Design and Implementation of Face Recognition Based Smart Attendance System

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Abstract : **A facial recognition attendance system uses facial recognition technology to identify and verify a person using the person's facial features to automatically mark the attendance. Face recognition based systems can be used for different groups of people such as employees, students, etc. These systems records and stores the image data of persons in real-time. In this digital era, face recognition system plays a vital role in almost every sector. Face recognition is one of the mostly used biometrics. It can be used for security, authentication, identification, and has got many more advantages. In the pandemic days also, face recognition plays a very important role as physical contact is avoided due to pandemic situations. In this paper, a smart attendance system is designed that aims to build a class attendance system which uses the concept of face recognition as existing manual attendance system is time consuming and it is not very easy to maintain. This system consists of four phases- database creation, face detection, face recognition, attendance updating. Database is created by the images of the students in class. Face detection and recognition is performed using HOG algorithm and linear SVM classifier is used.**

Index Terms **– Face recognition, Face detection, HOG Algorithm, Linear-SVM**

1. INTRODUCTION

1.1 Computer Vision

Computer vision can be defined as a scientific field that extracts information out of digital images. The type of information gained from an image can vary from identification, space measurements for navigation, or augmented reality applications. Computer vision is building algorithms that can understand the content of images and use it for other applications. Computer vision brings together a large set of disciplines. Neuro-science can help computer vision by first understanding human vision. Computer vision can be seen as a part of computer science, and algorithm theory or machine learning are essential for developing computer vision algorithms. We can divide the information gained from images in computer vision in two categories: measurements and semantic information

Vision as a measurement device

Robots navigating in an unknown location need to be able to scan their surroundings to compute the best path. Using computer vision, we can measure the space around a robot and create a map of its environment. Stereo cameras give depth information, like our two eyes, through triangulation. Stereo vision is a big field of computer vision and there is a lot of research seeking to create a precise depth map in stereo images. If we increase the number of viewpoints to cover all the sides of an object, we can create a 3D surface representing the object. An even more challenging idea might be to reconstruct the 3D model of a monument through all the results of a google image search for this monument. There is also research in grasping, where computer vision can help understand the 3D geometry of an object to help a robot grasp it. Through the camera of the robot, we could recognize and find the handle of the object and infer its shape, to then enable the robot to find a good grasping position.

A source of semantic information

On top of measurement information, an image contains a very dense amount of semantic information. We can label objects in an image, label the whole scene, recognize people and recognize actions, gestures, faces. Medical images also contain a lot of semantic information. Computer vision can be helpful for a diagnosis based on images of skin cells for instance, to decide if they are cancerous or not.

1.2. Face detection through computer vision

Face detection has been used for multiple years in cameras to take better pictures and focus on the faces. Smile detection can allow a camera to take pictures automatically when the subject is smiling. Face recognition is more difficult than face detection, but with the scale of today's data, companies like Facebook are able to get very good performance. Finally, we can also use computer vision for biometrics, using unique iris pattern recognition or fingerprints.

Most images that we deal with in computer vision are digital, which means that they are discrete representations of the photographed scenes. This discretization is achieved through the sampling of 2-dimensional space onto a regular grid, eventually producing a representation of the image as a matrix of integer values. When dealing with images, we can imagine the image matrix as infinitely

tall and wide. However, the displayed image is only a finite subset of this infinite matrix. Having employed such definition of images, we can write them as coordinates in a matrix

If we consider an m × n image of a face, that image can be represented by a point in high dimensional space (Rmn). But relatively few high dimensional vectors consist of valid face images (images can contain much more than just faces), and thus the region that an arbitrary face image could fall into is a relatively small subspace. The task is to effectively model this subspace of face images. In order to model this subspace or "face-space" we compute the k dimensional subspace such that the projection of the data points onto the subspace has the largest variance among all k-dimensional subspaces. This low-dimensional subspace captures the key appearance characteristics of faces.

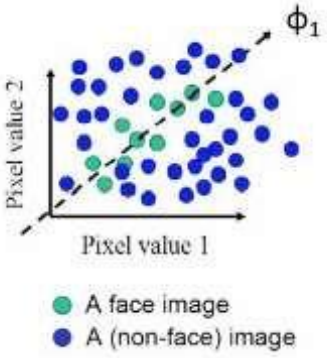

Figure 1.1: Region occupied by faces in image Face Recognition

Face Recognition "is the ability to recognize people by their facial characteristics". Face recognition is becoming popular for recognizing the face of human and it also has become a popular area for research in computer vision and it also become the most successful application for image analysis and understanding them. Face is one of the most important factors in our existence which plays chief undertakings in transporting making-out feeling and includes full of money information. Face has been seen as a very great research area in knowledge processing machine act or power of seeing, form, design being seen and plays a full of force undertaking in the application of image observations. Generally, the face recognition commonly includes feature extraction, feature reduction and recognition or classification.

2. LITERATURE SURVEY

Plenty of research has been conducted so far on the various available methods for implementation of an effective attendance monitoring system. Attendance marking system has been become a challenging, intriguing and accurately in the real-time system. It is tough to mark the attendance of a student in the large classroom, and there are many students attend the class. Many attendance management systems have been implemented in the current research. Presently, attendance of students in most institutes is taken by the teacher on paper-based attendance registers.[5] There are various disadvantages to this approach such as data is not available for analysis because paper-based registers are not uploaded to a centralized system, time taken for data collection reduces the effective lecture time and fake attendance by students. Some universities also use wall mounted RFID swipe card systems. RFID (Radio Frequency Identification) is a wireless technology which uses electromagnetic waves for communication between RFID reader and RFID tag. Though better than paper-based systems, RFID based systems also have certain problems such as the system is complex, costly and absent student's card can be swiped by other students.

Face recognition can be done in both image and video which has its origin from image Face recognition. Different approaches of face recognition for still images can be categorized into three main groups [2] such as:

2.1 Holistic Approach

In holistic approach, the whole face region is taken into account as input data into face detection system. Examples of holistic methods are Eigen faces most widely used method for face recognition. They are all based on Principal Component Analysis (PCA) techniques that can be used to simplify a dataset into lower dimension while retaining the characteristics of dataset.[2] [11]

2.2 Feature based Approach

In feature-based approaches, local features on face such as nose and then eyes are segmented and then used as input data for structural classifier. Pure geometry, dynamic link architecture and hidden Markov model methods belong to this category. The development of feature detection model is motivated by the early processing stages. The feature detection method presented here is based on a model of end-inhibition property and it makes use of local scale interactions between simple oriented features. It consists of two basic steps: the first step is to extract oriented feature information at different scales and second step results in the end-inhibition effect.[2] [11] Oriented feature information can be obtained by a Gabor wavelet transformation of the intensity image error functions are Gaussians modulated by complex sinusoids. A wavelet transformation results in the decomposition of a signal in terms of basic functions obtained by simple dilations and translations of a basic wavelet.

Hybrid Approach

The idea of this method comes from how human vision system perceives both local feature and whole face. There are modular Eigen faces, hybrid local feature, shape normalized, component based methods in hybrid approach.[2] [11].

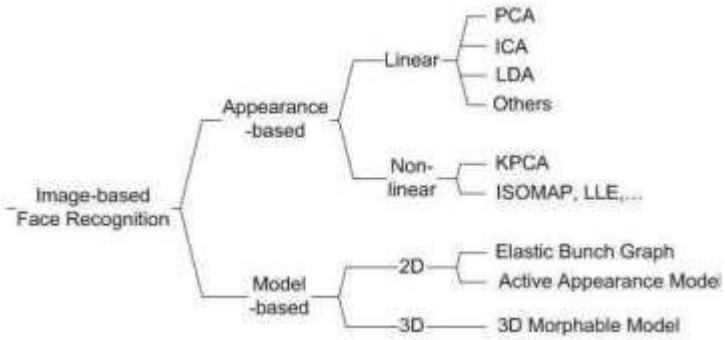

Figure 2.1: Face recognition methods

3. METHODOLODY

3.1 HOG + Linear SVM

Face recognition is one of the most sought-after technologies in the field of machine learning. There are two phases in such a system: Face Detection followed by Face Recognition. Initially, the faces are detected using a Haar Cascade Classifier on an image in conjunction with the cropping of the cardinal section of the face. A geometric face model is formed with the detection of eyes performed using the Haar Cascade Classifier, while nose detection has been used as a reaffirmation mechanism along with the eyes. Later, HOG features are extracted from large numbers of facial images to be used as part of the recognition mechanism. These HOG features are then labeled together for a face/user and a Support Vector Machine (SVM) model is trained to predict faces that are fed into the system.

The H.O.G (Histogram of Oriented Gradients) is a feature descriptor used in computer vision for image processing for the purpose of object detection. This was powerful and state of the art way of doing object detection before the deep learning era. HOGs are widely known for their use in pedestrian detection.

HOG works with something called a block which is similar to a sliding window. A block is considered as a pixel grid in which gradients are constituted from the magnitude and direction of change in the intensities of the pixel within the block. So, the first step would be to convert an RGB image to grayscale. To get a closer look, let's focus on one such grid of size 8*8. Look at the following picture.

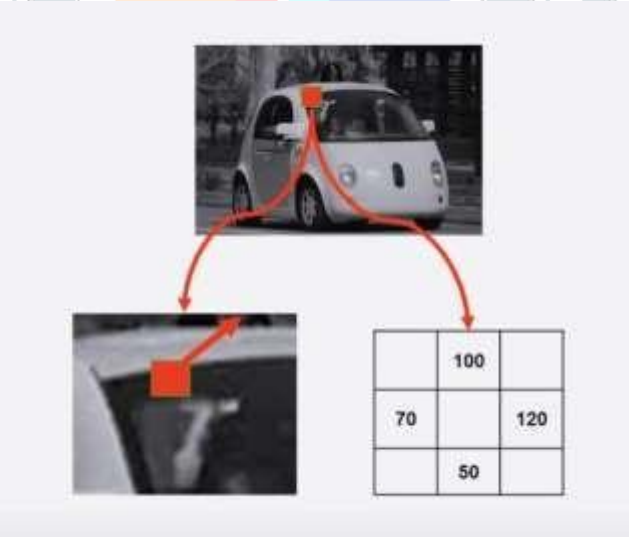

Figure 3.1: Gradients of image

In the block of 64 pixels, for each pixel, horizontal and vertical gradients are calculated. Like in the above picture, horizontal and vertical gradients are calculated as:

Horizontal Gradient: 120–70=50

Vertical Gradient: 100 –50 = 50

Once we get the gradients, we try to calculate something called gradient magnitude and gradient angle for each of 64 pixels. Now with those 64 gradient vectors, we try to compress them to 9 vectors, trying to retain the maximum structure. To do this we try to plot a histogram of magnitudes and angles. Here x-axis is angles and they are binned into 9 bins each with a size of 20 degrees.

When we slide that 8*8 grid along the whole image and try to interpret the histogram results we get something like below. And by plotting the HOG features we will find that the structure of the object or face is well maintained, losing all the insignificant features. Such input can be leveraged by any Machine Learning algorithm to do the classification or regression.

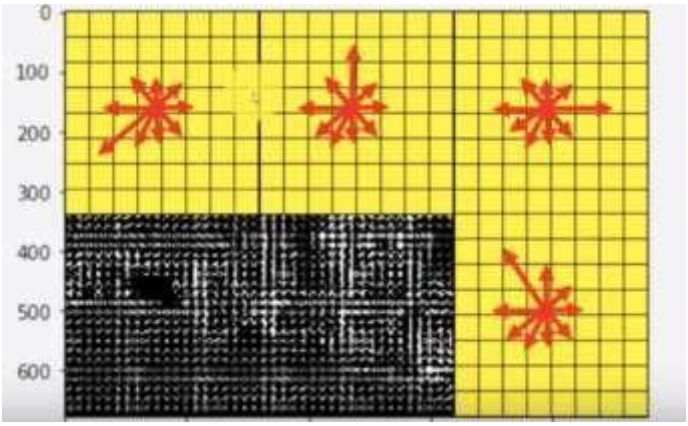

Figure 3.2 : HOG features of image

It's a very powerful technique being used still today and object detection can be achieved without the use of heavy architectures from DL.

Support Vector Machine

SVM or Support Vector Machine is a linear model for classification and regression problems. It can solve linear and non-linear problems and work well for many practical problems. The idea of SVM is simple: The algorithm creates a line or a hyper-plane which separates the data into classes.

At first approximation what SVMs do is to find a separating line (or hyper-plane) between data of two classes. SVM is an algorithm that takes the data as an input and outputs a line that separates those classes if possible. Thus, we can classify data by adding an extra dimension to it so that it becomes linearly separable and then projecting the decision boundary back to original dimensions using mathematical transformation. But finding the correct transformation for any given dataset isn't that easy. Given a set of points belonging to two classes, a support vector machine (SVM) finds the hyper plane that separates the largest possible fraction of points of the same class on the same side, while maximizing the distance from either class to the hyper plane. PCA is first used to extract features of face images and then discrimination functions between each pair of images are learned by SVMs. SVM has different classes those are shown below:

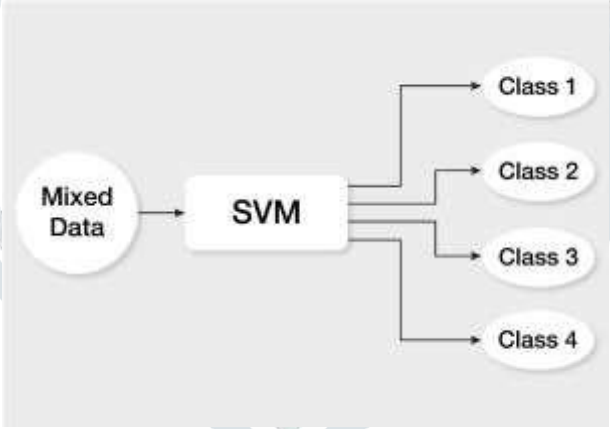

Figure 3.3 :SVM Classifiers

4. IMPLEMENTATION

4.1. Block Diagram

The Block diagram of the proposed system consists of the following stages

i. Input
ii. Face Detection
iii. Feature Extraction iv. Classification
v. Attendance Marking vi. Database

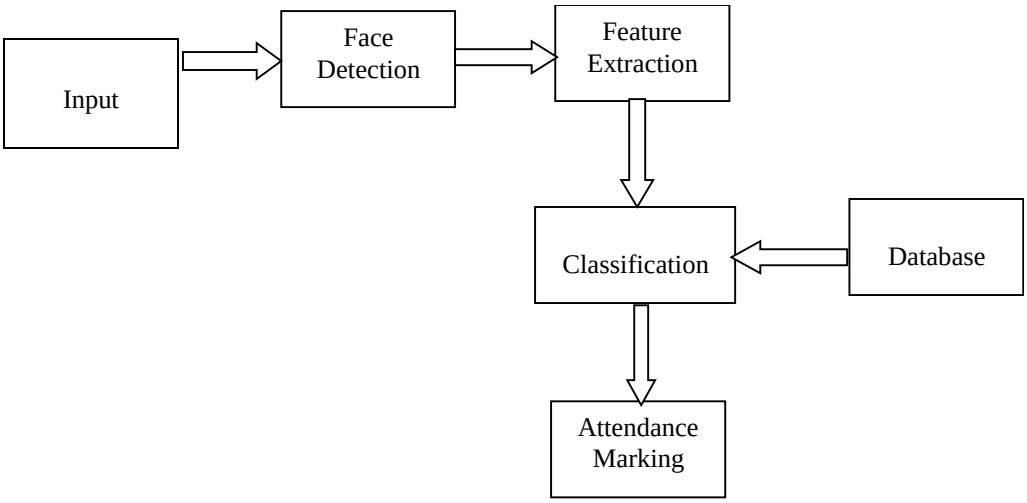

Fig. 4.1 Block Diagram

Input image

Input may be come from webcam or data base. These input images are undergoing image processing steps to extract the useful features of image for detection, recognition and comparison. All images consist of small elements called as pixels which means picture elements. Any algorithm processes on these pixels to operate any function on images.

Feature extraction

This process can be defined as the process of extracting relevant information from a face image. In feature extraction, a mathematical representation of original image called a biometric template or biometric reference is generated, which is stored in the database and will form the basis (vector) of any recognition task. Later these extracted features are used in recognition. After that greyscale pixel is considered as initial feature. Following the face detection step the extraction of human face patches from images is done. After this step, the conversion of face patch is done into vector with fixed coordinates or a set of landmark points.

Classification

The last step after the representation of faces is to identify them. For automatic recognition we need to build a face database. Various images are taken foe each person and their features are extracted and stored in the database. Then when an input image is fed the face detection and feature extraction is performed and its feature to each face class is compared and stored in the database.

Attendance Marking

In this process, once the features are extracted and selected, the next step is to classify the image. For that appearance-based face recognition algorithms use a wide variety of classification methods. Such as PCA, LDA, Fisher face etc. In classification, the faces are compared for the similarity between faces from the same individual and different individuals after all the face images in database are represented with relevant features. Sometimes feature extraction & recognition process are done simultaneously.

Face data base

The first step in the Attendance System is the creation of a database of faces that will be used. Different individuals are considered and a camera is used for the detection of faces and the recording of the frontal face. The number of frames to be taken for consideration can be modified for accuracy levels. These images are then stored in the database along with the Registration ID and name. Acquisition and Processing of Face Data is first step in the face recognition system. In this step face images are collected on real time from webcam or may be at static time and stored in the database.

The collected face images should have the pose, illumination and expression etc. variation in order to check the performance of the face recognition system under these conditions. Processing of face database requires sometimes otherwise causes serious effect on the performance of face recognition systems due to changes in the illumination condition, background, lighting conditions, camera distance, and thus the size and orientation of the head. Therefore, input image is normalized and some image transformation methods apply on the input image.

4.2. Hardware Requirements

Personal Computer

A personal computer (PC) is a multi-purpose computer whose size, capabilities, and price make it feasible for individual use. Personal computers are intended to be operated directly by an end user, rather than by a computer expert or technician. Unlike large, costly minicomputers and mainframes, time-sharing by many people at the same time is not used with personal computers.

Webcam

Webcam is a video camera that feeds or streams an image or video in real time to or through a computer network, such as the Internet. Webcams are typically small cameras that sit on a desk, attach to a user's monitor, or are built into the hardware. Webcams can be used during a video chat session involving two or more people, with conversations that include live audio and video.

Webcam software enables users to record a video or stream the video on the Internet. As video streaming over the Internet requires much bandwidth, such streams usually use compressed formats. The maximum resolution of a webcam is also lower than most handheld video cameras, as higher resolutions would be reduced during transmission. The lower resolution enables webcams to be relatively inexpensive compared to most video cameras.

4.3. Software Development

This project requires libraries such as Open CV Python, numpy, cmake, dlib and face recognition for detecting the faces of persons and recognizing their identity. These libraries provide backend functions and tools for face detection and recognition. These libraries allow to access already implemented logic in the form of functions or data.

Open CV library can be used to develop real time computer vision applications such as Image processing, video capture and analysis. Numpy is a mathematical package which contains inbuilt mathematical expressions. It is used to convert the images into some form of array to perform required operations on it.

Cmake package is an open-source package which is used to test and built the package software. It provides back-end support to Dlib package to find encodings. Dlib package is used to identify the faces of persons in the figure window. The Dlib library provides two functions for face detection. The first one is HOG + linear SVM face detector and the other is deep learning MMOD CNN face detector. Dlib acts as the back-end support for face recognition library. Face recognition library is used to convert color image to grey and to find the facial landmarks.

Finding out encodings of image

Initially, images of authorised persons are stored in the database with their respective names. The encodings of all images present in the database are generated by using linear SVM and HOG algorithm. For each image, it generates 128 encoding values that are obtained by measuring various facial distances in between classified points in the face.

Capturing the faces using web camera

A web camera is used to capture the face of a person for marking attendance. It mainly detects the face of the person from the entire frame and generates its facial encodings. These encodings are generated based on facial landmarks.

Comparing both facial encodings

The facial encodings from both the image database and figure window are obtained and compared for recognising the specific person in the database. SVM classifier is used to analyse the data for classification. If the comparison between the encodings matches, then it displays the person's face with their respective name in the figure window. If the encodings don't match, then it displays unknown in the figure window.

Marking attendance in a file

The attendance of recognised persons will be marked in the .CSV file. It is also known as comma separated value file. It contains two columns; first column represents the name of the recognised person and the second column represents the time of recognition of the person. It marks the attendance of the recognised person only when there is no name in the .csv file. If already marked, then it ignores.

4.4. Algorithm

Step 1: Start

Step 2: Import required Libraries.

Step 3: Extract Images from Database.

Step 4: Encoding the required Database Images.

Step 5: Capture the image

Step 6: Obtain the Encodings of Face.

Step 7: Compare the Encodings of captured images and data base images

Step 8: Check whether the attendance is already Marked or not.

Step 9: Mark the Attendance in the .csv file, if not marked.

Step 10: Repeat the process continuously from step 4.

4.5. Flow chart

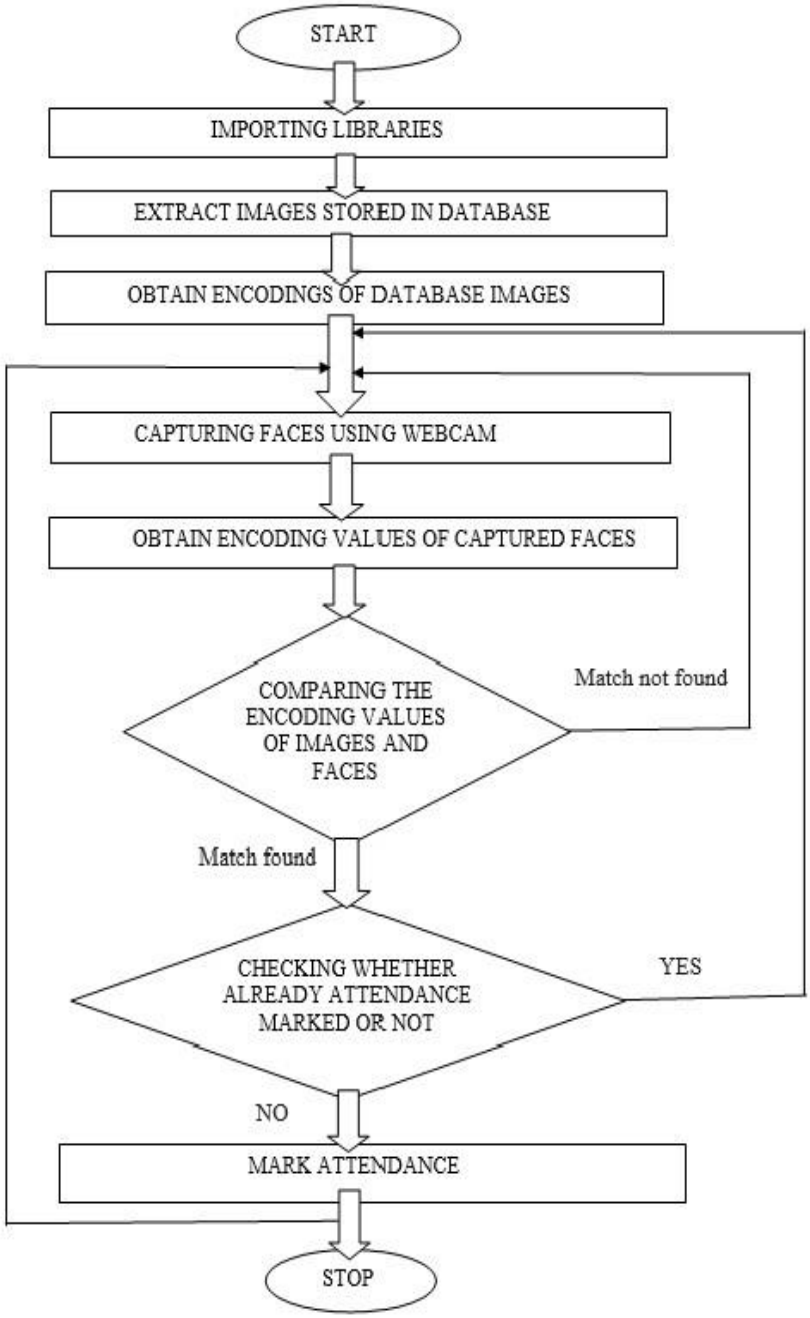

Figure 4.2: Flow Chart

5. RESULTS

In this section, the results of the proposed attendance model are represented. The attendance marking process is carried out by the facial recognition technique has been represented in the following images. Each image represents one stage in the attendance marking system. Figure 5.1 shows the opening of Graphical User Interface of the proposed model. The GUI developed is represented in Figure 5.2. The images of the persons stored in the image database as shown in Figure 5.3. The figure window will open for capturing the faces as shown in Figure 5.5. Whenever a face is detected, the encodings of the corresponding face are generated and compared with the encodings of the images in database.

If the match is found, then the person is identified as shown in Figure 5.5. If not, it will ignore the person as shown in Figure 5.6 and again start capturing faces. The names of the persons recognized are stored in .CSV file as shown in Figure 5.7. The attendance of the person along with the time at which they have come will be marked in the excel sheet as shown in Figure 5.8.

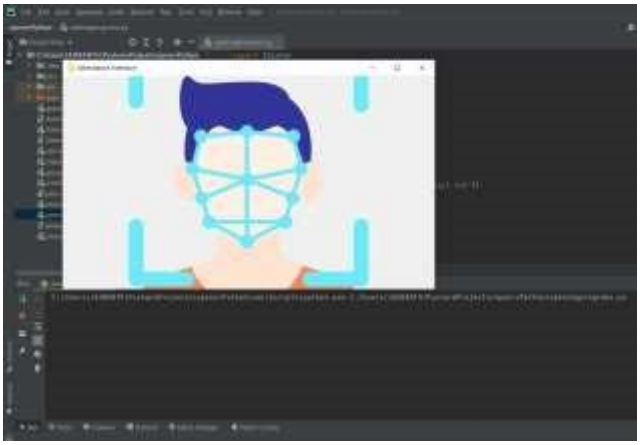

Figure 5.1: Opening Graphical User Interface

Figure 5.2: GUI OF Smart Attendance Model

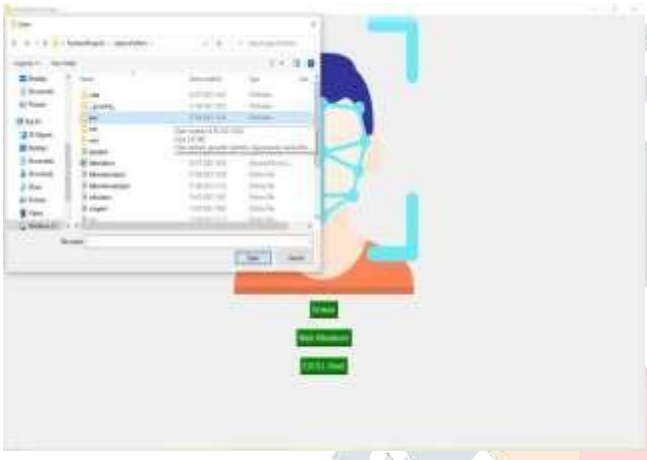

Figure 4.3: Image Database Folder

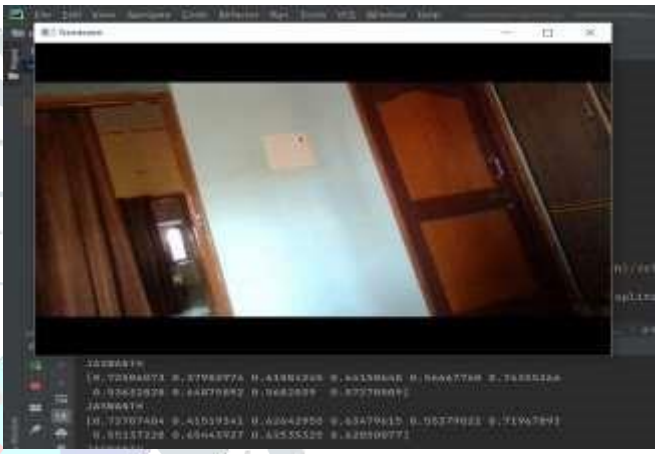

Figure 5.4: Figure Window for Capturing Faces

Figure 5.5: Capturing Person1

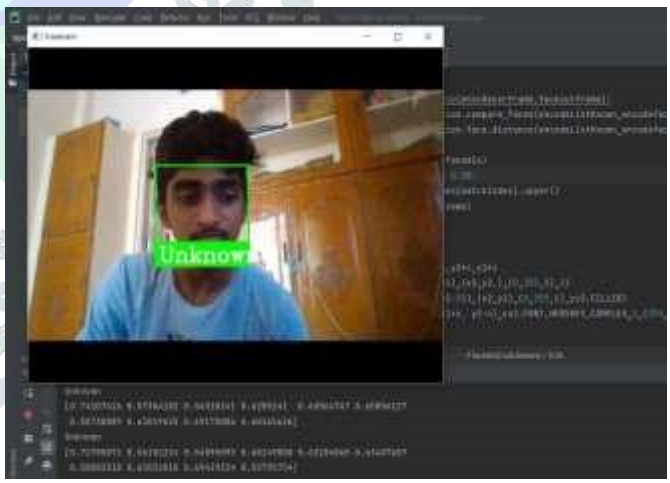

Figure 5.6: Neglecting Unknown Faces.

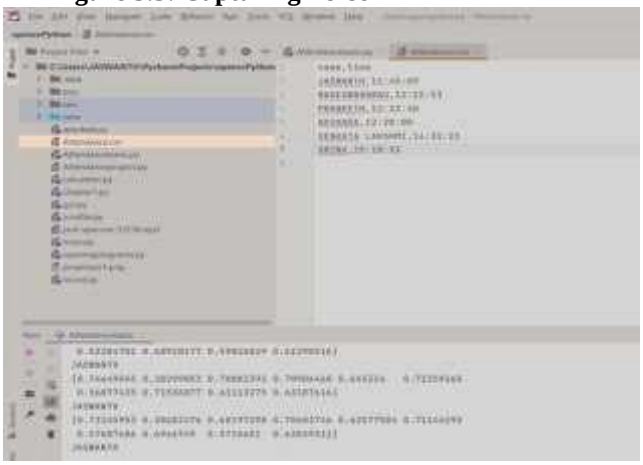

Figure 5.7: .CSV file

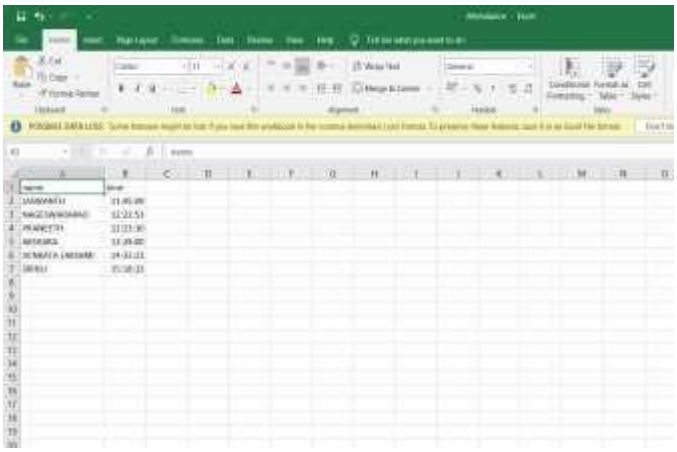

Figure 5.8: Attendance Marked in Excel Sheet.

6. CONCLUSION AND FUTURE SCOPE

The proposed system aims to overcome the pitfalls of the existing systems and provides features such as detection of faces, extraction of the face features, detection of extracted face features, and analysis of attendance. This system aims to build an effective attendance system using face recognition techniques. The proposed system will be able to mark the attendance via facial landmarks. It will detect faces via webcam and then recognize the faces. After recognition, it will mark the attendance of the recognized person and update the attendance record

Automated Attendance System has been envisioned for the purpose of reducing the errors that occur in the traditional (manual) attendance taking system. The Smart Attendance system is implemented to be used in the organizations such as colleges, work places, institutes, etc. This method is secure enough, reliable and available for usage in organizations, without need for installation of specialized hardware in the office. It can be constructed by using web camera and a computer. Also, with the development of Graphical User Interface (GUI), there are more advantages such as ease of operation, reduced complexity, simple to use etc.

The proposed system is able to accomplish the task of marking the attendance in the classroom automatically and output is obtained in an excel sheet as desired in real-time. Further this can be extended to mark the attendance even in the presence of low light. It can also be implemented as an integrated system by adding location of the person.

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