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Face Recognition using Haar Cascade and Local Binary Pattern Histogram in OpenCV

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***Abstract*- One of the most unique features that a human body can possess is the Face. This feature can be used to create a system that uniquely differentiates among different people. Face Recognition is one such system that detects a particular face by facial features. In contrast to the traditional methods of collecting attendance by calling out students' names by the teachers in a university/school or marking it in the registers at the main gate of any organization, this one consumes less time, effort, is more efficient, and also is a contactless method of doing the same. In this paper, we worked on a model that uses facial recognition technique to mark students' attendance in an automated attendance management system using the Haar cascade classifier and LBPH algorithm. This one-time generation of dataset and face detection from the existing recognized images in this proposed system, is a more accurate and more improved system to collect attendance, thus leaving behind the tedious manual task.**

***Keywords*-- Face Detection, Face Recognition, OpenCV, LBPH, Python, Deep Learning, etc.**

I. INTRODUCTION

Be it an organization or a university/school, keeping a record of the attendance is one of the key tasks which is performed on a daily basis. As technology advances, old methodologies are replaced with modern techniques. In the field of recording attendance, the former ways of collecting data such as in registers or calling out names and marking present are succeeded with facial recognition or biometrics. Facial recognition is a biometric system. includes a comprehensive set of both classic and state-of-the-art computer vision and machine learning algorithms. The face is the most unique feature of any human, helps in building different types of software that we use nowadays. There are two forms of frameworks mostly used for student attendance, which are Manual Attendance System (MAS) and Automatic Attendance System (AAS). Most of the time in the Manual Attendance System, the workers could experience problems in approving and maintaining each student's record during a classroom all the time. Currently, there are numerous techniques or methods available to detect faces. Linear Discriminant Analysis (LDA) [5], Gabor Feature [6] to name a few. But we only focus on one of them, that is Local Binary Pattern Histogram (LBPH) [7,8] which is present in the OpenCV Library. This paper is further divided into five more sections. Section (II) Literature survey which provides an overview of current knowledge, used while writing this paper. Section (III) Proposed Framework which is a complete description of the working of the system. Section (IV) The Results & Discussion section contains the outcome of our experiment. Section (V) contains the Future Scope of the techniques used in this experiment. Section (VI) contains all the references mentioned in the paper.

II. LITERATURE SURVEY

Table 1. Comparison of work done using Haar Cascade, OpenCV and LBPH

Author	*Methodologies*	*Objective*	*Dataset*	*Performance parameter*
Budima n et al. [9]	Haar Cascade Classifier	Use of Haar cascade classifier for localization of white blood cell images.	Blood sample, White blood cell images,	Precision and Recall

Choudhary et al. [10]	Haar Cascade Classifier	Vehicle Detection and Counting using Haar Feature Based Classifier	CCTV footage	Accuracy
Wu et al. [11]	Local Binary Pattern Histogram (LBPH)	Networked Fault Detection of Field Equipment from Monitoring System Based on Fusing of Motion Sensing and Appearance Information	EWVD dataset,	AUC
Xu et al. [12]	Local Binary Pattern Histogram (LBPH)	Eyes States Detection by Boosting Local Binary Pattern Histogram Features	CASPEAL Database	ROC Curve
Vaidya et al. [13]	OpenCV	Handwritten Character Recognition Using Deep-Learning	NIST Dataset	Accuracy
Kiran et al. [14]	OpenCV	Driver Drowsiness Detection	Facial features, head positions	Accuracy
Setjo et al[15]	Haar Cascade Classifier	Thermal Image Human Detection	Thermal images taken using FLIR HS-307 Thermal camera	Precision and Recall
Sharma et al[16]	OpenCV	American Sign Language Translator	Speech Audio Files	Accuracy, Sensitivity, Connectivity
Jadhav et al[17]	OpenCV	Real-Time Human Detection and Monitoring Social Distancing for Covid-19	Face images	Accuracy
Javed et al[18]	Local Binary Pattern Histogram (LBPH)	Secure Lock System	45 Face Pictures Dataset	Accuracy

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Biometric systems [1,2] have been in use for more than 100 years. Hand images, iris pattern recognition, face recognition, signature analysis, speech recognition, palm prints and, others, biometric systems have become the most essential part of the security section, organization attendance, banking, mobile access, and authentication, and many more. Here in our research, we have worked on a facial recognition system to mark the attendance by using an approach based on Machine Learning [3]. OpenCV [4], an open-source library, Rezha Aditya Maulana Budiman [9] along with Balza Achmad, Faridah, Agus Arif, Nopriadi, and Luthfi Zharif proposed a method to localize and detect white blood cells images of the blood sample. The system is able to distinguish white blood cells from red cells as well as other objects using haar feature with an intensity similar to the white blood cell nuclei. Shaif Choudhary [10] with Soummyo Priyo Chattopadhyay and Tapan Kumar Hazraj developed a system to detect and count vehicles for traffic surveillance systems using haar features based classifiers. Chunxue Wu1[11], Shengnan Guo,Yan Wu, Jun Ai, and Neal N. Xiong worked on a system that monitors the working conditions of unsupervised equipment in the field using multimodal features to detect faults in terms of the appearance and motion patterns of equipment by extracting texture features through Local Binary Pattern Histograms(LBPH). Cui Xu[12], Ying Zheng, and Zengfu Wang presented a model in which they considered the detection of eye states as a binary classification problem of classifying the eyes into one of the two categories: closed (positive) or open (negative). Rohan Vaidya [13], Darshan Trivedi, and Sagar Satra made use of OpenCV to propose a method for offline handwritten character recognition. V B Navya Kiran [14], Raksha R, Anisoor Rahman, and Varsha K N used machine learning techniques to present an all-inclusive survey of recent works related to driver drowsiness detection and alert systems. They have shown an arithmetic-based method to solve the problem related to the detection of drowsiness. In Thermal Image Human Detection, Christian Herdianto Setjo[15], Balza Achmad, and Faridah discussed the application of the haar cascade classifier to detect the presence of humans in thermal images. Vijay Kumar Sharma [16], Naman Malil, Rachit Arora, Riddhi Jain, and Prachi Gupta worked on creating a system of speech recognition by making use of PyAudio Library to provide the user with a virtualized output of the video input which would be very helpful for the deaf and dumb. Raja Rajeshwari Jadhav [17], Dr.S.L. Lahudkar propose a framework, able to automatically detect numbers. of human bodies present in a single image, acquired by a traditional low-cost camera. In this paper, the Viola-Jones algorithm is used to detect human monitoring social distancing norms. The system is divided into two parts, the first part is about person detection whereas the second part is about monitoring whether people are following social distancing or not, it is applicable if the image contains more than one human. Shaik Mohhamad Javed. Preethi P, Mrs. Geetha K, Busetty Varun Sai Datta, and K. Nikhil Sai Chowdary together proposed a system that builds up a smart door for security purposes using OpenCV and raspberry pi

III. PROPOSED FRAMEWORK

3.1 Architecture

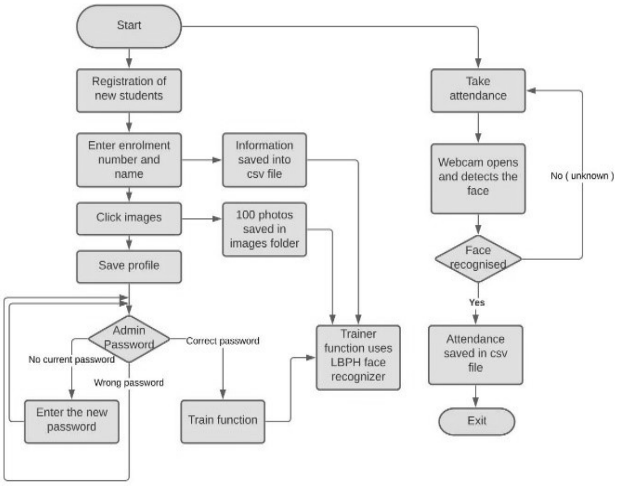

Figure 1. Flow Chart of the Architecture of the Proposed System

The proposed system is physically divided into two sections i.e., the student/employee database and attendance database. The student database is responsible for storing all the necessary details of the student/employee. The Attendance database holds the records of daily attendance. In order to create a student's profile, first, we need to type in all the details which are asked in the GUI. Once this is done, the system will automatically create a database (CSV file) in which details will be updated of the same. Further, by clicking on taking Images, the system will start to take the images (100 images/frames) of the student/employee of which the details were entered above. On completion of this, the system will again create a database for the taken images in a folder namely "Training Images" for the training of the cascade classifier. Once done, we then save the profile of the person and the system then will prompt for a password. This password can be changed in the menu section of the UI.

After these images are trained. On the other hand, the attendance section has a very simple and easy-to-use architecture. Once we click on the "Take Attendance" button from UI, the camera frame pops up. The LBPH recognizer runs through the classifier and identifies if the face is similar to any of the trained data or not. If yes, then it shows the name with a rectangular box marked on the boundary of the face. Once all the faces are recognized by the High-Definition Camera set up in the room with the system, the administrator can mark the attendance easily with just a click of a button. The update in the attendance record is then shown in the table on the right side of UI and also a database (CSV file) of the same is created of the daily record.

3.2 Methodology

This section contains the way our system works, which further has 4 sections: Generation of the dataset, training the images, face recognition, and marking the attendance.

3.2.1 Generation of the dataset

The first and foremost thing to mark the attendance by recognizing a face is to generate a dataset. The images stored will be used in further detection of the face. In order to save the data of students, first, we need to detect the face. This is done using a Haar cascade classifier. To identify faces in an image or in a real-time video, we have an object detection algorithm, Haar Cascade [19]. The function of Haar Cascade is trained from a lot of images that are both positive as well as negative. Now on the basis of the trained images, objects are detected in the other Images. Edge features, Line-features and, Four rectangle features are the 3 types of haar-like features.

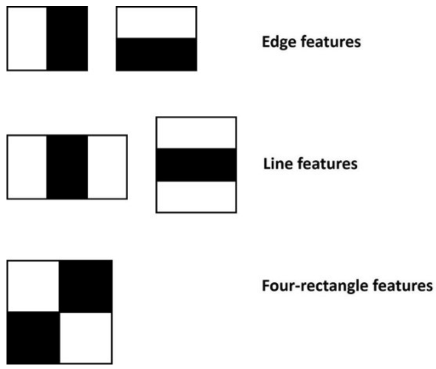

Figure 2. Haar-like Features

These features are the first and initial step for our classification. These features include calculations. These calculations are the addition of the intensities of each pixel in each region. Further, the difference between the sums is calculated. Now integral images are used to increase the calculation. Creating sub rectangles instead of pixels. Then it creates an array of these sub-rectangles. After this step, we use the Adaboost algorithm. We know not all captured images are not relevant. We only need those images that are clear and accurate. Adaboost creates a strong classifier using the combination of the weak ones. It chooses the most relevant features. The function cv2.VideoCapture(0) opens up the webcam and the haar cascade classifier recognizes the face in the camera frame. Once the face is recognized, the system takes 100 images of the student/employee when the "Take Images" button is clicked.

Figure 3. Dataset generated as Training Images

3.2.2 Training of Images

The images generated as Training images are then stored in a NumPy Array and with the help of the LPBH algorithm, the next steps are taken. LBPH is an algorithm that can recognize both the front face as well as the side face. To get images of dimension (m x m), we divide the image into parts of the same height and width The local binary operator is used for every region. A window of size 3 x 3 helps define the LBP operator.

$$LBP(x_c - y_c) = \sum_{p=0}^{p=1} 2_s^p (i_p - i_c)$$

Here, i_p and i_c are grey level values. These are values of central pixel and surrounding pixels(P).

Using the following function, it compares a particular pixel to its 8 neighbour pixels.

$$s(x) = \begin{cases} 1, x \geq 0 \\ 0, x < 0 \end{cases}$$

The value here is set to 1 for the value of the neighbour which is greater than or equal to the central value, if not, then it is set to 0. This results in 8 binary values from the surrounding neighbours. Once these 8 values are combined, as a result, we get a binary number of 8-bit which is converted into a decimal number. This resultant decimal number we get is the pixel LBP value which ranges between 0-255. Since it was noticed that this could not encode the details varying in scale, the algorithm was introduced to circular LBP that used different numbers of radius and neighbours. After a few more calculations, the LBP value histogram is generated. The number of related LBP values in the region creates a histogram. After the introduction of a histogram for every region, all of the histograms are integrated to shape a single histogram and that is referred to as a character vector of the image. These merged histograms are then saved in a file with an extension. yml by the recognizer.

3.2.3 Face Recognition

The face is recognized by the LBPH recognizer in the camera frame. The LBPH algorithm creates another set of histograms for the face in the camera frame and compares them with the ones which were created for the training images. The Euclidean distance is calculated by comparing the test attributes with the stored data attributes. This is used to compare training images. Here the minimum distance between the original image and the test image is used to calculate the correspondence ratio. The distance is given by the following formula:

$$d(a,b) = \sqrt{\sum_{i=0}^{n} |a_i - b_i|^2}$$

If the test face of the image matches with images in the database. We get ID as our result.

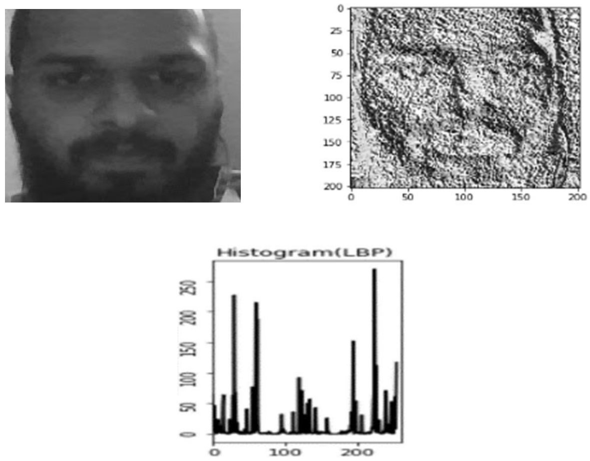

Figure 4. Local Binary Pattern & Histogram of the Detected Face

3.3.4 Marking of Attendance

Once everything is done, the only thing remaining is to mark the attendance of the recognized student. To mark a student as a present, the "Take Attendance" button is clicked. Right after clicking the button, the marked attendance is shown on the right side of the UI as well as this automatically creates a CSV file. With the help of Pre-installed High-Definition Cameras in the lecture halls or wherever needed, which will be acting as a list of students and
detecting all of them at the same time, will mark the ones present who are recognized by the camera. In our system, we have set the minimum confidence level as 75 percent. In other words, we can say that the face in the camera frame should match the training images of the very same person at least 75 percent in order to get the attendance marked.

Id	Name	Date	Time
1	User 1	19-05-2021	22:59:34
2	User 2	19-05-2021	23:02:26
3	User 3	19-05-2021	23:03:48
4	User 4	19-05-2021	23:04:44
5	User 5	19-05-2021	23:05:31

Figure 5. Data in CSV File

IV. RESULTS & DISCUSSION

The implemented system successfully creates a dataset of every student by capturing 100 images of each of them. Once all these images are saved/trained in the system, the user goes further to mark attendance. For this experiment, images were taken for 5 people which means 500 images/frames were captured at least 10 times.

Table 2. Detection Accuracy according to Backgrounds

User	No. of Frames (per person)	Accuracy with Exhaustive Background	Accuracy with Plain Background
User 1	100	0.91	0.93
User 2	100	0.90	0.94
User 3	100	0.88	0.93
User 4	100	0.89	0.92
User 5	100	0.87	0.92
	Average Accuracy	0.89	0.928

The average accuracy of the system to capture the positive image i.e., face images was 89 % when there were too many objects in the background. In other words, 11 times out of a hundred, non-face images were also detected/captured by the images when the background in the camera frame was exhaustive as mentioned in Table 2. For plain backgrounds, the average accuracy was found to be 92.8 %. We already know that generating a dataset is a one-time process, therefore it only requires the administrator to mark the attendance whenever needed. This process has not only reduced the time but also the efforts of the professor/teacher. The csv file is accurate and easy to use for updating and maintaining records. By experimenting with this system, we have created a basic face recognition, which can further be used to create complex security systems or something similar. This system has proved to consume much less time than the older methods being used. It was successfully created using tkinter, which is a python interface package. The UI is responsive and fast, meaning it does not lag while taking action. The left side of the UI is the section where the students/employees enter their data thus creating their database. On the other hand, the right section has been designed to hold the command for the attendance database. It also displays the attendance of the student right after being marked present.

Table 3. Pros and cons of commonly used face recognition algorithms.

Algorithm	Pros	Cons	Accuracy
Local Binary Pattern Histogram (LBPH) [20]	1.Represent local features. 2. Robust against monotonic grayscale transformations 3. low computation complexity 4. Recognizes both front and side faces	1.Produces long histograms, thus slowing down the speed of recognition. 2.Not invariant to rotations	98% ± 1.24%
Eigenfaces [21]	1. Raw intensity data are used directly for learning and recognition 2. No knowledge of geometry and reflectance of faces is required	1. Sensitive to light. 2. Sensitive to pixel misalignment 3. Sensitive to pose and facial expressions	99% ± 0.87%
Fisher faces [22]	1. Achieves greater between-class scatter, thus making classification easier compared. 2. Insensitive to light	1. If between class scatter is large, then within-class scatter could be large.	100%

V. CONCLUSION & FUTURE SCOPE

The system proposed in this paper is precisely based on the attendance system for a particular organization institution for students/employees. We tried our best to make a simpler version of the commonly used attendance system. This system takes attendance of students one after the other only after the system recognizes them. The result of our experiment is a faster, simpler, and easier to use system with almost 90% accuracy. We know some diseases that cause changes in appearance, so our next goal would be to develop a system that would be helpful in detecting such diseases. Such systems are being used already like in, the National Human Genome Institute Research Institute, the USA for detecting a disease in which a portion of the 22nd chromosome missing. This is DiGeorge syndrome. Since such systems are more in use and proven beneficial, the facial recognition technology will be used in many more areas and will provide ease for the users. In the future, we can also work on a system that can be used to ensure the individuals or members for any organization that needs access control at specific areas to ensure that only verified individuals are provided with the facilities like laboratories, and other important documents and information.

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