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Automated Attendance System

Recognition System Based on Facial Features

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Abstract

Consider a situation where you need to identify each and every person in a room and categorize each of the persons as present or absent. To mark the presence of hundreds of people in a room takes a lot of time, which means you can eventually be left out with less time to explain the main aim of that meeting, class, or some other things. In such cases, either we may need a lot of time for a meeting or we may need more people to accomplish the tasks. In the present world, time is considered equivalent to money. If you lose your time you will lose your money. Many education institutions and offices see this as a very important consideration to maintain their busy schedule.

In this study, we came to know that many institutions and offices are facing the same issue, so as engineers we decided to take this as a challenge and try to find a solution to it. Our main objective of this project is to make a working model, which helps in marking the attendances of the person automatically and saves precious time. We can say that human effort is simply replaced by our end product which helps the person to spend more time efficiently.

To replace the human effort with an easy and cost-efficient system that has accurate results, we are using a Raspberry Pi 4 Model B as a microcontroller and along with it, we are using a Raspberry Pi camera module to capture the image of the person. To control and give the commands to the microcontroller, we are using MATLAB as a programming language that interprets the commands given by the user.

Using this Raspberry Pi system with a camera module attached to the Raspberry Pi, We can capture the image of the person who comes in front of the camera. Once the person images are captured, the microcontroller starts running the program which can predict the face of a person from the pre-trained database that we have previously stored in the system. Once the prediction is done, the face of the person is automatically marked as present in an excel sheet under the predicted name.

We are concluding that by using the automated attendance system one can avoid the manual marking of persons and save time. For further future works, one can use a good resolution camera module to capture the images clearly and can use the python coding method to access face recognition. We can also develop a mobile application, that can access the camera present in the smartphone which can be used to capture the images and mark the attendances automatically.

Keywords: Camera Module, MATLAB, Python, Raspberry Pi

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Contents

Abstract **i**

List of Figures **iv**

List of Tables **v**

List of Acronyms **vi**

1 Introduction **1**

2 Survey of Related Work **3**

2.1 Biometrics 4

2.2 Face recoginition 5

3 Problem Statement, Objectives and Main Contribution **7**

4 Solution **9**

4.1 Modeling 9

4.2 Implementation 14

4.2.1 Hardware implementation 14

4.2.2 Software Implementation 18

5 Results **23**

6 Conclusions and Future Work **25**

References **27**

A Consent **30**

List of Figures

2.1 Fingerprint recognition [1] 4
2.2 Speech Recognition [2] 5
2.3 Iris Recognition [3] 5

4.1 Flow of controls for the face recognition system 10
4.2 Working principle of SVM [4] 12
4.3 Pre-processing Stage 13
4.4 Training Stage 13
4.5 Predicting Stage 14
4.6 Image of Raspberry Pi connection with camera module 15
4.7 Image of Raspberry Pi 4 Model B 16
4.8 Image of Raspberry Pi Camera Module 2 17
4.9 Setup dialogue box 19
4.10 Commands for capturing images 20
4.11 Pre-processing stage implementation 20
4.12 Implementation of the Training stage 21
4.13 Implementation of Predicting stage 22

5.1 Attendance sheet 24

A.1 Consent document 31
A.2 Rules of registering personal data for this project 32

List of Tables

4.1 Table of functionalities for the system 11
4.2 Table of extra packages in MATLAB 18

5.1 Table of accuracy for the images 23

List of Acronyms

- API - Application Programming Language
- ARM - Advanced RISC Machine
- BLE - Bluetooth Low Energy
- BSi - Back Side Illuminated sensors
- CNN - Convolutional Neural Network
- CSI - Camera Serial Interface
- DNA - Deoxyribonucleic Acid
- DSI - Display Serial Interface
- ECOC - Error Correcting Output Codes
- GHz - Gigahertz
- GPIO - General Purpose Input and output
- HDMI - High-Definition Multimedia Interface
- HOG - Histogram of Oriented Gradients
- ID - Identity Document
- IMX - Interactive Music Exchange
- LAN - Local Area Network
- MATLAB - Matrix Laboratory
- MIPI - Mobile Industry processor Interface
- NIST - NAtioanl Institute of Standard and Technology
- POE - Power Over Ethernet
- RFID - Radio Frequency Identification

- RGB - Red Green Blue
- SD - Secure Digital
- SDRAM - Synchronous Dynamic Random Access Memory
- Soc - System on chip
- SSID - Service Set Indentifier
- SVM - Support Vector Machine
- USB - Universal Serial Bus
- VGA - Video Graphic Array
- V4L - Video 4 Linux

Chapter 1

Introduction

We often wonder how one can identify a person in a humongous crowd and can confidently say that he/she is the one you are finding. Over the past few decades, there has been a substantial increase in the population across the world. Present figures of the world population are approximately 7.9 billion and growing. As with the increase in population, it has become a very difficult task to identify the persons manually as people go to different places in their daily life. To mark the presence of the people in the olden days, people do it manually by taking the name of the person and identifying them.

When we come to educational institutions, marking the attendance of the student is in many cases considered as a mandatory part of the curriculum. We follow the manual process of taking attendance as explained above either by calling or taking the signature of the student. Nowadays with the increase in the number of admitted students, the process of manually marking the presence of students is taking a lot of time. To overcome this, education institutions started providing ID cards and RFID to the people coming to institutions. This scenario is the same for offices too and it is a basic way of identifying a person.

Using RFIDs people also can mark the presence of another person, who is not present in that place. The basic principle of RFID technology is to use the radio-frequency signal to be transmitted by the reader. The recorder of RFID is encoded and loaded into a high-frequency carrier signal and then transmitted by the antenna. If the signal received by the reader or recorder is in the range, then the corresponding card chip circuitry performs voltage doubling rectification, modulation, decoding, and then evaluates the command request, password, authority, etc. Any other person can use the RFID tag of another person which may lead to malfunctioning of the noting down the attendance.

With advancements in technology, people found a new way of identification process using biometrics as each person has different types of biometrics which are unique. It becomes an easy task to identify the person by using their biometrics. In the biometric recognization process, we have different types of identification techniques like using fingerprint identification, iris, speech, and face recognition. In this technology, some of the identification techniques are quite expensive. Iris recognition systems are expensive as they require good cameras for iris recognition. Speech recognition systems can not be effective in the case of mute people. Fingerprint recognition is not accurate in case of any damage caused to the fingers. So we came up with a cost-effective identification system using face recognition.

In this system, we require two hardware components which are the microcontroller unit like Arduino or a microprocessor like Raspberry Pi and the camera module which can be connected to the microcontroller/microprocessor. We are using Raspberry Pi 4 Model B and a Raspberry Pi camera module version 2 to capture the image. We also require a programming language to control the Raspberry Pi board and give commands to it. We are using MATLAB as the programming language. This is cost-effective, portable, and wirelessly accessible that can be just used by giving an external power supply.

As marking attendance of the students or people coming to the educational institutions is mandatory, we can fix this system at the entrance of the classroom, lab, or seminar hall where we have to take the attendance of people. When a person enters the room and comes in front of the camera, the camera module starts to take the images of the person and store them. Later these images are predicted in the database that we previously created. Once it predicts the image of the person in the database, it marks the attendance of the person in an excel sheet. It saves a lot of time by avoiding the manual attendance process. This scenario can be implemented in offices as well.

In our report, we have six chapters in which each chapter describes a particular aspect of our project. The second chapter mainly focuses on the survey of different researchers works who have tried to find a solution, to recognize a person using different identification techniques. The third chapter describes the problem statement, objectives of our project, and the hypothetical solution for the problem. In the fourth chapter, we mainly focus on the solution part of our project which consists of two subsections namely modeling and implementation. In the fifth chapter, we go through the results. Lastly, we are going to conclude our report by conclusion and future work chapter which describes future developments of our project.

Chapter 2

Survey of Related Work

In our day-to-day life, we go to different kinds of places such as offices, schools or colleges, airports, border security, banks, financial institutes, healthcare organizations, hotels, law enforcement agencies, etc, where different people meet up together in large number. In such places, it is important for organizations or institutions to be aware of people entering or leaving and also need to recognize their identity by some means. In a recent survey, it is stated that over 75% of companies around the world are utilizing different recognizing techniques to distinguish over a throng [5].

Before the technology has evolved, recognizing a person is done through manual identification, where every person is called by their name or by taking the signature of the person while entering the room. Based on the list gathered from the above methods the presence of a person is determined. As the population has substantially increased over the past few decades, it has become a quite complex task to manually evaluate a person's presence. The current average population increase is estimated at over 81 million people per year [6].

As technology has evolved over the past few years, there is an increase in the tendency of replacing human effort with a technical device. To recognize a person we use different identification techniques using our present advanced technologies, like ID cards, biometrics, RFID tags, etc. In ID (Identity document) cards we have bar codes or black magnetic strip called magstripe, which contains details of the person [7]. In RFIDs, we use an electromagnetic or electrocoupling effect that uses radiofrequency portions of the electromagnetic spectrum to uniquely identify a person [8].

These technologies are good at identifying a person's identity but cannot distinguish whether the person holding the ID is the authorized person or an imposter. This is proved by the DNA evident investigation team, an organization under the government of the United States (U.S), which stated that 69% of the more than 375 wrongful convictions have been made under different cases [9]. Later with the development of technology the scientist developed a biometric identification technique to recognize a person.

2.1 Biometrics

Biometrics are physical characteristics of a person that determines the unique features in every person. To define this in technical terms biometrics are the application of image processing that uses different physiological or behavioural characteristics to determine a person. A recent survey on present growing biometric technology stated that the market for biometric technology will reach 55.42 million dollars by 2027 [10]. In biometrics, we use different types of physical features to recognise a person like fingerprints, iris, voice recognition, and face recognition.

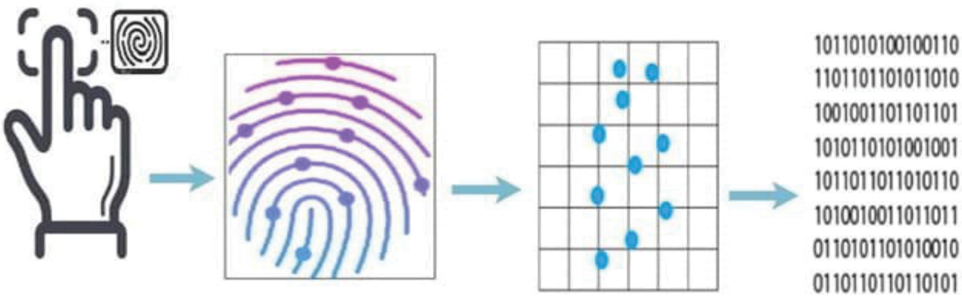

Figure 2.1: Fingerprint recognition [1]

In fingerprint biometrics, we distinguish between the persons based on the unique physical patterns on their fingers. Distinctive examinations demonstrate that no two people have similar fingerprints [11]. There have been many projects on fingerprint recognition and most of them consists of two stages. One where they use a database to train or store the details of different people and two, the recognition mode, where the features are matched with the stored data [12][13]. Figure 2.1 represents the training mode of fingerprint recognition system.

This fingerprint recognition has various applications in different fields mainly in the field of security. In a recent study on fingerprints, it is stated that as we grow older, after the age of 62, the pattern on our fingers starts to change that may mismatch your fingerprint [14]. Sometimes our fingerprint may not be detected due to some physical damage on our finger, which reduces the efficiency of fingerprint recognition. Research under National Institute of Standards and Technology (NIST) stated that the average performance rate for a fingerprint determination system is about 98.6% [15].

Speech recognition is the process of analyzing the entire phrase in order to promptly and effectively provides the appropriate outcome [16]. In most of the voice recognition projects they use two approaches in recognizing a person, they are text independent and text dependent. Most of these are used by disabled persons to evolve along with the fast growing technology. One of the Speech recognition systems are represented in figure 2.2. There are some disadvantages

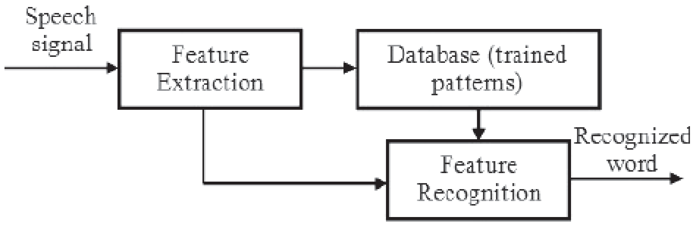

Figure 2.2: Speech Recognition [2]

as well, due to the external environment noises, the recognition of the voice may not be more accurate [17].

Determining a person based on the physiological feature of the person's eyes is stated as iris biometrics. In the iris recognition technique, we have four steps. They are image capture, compliance check and image enhancement, image compression, and biometric template creation for matching [18]. Figure 2.3 represents the flow of controls in the most of the iris recognition systems. There are some disadvantages in iris recognition also, like we cannot use regular camera for iris recognition, it requires IR light sensor for more accuracy.

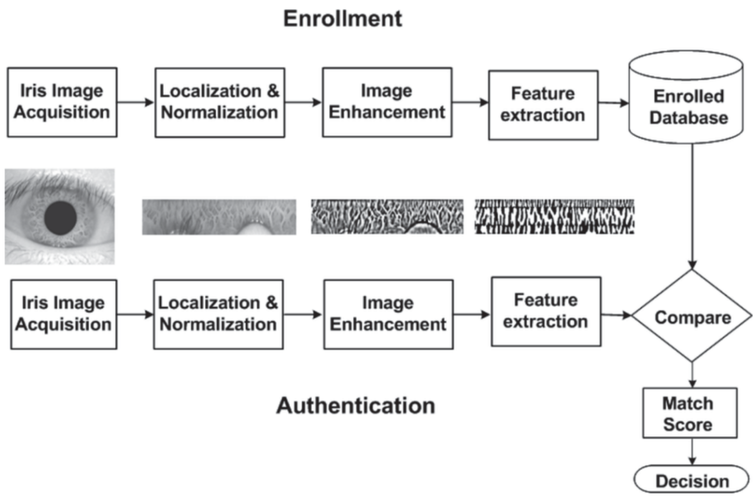

Figure 2.3: Iris Recognition [3]

2.2 Face recoginition

Out of these biometric techniques face recognition technology provides robust and numerous applications in our day-to-day life. Research conducted by the National Institute of Standards and Technology's Facial Recognition Vendor Test says that facial recognition accuracy hits over 99.6% [19]. In face recognition systems we use various feature points in human faces like eyes, eyebrows, nose, mouth, chin, and ears.

There has been an increase in demand for the face recognition systems in various fields, like border security, surveillance cameras, airports, public places, etc, over the last few decades. Most of the systems developed on face recognition so far are based on the machine learning and deep learning algorithms [20]. Most of the systems present now are very expensive, so we develop a user-friendly system and also cost efficient.

Chapter 3

Problem Statement, Objectives and Main Contribution

In the previous chapter, we have discussed about the places where most organizations use different recognizing techniques to recognize a person. In this chapter, we mainly concentrate on the problems faced by many organizations or institutes to recognize a person and the need for the face recognition system. We are also going to discuss about the objectives and contributions in solving these problems using a face-recognizing system.

Let us consider an institution or an office containing thousands of people, working together. As part of their work requirement, different people may arrive to the office at different times of the day. So organizations have a need to maintain a track on people entering and leaving the place. Similarly, with the institutions having thousands of students and hundreds of working staff, it can be of importance to keep a track on the persons entering and leaving the building.

We think that noting down the attendance of students manually is a little bit time consuming and maybe we can use this time for a useful work. Sometimes taking attendance of a students manually in a classroom, crowded with thousands of students, may be a very difficult task for the instructor or a teacher to accomplish. There is a need of technology that replaces this time consuming process.

The problem mentioned above is being solved by many people with different approaches and with different technologies in our vast world. As mentioned in chapter 2, there have been many projects and many subsequent studies on recognition systems that helps people to recognize a person through different fast growing technologies. Face recognition systems have been very expensive and have less accuracy in most of the common methodologies used in recent projects. The accuracy in face recognition system is one of the major factors that contribute to the overall system's performance. Most of the systems that are evolving now are either expensive and more accurate or less expensive and less accurate.

There are some ethical consideration and limitation issues for using facial recognition technologies due to various factors that include racial bias due to testing inaccuracies, racial discrimination in law enforcement, data privacy, lack of informed consent and transparency, mass surveillance and data breach and ineffective legal support [21].

Facial recognition bans are present in San-Francisco, Somerville, Oakland, San Diego, Boston and Portland [22]. On May 6, 2019, ban of facial recognition in San Francisco on concern of privacy and civil rights as facial recognition gains traction as a law enforcement tool. In Europe, at the end of august 2020, Sweden's Data Protection authority decided to ban facial recognition technology in schools. In order to obey these law we need to some authentication from different persons to use their personal information as data for processing the system. This may change according to the country you live in.

In our system before taking the pictures of a person the person should sign the consent (see figure A.1 and A.2 for the consent). This enables the person to know about the use of the face images in our project and also can know how long we are going to work on his/her face. The main purpose of the consent is to helps us in gathering the images of different persons willingly.

Let us consider the research questions that our objectives mainly concentrate on.

- How one can note down attendance automatically?
- Can we detect the faces through a camera wirelessly and up-to what accuracy?
- How long it is going to take the system to detect a person's face, and how is this time depending on the precision wanted?

Our main objective is to develop a face recognizing system that replaces human effort in verifying the person's presence and save the user's time. The system we develop is more reliable and also capable of handling large amounts of data sets at the same time. We aim for cost efficient system have high accuracy in predicting the face identity of a person in the database. Detecting a face using different algorithms and keeping track on people entering the classroom which will be explained in the next chapter.

Chapter 4

Solution

In the previous chapter, we have discussed the problems that are being faced by many organizations in recognizing a person's presence along with the hypothetical solution to it. In this chapter, we are going to discuss the solution to the problem and the functioning of the model. This chapter consists of two sections namely modeling and implementation. The modeling part consists of a detailed explanation of the Raspi based system functionalities and way of implementation. The implementation section consists of a complete overview of the working model that we have developed.

4.1 Modeling

As mentioned in the above chapters the necessity for a face detection system has been increased, the systems that already have implemented are expensive. So it is essential that the system that is being implemented should be cost-efficient, easily movable, and user-friendly. So we came up with a solution that can satisfy all these conditions. So we propose a solution of Raspi based system which consists of a Raspberry Pi 4 Model B as a micro-controller with the Raspberry Pi camera module which helps us to implement the system for real-time detection.

The work flow of the face recognition system can be expressed as shown in figure 4.1. In order to detect a face through the face recognition system, we need to extract the features from the image, and we need to process them. We use some machine learning algorithms and some parts of the Convolutional Neural Networks (CNN) to classify the faces of different people. We use MATLAB programming tool to program our system. This system is called as the Raspi based recognizing system. These techniques and algorithms help us to overcome the problems discussed above.

This Raspi based system is a portable device that can be wirelessly operated by the user and it is user friendly device as well. This system consists of Raspberry Pi 4 model B board along with the camera module which help us in detecting a real time face. Table 4.1 depicts the functionalities and technologies that can be implemented to satisfy the above conditions.

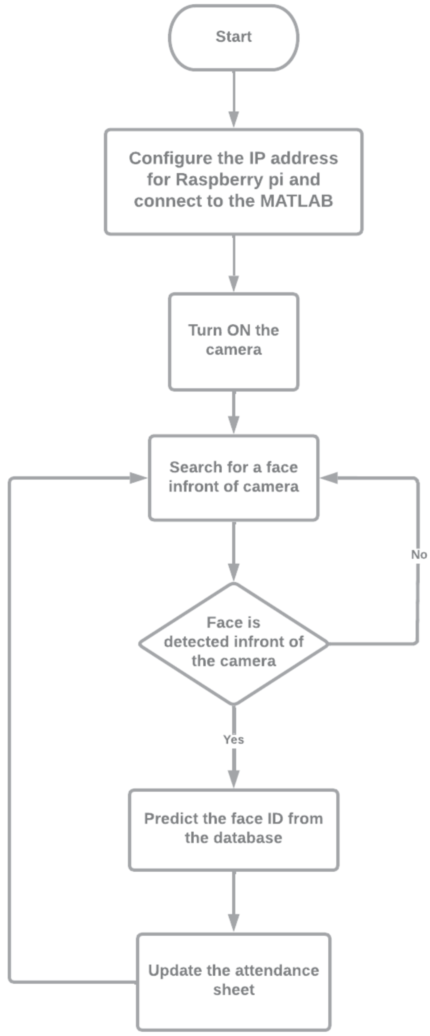

Figure 4.1: Flow of controls for the face recognition system

There are six different functionalities that our system can accomplish. The first functionality is acquiring an image of a person's face. This can be implemented using Raspberry Pi 4 Model B with a Raspberry Pi camera module, a functionality that helps the user to move the device anywhere he/she wants. The second functionality is detecting a face in an image which is helpful in resizing an image. To accomplish this functionality, we use a cascade object detector in the computer vision toolbox in MATLAB which detects the faces inside an image.

Feature extraction from an image is necessary for any face recognition system. This helps us to know about the feature points that are present inside an image and that can help to distinguish between different persons. Extracting features of a face from an image can be accomplished through the HOG (Histogram of

Table 4.1: Table of functionalities for the system

Functionalities		**Possible technologies and algorithms**
General	**Specific**	
Capturing image wirelessly	Face of a person	Raspberry Pi 4 model B with Raspberry Pi Camera module
Detection	Face in an image	Cascade object detector in Computer vision toolbox MATLAB
Feature extraction	Face features	HOG (Histogram of Oriented Gradients) feature extraction and points tracker in computer vision toolbox
Classification and prediction	Data sets containing of different faces and respective labels	SVM (Support Vector Machine) classifier
Update	Attendance sheet	Using MATLAB and Microsoft Excel sheet

Oriented Gradients) feature descriptor that counts the occurrence of gradient orientation in localized portions of the face [23]. This HOG feature extraction is readily implemented using a computer vision toolbox in MATLAB.

Whenever there are humongous databases we need to classify them into different subsections to identify a specified type of file. The same applies to the images of different persons. To classify the images of different faces we use SVM (Support Vector Machine), a machine learning algorithm that can analyze data for classification and regression analysis [24]. The SVM is also called a maximum margin classifier that is, it classifies different objects of different classes with the hyperplane with maximum marginal distance using the support vectors.

Let us consider we are giving n points of the face in an image in the form of (X1,y1), (X2,y2), ..., (Xn,yn), where y is either 1 or -1 depending on the class X belongs, X is p dimensional vector and W is a vector perpendicular to hyperplane (decision line), where p is the number of data points in an image. The dot product of both W and X can be written as

$$\vec{X}.\vec{w} = C \text{ (the point lies on the decision boundary)} \tag{4.1}$$

$$\vec{X}.\vec{w} > C \text{ (Positive samples)} \tag{4.2}$$

$$\vec{X}.\vec{w} < C \text{ (Negative samples)} \tag{4.3}$$

The above equation 4.1 can be rewritten as equation of hyperplane as follows

$$\vec{X}.\vec{w} + b = 0 \ , \tag{4.4}$$

$$where \ b = -C$$

y can be determined as

$$y = \begin{cases} \ \ 1 \ \ for \ \vec{X}.\vec{w} + b >= 1 \\ \text{-1} \ \ for \ \vec{X}.\vec{w} + b <= -1 \end{cases} \tag{4.5}$$

Figure 4.2 depicts how an SVM classifier uses hyperplane to divide the points of two different classes with maximum marginal distance. According to the value of y, the prediction of the class will be made by the SVM classifier. If the value of y is 1 the point belongs to the positive side of the hyperplane and if the value of y is -1 it belongs to the negative side of the hyperplane.

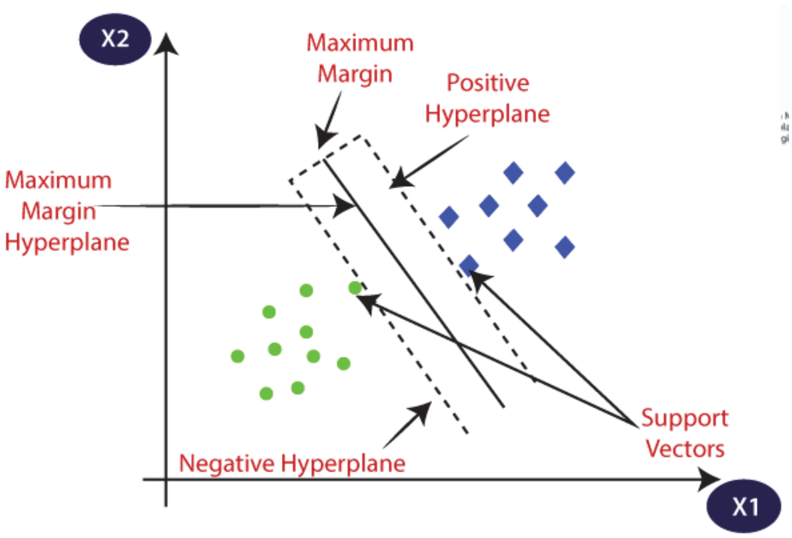

Figure 4.2: Working principle of SVM [4]

The last functionality is to update the attendance sheet of the class automatically. So we used MATLAB programming software to automatically update the excel sheet of attendance in the present folder. MATLAB helps us to communicate with a different types of files in a folder and can read the data from the file automatically. We program it in such a way that the excel sheet is updated when the system predicts the person's face and automatically updates it.

Our system can broadly be classified into three different stages. Initial stage is pre-processing, where images of different faces are stored as a database in a folder. These images are used to train a classifier model which eventually can compare the features of different images and classify them accordingly. To accomplish the first stage of the system we need to initialize the camera module in Raspberry Pi.

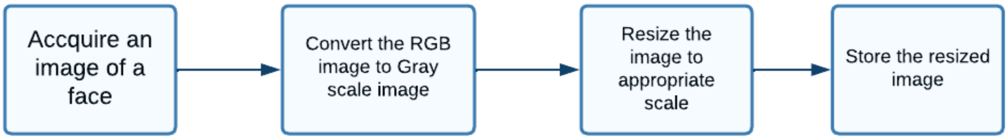

Figure 4.3: Pre-processing Stage

We collect 300 images per person to have more feature points for more accurate results. Figure 4.3 depicts the working of pre-processing stage.

In this stage, we also convert the 3-dimensional representation, which is an RGB image, to 2-dimensional representation which is a grayscale image. We detect the face in the captured image using the above algorithms and scale them to appropriate sizes that help us in having large sets of unbiased images that have identical sizes. This helps us to concentrate more on the facial features rather than on other objects of the image. These resized images are now stored in the folder as our database. This pre-processing stage is implemented for both training the database and predicting a face id through a query face.

The second stage is the training stage where we train the SVM model using the database images that we have used during the pre-processing stage. In this stage firstly we read an image from the database and extract the HOG features from the image. After this, we give these feature extracted images to the SVM classifier to classify different faces. This stage of the system is very important to predict a face of a person. Figure 4.4 depicts the stages of the training stage.

Figure 4.4: Training Stage

The last stage is the predicting stage where we predict the face ID of a query image and update the attendance sheet with the respective face ID. Firstly we acquire a query image through the Raspberry Pi 4 board and the camera module and we store them in a separate folder. Then we read the query image and do pre-processing to it so that it can focus on the face in the query image. After pre-processing we give it to the SVM classifier model to predict the face ID of the image.

After predicting the face ID by the classifier, we match this face ID with the names on the attendance sheet. If the face ID predicted is present in the

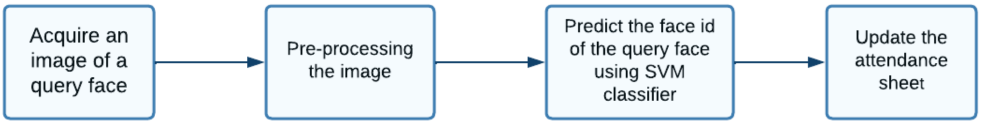

Figure 4.5: Predicting Stage

attendance sheet as an expected ID, we update the field of attendance as a present. If the predicted ID is not present in the attendance sheet then we store the face image in a separate folder for manual verification purposes and figure 4.5 represents the predicting stage of the system.

4.2 Implementation

We have previously discussed the modeling, and now we discuss the implementation of our model. In this section, we have two subsections namely hardware implementation and software implementation. In the hardware implementation, we discuss about the hardware components we used to accomplish this project. In the software implementation part, we will go through the programming language that we used to control the hardware components which is Matlab programming. In the software implementation, we explain different modules, tools, and packages that we have used in our code to capture and predict different faces.

4.2.1 Hardware implementation

In this hardware implementation, we use two hardware components namely Raspberry Pi 4 computer Model B and Raspberry Pi Camera module 2. We use an SD card of size 16 GB to boot the system properties and support MATLAB packages on to the Raspberry Pi board. Using this SD card, we configure the SSID and password of our network and load the packages onto the board. The configured SD card is inserted into the SD card slot in the Raspberry Pi board. This enables the Raspberry Pi board to connect to the network wirelessly and enables the user to program the device.

The camera module enables us to capture the images and predict the face id of a person in real-time. In figure 4.6, we connect to the CSI port in the Raspberry Pi board with Raspberry Pi camera module v2. We used USB C port to provide the power supply to the Raspberry Pi. We connected the Raspberry Pi board wirelessly to MATLAB in order to program the entire system.

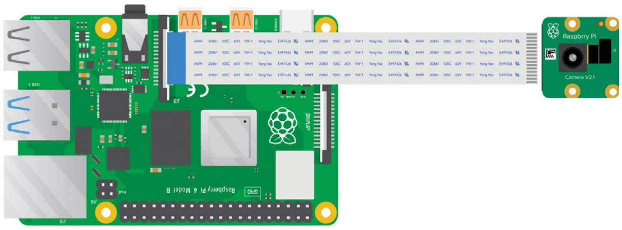

Figure 4.6: Image of Raspberry Pi connection with camera module

Raspberry Pi 4 computer Model B

Raspberry Pi is the name of a series of single-board computers produced by the Raspberry Pi Foundation, a British charity dedicated to making computer science education more accessible. The Raspberry Pi was released in 2012, and since then several iterations and versions have been released. The original Pi had a 700 MHz single-core CPU and just 256 MB of RAM, while the latest model has a quad-core CPU clocked at over 1.5 GHz and 4 GB of RAM. There are several generations of the Raspberry Pi family, from the Pi 1 to the Pi 4, and even the Pi 400. Most generations have generally had an A model and a B model. The Model B board has more applications than model A like model B has more USB ports, more memory, and an Ethernet port when compared to model A boards.

The Raspberry Pi is a small single-board computer, when connected to peripherals such as a keyboard, mouse, and display, it can function as a mini PC. The Raspberry Pi 4 Model B is the latest product in the popular Raspberry Pi series of Computer. Raspberry Pi 4 Model B was released in June 2019. It offers a revolutionary increase in processor speed, multimedia performance, memory, and connectivity over previous-generation devices, like Raspberry Pi 3 Model B+, for maintaining backward compatibility and a similar level of power consumption. For the end-user, the Raspberry Pi 4 Model B is a desktop computer. Performance is comparable to x86-based PC systems.

Specifications of Raspberry Pi 4 Model B :

- Processor: Broadcom BCM2711, quad-core Cortex-A72 (ARM v8) 64-bit SoC @ 1.5GHz
- SDRAM : 4GB
- Connectivity:
  - 2.4 GHz and 5.0 GHz IEEE 802.11b/g/n/ac wireless LAN
  - Bluetooth 5.0, BLE
  - Gigabit Ethernet
  - 2 × USB 3.0 ports

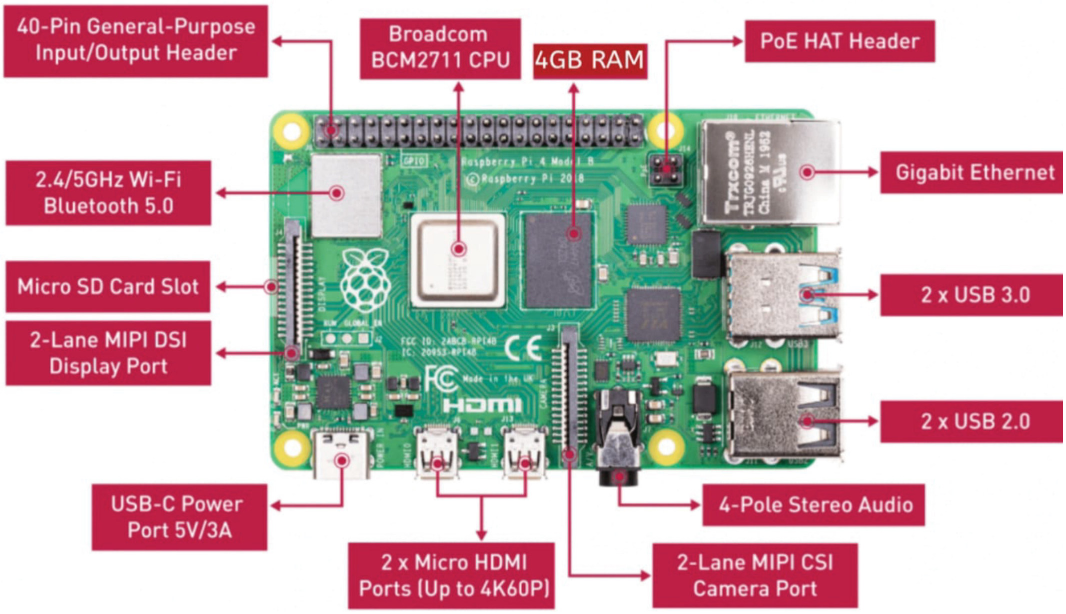

Figure 4.7: Image of Raspberry Pi 4 Model B [25]

  - 2 × USB 2.0 ports

- GPIO: Standard 40-pin GPIO header(fully backward-compatible with previous boards)

- Multimedia :

  - 2 × micro HDMI ports (up to 4Kp60 supported)
  - 2-lane MIPI DSI display port
  - 2-lane MIPI CSI camera port
  - 4-pole stereo audio and composite video port
  - H.265 (4Kp60 decode)
  - H.264 (1080p60 decode, 1080p30 encode)
  - OpenGL ES, 3.0 graphics

- SD card support: Micro SD card slot for loading operating system and data storage

- Input power:

  - 5V DC via USB-C connector (minimum 3A)
  - 5V DC via GPIO header (minimum 3A)

  - Power over Ethernet (PoE)–enabled (requires separate PoE HAT)

- Environment: Operating temperature 0–50ºC

Raspberry Pi camera module V2 :

The Raspberry Pi 2 camera module replaced the original camera module in April 2016. The version 2 camera module features an 8-megapixel Sony IMX219 sensor (compared to the 5-megapixel Omni-Vision OV5647 sensor of the original camera module). The camera module version 2 is used to record high-resolution video and still images. It's easy to use for beginners and has a lot to offer advanced users if you want to expand your knowledge. There are many examples online of people using it for time-lapse, slow motion, and other videos. You can also use the libraries that come with your camera to create effects.

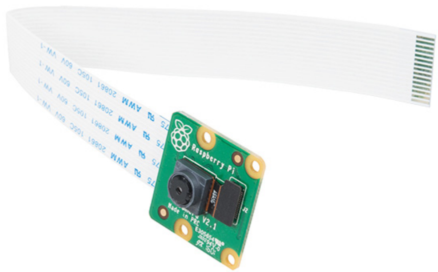

Figure 4.8: Image of Raspberry Pi Camera Module 2

You can read all the details about the IMX219 and the Exmor R back-illuminated sensor architecture on Sony's website, and it is more than just a resolution upgrade: it's a significant improvement in image quality, color fidelity, and low-light performance. It supports 1080p30, 720p60, and VGA90 video modes, as well as photo capture. It connects to the CSI input of the Raspberry Pi with a 15 cm ribbon. The camera works with all Raspberry Pi 1, 2, 3, and 4 models. It can be accessed via the MMAL and V4L APIs, and several third-party libraries are available, including the Pi camera Python library. The camera module is very popular for home security and wildlife trapping applications.

Specification of Camera module

- Resolution - 8 megapixel native resolution sensor-capable of 3280 x 2464 pixel static images

- Extended supports upto 1080p30, 720p60 and 640x480p90 video
- Size - 25mm x 23mm x 9mm
- Weight - 3g
- Connects to the Raspberry Pi board via a short ribbon cable (supplied)
- Image sensor - Sony IMX219PQ high-speed video imaging and high sensitivity
- Dimensions 1.4m X 1.4m pixel with
- Technology used OmniBSI
- Optical size - 1/4"

4.2.2 Software Implementation

In this section, we elaborately explain about the modules, functions, and programming tools that we have used in MATLAB to implement our system. As stated in the hardware implementation part we use a micro SD card in order to boot the system and connect with MATLAB. Let us see how to connect the Raspberry Pi board with the MATLAB wirelessly. We need some packages that are to be loaded onto the Raspberry Pi board before connecting to MATLAB. This can be done by uploading the packages onto the external micro SD card and insert the SD card in the slot given on the board.

There are some packages that we need to install in MATLAB, before programming the system. The packages stated in table 4.2 are installed in order accomplish different tasks.

Table 4.2: Table of extra packages in MATLAB

Support packages in MATLAB	**Use of the package**
MATLAB Support Package for Raspberry Pi Hardware	Connecting Raspberry Pi board to MATLAB, capturing images
Computer Vision toolbox	Cascade object detection, HOG Feature extraction
Statistics and Machine learning toolbox	Support Vector machine classification and prediction
Image processing toolbox	Cropping and resizing of an image

Firstly we need to connect the Raspberry Pi board to the MATLAB using the support package mentioned in table 4.2. After installing the Raspberry Pi support package in the MATLAB a dialogue box appears on the screen as shown in figure 4.9. We selected the Raspberry Pi model B board and followed the instructions and installed the packages, network parameters onto the micro SD card. The micro SD card is now inserted in the micro SD card slot of the Raspberry Pi board. The Raspberry Pi takes some time in order to boot the system.

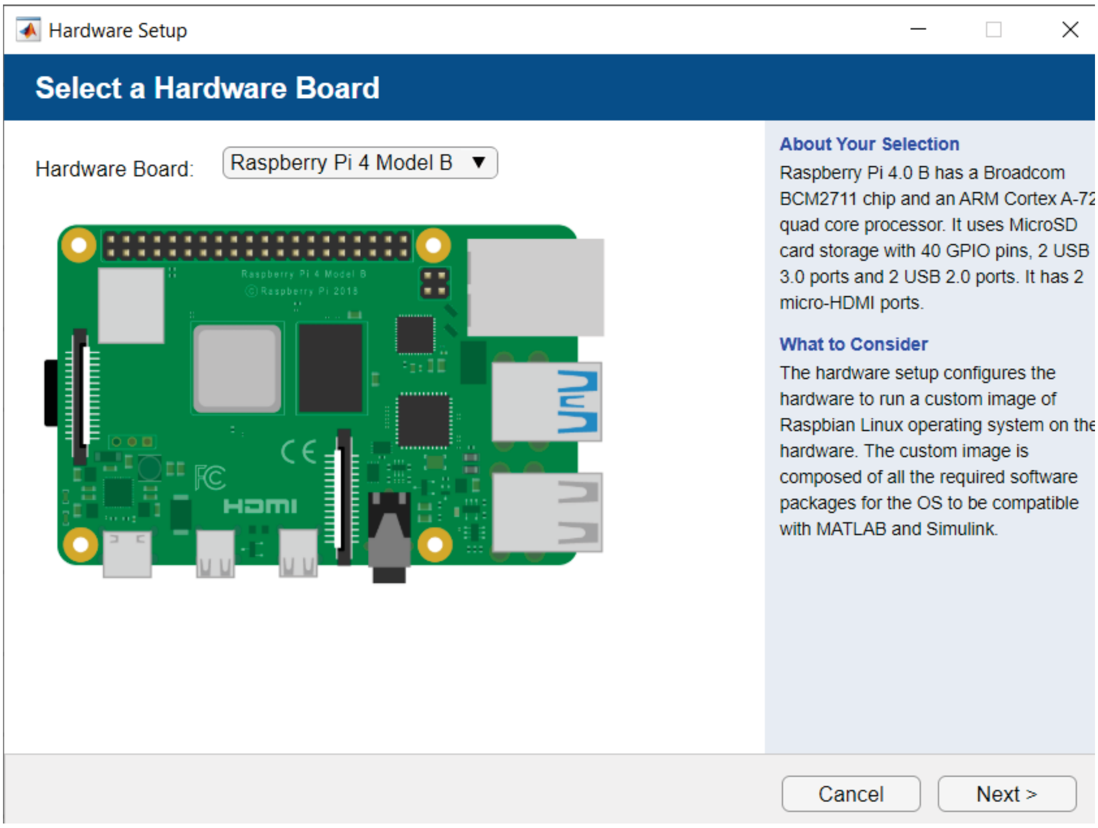

Figure 4.9: Setup dialogue box

After booting the system, the Raspberry Pi board is given a particular IP address which is detected by MATLAB and enables the connection between the Raspberry Pi board and MATLAB. We have to remember that both the Raspberry Pi and the system using MATLAB should be connected to the same wireless network. From the figure 4.10 we can capture an image with the Raspberry Pi board. By using this camera we can load an RGB image by calling *'snapshot(Cameraboard-object)'* as mentioned in figure 4.10.
Let us now discuss about the implementation of the different stages, as mentioned in the Modeling section, through MATLAB in a detailed manner.

```
% Create the webcam object.
mypi = raspi();
myCam = cameraboard(mypi);
% Capture the image.
videoFrame = snapshot(myCam);
```

Figure 4.10: Commands for capturing images

Pre-processing stage

As mentioned in the previous section this stage is used in both training stage and also in predicting stage. From figure 4.3 we need to acquire a 3-dimensional RGB image, which can be implemented using the Raspberry Pi board with the Raspberry Pi camera module with the appropriate command as mentioned in the previous paragraph. The captured image is a 3-dimensional image, an RGB image, which requires more space to store these images. So to reduce the memory usage we convert the RGB image into a gray scale image. This gray scale image has only one pixel plane, while the RGB image has three planes namely Red, Green and Blue.

The next step in this stage is the resizing and cropping of the gray scale image to appropriate size depending on the face of a person in the image. To detect a face in an image, we use cascade object detector in the computer vision toolbox which helps us in detecting different objects like person's face, eyes, nose, mouth and body. It uses the Viola-Jones detection algorithm and a trained classification model for detection of different objects and different persons [26]. Figure 4.11 depicts how to implement this pre-processing stage using the computer vision tool box and the image processing toolbox in the MATLAB. This processing is done for every image we store in our database and every image we capture during the predicting stage.

```
%create a cascade detector object
faceDetector = vision.CascadeObjectDetector('FrontalFaceCART','MinSize',[200,200]);
bbox = faceDetector.step(videoFrame);
%crop to detected face size
face = imcrop(videoFrame, [bbox(1) bbox(2) bbox(3) bbox(4)]);
scale = 500/size(face,1);
%resize the image to the appropriarte scale
faceid = imresize(face,scale);
%convert RGB image to Gray scale image
faceid = rgb2gray(faceid);
```

Figure 4.11: Pre-processing stage implementation

Training stage

In this stage, we basically have three commands. The first one is to read an image from a folder in the database, the second one is extracting the Histogram Oriented Gradient (HOG) features from an image and last one is training the Support Vector Machine (SVM) classifier model using the database images and labels, see figure 4.4. To read a large number of data images in the MATLAB we have *'imageSet'* command to read a particular file in the current directory. It can store these images which enables us to process any image within the specified folder.

After reading the images in the database, we have to extract the HOG features from the image to train a classifier. HOG features are nothing but extracting the edge directions in an image that can differ from one image to another image. This can be accomplished using the computer vision toolbox which has a built-in function to execute this command. The extracted features are stored in a variable and later given to the machine learning classifier.

```
%Read set of images in  the database
Database = imageSet('faces datected','recursive');
%to extract the HOG features in an image
features = extractHOGFeatures(Database(1),2);
%Label of the image dataset in the database
traininglabel = Database(1).Description;
%Train the SVM classifier using the features and the label
faceclassifier_2 = fitcecoc(features,traininglabel);
```

Figure 4.12: Implementation of the Training stage

Before going to implement the training of the SVM classifier we need to know what are the functions that can classify the images and the labels. We use the Fit model classifier that can classify the data sets using binary Support Vector Machine with one versus one coding design, which takes the database image sets and the database labels parameters as the inputs arguments. We used ECOC (Error Correcting Output Codes) model to predict the face labels of the image and to classify the database images. There is command in the Statistics and Machine learning toolbox that returns an ECOC model using the predictors in table database images and the class labels. Figure 4.12 represents the implementation of the training stage which is done for every image in the database.

Predicting stage

In the predicting stage, there are four levels namely acquiring an images from the Raspberry Pi up-to desired amount of time, pre-processing the image, predicting the label of the face using SVM classifier and lastly updating the attendance sheet. As shown in figure 4.5, the first two stages are easily implemented using the above mentioned commands in the previous subsections in the software implementation. Now we have to predict the label of a face and update the attendance sheet automatically.

To predict a face label using the images in the database we use the trained classifier model which is done in the previous stage, that is in the training stage. The computer vision toolbox in the MATLAB has an inbuilt command that can predict the labels of the given classifier taking only two commands. One is the trained classifier model and the other one is labels of the classifier. The next step is to update the predicted person's label in the excel sheet as present.

```
%read an image from the current attendance folder
q = read(Database2(1),k);
%Predict the label of the person using SVM training classifier
personlabel_2 = predict(faceclassifier_2,features_q);
%Read the attendance sheet excel
[~,~,raw] = xlsread('attendance.xlsx');
% Compare user input string with entries in the Excel sheet
p = strcmp(personlabel_2,raw);
%Get Row number
rowNum = find(p==1);
% Update in the excel sheet
writematrix('Present','attendance.xlsx','Sheet','Sheet1','Range',strcat('B',rownum));
```

Figure 4.13: Implementation of Predicting stage

To read an excel sheet in the current directory we can use xlsread command in the MATLAB, which can read the entire excel sheet document that user had specified. The predicted label can be compared with the cells in the excel sheet by comparing strings in the excel sheet with the label. This will return the row number in the excel sheet which can enable us to write the particular string beside the person's name. This can be done by using figure 4.13 implementation. These are the modules and functions we have used to implement our project.

Chapter 5

Results

Before going to the results part, let us categorize different terminology of the system while using any recognition system. To distinguish the accuracy in a more detailed way we use four terms namely, True positive, False positive, True negative, and False negative. These are often referred to as confusion matrix in the field of machine learning.

True positive refers to the successful identification of a condition present. False positive refers to the wrong identification of the condition present. True negative refers to the successful identification of the absence of the condition. False negative refers to the wrong identification of the absence of the condition.

In our project, our condition is to identify the person in the database. True positive in our case is if the person in the database is identified correctly. False positive is if the person is not in the database but is identified as a person in the database. False negative is if the person in the database is not identified correctly. True negative is if the person is not identified but also not present in the database.

Table 5.1: Table of accuracy for the images

Person label in the Database	**Number of Testing images of a person**	**Number of true positives**	**Number of false positives**	**Accuracy =** $\frac{\textbf{Correct classifications}}{\textbf{All classifications}}$
A	6	4	2	66.67%
PR	12	12	0	100%
SCR	2	2	0	100%
Venk	4	4	0	100%
CH	3	3	0	100%
Average accuracy				93.33%

Let us take the images in the database and test the system's accuracy. We have collected 15 different person faces in the database. For each face, we collected 200 training images as the database. We have tested the classifier model by giving a query image from the Raspberry Pi camera as mentioned in the implementation section. We tested five different person's faces from the database with the system and calculated the accuracy. Table 5.1 show the outcome of the results of the test.

Some of the images we tested are predicted as the different person within the database. True positives in table 5.1 represent the images that are exactly matched with the images in the database. False positives represent the images that are mismatched with the database images. This mismatching of images is mainly due to the similar type of features in the images. The accuracy of the system that we developed is approximately 93.33% as stated in table 5.1. The total time consumed in taking the images from the Raspberry Pi to process and predict is nearly 5 minutes for 27 input images. The updating of the excel sheet for these persons has been done as shown in figure 5.1.

	A	B	C	D	E
1	**Names**	**A/P**			
2	b2				
3	A	Present			
4	RGS				
5	SCR	Present			
6	PR	Present			
7	Venk	Present			
8	venkat				
9	Va				
10	DC				
11	GM				
12	SAD				
13	Omk				
14	NS				
15	NR				
16	CH	Present			
17					
18					
19					
20					
21					

Sheet1 Sheet2

Figure 5.1: Attendance sheet

Chapter 6

Conclusions and Future Work

After a detailed explanation in all the previous chapters lastly, we want to conclude with a summary of what we have accomplished and also the future works regarding the face recognition systems. To accomplish the task of noting down the attendance automatically through our solution, we have used Raspi based system that captures the pictures of different persons and update the attendance automatically without any manual work. We capture these pictures using Raspberry Pi board with the camera module that is connected to MATLAB. The process of giving commands from MATLAB to the Raspberry Pi board is done wirelessly, which enables us to make the device portable.

There have been many advantages by using this automated attendance system. It is mainly used to reduce the time consumed in taking attendance. This low-cost portable device helps the institution or organization to replace their human effort. The system accuracy is about 93.33% and the time consumed to take the attendance automatically by the system, is nearly 5 minutes. By this, we can say that the above stated problems have been answered through our solution.

We used MATLAB to program and store the database images of the system. We can even simplify this system by deploying the database images and the program onto the Raspberry Pi board without connecting to MATLAB. This simplifies the system by reducing the external monitoring of the user through MATLAB. One can run more number tests with more persons with the system to show that, the system can deal with large number of databases.

We used the machine learning algorithms in MATLAB to predict the face labels from the database. One can use the Python programming language to implement this system using other feature mapping techniques. The system accuracy can be improved by using more advanced feature mapping techniques like Convolutional Neural Networks (CNN) and Artificial Intelligence. Our system consumes almost 5 minutes to update the attendance sheet. To overcome this, we can use deep learning techniques to train our model and map different features, which helps in performing the tasks in less time. One can also develop a mobile application to see the outcomes of the system instantly.

To improve the accuracy of the system we may use higher-level image processing techniques like CNN (Convolutional Neural Networks) and some deep learning algorithms. We have an accuracy of 93.33% which can be improved with better lighting conditions near the camera setup. We used SVM (Support Vector Machine), a machine learning technique to match the features of different images of various faces with the database images, as mentioned in chapter 4. By using CNN we can even map the detailed information of the image where we can differentiate the same person of different ages.

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Appendix A

Consent

Participation in student project with face recognition

This is a written consent on participation in the student project "Automated attendance system" performed at Department of Mathematics and Natural Sciences at BTH in the year 2022.

The volunteering test persons are invited to a lab, where a set of facial photos are taken by the students by using the lab equipment (Raspberry Pi with a camera module).

Before this the test persons will be informed about the aim of the project and the use of the gathered images, and they will sign a written consent.

No additional data such as the person's name, age or gender will be added to the data. The images will be labelled with just a number, letter or other word. The data base with the photos can only be accessed by the two involved students and their supervisor, and will be deleted no later than 2022-09-30.

Signature

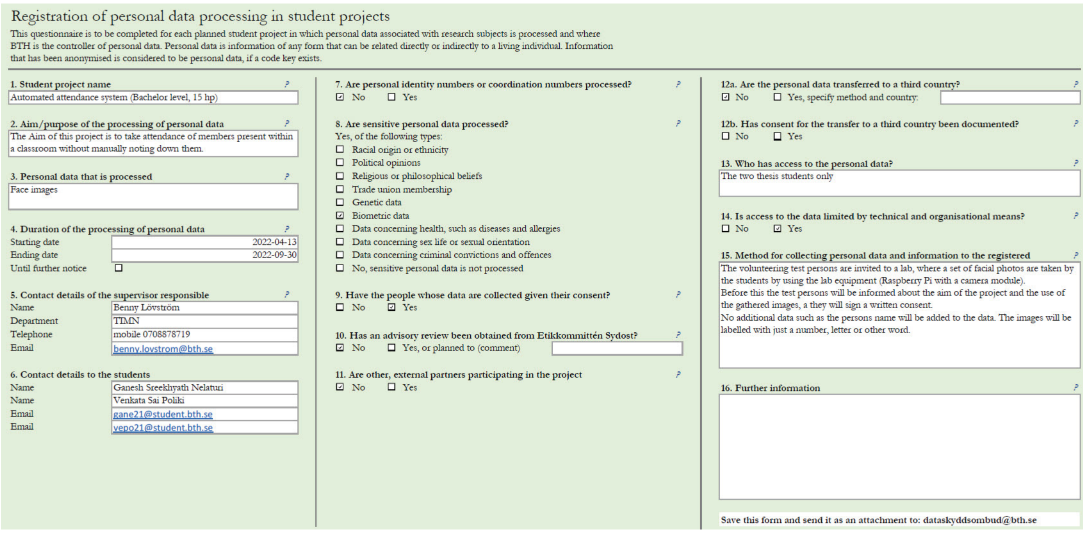
I have been informed about the project and read the text above, and I agree to have the photos of me used in the database of the project.

____
Date

____
Signature

____
Name

Figure A.1: Consent document



Registration of personal data processing in student projects

This questionnaire is to be completed for each planned student project in which personal data associated with research subjects is processed and where BTH is the controller of personal data. Personal data is information of any form that can be related directly or indirectly to a living individual. Information that has been anonymised is considered to be personal data, if a code key exists.

1. Student project name
Automated attendance system (Bachelor level, 15 hp)

2. Aim/purpose of the processing of personal data
The Aim of this project is to take attendance of members present within a classroom without manually noting down them.

3. Personal data that is processed
Face images

4. Duration of the processing of personal data

Starting date	2022-04-13
Ending date	2022-09-30
Until further notice	☐

5. Contact details of the supervisor responsible

Name	Benny Lövström
Department	TIMN
Telephone	mobile 0708878719
Email	benny.lovstrom@bth.se

6. Contact details to the students

Name	Ganesh Sreekhyath Nelaturi
Name	Venkata Sai Poliki
Email	gane21@student.bth.se
Email	vepo21@student.bth.se

7. Are personal identity numbers or coordination numbers processed?
☑ No ☐ Yes

8. Are sensitive personal data processed?
Yes, of the following types:
- ☐ Racial origin or ethnicity
- ☐ Political opinions
- ☐ Religious or philosophical beliefs
- ☐ Trade union membership
- ☐ Genetic data
- ☑ Biometric data
- ☐ Data concerning health, such as diseases and allergies
- ☐ Data concerning sex life or sexual orientation
- ☐ Data concerning criminal convictions and offences
- ☐ No, sensitive personal data is not processed

9. Have the people whose data are collected given their consent?
☐ No ☑ Yes

10. Has an advisory review been obtained from Etikkommittén Sydost?
☑ No ☐ Yes, or planned to (comment)

11. Are other, external partners participating in the project
☑ No ☐ Yes

12a. Are the personal data transferred to a third country?
☑ No ☐ Yes, specify method and country:

12b. Has consent for the transfer to a third country been documented?
☐ No ☐ Yes

13. Who has access to the personal data?
The two thesis students only

14. Is access to the data limited by technical and organisational means?
☐ No ☑ Yes

15. Method for collecting personal data and information to the registered
The volunteering test persons are invited to a lab, where a set of facial photos are taken by the students by using the lab equipment (Raspberry Pi with a camera module).
Before this the test persons will be informed about the aim of the project and the use of the gathered images, a they will sign a written consent.
No additional data such as the persons name will be added to the data. The images will be labelled with just a number, letter or other word.

16. Further information

Save this form and send it as an attachment to: dataskyddsombud@bth.se

Figure A.2: Rules of registering personal data for this project

Faculty of Engineering, Blekinge Institute of Technology, 371 79 Karlskrona, Sweden