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Contactless Attendance System Using Raspberry Pi4

Madhurima Roy, Rajdeepa Das, Rajatsubhra Pal, Kaushik Roy and Prof. Joyati Chattopadhyay

Abstract— **Traditional attendance-taking techniques have several flaws. To address these challenges, most institutions have adopted a contemporary approach and embraced technology for greater accuracy, such as RFID and biometric systems. However, these systems have limitations of their own. For example, RFID identification may be lost or misused, resulting in false identification, and biometrics can be time-consuming, which is a concern since attendance is typically collected during peak hours. Due to these difficulties, both of these strategies are inefficient.**

Our project aims to create a contactless attendance system that uses deep learning-based facial recognition. This system will allow various businesses to save time and costs while improving security. Our project is an all-in-one package that includes both hardware and software and can be used without the need for additional devices. This makes our proposed system both independent and user-friendly.
The proposed hardware system consists of a Raspberry Pi 4, a camera for facial identification, a keyboard for ease of access, and a touch-enabled screen. We use OpenCV's face detection and the deep learning-based dlib package, which allows our solution to be efficient on a low-power computing device like the Raspberry Pi, making it deployable anywhere.

Index Terms- **AI, Covid-19, Facial Recognition, Feature Extraction, Image Recognition**

I. INTRODUCTION

This project's primary purpose is to create an efficient and effective contactless attendance system that can be used in the current covid situation.

Madhurima Roy is with the Department of Electronics and Communication, Techno International New Town, Kolkata, India (email: madhurima.roy1908@gmail.com).
Rajdeepa Das is with the Department of Electronics and Communication, Techno International New Town, Kolkata, India. (email: rajdeepadas.dgp@gmail.com).
Rajatsubhra Pal is with the department of Electronics and Communication, Techno International New Town, Kolkata, India (email: rajatsubhrapal2000@gmail.com)
Kaushik Roy is with the department of Electronics and Communication, Techno International New Town, Kolkata, India (email: roy.kaushik.8.5.2001@gmail.com).
Joyati Chattopadhyay is with the department of Electronics and Communication, Techno International New Town, Kolkata, India (email: mail2joyati@gmail.com).

The current attendance system has a lot of doubtfulness, which leads attendance taking to being inaccurate and inefficient. The current biometric technology, such as Thumb Recognition, is not ideal in our current situation, hence a contactless attendance system is required. The human face is vital for identification and is frequently used in numerous applications such as human monitoring, attention analysis, and human-machine interaction since it is one of the natural characteristics that can used to identify a person uniquely. As a result, it is utilized to trackdown identity because the chances of a face deviating or being copied are low, making it more secure. The suggested framework is divided into two stages.

1. Development of the face database
2. The procedure for recording attendance

This system captures photos of the students for face identification and recognition using a camera. The collected images are saved in the database one by one. Machine learning, Python, OpenCV, and Deep Learning are used.
During the attendance-taking process, the taken image is compared with the face database one at a time to search for the students' faces, and attendance is marked when a match is found in the database. Another benefit of this approach is the huge reduction in proxy attendance. This kind of system is suitable for tracking attendance due to its portability which may be used simply executing the Python program through the GUI. The recorded attendance is displayed on the Excel sheet to persuade the user. The technology automatically determinesattendance, saving both human resources and time.

II. THE CHALLENGES

Attendance systems such as biometric fingerprints and RFID have weaknesses and require a lot of time to take attendance for every student. During today's COVID-19 situation, the human- machine interfacing link is particularly dangerous since it can yield a chain of COVID-19 infections. With all of these considerations kept in thought, an automatic attendance system based on facial recognition can be constructed. To do this, a real-time student attendance system is required, which means that the identification operation must be completed

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within timeconstraints to avoid omission. When the backdrop, lighting, position, and expression of the students vary, the recovered attributes from facial images that identify their identities must remain constant. The performance will be evaluated based on its high accuracy and short computation time.

1. Exactness - Exactness is required for a well-functioning face recognition-based admission control system. Reduced precision causes more manual associations and abrogates, as well as more efforts by authorized individuals to get access.
2. Speed - For access control purposes, face-recognized proof must be performed in a fraction of a second. It has a big impact if your platform maintains this component during high-volume hours, such as morning peak hours. As a result of the poor speed, bottlenecks would occur, placing strain on the system.
3. Robustness – When dealing with a large number of contacts, processing high data throughput should not overload the system. A decent face recognition solution measures a raw video transfer without requiring recoding or pre-processing. It recognizes faces, attempts to remember them, and delivers relevant commands to the framework's other components. Many frameworks still employ image-based recognition, which eats processing time and delays processing to less than real-time processing.

III. LITERATURE SURVEY

Many corporations, firms, and establishments are using RFID technology, biometric fingerprint identification, iris recognition, and paper registers to maintain attendance records. However, these methods may be time-consuming and constitute a waste of resources.

[1] RFID (Radio Frequency Identification) uses electromagnetic fields to detect and communicate with tags connected to people. However, RFID is dependent on physical tags and the user to properly make use of the system. If the RFID receiver is damaged or the tags are misplaced, problems may arise in the system. This makes the RFID system susceptible to failure and user error.

Biometric fingerprint identification systems as implemented by [2] use fingerprints as unique data. They are among the most accurate systems in use. However, identifying a unique fingerprint from a group of listed fingerprints can be a difficult process. The fingerprint system cannot monitor any information about the original fingerprint, and it could be deemed false as numerous algorithms monitor that any fingerprint can be rebuilt by small templates.

Another form of implementation used by [3] is Iris Recognition. The iris of an individual is examined, stored, and then used for comparison, and is managed automatically within the database. However, there is a problem in capturing the iris of students or staff. As a result, facial recognition with low illumination impact is frequently used.

The attendance system implemented by authors of [4] has been enhanced by using Near Field Communications (NFC) technology and a mobile application. During college enrollment, each student receives an NFC tag with a unique identification. Each class's attendance is then recorded by touching or moving these tags on the lecturer's cell phone. The camera of the phone will capture the student's face before sending all the data to the college server to be validated and certified. However, when the NFC tag is not individually marked by the original owner, this method cannot detect the violation automatically. Also, the use of a cell phone as an NFC reader was found to be very inconvenient for instructors. What would happen if the lecturer failed to bring their cell phone to work? Furthermore, many people do not want to use their personal smartphones in this manner due to various privacy concerns. Therefore, other methods such as biometric data or face data, should be employed instead of NFC tags.

The authors of [5] conduct studies to acquire the best facial recognition algorithm provided by Haar-Cascade Classifier with OpenCV, which must be taught to detect human faces before it can be used for face detection. This option is called feature extraction, and then face recognition is performed by Local Binary Pattern Histogram. Following the recognition of the faces, attendance is recorded on the sheet.

The authors in [6] aim to obtain the best face detection algorithm (Eigenface and Fisherface) provided by OpenCV by comparing the Receiver Operating Characteristic (ROC) curve and then implementing Support. In the experiments conducted in this article, the ROC curve showed that Eigenface performs better than Fisherface. The system implemented with the Eigenface algorithm achieved an accuracy rate of 70% to 90%.

IV. PROPOSED SOLUTION

In light of the continuing COVID-19 epidemic, physical interaction with any technology is extremely dangerous and can be fatal. As a result, the majority of automated services that donot interface directly with humans are established. The automatic student/employee attendance system is designed withthis in mind. The attendance system is classified into two separate groups: biometric based and QR code based. Both strategies have their own set of advantages and disadvantages.

Hardware:

- Raspberry pi4
- Web camera
- TFT Touch Screen LCD 5’
- Keyboar

dSoftware:

- Python programming language
- LINUX
- Open CV
- Dlib Library

- Excel

There are four major processes to Face detection and Recognition which are as follows:

1. Image Pre-processing

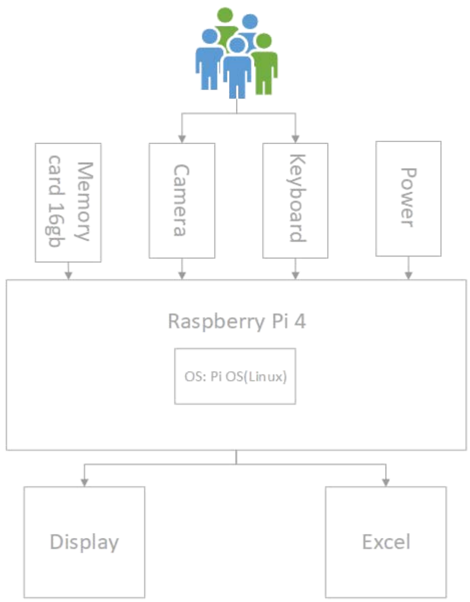

Figure 1: Diagram of Proposed System

2. Face Detection
3. Recognition of Faces
4. Marking Attendance and exporting to file

1. Image Pre-processing

The raw input image from the webcam is enhanced for improving the quality of the object in accordance to the human aspect. There are various techniques for image processing but in this project, we simply change the colour space of the image from BGR to RGB and resize the input image. We also transfer the image to grayscale since the deep learning model uses grayscale imagery.

2. Face Detection

This project uses Deep Learning to detect faces. We are making use of Dlib. A contemporary C++ toolkit called Dlib contains tools and algorithms for machine learning. We make use of Deep learning-based object detection: the HOG face detector for better performance, albeit at the cost of a little accuracy.
It computes the features using both the gradient's angle and the magnitude, making it superior to other edge descriptors. It creates histograms with the help of orientation of gradient and magnitude.

3. Recognition of Faces

Human-face recognition is an essential and painstaking task in the area of computer vision. The face encodings from the input image are detected and stored in a file along with the location of the faces in the frame. The face encodings are the data points used to identify a particular face and to differentiate it from other faces. Thus, it is a crucial part of our project. Once the encodings are stored, we can use that data to recognize individual faces and match them to the corresponding person they belong to.

4. Marking Attendance and exporting to file

This system keeps an attendance record for each person who marked their attendance based on the face traits they entered. A separate attendance sheet with all of the students'/employees' names is kept for attendance generation. A cell array stores all of the students' attendance for a given day. When a student's face matches a stored face in the file, the particular student's attendance is marked; otherwise, there is no storing. We have 3 separate columns for students or employees. The first entry is for the Roll Number or the ID, the next is for the Names, and the third is for the date.

V. WORKING PRINCIPLE

Histogram of Oriented Gradients (HOG), extracts feature descriptions from an image. This method counts instances of gradient orientation in the localised area of the image. This technique is extremely related to Scale Invariant Feature Transformation (SIFT) and Edge Orientation Histograms. HOG computes the features of an image using magnitude and angle of gradient, making it better than other edge descriptors. It creates histograms accordant with gradient's magnitude and directions.
Take the input image for which HOG features are to be calculated. The image should be resized to 128 by 64 pixels.
Calculate gradient of the image.
Combine magnitude and angle to create gradient.
For a block of 3x3 pixels, calculate G_x and G_y for each pixel.
G_x and G_y is to be calculated by using the formulas (1) and (2) for each pixel.

$$(r, c) = (r, c + 1) - (r, c - 1) \quad (1)$$

$$(r, c) = (r - 1, c) - (r + 1, c) \quad (2)$$

Once the calculation is done, the angle and magnitude for eachpixel are to be calculated using the formulas (3) and (4).

$$Magnitude(\mu) = \sqrt{G_x^2 + G_y^2} \quad (3)$$

$$Angle(\theta) = \left|\tan^{-1}\left(\frac{G_y}{G_x}\right)\right| \quad (4)$$

To create blocks, divide the magnitude and angle of the gradient into 8x8 cells after collecting the gradient for each individual pixel. Calculate a 9-point histogram for every block. The angle range of each bin in a 9-point histogram, which has 9 bins, is 20degrees.

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These histograms, with the bins can be plotted to indicate the gradient's intensity for that bin.
Each bin has boundary of (5):

$$[\Delta\theta \cdot j, \Delta\theta \cdot (j+1)] \tag{5}$$

$$Step\ Size(\Delta\theta) = \frac{180^{\circ}}{Number\ of\ bins} = 20 \tag{6}$$

Centre value of bin:

$$= \Delta(j + 0.5) \tag{7}$$

By first computing the j^{th} bin value, we can then determine the corresponding values for the j^{th} and $(j+1)^{th}$ bins using the provided formula for every cell in blocks. This order of computation is essential to accurately calculate the values for both bins based on the j^{th} bin value respectively.

$$j = \left[\left(\frac{\theta}{\Delta\theta} - \frac{1}{2}\right)\right] \tag{8}$$

$$V_j = \mu.\left[\frac{\theta}{\Delta\theta} - \frac{1}{2}\right] \tag{9}$$

$$V_{j+1} = \mu.\left[\frac{\theta - c_j}{\Delta\theta}\right] \tag{10}$$

For every pixel, the values of V_j and V_{j+1} are computed and stored in an array as bin values for the j^{th} and $(j+1)^{th}$ bins, respectively. Each block is represented by an array that serves as a bin for storing these computed values.

As soon as the histogram calculation for each blocks is finished, 4 blocks of a 9-point histogram matrix are merged into a new block of 2x2. In an overlapping manner the join up is done with a stride of 8 pixels. We interconnect all the 9-point histograms for all the 4 cells in a block where each components cell to form a 36-feature vector.

Normalize 'fb' values for every block using L2 norm (11):

$$f_{bi} \leftarrow \frac{f_{bi}}{\sqrt{\|f_{bi}\|^2 + \epsilon}} \tag{11}$$

We calculate the value of k by the formula (12):

$$k = \sqrt{b_1^2 + b_2^2 + b_3^2 + \cdots \cdots\cdots\cdots + b_{36}^2} \tag{12}$$

$$f_{bi} = \left[\left(\frac{b_1}{k}\right), \left(\frac{b_2}{k}\right), \left(\frac{b_3}{k}\right), \cdots\cdots\cdots\cdots, \left(\frac{b_{36}}{k}\right)\right] \tag{13}$$

The normalization reduces the effect of changing contrast among different images of same object. A 36-point feature vector is created from every individual block. Horizontally there are 7 blocks and vertically 15 blocks.
The total length of HOG feature set, therefore, becomes: 7 x 15 x 36 = 3780. Thus, we obtain the Histogram of Oriented Gradients features of the image.

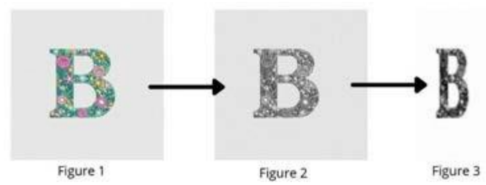

Figure 3: Oriented Gradients features of the Image

On the widely used "Labelled Faces in the Wild" benchmark, with an accuracy of around 99.38%. This indicates that, given two face photos, it accurately predicts if the photographs are of The same person 99.38%of the time, which is comparable to other cutting-edge models.

VI. METHODOLOGY

Step 1: Set up the hardware components as shown in Figure 1.
Step 2: Create a student file that stores their individual names, roll numbers, and facial data.
The file should be saved as a Python (.pkl) file.
Step 3: Launch the attendance tracking program.
Step 4: Compare the facial data of the person in front of the webcam to the data saved in the database.
Show the names and save attendance if the faces match.
Step 5: Export the attendance record to an Excel spreadsheet.
Step 6: Create a graphical user interface (GUI) to facilitate user interaction.
Step 7: The GUI should include the following features:

- New students are being added to the database.
- Matching faces to give attendance and saving therecord in an excel file
- Accessing the excel file in order to export andview the attendance record

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VII. RESULTS

- The GUI application:

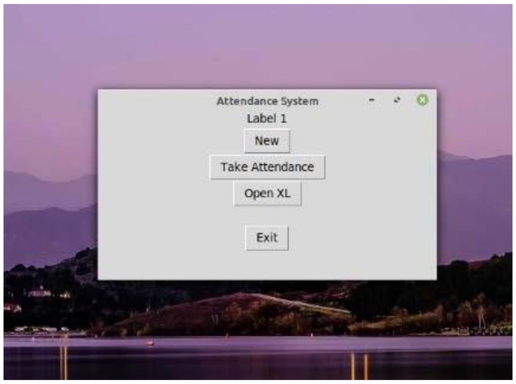

Figure 2: The GUI application

- Creation of Database of Students:

Figure 4: Capturing of facial data for recognition

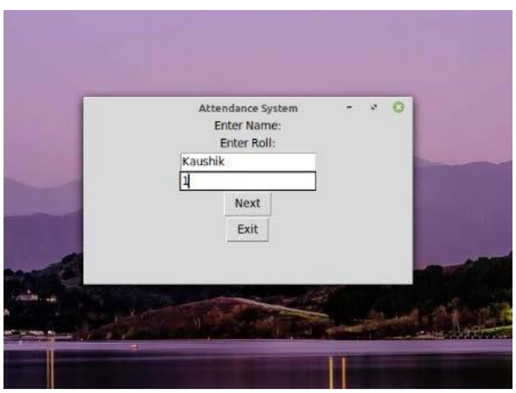

Figure 5: Registering Students

- Recognizing Faces from the Database:

Figure 6: Face Recognition

- Attendance recorded in Excel Sheet:

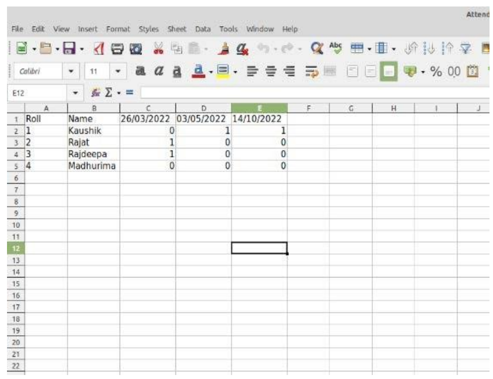

Figure 7: Attendance Record in Excel

VIII. CONCLUSION

We chose to design contactless attendance-system based on the requirement of the daily needs and desires of the society. Technological breakthroughs force us to think uniquely and develop concepts that have the potential to change the world. We require a system that is not only efficient and effective, but also simple, flexible, convenient, and reliable, and that can be expanded by adding new modules. Also, in this covid situation, physical interaction between humans and machines is quite dangerous, therefore it will lessen the risks. It has a reduced rate of false detection and a better rate of recognition. When used on its own, the Raspberry Pi increases job mobility and functions as a standalone piece of hardware. As a result, it is a very effective contactless attendance management system created with artificial intelligence.

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X. BIOGRAPHIES

Madhurima Roy is currently pursuing a Bachelor's Degree in Electronics and Communication Engineering from Techno International New Town, Kolkata, West Bengal, India. The institution is affiliated with Maulana Abdul Kalam Azad University, Kolkata, West Bengal, India.

Rajdeepa Das is currently pursuing a Bachelor's Degree in Electronics and Communication Engineering from Techno International New Town. The institution is affiliated with Maulana Abdul Kalam Azad University, Kolkata, West Bengal, India.

Rajatsubhra Pal is currently pursuing a Bachelor's Degree in Electronics and Communication Engineering from Techno International New Town. The institution is affiliated with Maulana Abdul Kalam Azad University, Kolkata, West Bengal, India.

Kaushik Roy is currently pursuing a Bachelor's Degree in Electronics and Communication Engineering from Techno International New Town. The institution is affiliated with Maulana Abdul Kalam Azad University, Kolkata, West Bengal, India.

Joyati Chattopadhyay completed her M.Tech on 2009 from Maulana Abdul Kalam University, West Bengal, India. She is currently assistant professor of Department of Electronics and Communication Engineering, Techno International Newtown, Kolkata, West Bengal, India. She has guided many project with students. She has book chapters, conference, and journals

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