Supervisor Recommendation

This is to certify that the thesis entitled “Automated Face Recognition Based Attendance System Using RetinaFace and Facenet” submitted by Mr.Ravi Lamichhane, Mr. Sanil Khadka, and Mr. Prabin Pal in partial fulfillment of the requirement for the Degree of Bachelor of Computer Science and Information Technology has been completed under my supervision. I recommend the thesis for acceptance and approval.

—----------

Janak K Lal
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Certificate Of Approval

This is to certify that Sanil, Ravi, and Prabin has successfully completed the project on face recognition attendance system using CNN under my supervision. The project involved the development of a face recognition attendance system using CNN that identifies the face of the registered user and marked the attendance recognizing their face efficiently.

I have evaluated the project and found it to be well-conceived, well-executed, and well-documented. The project demonstrated knowledge and skills in machine learning, and data analysis. The results of the project were satisfactory and met the objectives of the project. The report submitted by them is thorough and comprehensive, and provides a detailed description of the methodology, experimental setup, results, and analysis. The report also includes critical evaluation of the limitations and challenges of the project, and recommendations for future work.

Based on the quality of the project and the report, I am pleased to recommend Sanil, Ravi, and Prabin for the successful completion of the project on face recognition attendance system using CNN.

Janak K Lal

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Acknowledgment

We take this opportunity to express our deepest and sincere gratitude to our supervisor Janak K Lal, for his insightful advice, motivating suggestions, invaluable guidance, help and support in the successful completion of this project and also for his constant encouragement and advice throughout our Bachelor's program. Their expertise and encouragement helped me shape my research and significantly improved the quality of my work.

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Once again, we are deeply grateful to everyone who has contributed to my final year project. Their support and encouragement were critical in achieving my goals, and We will always cherish their contribution.

Abstract

The traditional paper-based attendance system has many drawbacks, such as being time-consuming, inefficient, and prone to errors. In this paper, we propose an Automated Face Recognition Based Attendance System (AFRAS) that uses deep learning algorithms to automate the attendance process. The attendance is taken in every schools, colleges and library. Traditional approach for attendance is professor calls student name record attendance which is a tedious process. The manual work included in the maintenance and management of the traditional attendance sheets is difficult. To avoid these problems, we have developed system that identify an individual by comparing live capture or digital image data with stored record for that person. The developed system is a Web-based application which capture live image of student, then identify and recognize the individual and mark attendance. By using the web-based application the staff should capture the entire class to mark the attendance for that session. In our system we have used CNN algorithm to build the face recognition model. Convolutional neural networks, i.e., ConvNets were first comes to existence in the 1980s.
CNN is composed of multiple layers of artificial neurons [13]. The behavior of each neuron is decided by its weights. It is a classification structure for classifying images into various labeled classes [14][15].

Keywords: Web-Based application, Face detection, Face recognition, CNN, SVM classifier, Attendance

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List of Symbols and Abbreviation

2D	2-Dimension
3D	3-Dimension
AAS	Automated Attendance System
CCTV	Closed Circuit Television
CNN	Convolutional Neural Network
CSS	Cascading Style Sheets
CSV	Comma Separated Value
DB	Data Base
FRR	False Reject Rate FAR False Accept RATE
HFR	Human Face Recognition
HTML	Hyper Text Markup Language
IOT	Internet of Things
LBPH	Local Binary Patterns Histograms
LFW	Labeled Faces in the Wild NN Neural Network
MAS	Manual Attendance System
MLP	Multi Layer Preceptron
MTCNN	Multi-Task Cascaded Convolutional Neural Network
PIL	Python Imaging Library
SGD	Stochastic Gradient Descen
SVM	Support Vector Machine
VGG16	Visual Geometry Group 16

Chapter 1: Introduction

1.1 Introduction

In traditional class system, keeping record of the student attendance is one of the important issue school, college and university have to deal with. Generally there are two kind of attendance system namely manual and automated attendance system. With the Manual Attendance System (MAS) it is time consuming and more prone to mistakes. Using an Automated Attendance System (AAS) with the help of Human Face Recognition (HFR), which extracts the key features of the students with the help of Convolutional Neural Network (CNN) and determines the student identification based on the key features. Based on the identification, the attendance of the student is taken automatically.

The automatic attendance system with facial recognition performs the following task to operate.

1. Detect Face within the frame
2. Normalize the facial landmark
3. Extract key features of the face
4. Verify and identify face
5. Update the attendance database

1.2 Problem Statement

Every class starts with a delay due to a lecturer or a teaching assistant taking attendance of the students present in the class. This is a lengthy process and takes a lot of time if the class includes large number of students and many numbers of classes in a day. Also these attendance records are used by the staffs or the department to assign marks and monitor the attendance percentage which thus is a tedious task.

We saw a major flaw in this process as it consumes more important time and is prone to human errors. So we created an system that would detect and identify a student and then automatically do the attendance of the student. The input picture is taken from frames of Closed Circuit Television (CCTV) and store the attendance on the database.

1.3 Objectives

1. To detect and identify the face of students in live captured images using CNN Algorithm
2. To mark the attendance of the student based on their face identification and recognition

Overall, an Automated Face Recognition Based Attendance System aims to provide a reliable, efficient, and convenient solution for attendance management in various settings, such as educational institutions, workplaces, and public events.

1.4 Scope And Limitations

The scope of our project are:

1. The system can be implemented in various settings, such as schools, colleges, universities, workplaces, and public events.
2. The system can handle a large number of users and attendance records.
3. The system can be integrated with existing attendance management systems and databases.
4. The system can provide real-time attendance reports and analytics.
5. The system can improve the accuracy and efficiency of attendance taking.

The limitations of our project:

1. The accuracy of the system may be affected by various factors such as lighting conditions, facial expressions, and occlusions.
2. The system may not be able to recognize all faces equally well, depending on the quality of images and the training data.
3. The system may not be able to identify individuals accurately in case of identical twins or siblings.
4. The system may face privacy concerns and legal implications regarding the collection and storage of biometric data.
5. The system may require significant hardware and software resources, making it expensive to implement and maintain.

Overall, an Automated Face Recognition Based Attendance System has the potential to improve attendance management in various settings. However, it is important to consider the system's limitations and potential challenges before implementing it

1.5 Development Methodology

We have used Agile software Development Methodology for building this system. Agile software development refers to a group of software development methodologies based on iterative development, where requirements and solutions evolve through collaboration between self-organizing cross-functional teams. Agile methods or Agile processes generally promote a disciplined project management process that encourages frequent inspection and adaptation.Agile software development is more than practices such as pair programming, test-driven development, standups, planning sessions, and sprints.

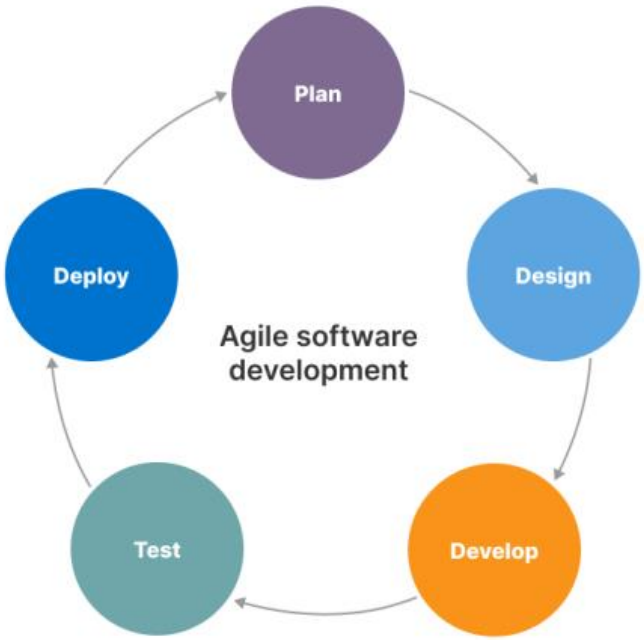

Figure 1. 1 Agile Development Process

To develop a face recognition-based attendance system, we followed a structured methodology that consists of several stages. These stages are:

1. Requirements gathering: In this stage, we identified the requirements of the Face recognition-based attendance system, such as the categories of facial structure to be classified, the features to be used for detection and identification, and the desired level of accuracy.
2. Data collection and preparation: In this stage, we collected the data for training the model and prepare it by cleaning and preprocessing, and augmentation. This involved

identifying sources of data, removing irrelevant information, and transforming the data into a format suitable for training the model.

3. Model development: In this stage, we developed the build the model using the prepared data. This involves selecting appropriate features for classification, training the model on the labeled training data, and tuning the model's parameters to optimize its performance.
4. Model evaluation: In this stage, we evaluate the model's performance on a separate testing dataset to measure its accuracy and effectiveness. This involves calculating metrics such as precision, recall, and F1-score, and using visualization techniques to analyze the results.
5. Model refinement: In this stage, we refined the model to improve its performance. This involves fine-tuning the model's parameters, selecting better features for classification, and experimenting with more advanced techniques for model training.
6. Integration and deployment: In this stage, we will integrate the Face recognition-based attendance system into a web application and deploy it for use by end-users.
7. Maintenance and updates: In this stage, we will ensure that the Face recognition-based attendance system continues to meet the needs of its users by performing maintenance and updates as necessary. This includes monitoring the system's performance, identifying and fixing bugs, and incorporating feedback from users to improve the system's accuracy and usability.

By following this structured methodology, we can ensured that the Face recognition-based attendance system is developed and deployed effectively, providing accurate and efficient results.

1.6 Report Organization

This report consists of five chapters and each chapter deals with different related topics.

1. **Introduction:** The first chapter is the introduction where the entire project is introduced and defined. This chapter has several parts such as introduction, problem statement, objectives, and report organization.

2. **Requirement analysis:** The second chapter deals with the requirement analysis, and feasibility analysis. This chapter consists of three parts i.e., data collection, algorithm

used and information about hardware and software that have been used to categorize the news as well as structuring system requirements.

3. **System Design:** The third chapter discusses the system design in detail. It clearly shows how data flows in the system, and how subcomponents of the system are connected and it shows the flow of activities in the system using UML diagrams.

4. **Implementation and Testing:** The fourth chapter consists of the implementation and testing process. It states the tools that were used including what specific task is accomplished with those tools. It mentions the major modules used along with snippets of source code. It also contains test cases that were used to get the qualitative product.

5. **Conclusion:** Finally, the fifth chapter concludes the project with future enhancement plans. Here we have stated limitation of the project and what can be done to enhance the project on the future.

Chapter 2: Background Study and Literature Review

2.1 Background Study

The traditional way of taking attendance involves manually recording student attendance, which is time-consuming and prone to errors. In contrast, an automated attendance system based on face recognition technology offers a more efficient and accurate alternative. Such systems use machine learning algorithms to extract unique facial features, which are then used to identify individual students and automatically record their attendance[2].

Face recognition technology has made significant strides in recent years, particularly in the areas of object detection and image processing. Convolutional neural networks (CNNs) have emerged as a particularly powerful tool for image classification and feature extraction, making them well-suited for face recognition applications[14][15].

Several face recognition-based attendance systems have been developed in recent years, ranging from simple systems that use a single camera to more sophisticated systems that utilize multiple cameras and advanced image processing techniques. One popular approach is to use a single camera to capture an image of each student's face and compare it to a database of previously recorded images to identify the student.

One of the challenges in developing a reliable face recognition-based attendance system is the need to deal with varying lighting conditions and facial expressions. To overcome this challenge, researchers have developed algorithms that use 3D face reconstruction techniques to create a more robust representation of the face.

In addition to improving accuracy and efficiency, face recognition-based attendance systems offer other benefits such as increased security and privacy. By using unique facial features as a means of identification, these systems can reduce the risk of fraud and identity theft. Furthermore, they can be used to track student attendance in real-time, allowing for more effective monitoring of student performance and engagement.

Overall, the development of face recognition-based attendance systems represents a significant step forward in the field of educational technology. With their ability to automate attendance

tracking, these systems can help schools and universities save time and resources while improving accuracy and security.

2.2 Literature Review

In the 1960s, initial efforts to implement facial recognition involved a partially automated system. To identify significant facial features like eyes, ears, noses, and mouths, marks were made on photographs. Subsequently, distances and ratios from these marks to a common reference point were calculated and compared to reference data. In the early 1970s, Goldstein, Harmon, and Lesk [1] created a system that relied on 21 subjective markers like hair color and lip thickness. However, it proved to be even more challenging to automate because many of the measurements were still manually conducted due to their subjective nature.

Fisher and Elschlagerb [2] approaches to measure different pieces of the face and mapped them all onto a global template, which was found that these features do not contain enough unique data to represent an adult face.

Another approach is the Connections approach [3], which seeks to classify the human face using a combination of both range of gestures and a set of identifying markers. This is usually implemented using 2-dimensional pattern recognition and neural net principles. Most of the time this approach requires a huge number of training faces to achieve decent accuracy; for that reason it has yet to be implemented on a large scale.

In their work, Sawhney and colleagues [4] introduced an automated system for managing attendance that involves two databases: one for students and another for attendance records. To mark attendance, a high-definition camera will be installed outside the classroom, which students can use to scan their faces upon entering the classroom. Another camera will be set up inside the classroom to capture images of all students, and facial detection and recognition algorithms will be applied to both cameras to analyze the faces and record attendance. The system utilizes Viola and Jones algorithm for face detection and Principal Component Analysis for face recognition. The purpose of this system is to improve security and prevent proxy attendance and fraudulent records.

Face Recognition System Using Machine Learning Algorithm[5]. The focus of this research is on a face recognition method that incorporates machine learning methods and principal component analysis

(PCA). Using PCA and linear discriminant analysis, it has also reached accuracy of 97 percent and 100 percent.

Sujata G. Bhele [6] In this paper mostly worked on the machine learning and deep learning models like SVM, ANN, CNN etc. which can help the model to perform the better result, here best model has chosen which can give true results. This paper explained various features extraction technique or algorithm like PCA, LDA etc. In this paper some other techniques have used which has normalize the size of image that is mostly affected the accuracy result.

Deep Face Recognition: A Survey[7.] The survey goes through a thorough audit of the new improvements on deep FR,covering expansive concepts on algorithm pattern,databases, conventions and application scenes.

Implementation of a specified face recognition system based on video[8]. This paper incorporates the algorithms of face detection and face recognition to build a video-based face recognition framework for effective and precise recognition of the specific characters in the video.

Shireesha Chintalapati [9] has proposed a brief summary about face recognition system and discussed some dimensionality and machine learning algorithm like PCA, LDA for feature extraction or dimensionality reduction and SVM, Decision tree machine learning algorithms. In this paper also mentioned some errors which mentioned the student details who has not present in the class which suggest that add more features to this type of system.

Jomon Joseph [10] has proposed the brief summary of the face recognition and explained the methods of their working. In this paper the dataset collected by using mobile camera. And used algorithms like SVM, CNN and some features extraction techniques like PCS. In this paper also given some information about MATLAB which is the multi-paradigm programming language and numeric computing environment, which created by MathWorks. MATLAB gives the platform to plotting of various work like functions, data, implementation of algorithm, creation of user interface etc.

Lin Zhi-heng et al. [12], proposed a classroom attendance system based on video face recognition technology. This system uses a camera installed in the classroom to obtain classroom video information. The video is first divided into a frame of static pictures, and from the pictures, several pictures with clear face and better light are selected for face recognition, and then the recognition results are aggregated and merged. This system mentions advantages

like it saves time, it will not interfere with the classroom and it can improve students learning efficiency.

I. Poona et al. [13], proposed an attendance system based on face recognition that uses Deep Learning technique (Neural Networks) which identify the individuals based on stored Image data sets [Image Recognition]. These networks use features to classify images. This network learns the features itself during the training process without the human involvement. Smart Attendance Systems involves the face detection and analyzes the data accurately. This approach has the ability to solve the time consuming traditional method of attendance system and paves way for new advanced technologies.

For the past two decades, the research area is mostly on face detection [14]. Face detection has been an active research area and there are applied by using many traditional and deep learning methods [15]. In these days, both of detection and recognition are recently trending for research area. For face detection, many methods can provide for face detection with good accuracy, it means that there are almost completely perfected in face detection field. Therefore, it is more challenges for recognition. From early 1990s to near 2000s, holistic 172 learning approach (eigenface, fisherface, SRC and CRC,etc) and local handcrafted approach (LBP, HD-LBP, etc) were used for face recognition area respectively. Later 2010, shallow learning and deep learning become popular and nowadays, deep learning is the best for face recognition [16]. FaceNet [17] is a deep convolutional neural network. It provides achieves a new record accuracy of 99.63% and provides 95.12% on YouTube Faces DB [9].

Chapter 3: System Analysis

3.1 System Analysis

System Analysis is the process of collecting and interpreting facts, identifying the problems, and decomposition of a system into its components. It is done to study a system and its parts to identify the objectives and challenges.

3.1.1 Requirement Analysis

There are many requirements of the system which should be analyzed so that effective output can be produced with available resources. Following requirement analysis are carried out for the effectiveness of our system.

i. Functional Requirement:

Face Detection from the image: Face in a given image is detected using RetinaFace algorithm and the important landmarks of the face are identified.

Face Recognition in given image: After the face is detected, the face is recognized by comparing with the data-sets provided using CNN algorithm

Update attendance of students: Attendance of students is taken by face recognition and face detection algorithm and faculty an see the list of students who is absent or present.

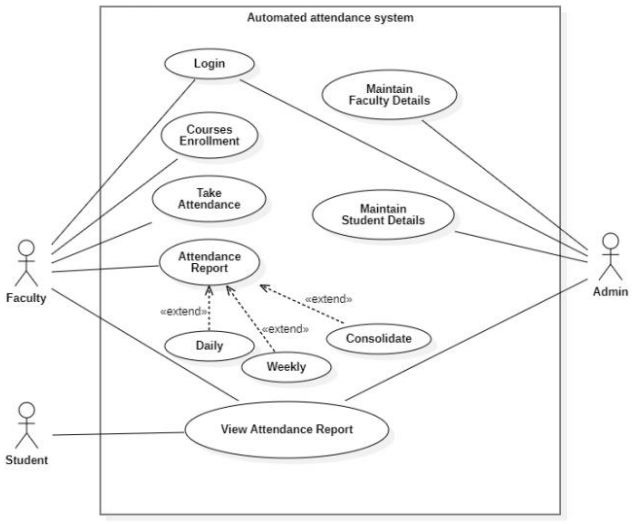

Figure 3. 1 Use Case Diagram

In the system, Faculty and Students were the primary actors while the college admin was the secondary actor. Student views their attendance report while Faculty can view, take attendance after logging into the system.

ii. Non-Functional Requirements

These requirements are not needed by the system but are essential for the better performance of software. The points below focus on the non-functional requirement of the system.

a) **Reliability:** As the system have a centralized database, so the system is not able to connect the centralized database if the LAN fails or the server is down due to hardware orsoftware failure.
b) **Availability:** The system is accessed to the authorized users like teachers to analyse the student's attendance, student to view their performance, admin to add update students' records.
c) **Security:** The system is secured because only authorized users can access the system with username and password.
d) **Portability:** The software is web-based application. So, it is platform is platform independent and is independent of operating system. So, the project is portable.
e) **Accuracy:** The software gains accuracy enough to predict the students faces for the attendance and recognize the students.
f) **Performance:** The software is implemented using algorithms like CNN, so there is a good performance of our project with high accuracy.

3.1.2 Feasibility Analysis

i. Technical Feasibility:

The technical requirement for the system is economic and it does not use any other additional hardware and software. Technical evaluation. So, our project is technically feasible.

ii. Operational Feasibility: The system working is quite easy and easy to use as we made an attractive interface. Users requires no special training for the operating of system. Technical performance includes issues such as determining whether the system can provide the right information for the Department personnel student details, and whether

the system can be organized so that it always delivers this information at the right place and on time using intranet services. So, the project is feasible as of its operation.

iii. Economic Feasibility: The system developed is economic as it is developed with respect to educational institution's point of view. The total expenditure of the project is just computational power. The dataset and computational power required for the project are
easily available. The computational power is easily obtained from our own laptop.
So, the project is economically feasible.

iv. Schedule Feasibility: The time that was taken to complete the project is four months. The project was completed on time with greater accuracy and the functionalities that was targeted for the project.

We adopted the Scrum framework, which employs an incremental and iterative approach. The project life cycle was broken down into smaller, more specific time frames known as sprints, each lasting between two to four weeks. After the successful completion of each sprint, we incrementally advanced our model development. A project Backlog was created to keep track of the To-Dos, which were prioritized. A Scrum Master was designated for each sprint, who was responsible for ensuring its success. The Scrum Master managed ongoing communication between team members to keep everyone informed and on the same page.

Sprint Length	2-4 weeks
Number of working days per week	3 days
Number of working hours per day	2-3hrs
Number of working hours per sprint	18-22hrs

Figure 3. 2 Scrum Master

We created 7 sprints in total for our project for which first sprint was created for creating project plan and studying papers. Second sprint was created to create database of student faces. Third sprint was created to implement data augmentation, fourth to apply CNN. The fifth sprint was to deploy project into our project. We created sixth sprint for model tuning. The last sprint was created for documentation.

3.1.3 Structured Analysis

i. Data Modeling with (ER) Diagram

The abbreviation ER Diagram refers to Entity Relationship Diagram. ER diagrams are useful for illustrating the logical framework of databases. These diagrams are built upon three fundamental concepts: entities, attributes, and relationships. Entities possess a specific number and variety of attributes, and they are connected by specific relationships. In our case, we have identified Student, Teacher, and Attendance as three entities. Our data is stored in a JSON file.

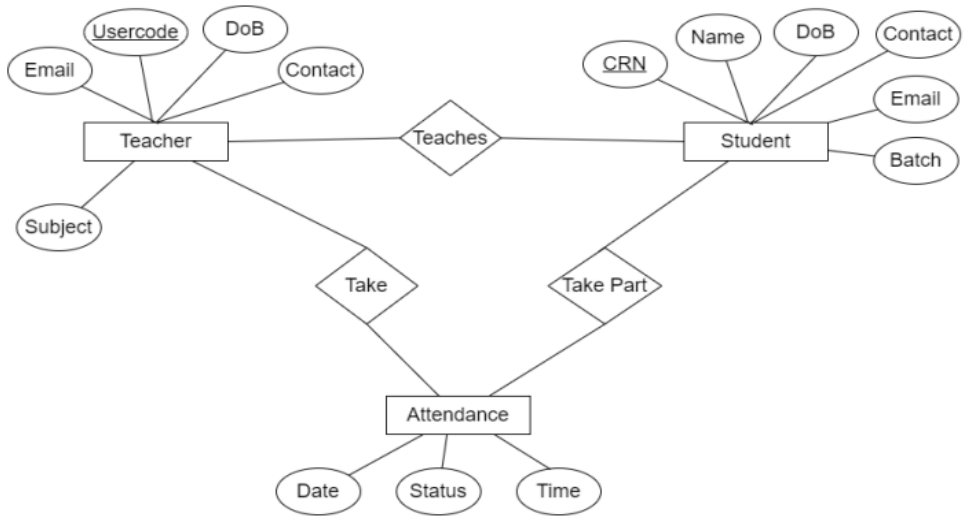

Figure 3. 3 ER Diagram

ii. Process Modelling with Context Diagram

a. (Level 0 DFD)

The illustration presents the main process in a single node to introduce the project context. This context explains how the project works in just one look. The user feeds data into the system and then receives the output from it.

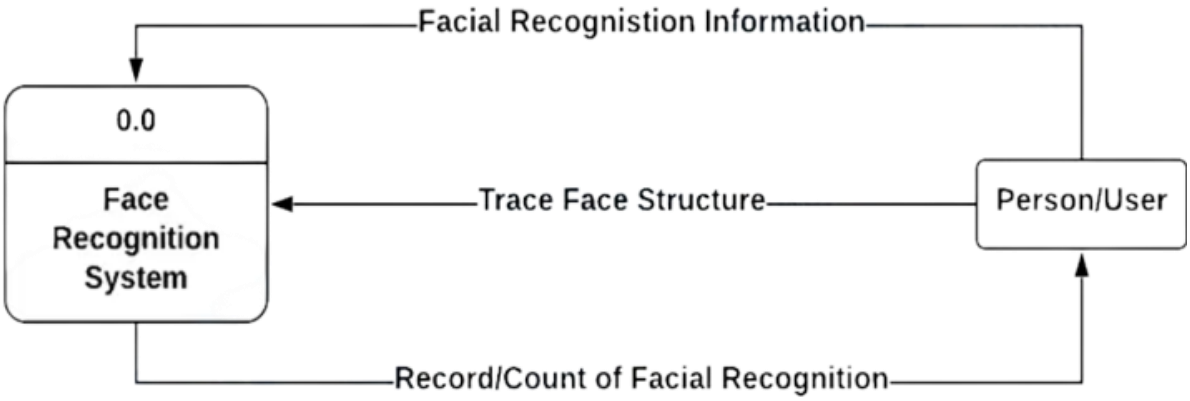

Figure 3. 4 Level 0 DFD

b. Level 1 DFD

A level 1 DFD notates each of the main sub-processes that together form the complete system. We can think of a level 1 DFD as an "exploded view" of the context diagram.

Specifically, level 1 shows the broader details of Face Recognition System DFD Level 0. This is to clarify the paths (flow) of data and its transformation from input to output.

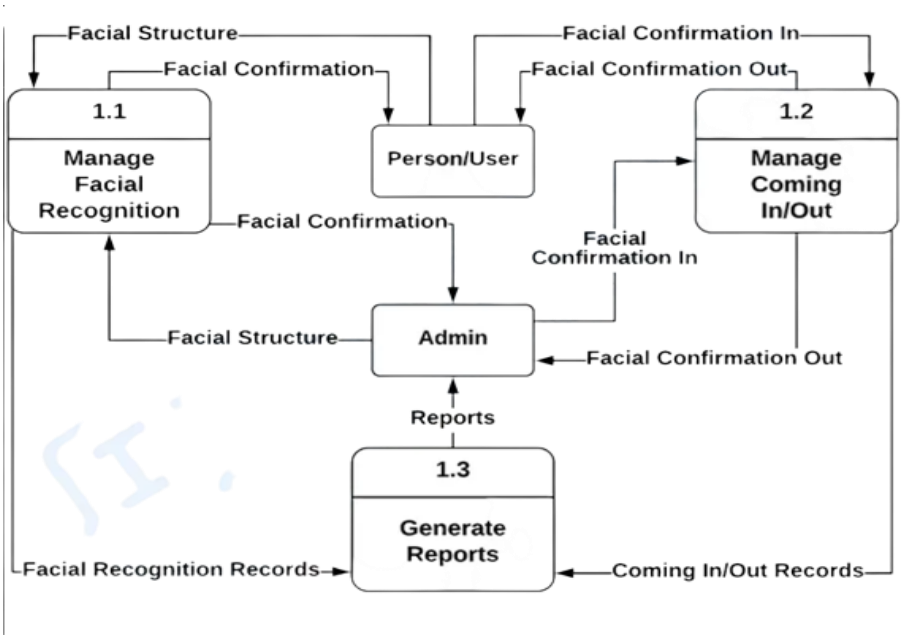

Figure 3. 5 Level 1 DFD

Chapter 4: System Design

4.1 Structured Design

The system design of our face recognition-based attendance system involves multiple stages of development. It begins with the selection and integration of various hardware and software components to create a cohesive system that can capture and recognize faces accurately. The system design further includes the development of robust algorithms for face detection and recognition, as well as the implementation of a user-friendly web application for accessing attendance records.

To ensure the accuracy and efficiency of the system, we have designed it to follow the principles of the Scrum framework, utilizing incremental and iterative development methodologies. We have identified the key entities, attributes, and relationships involved in the system, which will be illustrated through the use of Entity Relationship (ER) diagrams. The development of the system will follow a series of sprints, with each sprint being managed by a designated Scrum Master.

In addition to the core functionality of capturing and recognizing faces for attendance purposes, the system design also incorporates features for maintaining and updating the attendance database, generating attendance reports, and providing real-time notifications to teachers and students. Overall, our face recognition-based attendance system has been designed with scalability, reliability, and user-friendliness in mind.

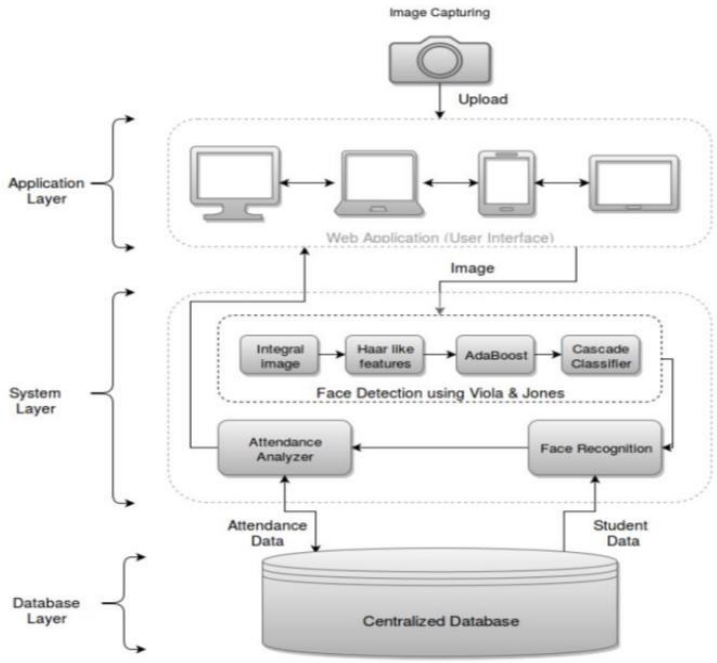

Figure 4. 1 Different data and application layer

i. Forms and Report Design

The design of forms and reports is an essential component of any attendance management system, and our Face Recognition Based Attendance System is no exception. Our system is equipped with advanced features that allow for the creation of custom forms and reports to meet the specific needs of users.

Our system's interface includes a user-friendly form designer that allows users to design forms according to their requirements. This feature enables users to collect specific information from students or teachers during the attendance-taking process. The forms can be customized with various fields and sections and easily accessed through the web application.

Furthermore, our system provides comprehensive reporting capabilities that enable users to generate various reports for attendance-related data. Reports can be customized to show attendance records by class, subject, or date, and can be exported to various formats such as PDF, Excel, or CSV. Users can also generate reports on students' attendance performance, such as absence and tardiness, helping teachers to monitor and improve students' attendance records.

Overall, the forms and report design features of our Face Recognition Based Attendance System offer a flexible and effective means of managing attendance records, providing users with the necessary tools to design custom forms and generate insightful reports.

ii. Interface and Dialogue Design

In any software project, the interface and dialogue design play a crucial role in ensuring that users can interact with the system intuitively and efficiently. For our face recognition-based attendance system, we have focused on designing an interface that is user-friendly and easy to navigate.

We have incorporated a simple and elegant design for our web application, enabling students and staff to access their attendance records with ease. The interface consists of a login page, a dashboard, and attendance records pages, where users can view their attendance records with detailed information. Our dashboard is interactive and provides users with real-time updates of their attendance status.

Moreover, we have designed a user-friendly dialogue system, which guides the users throughout the attendance marking process. Our system uses clear and concise instructions, making it easy for students and staff to follow. The system also provides prompt feedback to users about their attendance status.

4.2 Algorithm Details

Convolutional neural networks

Convolutional neural networks, i.e., ConvNets were first comes to existence in the 1980s.
CNN is composed of multiple layers of artificial neurons [13]. The behavior of each neuron is decided by its weights. It is a classification structure for classifying images into various labeled classes [14][15].

The different layers of CNN take out image features and learn to categorize the images. It is one of the types of feed-forward neural network in DL and AI. CNN has the capability to extract the each and every portion of input image, which is known as by name receptive field. It is assigning the weights for

each neuron based on the significant role of the 80 receptive field. So that it can be discriminate or find the difference between the importance of neurons from one another[12].

The Convolution layer's fundamental aim is to extract features from the input data, that is an image[5]. By learning picture characteristics using small squares of the input image, convolution preserves the spatial distribution between pixels. A network of trainable neurons is being used to convolute the input image [8].

In this paper we have covered the different layers of convolution used in the project. In our proposed architecture, there are 20 layers which include:

1. 1. Two 2D Convolutional Layer (Conv2D)
2. 2. Two Batch Normalization Layer
3. 3. Two Max Pooling Layer
4. 4. One Dense Layer

Taking input from the preceding layer, the CNN layer creates a feature map or convoluted matrix. By utilising a two-dimensional convolutional layer to recover features from the prior input, the batch normalization layer is utilized to normalize the input and eliminate the issue of fading gradient [7] and increasing gradient. One of the regularisation approaches employed in this study to deal with the overfitting problem is the dropout. The dropout layer[7] is used to avoid overfitting, while the max pooling layer is used to reduce the input's dimensionality.

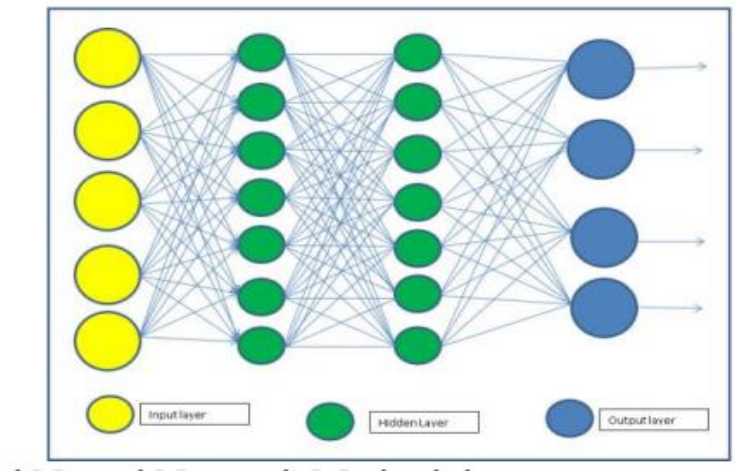

Figure 4. 2 Pooling Layer of CNN

Chapter 5: Implementation and Testing

5.1 Implementation

A face recognition attendance system was developed which has a feature of automatic attendance using face. To develop a working system implementation was done in 3 phases. First phase was the implementation of the CNN algorithm along with the preprocessors of image data. Second phase was the implementation of the backend API along with the attendance record system. Finally, the third phase was implementation of frontend i.e. a website for the user to do attendance using face.

5.1.1 Tools Used

a) **Python:** We used Python interpreter to build the system. Python libraries were utilized such as NumPy for mathematical computations, Pandas for handling data frames, and Flask for web development. The attendance data was stored in a MySQL database for easy retrieval and management.

b) **Flask:** To build a face recognition based attendance system, Flask was used as the web framework. Flask provides a lightweight and flexible way to create web applications with Python. The system consists of three main parts: face detection, face recognition, and attendance marking. To implement these features, the OpenCV library was used for face detection and recognition, and a Excel sheet was used to store attendance records. The Flask application was set up with routes to handle requests for the different parts of the system. The face detection and recognition were implemented as separate routes, and the attendance marking was handled by a separate function that updated the sheet with the attendance records.

c) HTML and CSS: To build the face recognition-based attendance system, we used HTML and CSS to create the front-end interface we started by using HTML to structure the page layout, creating divs and containers to organize the different sections of the page. Then, we used CSS to style the elements, applying colors, fonts, and spacing to create a visually appealing design.

d) Tensorflow

The TensorFlow API was used to build and train the model, and to integrate it with the front-end of the attendance system. This allowed for seamless and accurate recognition of individuals in real-time, making attendance-taking faster and more efficient. Overall, TensorFlow played a crucial role in building the face recognition capabilities of this attendance system.

e) Visual Studio Code

Visual Studio Code, also commonly referred to as VS Code, is a source-code editor made by Microsoft with the Electron Framework, for Windows, Linux, and macOS. We have used this platform to write core python programs and Frontend codes.

5.1.2 Description of major classes and functions

1. **Data augmentation** is a common technique used in Convolutional Neural Networks (CNNs) to increase the amount of training data and improve the performance of the model. It involves creating new training examples by applying various transformations to the existing images, such as rotation, flipping, scaling, cropping, and color adjustments.

Figure 5. 1 Data Augmentation

2. Implementation of CNN Algorithm

In this project we have covered the different layers of convolution used in the project. In our proposed architecture, there are 20 layers which include:

1. 1. Two 2D Convolutional Layer (Conv2D)
2. 2. Two Batch Normalization Layer
3. 3. Two Max Pooling Layer
4. 4. One Dense Layer

Taking input from the preceding layer, the CNN layer creates a feature map or convoluted matrix. By utilising a two-dimensional convolutional layer to recover features from the prior input, the batch normalization layer is utilized to normalize the input and eliminate the issue of fading gradient [7] and increasing gradient. One of the regularisation approaches employed in this study to deal with the overfitting problem is the dropout. The dropout layer[7] is used to avoid overfitting, while the max pooling layer is used to reduce the input's dimensionality.

1) **Max pooling:** Here we heve used 2x2 max pooling layer, the input feature map would be divided into non-overlapping 2x2 sub-regions, and the maximum value within each sub-region would be selected. The resulting feature map would have half the width and height of the original feature map, and would retain the most important features.

2) **Encoding Label & Categoricalization:** Label encoding involves assigning a unique numerical value to each category in a categorical variable. For example, if we have a variable 'color' with three categories 'red', 'blue', and 'green', we can assign the values 0, 1, and 2 to each category respectively using label encoding. This creates a numerical representation of the categorical variable that can be processed by machine learning algorithms. However, label encoding can create a numerical order that may not exist in the original data, and algorithms may mistakenly interpret this as meaningful information.

   Categoricalization, on the other hand, creates a binary representation of each category, also known as one-hot encoding. In this technique, a binary vector is created for each category in the variable, where the corresponding value is 1 and all others are 0. Using the same 'color' example, categoricalization would create three binary vectors [1, 0, 0], [0, 1, 0], and [0, 0, 1] for 'red', 'blue', and 'green' respectively. This technique preserves the categorical

nature of the variable and can prevent algorithms from interpreting any numerical order as meaningful information.

CNN Model Creation: The model architecture consists of four convolutional layers with ReLU activation function followed by max pooling layers. The first two convolutional layers have 64 filters, while the next two have 128 filters. The size of the convolutional filters is (3,3) for all layers.

After the convolutional layers, the model has a flatten layer to convert the output of the convolutional layers into a 1D vector. Then, there are three fully connected (dense) layers with ReLU activation function. The output layer has a number of neurons equal to the number of classes in the dataset, and the activation function used is softmax.

Training of CNN model:

We have build Convolutional neural network (CNN) model using the Keras library for deep learning. The model is trained on a dataset consisting of input data x_train and corresponding target labels y_train.

The input_shape variable is assigned the shape of the first input in the training data. This shape is used to define the input layer of the CNN model.

The EPOCHS and BATCH_SIZE variables are defined to specify the number of epochs (training iterations) and batch size for training the model. We have used 10 Epochs and 32 Batch size for training of model.

The model.fit() method is called to train the model on the training data. The x_train and y_train variables are used as input to the model during training. The epochs parameter specifies the number of times to iterate over the entire training dataset. The batch_size parameter specifies the number of samples to use in each training batch. Finally, the validation_split parameter specifies the fraction of the training data to be used as a validation set during training. In this case, 15% of the training data used for validation

```
Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 conv2d (Conv2D)             (None, 48, 48, 64)        640

 conv2d_1 (Conv2D)           (None, 46, 46, 64)        36928

 max_pooling2d (MaxPooling2D  (None, 23, 23, 64)       0
 )

 conv2d_2 (Conv2D)           (None, 21, 21, 128)       73856

 conv2d_3 (Conv2D)           (None, 19, 19, 128)       147584

 max_pooling2d_1 (MaxPooling  (None, 9, 9, 128)        0
 2D)

 flatten (Flatten)           (None, 10368)             0

 dense (Dense)               (None, 128)               1327232

 dense_1 (Dense)             (None, 64)                8256

 dense_2 (Dense)             (None, 12)                780

 activation (Activation)     (None, 12)                0

=================================================================
Total params: 1,595,276
Trainable params: 1,595,276
Non-trainable params: 0
```

Figure 5. 2 Model Description

```
Non-trainable params: 0
_________________________________________________________________
Epoch 1/10
271/271 [==============================] - 97s 352ms/step - loss: 2.1458 - accuracy: 0.3764 - val_loss: 1.2341 - val_accurac
y: 0.5869
Epoch 2/10
271/271 [==============================] - 89s 328ms/step - loss: 1.0344 - accuracy: 0.6630 - val_loss: 0.8430 - val_accurac
y: 0.7268
Epoch 3/10
271/271 [==============================] - 105s 388ms/step - loss: 0.6933 - accuracy: 0.7731 - val_loss: 0.7365 - val_accura
cy: 0.7621
Epoch 4/10
271/271 [==============================] - 101s 374ms/step - loss: 0.4433 - accuracy: 0.8524 - val_loss: 0.4733 - val_accura
cy: 0.8477
Epoch 5/10
271/271 [==============================] - 100s 371ms/step - loss: 0.2639 - accuracy: 0.9129 - val_loss: 0.4189 - val_accura
cy: 0.8791
Epoch 6/10
271/271 [==============================] - 104s 383ms/step - loss: 0.2008 - accuracy: 0.9324 - val_loss: 0.3889 - val_accura
cy: 0.8810
Epoch 7/10
271/271 [==============================] - 106s 390ms/step - loss: 0.1407 - accuracy: 0.9536 - val_loss: 0.5435 - val_accura
cy: 0.8634
Epoch 8/10
271/271 [==============================] - 106s 391ms/step - loss: 0.1013 - accuracy: 0.9666 - val_loss: 0.3552 - val_accura
cy: 0.8987
Epoch 9/10
271/271 [==============================] - 89s 328ms/step - loss: 0.0758 - accuracy: 0.9755 - val_loss: 0.3015 - val_accurac
y: 0.9229
Epoch 10/10
271/271 [==============================] - 95s 351ms/step - loss: 0.0645 - accuracy: 0.9798 - val_loss: 0.4803 - val_accurac
y: 0.8974
```

Figure 5. 3 Model Training Epoches

5.2 Testing

Precision, Recall and F-measure are taken to validate the classifier's performance. Other than that various test cases were created to ensure that the system delivers optimal performance to its user. The overall test ensure validity and reliability of the system.

5.2.1 Test case for unit testing

The functionality of each unit of the system is tested against the following test cases.

Table 5. 1 Unit Testing Test cases

Test no.	Unit	Test	Expected Result	Test Outcome	Evidence
1	Checked the face data collection with open cv	Open the video frame from open cv	Diffent augmented faces of data collected and converted in gray	Successful	Test A
2	Check the input id and name register to	Given the user Id and name of student	Data base created with given name and Id	Successful	Test B
3	Check Registration of the user with face	User is pointed ahead the camera to take the 50 sample of faces	User with the face and details is registered in database	Successful	Test C
4	Check the accuracy of attendence	Attendence is taken by the register user by using camera to	Successfuly the attendance is recorded in the system with the face	Successful	Test D

		recognize the face	of registered user		

5.2.2 Test case for system testing

Individual modules passing the unit test are combined together and tested as a group. The test proceeds as shown below.

Table 5. 2 Test Cases For System Testing

Test no.	Unit	Test	Expected Result	Test Outcome	Evidence
1	Checked the accuracy of face recognition and detection	Different People are registered and attendance is taken	Correct people are detected with their registered name shown in the screen	Successful	Test E
2	Check the overall attendance system	Data is fetched from the backend to frontend and vice versa.	Each day attendance is shown in frontend and can be saved in Xls files as a reference for future	Successful	Test F

5.3 Result Analysis

15% of the data is used for validation of the model whereas the remaining 85% is used for training the model. The accuracy we were able to achieve is 91%. Below is the Confusion matrix of the classifier in each category:

	precision	recall	f1-score	support
Ariel_Sharon	0.91	0.86	0.88	146
Colin_Powell	0.89	0.87	0.88	145
Donald_Rumsfeld	0.83	0.94	0.88	156
George_W_Bush	0.92	0.84	0.88	161
Gerhard_Schroeder	0.83	0.83	0.83	156
Hugo_Chavez	0.96	0.85	0.90	151
Jacques_Chirac	0.90	0.85	0.87	143
Jean_Chretien	0.92	0.92	0.92	154
John_Ashcroft	0.96	0.85	0.90	137
Junichiro_Koizumi	0.79	0.96	0.87	129
Serena_Williams	0.96	0.95	0.96	171
Tony_Blair	0.77	0.87	0.82	151
Total Accuracy				
accuracy		0.88	1800	
macro avg	0.89	0.88	0.88	1800
weighted avg	0.89	0.88	0.88	1800

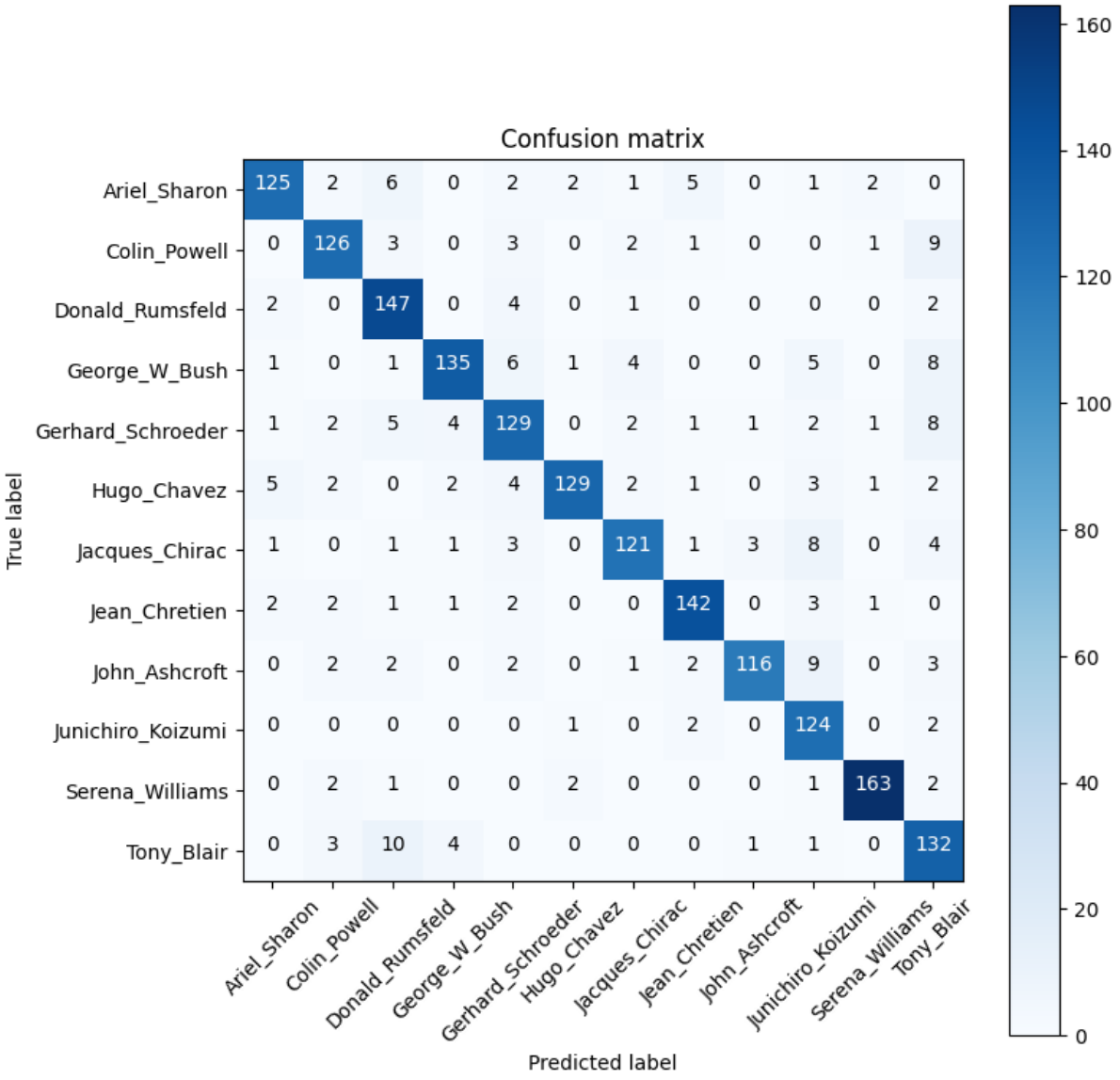

Figure 5. 1 Confusion Matrix

Chapter 6: Conclusion and Future Recommendation

6.1 Conclusion

We have successfully developed a face recognition-based attendance system using Convolutional Neural Network (CNN) algorithm. Our system utilizes a trained deep-learning model for face detection and recognition, and a combination of label encoding and categoricalization techniques to preprocess the data for classification.

We have tested our system using a dataset of facial images and achieved high accuracy rates in face detection and recognition. Our system is also efficient in terms of processing time and can handle a large number of images in real-time.

6.2 Limitations and Future Enhancements

a) Limitations

As far as we could, we tried our best to make the project perfect.

Even though there are some limitations that we were unable to implement in the project despite of our efforts. Some of them are listed below:

1. We could not integrate live CCTV video

b) Future Enhancement

As we have some limitations in our project, we can enhance our project. Some of the enhancements that can be done in our project are

1. Integrating live data from CCTV
2. Decreasing the processing time by building detection,and classification in a single model.
3. Automatic network sync upon addition of a new node in the network
4. Building a mobile app for the project.

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Appendix A

Appendix

A.1 Capture of 50 face data samples

Using the open-cv we first capture the 50 samples data of users to train them in the model that we can get accurate attendance of them.

Figure A. 1 50 Frame Of Capture Image

A.2 User Interface to interact with the user

We have created a simple UI to take the user input such as roll number/user-id and their name.

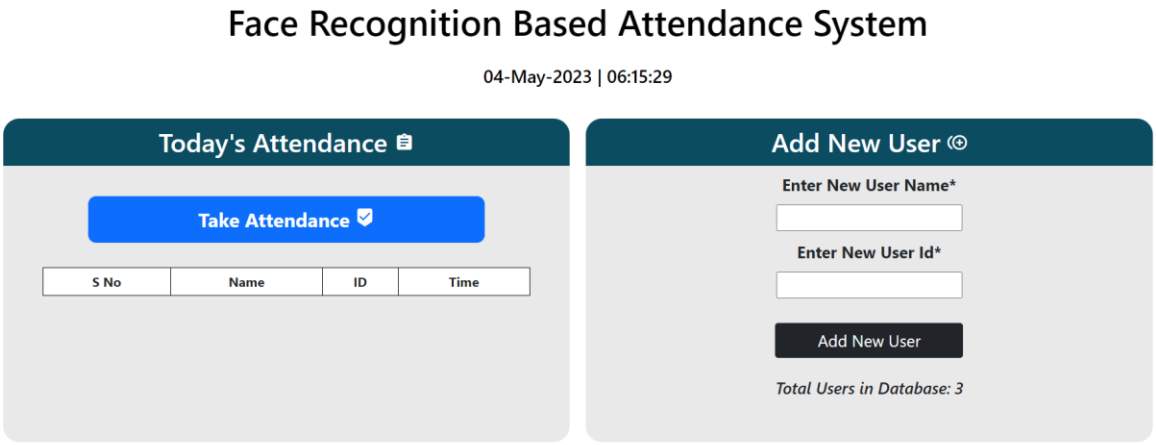

Figure A. 2 Simple User Interface

A.3 Registering the user with face

After giving the user-id and name camera will open to take the 50 samples of the user face.

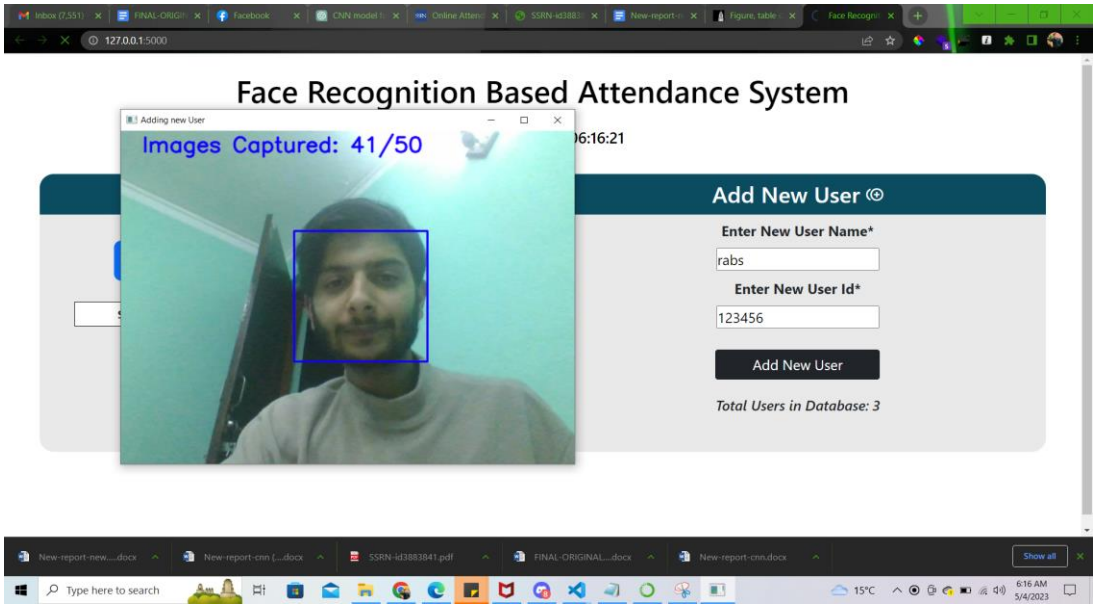

Figure A. 3 Registering the user

A.4 Detection of the registered user

As soon as the user clicks to mark the attendance the camera will open to detect and recognize the registered user.

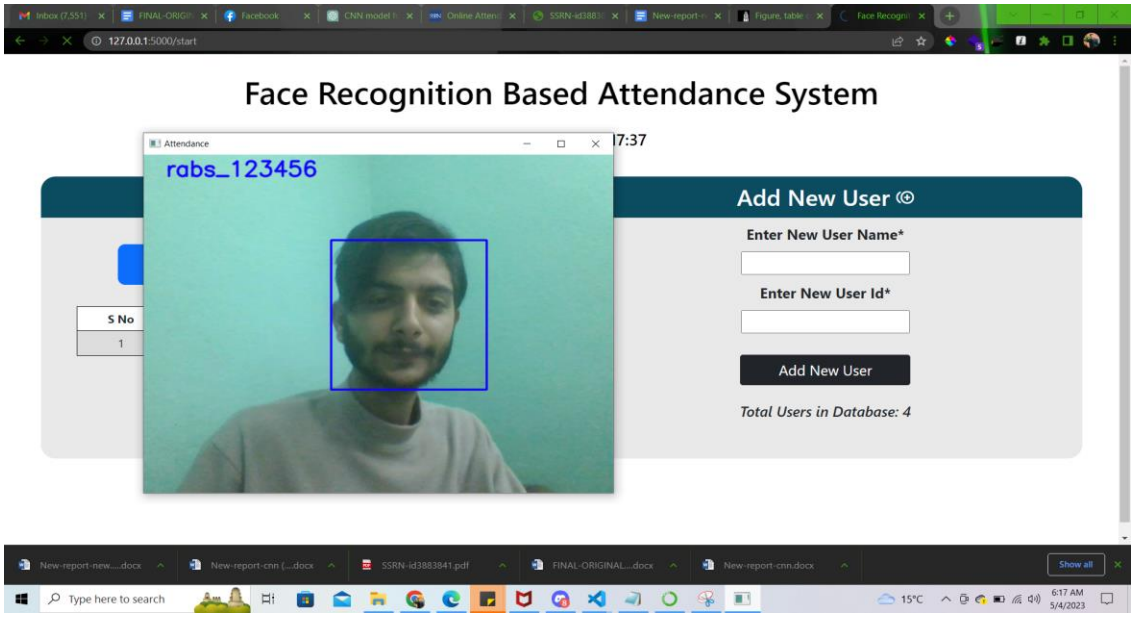

Figure A. 4 Detection of registered user

A.5 Marking the attendance

At last the attendance of registered user will be marked and entry can be shown in the UI as well with the respective time.

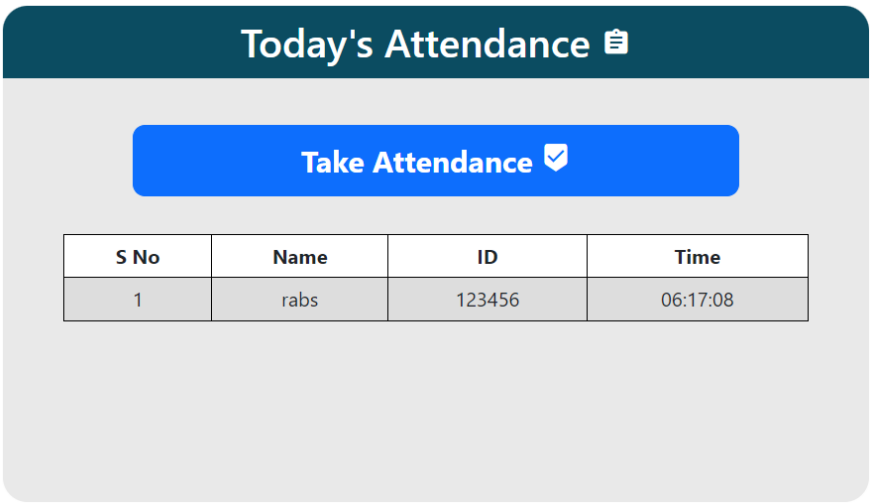

Figure A. 5 Updating attendance