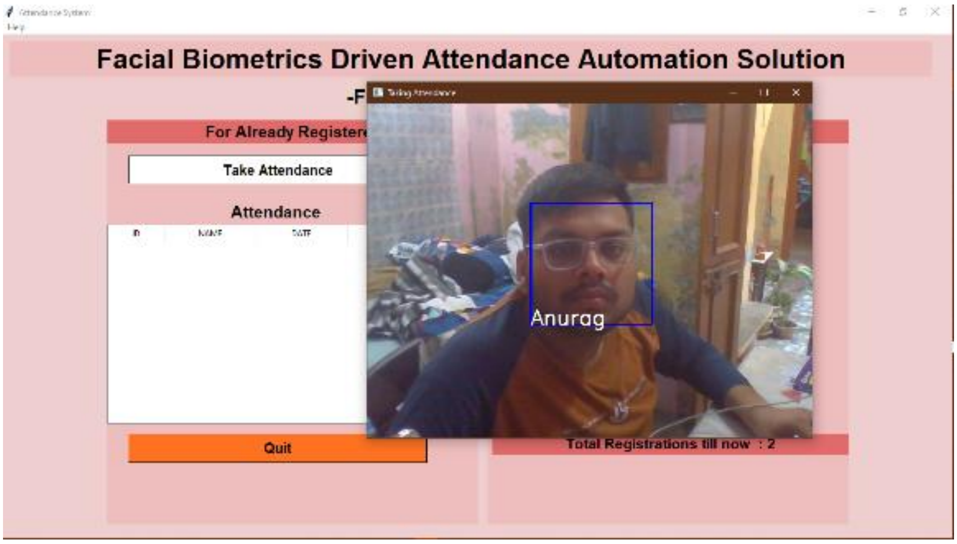

Figure 6. Taking attendance.

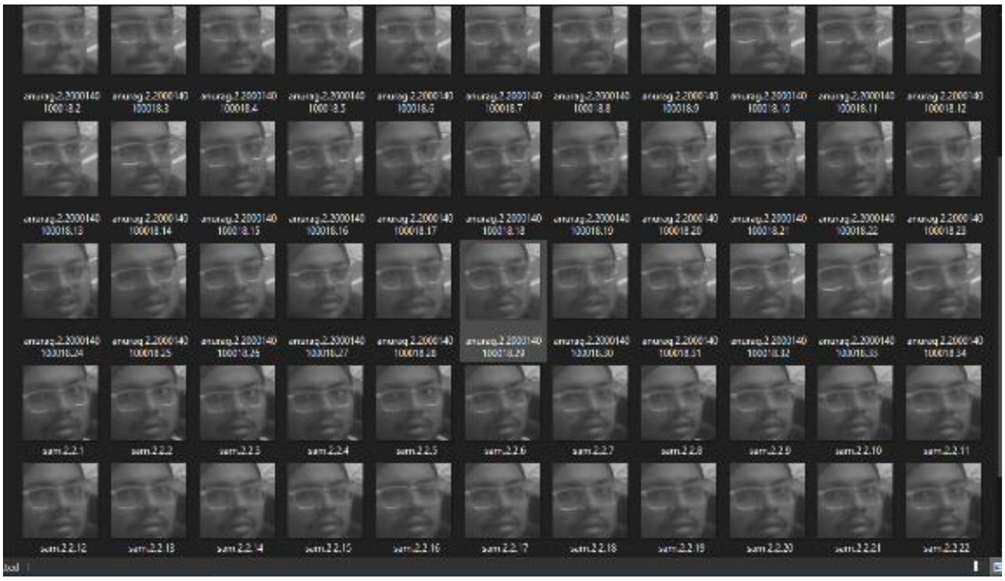

Figure 7. Trained dataset.

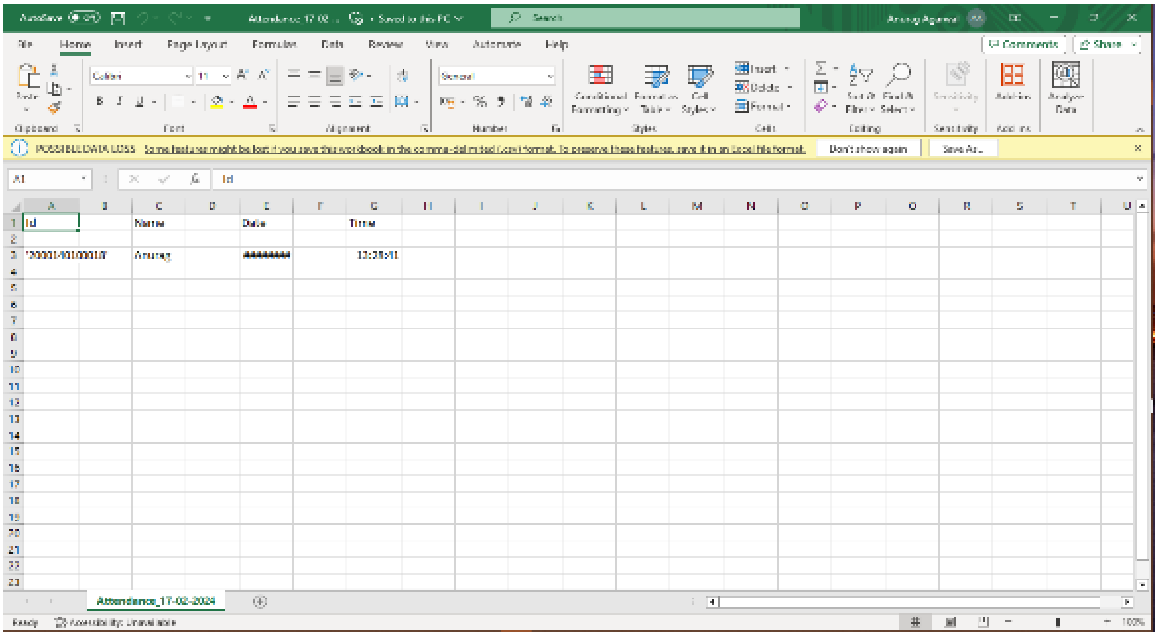

Figure 8. Attendance record.

CONCLUSION AND FUTURE WORK

Automated attendance systems utilizing face recognition techniques have demonstrated notable time-saving benefits and enhanced security measures. Furthermore, these systems have the ability to recognize individuals whose identity is not known. LBPH emerges as a superior algorithm in real-time scenarios, exhibiting superior recognition rates and minimal false positives compared to other methods.

Classifiers like SVM (support vector machine) and Bayesian methods demonstrate superior performance compared to distance classifiers as well. The project successfully achieves the following objectives:

1. Detecting facial segments within video frames.
2. Extracting relevant features from the identified faces.
3. Classifying these features to identify recognized faces.
4. Recording the attendance of identified students.

Future endeavors aim to enhance algorithmic recognition rates in instances of unintentional changes in individuals' appearances, such as head shaving, wearing scarves, or growing a beard. Currently, the system's recognition capability is limited to face angles up to 30°, necessitating further refinement. While the project has made significant strides, there remains room for improvement by incorporating additional features to enhance its reliability and effectiveness.

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