A Minor Project Report on

A Real-time Classroom Attendance System Utilizing Viola–Jones for Face Detection and LBPH for Face Recognition

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Abstract

The face of a human is crucial for conveying identity. Computer scientists, Neuro scientists, and psychologists, all exploits this human feature using image processing techniques for commercial, and law enforcement applications. Likewise, this feature can be invited into classrooms to maintain records of students' attendance. Contemporary traditional way of recording attendance involves human intervention and requires cooperation of the students which is hectic and contribute towards waste of class time. An automated real-time classroom attendance system detects students from still image or video frame coming from a digital camera, and marks his/her attendance by recognizing them. The system utilizes Viola–Jones object detection framework which is capable of processing images extremely rapidly with high detection rates. In the next stage, the detected face in the image is recognized using Local Binary Patterns Histogram.

Keywords–Computer vision; face detection; face recognition; feature extraction; image processing; Local Binary Patterns Histogram; object detection; Viola-Jones object detection.

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Chapter 1

Introduction

Human face is crucial for conveying identity. This human feature can be exploited to be applied in large number of real life activities like tracking employees, surveillance of criminals, finding information about celebrities and much more. But face is a dynamic object and has a high degree of variability in its appearances. For computer to be able to understand this variability in appearances of human face, face detection and face recognition methods have been introduced. These domains, over the past several years has received significant attention and are increasingly used to solve complex human problems.

Maintenance of attendance records play a vital role in the analysis of performance of any organization. Every institute has their own method of monitoring attendance of students or staffs. In the classroom, the traditional way of marking attendance involves a human calling out the name of the students individually. This contemporary attendance marking method is hectic and time consuming, as usually 5-10 minutes is required to record the attendance, which is a wastage of useful class time [1]. Furthermore, this traditional attendance system is not secure altogether as it can be manipulated and altered on the wish of some naughty factors.

An automated real-time classroom attendance system performs the daily activities of attendance marking with reduced human intervention. This system based on

face detection and recognition automatically detect students' faces from still image or video frame coming from a digital camera, and marks his/her attendance by recognizing them.

1.1 Problem Statement

The main problem with the traditional attendance system is that it is subject to manipulation and there remains chances of human error during data entry. Though it is easier to implement and saves technology expenses, the organization cannot benefit from the innovations of data analysis which has huge implications. In addition to this, contemporary attendance method at classroom requires human intervention and cooperation from students which contribute towards wastage of precious class time.

1.2 Project Objectives

Considering the needs and challenges aforementioned, this project aims to accomplish the following:

1. Accurately match detected students faces to those on the database.
2. Develop an intuitive user interface for navigation of functionalities within system.

1.3 Significance of the project

The motivation for development of this attendance system relies on a desire to reduce the wastage of class time arising as a result of using traditional way of marking attendance. Usually this traditional way of marking attendance takes about 5-10 minutes, which is a complete waste of useful class time. Furthermore, traditional way of attendance is not secure altogether as it can be altered easily. This attendance system

replaces hectic, insecure, time consuming process with automatic face detection and recognition based attendance system.

1.4 Scope and Limitations

The project focuses on marking attendance based on face detection and recognition techniques, and storing the result in a database system that allows efficient retrieval of attendance data whenever required. Due to scope of project and time constraint, this system is not able to address many of the management features such as report generation that are desired in the attendance 'management' system. The developed system requires a student to stand in a predefined area to maximize the detection and recognition rate which can still be a little hectic process.

1.5 Report Organization

This document presents the workflow for the realization of the classroom attendance system and it is organized into five chapters. This introductory chapter explains problem statement, objectives, significance, and scope and limitation of the project.

Chapter 2 summarizes studies on prior works in the field of attendance system. It highlights how attendance system has evolved over time and major technological innovations facilitating the system in present days.

Chapter 3 provides an account of tools and frameworks that are used for development of the system.

Chapter 4 presents brief summaries about the system implementation. It highlights how different tools and frameworks discussed in chapter 3 are utilized.

Chapter 5 highlights the deliverables and schedule of the project.

Finally, chapter 6 is the conclusion. Further work that can be done to extend the present systems are also explained.

Chapter 2

Literature Review

Attendance records play a vital role in the analysis of performance of any organization. The traditional way of marking attendance involves a human calling out the name of the students individually, which is hectic and time consuming. Automated classroom attendance system aims to nullify those aforementioned problems. Number of related literature based on automatic attendance currently exist and are reviewed below.

Face Recognition-based Lecture Attendance System [2], uses face recognition by taking pictures of whole class. As it will be difficult to estimate the attendance accurately using individual results of the face recognition system as the rate of face detection is usually low. Here the system proposes a method of estimation using the results of the face recognition system by continuous training. Continuous training improves the performance of the system. This system uses a capturing camera to capture and monitor the class continuously which sends the data to the face recognition module. This system considers the seating arrangement of the class is unaltered so that the positions of the seats is used to fetch student faces for marking attendance. In Student Monitoring by Face Recognition [3], the camera is fixed at a position where the entry and exit of the class room is clear and is used to capture the image of the entering student and leaving student. 3D Face recognition algorithm is used in the system. Detected student faces are stored as the test images in the database and

compares the existing student images using Eigen faces technique. If any entering student is matched with any image in the student database attendance is marked for that particular student for that day. Class Room Attendance System Using Facial Recognition System [4] tries to take attendance in the real-time. It takes the snapshot of the class which includes all the students present in the class. Then face detection algorithm is applied to the snapshot to detect the faces in the image. Images are subjected to face segmentation and then face recognition is done using the test image stored which tries to match with the student's database images and if match is found attendance is updated to the attendance database and the report is finally generated for the attendance of that particular day.

These automated classroom attendance approach uses modern computer vision algorithms to detect faces of students from a camera, and process them to record the attendance. The emergence of advanced object detection algorithms have taken false positive detection rate to nearly zero. The aim is to record the attendance with almost or no human intervention, however the approaches described above still requires some sort of cooperation from the students. Studies now have to be concentrated to modernize and bridge the little gap that is yet to be filled.

Chapter 3

Methodology

The classroom attendance system consists of a graphical user interface to interact with different functionalities that is provided by the system. The use case diagram for the system is shown below:

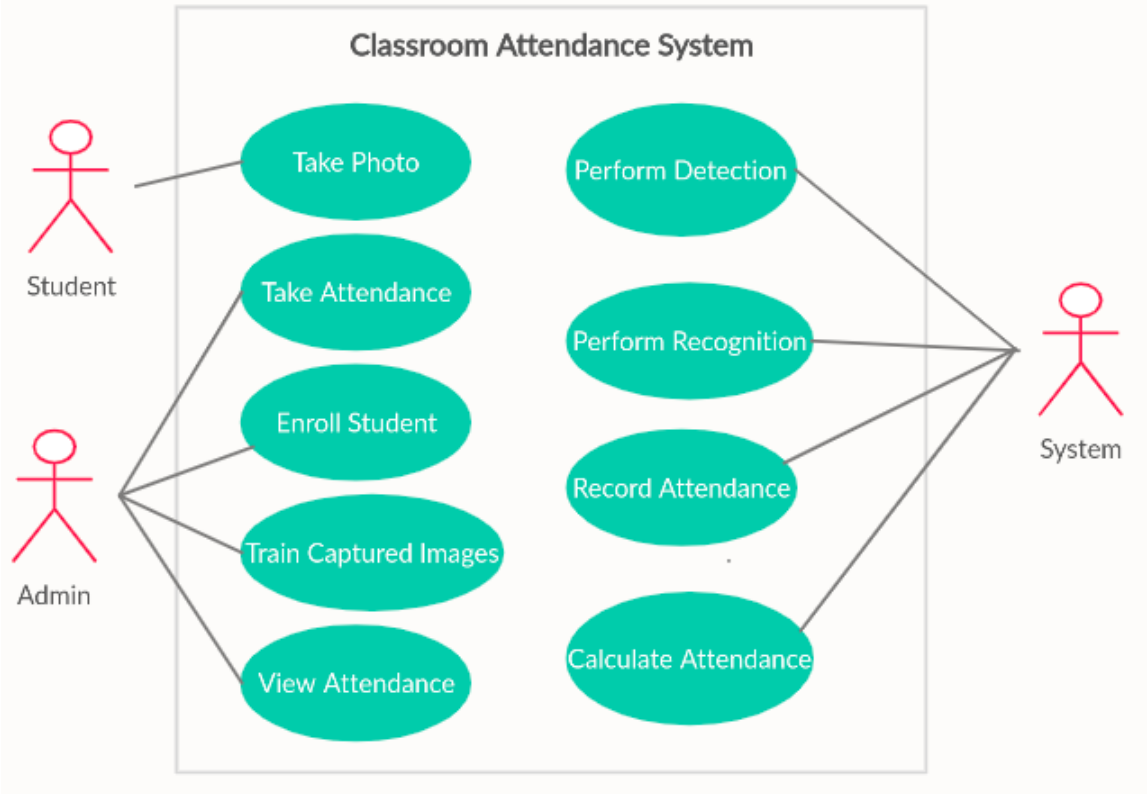

Figure 3.1: Use case diagram for Classroom Attendance System

The system consist of two actors: students, and admission officer, also known as admin. Admission officer is responsible for entering details of students into the system, whereas student volunteers to appear in front of camera to record the attendance. The system then detects and recognizes student.

The development of the system discussed above requires the use of different tools and frameworks. In the sections below, software process and necessary tools and frameworks whilst development of the software are discussed.

3.1 Agile Software Development

Agile software development [5] follows a series of experiments, as opposed to one linear project in which entire projects are pre-planned then fully built out before they are tested. The iterative approach in Agile development methodology allows to gather more frequent user feedback from clients earlier in the process, keeping the projects aligned, on track and relevant.

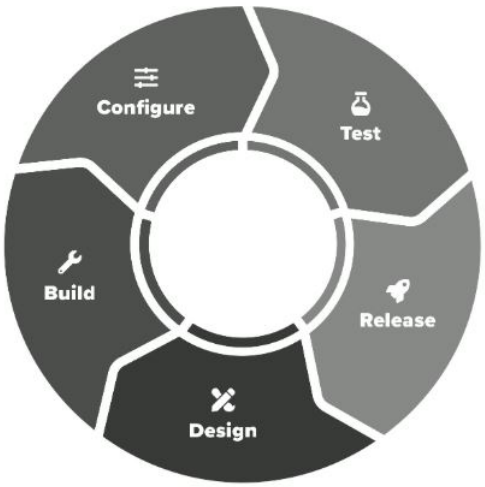

Figure 3.2: Agile development methodology

Kanban (Trello more specifically) framework of Agile software development was used during which the work was assigned to different members in a team and divided into "sprints". The sprints are the basic unit of progress delineated by a specific time-

frame usually 2-3 weeks which may consist of several tasks. Kanban boards were used to record the tasks which were labelled as "Things To Do", "Doing" and "Done".

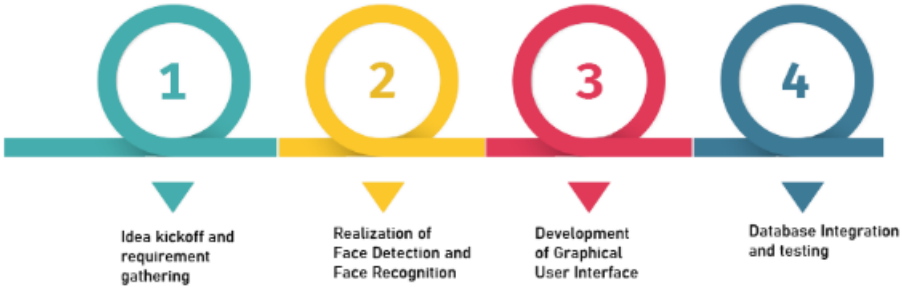

Figure 3.3: Sprints during development of project

3.2 Face Detection and Recognition

Face detection and localization from images is a key problem and a necessary first step in face recognition systems, with the purpose of localizing and extracting the face region from the background. The human face is a dynamic object and has a high degree of variability in its appearance, which makes face detection a difficult problem in computer vision. It is an essential step in face recognition. During the past several years, a wide variety of face detection and localization techniques have been growing fast.

Figure 3.4: Basic steps in face recognition

Categorization of face detection may depend on different criteria. In terms of modeling process used, the approaches to face detection may fall into two main categories: (1) local feature-based ones; (2) global methods. Their face detection regions are required by the comparative matching between the detecting region and constructed

template based on modeling. In the former ones, salient features such as the eyes, nose, and mouth are first located. Various measurements of these facial components are used to construct feature vectors. These approaches to face recognition basically rely on the detection and characterization of above individual facial features and their geometrical relationships. The latter ones, on the other hand, take a holistic view towards face recognition without explicitly finding facial features. They involve encoding the entire facial image and treating the resulting facial code as a point in a high-dimensional space and assume that all faces are constrained to particular positions, orientations, and scales.

3.2.1 Viola–Jones object detection

The Viola-Jones algorithm [6] is a widely used mechanism for object detection [7]. The main property of this algorithm is that it is capable of processing images extremely rapidly and achieving high detection rates.This is distinguished by three key contributions. The first is "Integral Image" which allows the features used by detector to be computed very quickly. The second is a learning algorithm, based on AdaBoost, which selects a small number of critical visual features from larger set and yields extremely efficient classifiers. The third contribution is a method for combining increasingly more complex classifiers in a cascade which allows background regions of the image to be quickly discarded while spending more computation on promising object-live regions.

3.2.2 Local Binary Patterns Histogram (LBPH)

LBP, introduced by Ojala et al. [8], is described as an ordered set of binary comparisons of pixel intensities between the center pixel and its surrounding pixels. It is used for extracting unique and useful features from pre-processed images and is the most efficient and newest approach for face recognition. With LBP it is possible to describe the texture and shape of a digital image [9]. Each pixel of an image is labeled with

an LBP code which is obtained by converting the binary code into decimal one. First it will divide the image to several small blocks from which the features are extracted. Then it will start calculating the LBP histograms for each block from the obtained features. After that it will combine all LBP histograms for that image to obtain one concatenated vector. Images can then be compared by measuring the similarity (distance) between their histograms. Several studies and research work indicates that face recognition using the LBP method provides very good results with different facial expressions, different lightening conditions, image rotation and aging of persons. Speed and discrimination performance of an LBP system is also magnificent.

3.3 Technology and Frameworks

LaTeX

LaTeXis a typesetting engine, used for the production of high-quality documents. The LaTeXphilosophy of separating presentation from content, allows authors to focus on the content of document rather than the visual appearance. For this reason, LaTeXis one the most preferred tools for scientists to publish scientific documents. The preparation of this document utilizes LaTeX.

Git

An open source distributed version control system called Git has been used through the project development process. It helps us in tracking changes in programs and coordinating work on those programs among the project team members.

Edraw Max

Edraw Max is a proprietary software developed by EdrawSoft and is used to create diagrams. Edraw Max helps in visualizing system's architectural blueprints in diagrams such as the class diagram, use case diagram, and sequence diagram. These diagrams are required for documentation purpose.

Python

Python is an interpreted, high-level, general-purpose programming language. Its language constructs and object-oriented approach aim to help programmers write clear, logical code for small and large-scale projects. Kivy GUI framework has been used for designing the graphical user interface.

OpenCV

OpenCV is an open source computer vision and machine learning software library. It includes state-of-the-art computer vision and machine learning algorithms such as Viola-Jones and local binary pattern histogram.

MongoDB

MongoDB is a document-oriented NoSQL database program. It stores information in collection, which is a set of MongoDB documents. MongoDB has a driver for Python called PyMongo. It is used to establish connection and communicate with MongoDB database.

Chapter 4

System Implementation

The realization of classroom attendance system utilizes various tools and frameworks. In following section, implementation details of the system are briefly discussed.

4.1 Image Acquisition

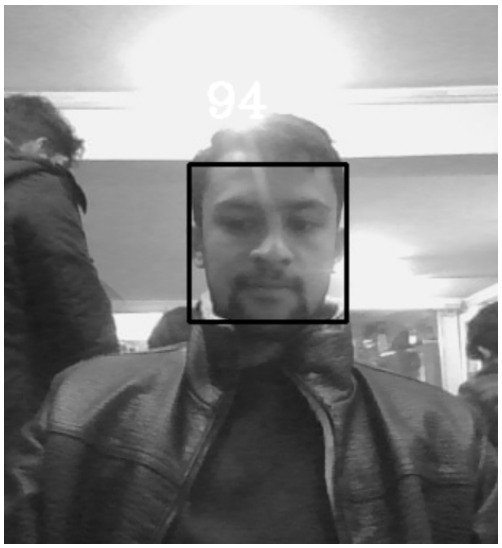

Figure 4.1: Image acquisition

Classroom Attendance System uses computers' camera to capture training images. For a single student 100 training images are captured. Each training image is converted from RGB mode to Gray-scale. These training images are feed forwarded

to the system for further processing.

4.2 Image Preprocessing

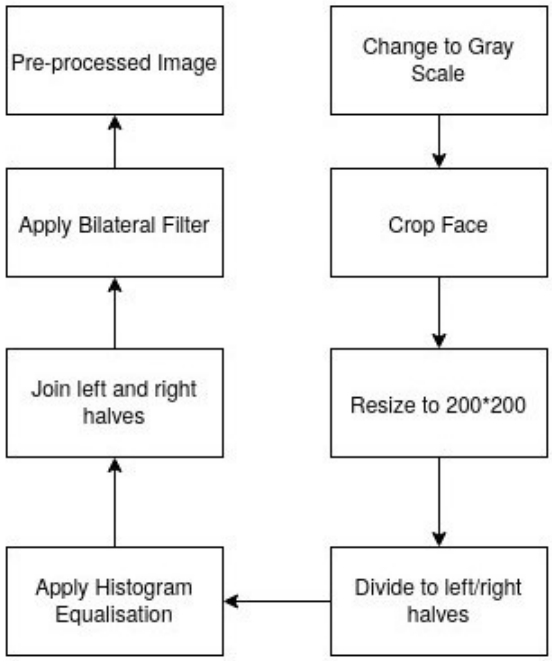

Figure 4.2: Preprocessing image after acquisition

4.2.1 Histogram Equalization

The resized image may have strong lighting on one side and weak lighting on the other. This has an enormous effect on the face-recognition algorithm. So histogram equalization is performed separately on the left and right halves of the face. For that, the resized image is cut into two halves and histogram equalization is performed on both halves separately. After that, the left and right halves are concatenated.

4.2.2 Bilateral Filter

A bilateral Filter is a non-linear, edge-preserving, and noise-reducing smoothing filter for images. It replaces the intensity of each pixel with a weighted average of intensity

values from nearby pixels. The system uses `bilateralFilter` method provided by OpenCV with sigmaColor value 75, sigmaSpace value 75 and diameter of 15 pixels.

4.3 Face Detection

After the image is taken and converted to gray-scale, Haar Cascade is used to identify the faces through the images. `haarcascade_frontal_face_default.xml` - a haar cascade designed by OpenCV is used to identify the coordinate of rectangle surrounding the face. Using this coordinate, the face is cropped from the image which removes unnecessary portion or background. Finally the cropped face is resized to 200 x 200 and is saved with `*.jpg` format.

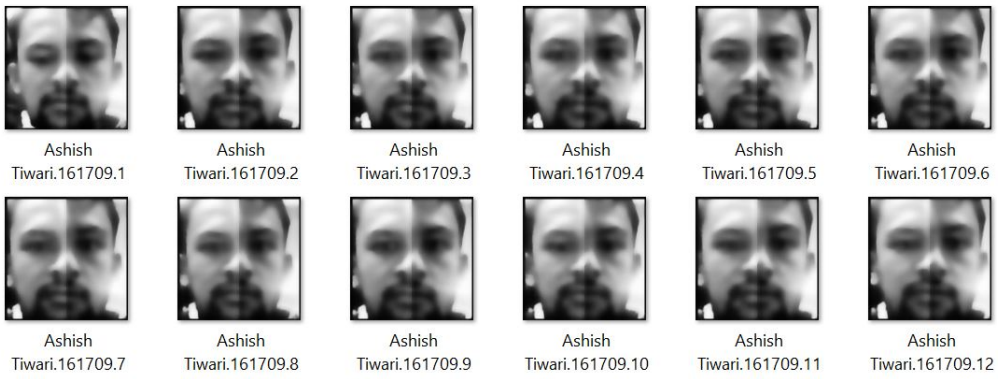

Figure 4.3: Detected faces after preprocessing

4.4 Image Recognition

For image recognition, the image is acquired, processed as described before. It is then feed into the trained model which returns "label" and "confidence". Based on the "label" and "confidence", attendance is recorded.

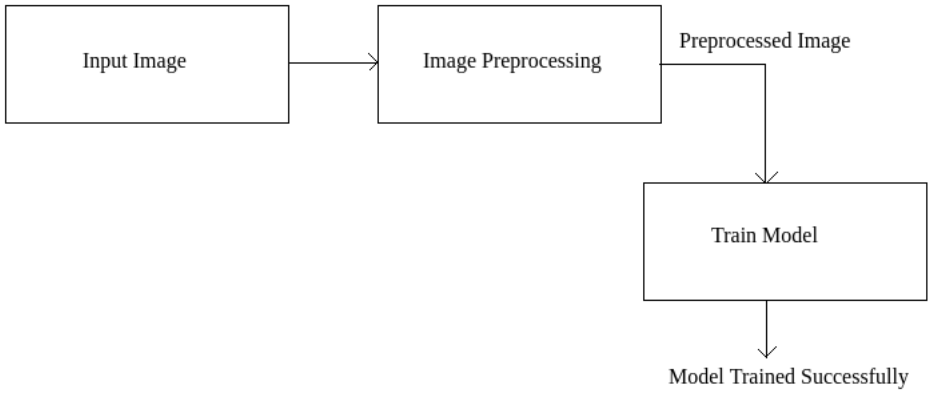

Figure 4.4: Training model for face recognition

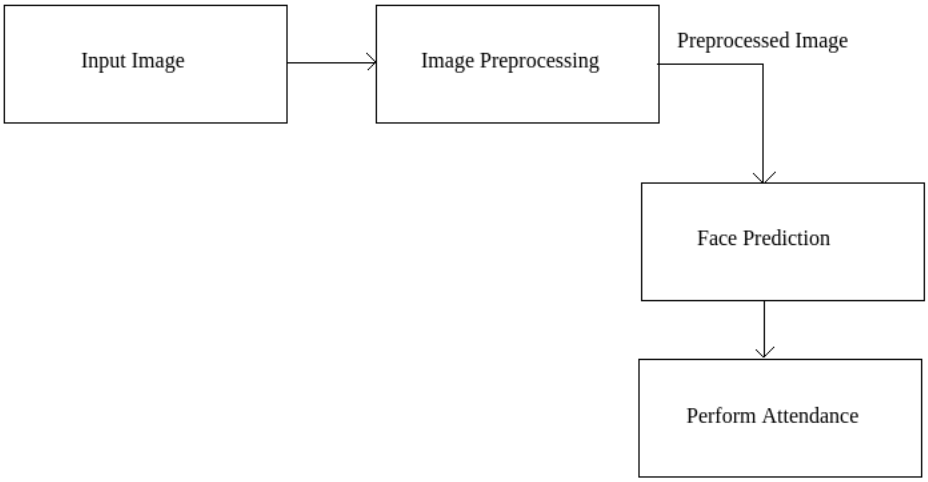

Figure 4.5: Performing face recognition

4.5 Database Integration

MongoDB stores student information and record of student attendance in the form of document. The MongoDB schema for student document is shown below:

4.6 GUI Development

This system uses `kivymd` which is an extension of Kivy, Python library for developing mobile apps and application sofware. `Kivymd` follows the Material Design developed

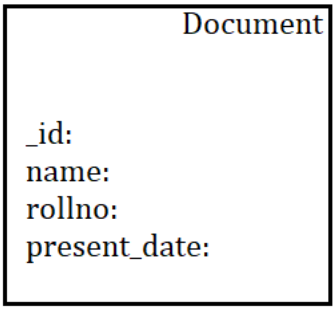

Figure 4.6: MongoDB schema for student document

by Google for creation of various elements in user interface which could be text fields, labels, and etc.

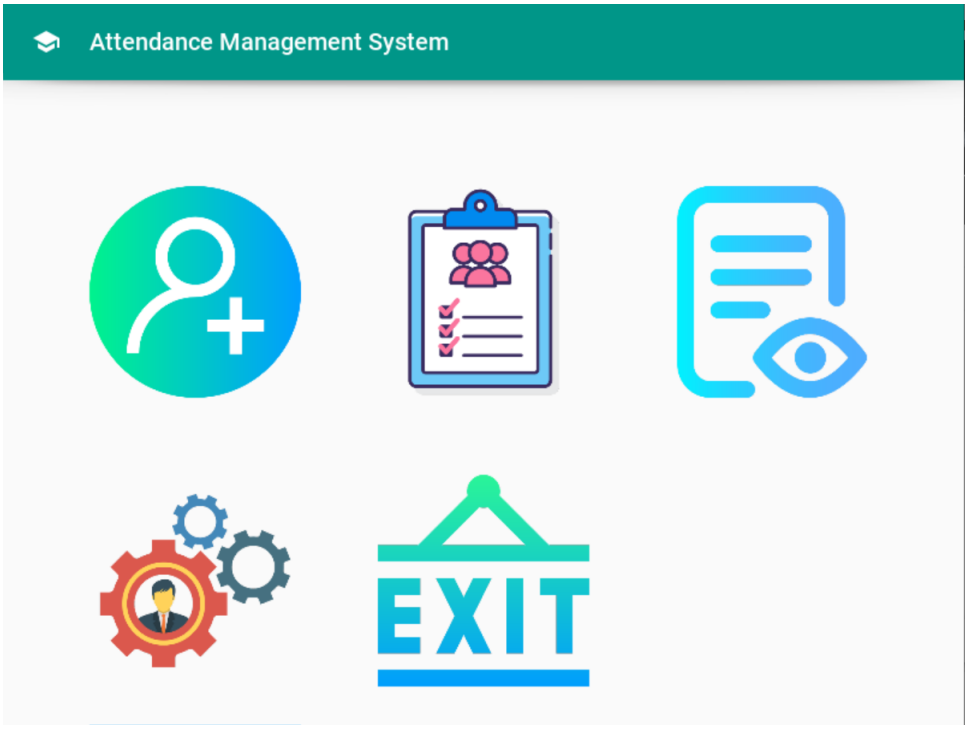

Figure 4.7: Landing screen of Classroom Attendance System

Chapter 5

Deliverable and Schedule

5.1 Deliverable

The project delivers an automated real-time classroom attendance system which performs daily activities of attendance marking with reduced human intervention. This attendance system replaces the contemporary hectic, insecure, time consuming process with automatic face detection and recognition based attendance system.

1. Record student attendance with minimal human intervention using machine learning algorithms for face detection and recognition.

2. Provide a graphical user interface to maximize user experience.

The source code of the project will be made open via GitHub by which related scholars can benefit. This also enables other people in the community to submit feedback and raise issues, so system can be improvised based on issues and feedback on the repository.

5.2 Task and schedule

The completion of the project took over two and half months period and work for initial requirement gathering and analysis began as soon as proposal got accepted.

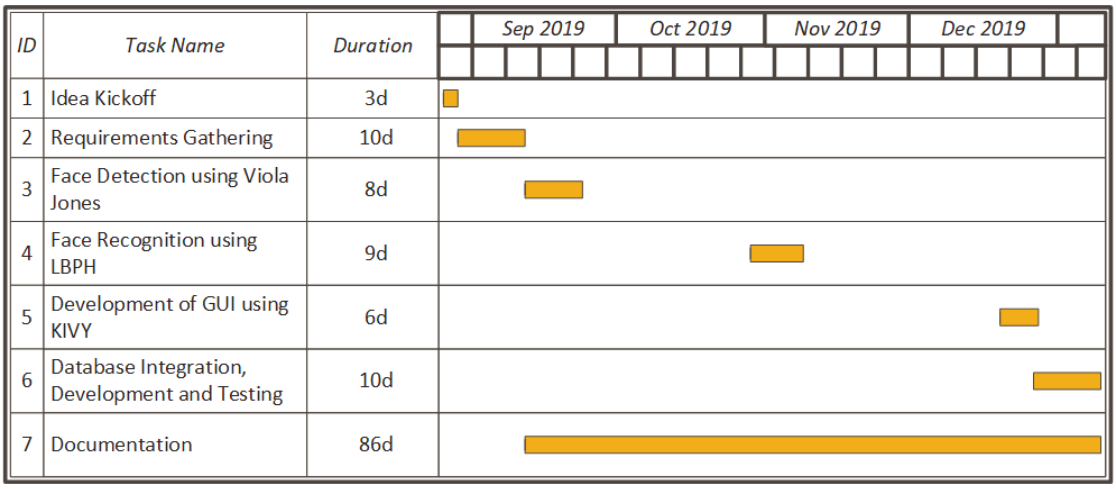

Figure 5.1: Gantt chart

The project was broken down into small modules and task being uniformly divided among project members. The development of system proceeded with the direct participation of all the team members. The use of Agile development methodology ensures that testing is done simultaneously at each sprints, ensuring delivery of the project by deadline.

Chapter 6

Conclusion

The completion of the project resulted in a software product that is able to automate the classroom attendance. The software doesn't require any sort of human intervention, which saves the precious class time. Moreover, the GUI built on top of the system helps the users to easily navigate through records which used to be hectic and time consuming process in traditional attendance system.

6.1 Future Work

The system in the future can be made able to detect and recognize the student in real-time from the feed coming from CCTV. Students behavior and their engagement in classroom at various lectures could be enhanced using artificial intelligence for the better delivery of class materials to the students.

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Biographies

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