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AFRICAN CENTER OF EXCELLENCE IN INTERNET OF THINGS

Research Thesis Title:

Designing a real-time Face recognition attendance using Machine Learning

A dissertation submitted in partial fulfilment of the requirements for the award of masters of science degree in internet of things: wireless intelligent sensor network.

Submitted by:

Marie Adeline UMURERWA(Ref. No:220020230)

December,2022

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Supervised by:

Main supervisor: Dr. Gaspard HARERIMANA

Co-Supervisor: Dr. Innocent KABANDANA

December,2022

DECLARATION

I, Marie Adeline UMURERWA with Ref No: 220020230, Master's student at the University of Rwanda, College of Science and Technology, African Center of Excellence in the Internet of Things-Wireless Intelligent sensor Networking, hereby declare that this work is original and it was never been presented at the University of Rwanda or in any other Universities or institutions for the academic award or any other purpose.

Marie Adeline UMURERWA

Signature:

Date: 17/12/2022

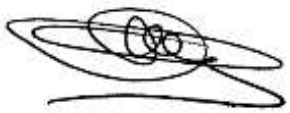
CERTIFICATION

This is to certify that the project work entitled “A real-time Face recognition attendance with Machine Learning” Is a record of the original work done by Marie Adeline UMURERWA (220020230) in

partial Fulfillment of the requirement for the award masters of Science in the internet of things at College of Science and Technology, the university of Rwanda during the academic year 2020-2022

This work has been submitted under the guidance of Dr. Gaspard HARERIMANA and Dr. Innocent KABANDANA.

Main supervisor: Dr. Gaspard HARERIMANA

Signature: 

Co-supervisor: Dr. Innocent KABANDANA.

Signature: 

Head of Master's studies: Dr. James RWIGEMA

Signature:

DEDICATION

I dedicate this dissertation,

To the almighty God,
To my family members,
To the management of the African Center of Excellence in the Internet of Things (ACE-IoT) for the skills and support that they provided to complete this dissertation,
To my supervisors, lecturers, and close friend, who supported me a lot during my master's studies!

ACKNOWLEDGEMENTS

I would like to take this opportunity to express my deepest gratitude to my Almighty God, for the unconditional and infinite love he has for me, and for making, by his grace, who I am today.

My sincere appreciation goes to my loving family for your prayers and encouragement during the internship period. I thank you for your patience, moral support, and understanding.

My deep appreciation to the management of ACE-IoT to Dr. Damien Hanyurwimfura and Dr. James Rwigema.

Special thanks to the colleagues and lecturers that showed and encourage me through this journey, particularly my supervisors of Dr. Gaspard HARERIMANA and Dr. Innocent KABANDANA for their supervision and support in this project. I am extremely grateful to you.

May God bless you all!

ABSTRACT

Systems for managing attendance are crucial for all organizations. One of the most often utilized biometrics for verifying human identity is the face. Most businesses in Rwanda utilize logbooks, cards, or fingerprints to track employees' attendance at work. However, because of COVID-19, which is an infectious disease, attendance has been discontinued due to concerns over its spread. This study describes real-time Face recognition attendance using Machine Learning, an Internet of Things (IoT)-based biometric face recognition solution. To capture the live streaming video, a high-quality camera with a Sony IMX477 sensor and a 16mm 10MP Telephoto lens connected to a Raspberry Pi 4 Model B, can send frames at a time to the cloud. The pre-trained FaceNet model is employed by the system to extract features from a face image after using MTCNN (Multi-Task Cascaded Convolutional Neural Networks) to recognize facial landmarks on images. Real-time image processing is done in the cloud, and attendance is recorded on a dashboard that is accessible from anywhere. The system sends the email to the employee using SMTP Protocol in case of arriving late /absent without permission. The result reveals that the system is safe, dependable, trustworthy, and does not require physical touch.

Keywords: Machine Learning, IoT, Face recognition, face detection, MTCNN, FaceNet

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LIST OF ACRONYMS

- IoT: Internet of Things
- ACEIoT: African Center of Excellence in the Internet of Things
- ML: Machine Learning
- MTCNN: Multi-Task Cascaded Convolutional Neural Networks
- FaceNet: Face recognition system
- CNN: Convolutional Neural Networks
- VGG 16:Visual Geometry Group from Oxford model with 16 layers depth.
- VGG 19: Visual Geometry Group from Oxford model with 19 layers depth.
- VGG face: Visual Geometry Group from Oxford model
- COVID-19: Coronavirus disease of 2019.
- Open CV: Open Source Computer Vision Library
- SMTP: simple mail transfer protocol
- FTP: File Transfer Protocol
- NMS: Non-maximum suppression
- P-Net: Proposal Network
- R-Net: Refine Network
- O-Net: Output Network
- RFID: Radio Frequency Identification
- LED: Light Emitting Diode
- VS Code: Visual studio code
- JSON: JavaScript Object Notation
- SQL: Structured Query Language
- AI: Artificial Intelligence
- FAR: False Acceptance rate
- FRR: False Rejection rate
- SSD: Solid-state storage device
- GPU: Graphic Processing Unit
- RAM: Random Access Memory
- WIFI: Wireless Fidelity
- RTX: Ray Tracing Texel eXtreme
- AI: Artificial intelligence

- DC: Direct current
- NFC: Near Field Communication
- FPS: Frame Per Second
- SMB: Small and Medium Business

CHAPTER 1 : GENERAL INTRODUCTION

1.1 Overview and Background

In the ’70s, fingerprint research technology beganwhich proved reliable over 50 years. In 1989 the research of face recognition technology began in the case of enforcingsecurity and the launching of fingerprint recognition products and widespread usage of it in most countries around the world in the 1990s[1]. Around 160 countries use facial recognition for security and collection of information technology [2]. Facial recognition technology can recognize human faces in pictures or videos, assess whether a face appears in two different pictures of the same person, or look for a face in a big database of images that have already been taken. Face recognition has been used in different areas such as security, computer vision, pattern recognition,etc. Facial recognition is one of the front-runner applications of AI. Artificial intelligence (AI) plays its role in enhancing the performance the basic daily tasks automatically like health factors etc. One of the techniques that can verify attendance due to the pandemic to stop the virus from spreading is machine learning, a subset of artificial intelligence that focuses on using data and algorithms to simulate human learning.

The world is suffering from Coronavirus disease (COVID-19) which is an infectious disease caused bythe SARS-CoV-2 virus as announced by The World Health Organization (WHO) on December 31, 2019[3]. Most people infected with thevirus will experience mild to moderate respiratory illness and recover without requiring special treatment. The virus can spread from an infected person’s mouth or nose in small liquid particles when they cough, sneeze, speak, touch, sing or breathe, The virus spreads more easily indoors and in crowded settings[4][5]. Several governments have implemented a new policy to combat the spread of Covid-19 illness by implementing Covid-19 Self-quarantine (Self-isolation at home)[6].Statistics show since the pandemic began that 600M have been infected, and 6.4M are dead worldwide [7]. In our country Rwanda, 130 k cases have been infected and 1.45K are dead [8]. This loss shows that COVID-19 is a serious pandemic that needs to be considered a priority to be prevented evenif high numbers of the population have been able to take vaccines but if you are fully vaccinated (which requires more than one dose), you can transmit the virus easily. As the world decided to continue normal life and to take high precautions, the transmission of this virus must be prevented at any cost.

Attendance plays a vital role in institutions/companies management to determine the key performance indicator of employees [9]. Employee attendance refers to their being at their assigned work during the necessary hours. It is the technique used to keep track of the time your employees put in and the time they spend on vacation. Attendance can be by punching RFID or NFC cards, Barcode, Fingerprint based attendance management systems, keeping track of employee hours on paper, utilizing spreadsheets, etc. but using a biometric method, is one of the best potential options to avoid the spread of disease within a company[10].

A biometric is the use of distinctive biological/behavioral characteristics to identify people by using a device that helps an organization record the attendance of its employees systematically. Businesses attempting to limit time theft and save expenses associated with lost productivity are now turning to biometric attendance systems as their weapon of choice. Face recognition is one of the methods developed to tackle these challenges and can help organizations to be able to stand on and increase productivity in this revealed unpredictable global pandemic. Therefore, institutions/organization needs to enhance the safety and health of the employees to struggle with it. It is a security mechanism used for providing access to an individual based on face recognition, which is pre-stored in a biometric security system. It is more precise in terms of data collection and verification.

The Internet of Things (IoT) allows device interconnection by centralizing data and connecting both physical and virtual objects. IoT has shown to be very important in the healthcare industry, especially now that the COVID-19 pandemic has changed the situation and social distancing is promoted globally. A real-time Face recognition attendance with ML is an IoT-based approach that combines sensors, actuators, and software, which collect frames through live streaming videos and sends them to the cloud, and records attendance in the dashboard in real-time. It takes automatic attendance without the intervention of the employees. The system will fall into two categories face detection and face recognition. There are methods to put face detection into practice, such as the MTCNN algorithm, for highly accurate face detection, deep Cascaded Convolutional Neural Networks are used. Then, using the FaceNet algorithm, it is possible to execute face recognition by extracting the most crucial features from facial images called face embedded after analyzing the geometric features of the frame.

Many researchers use a large number of IoT-based frameworks to track employee attendance carried out in developed countries and not in favor of the poor population in developing countries. My research uses IoT devices with machine learning, which use the MTCNN to detect faces and a pre-trained FaceNet model to extract features from frames.

The overall contributions of this research can be summarized as follows:

i. A framework based on machine learning for detecting and recognizing faces through live-streamed videos from cameras.
ii. Designing the dashboard to record attendance and generate statistics
iii. To incorporate a notification system that informs employees of their attendance status into the prototype that has been developed.

1.2 Problem Statement

Traditionally, manual attendance is done by signing in and out in a register, which increases the chances ofhuman error and is time-consuming which normally affects the productivity and the key performance of the employees. The data recorded manually is easier to be manipulated or falsified and this can significantly affect business activities and can be a costly affair.

In addition, most companies use fingerprints for staff attendance, which is a biometric solution that requires an exact match. Inexact matching can lead to two different forms of errors: false acceptance rate (FAR) and false rejection rate (FRR)[10]. False Acceptance: If an imposter's template is similar enough to the intra-user variation of the real user, they can be mistaken for one another. False Reject: If the biometric signal collected during authentication is of poor quality, even a legitimate user may be rejected. The technical term for this error is "false reject." If your submission does not fit your template, you have been unfairly rejected. Other attendance methods of the employees like RFID Cards which can be stolen, or misused by other employees to record fake attendance by asking a friend to punch their card for them when they are running late. Another method is comprised of a card NFC-based smartphone, backend server, and reporting equipment[11], [12]. Because NFC technology often includes a suite of associated devices, equipment, and upgrade-dependent standards, it may be too costly. This technique is not entirely risk-free. Hackers have devised creative methods of getting illegal

access to personal data held on phones, and the battle to protect that data is never-ending and can be a way of spreading the pandemic.

However, Due to the rise of different diseases like COVID 19 can be spread by touching each other or the material touched by an infected person. Thus, fingerprints, registers, and cards are using human intervention, which increases errors, which is not a good idea in the case there is a break-out disease as the disease can be transmitted or spread easily in the companies that use the above-said methods. Adopting this facial recognition attendance system can alleviate the aforementioned problems because it uses high-accuracy algorithms that do not rely on physical touch to identify personnel.

1.3 Aims and Objectives

1.3.1 General objective

The purpose of implementing this real-time Face recognition attendance with ML is to record the attendance of the employees with a touchless safety that can help in disease prevention and mitigation (COVID-19).

1.3.2 Specific objectives

- To design a prototype that improves the existing attendance system using the HQ camera to capture live streaming video, and record attendance in the dashboard using a face recognition mechanism with machine learning.
- To integrate the notification system into the developed prototype which will help the employees with their attendance status.
- To generate attendance statistics based on the data recorded in a data engine and data analysis.

1.4 Scope of Study

A real-time Face recognition attendance with ML is developed to be used in Rwanda, to record the attendance of workers by organizations/ institutions it offers touchless safety to the workers and records the attendance with high accuracy, and interacts with the employees by sending emails in case of being late without authorization from admin. This system can help in pandemic prevention and mitigation. This study emphasizes using IoT devices to collect the data (videos) from physical environments and be processed for ensuring the attendance record of the workers via the dashboard, which can be visualized, everywhere by the admin of the system. The period of study from 2020-2022. The geographical scope of the study applies to Rwanda, but owing to its necessity, other African nations and the rest of the world should adopt the system.

1.5 Significance of the Study

This study improves health and safety by reducing and preventing the pandemic in Rwanda, which benefits the health care of employees in all organizations, notably in Rwanda. The system is designed to record each employee's attendance in a touchless manner that is always available, capable of generating reports, and capable of sending emails to those who are not present without permission. This method benefits not only the workers but also the company, which will become profitable because of the workers' productivity and living standards, as well as the advancement of the national economy. The African Center of Excellence in the Internet of Things at the University of Rwanda is viewed as valuable to the nation since it produces creative people who are not useless but will contribute or give back to the community, drawing more students into the subject.

1.6 Hypotheses

The hypotheses of the study describe architectures for integration IoT based system, which is real-time face recognition attendance using Machine Learning to prevent and mitigate the transmission of the pandemic. It is using real-time streaming videos to record the attendance of the employees. The development of an IoT-Based face recognition attendance using machine learning is one of the solutions, which is easier to deploy, and saves technology expenses, the system records the attendance

of the employees using face recognition with machine learning via a dashboard from videos captured in real-time. The system sends emails to the employees, which are arriving late or absent without authorization from admin. The organization cannot only benefit from the innovations of data analysis, which has huge implications, but also from employee safety and health.

1.7 Organization of the Study

The document is organized as follows:

Chapter 1 presents the general idea of the thesis, chapter 2 presents a literature review, chapter 3 outlines the methodology applied in the study, chapter 4 presents the system design of my project, and how it works, chapter 5 shows experiments and results from the analysis, chapter 6 presents the summary of conclusions and recommendations.

CHAPTER 2 : LITERATURE REVIEW

2.1 Review of the Existing Face Recognition System

This chapter presents earlier work on facial recognition attendance systems, as well as the algorithms and methods utilized to implement those systems. More researchers had implemented different systems with different technologies using the facial recognition approach. This section discusses the existing solutions, existing open prototypes, and their limitations and finally shows the contribution of the research.

Sakshi Patel et al.(2018) developed a Face Recognition-based smart attendance system using the open CV algorithms on the python platform. To make use of IoT, an email feature is used which is inbuilt into the raspberry pi. SMTP helped to send the email to their parents. The project can be increasing the speed and accuracy of the model [13].E. Jose et .al(2019), This paper presents the implementation of an intelligent multicamera Face Recognition based surveillance system using FaceNet and MTCNN algorithm on Jetson TX2. The proposed portable system tracks the subject or the suspect with the camera ID/location together with the timestamp and logs his presence in the database, using multiple camera installations. This standalone system detects the person which was already given inthe dataset to track and an embedding being created was successfully detected with an accuracy of 97% and helped in the surveillance and tracking suspects system [14].

F Hamami et al. (2020), proposed Face Recognition Attendance Monitoring System for Lab Surveillance with Hash Encryption, a deep learning algorithm combined with big data technology to create smart attendance with face biometric methods. The prototype was able to recognize the faces in real-time and identify the details of employees with Hash Encryption [15].

G. Anitha et al.(2020), Face Recognition based attendance using MTCNN and FaceNet, use MTCNN to detect faces and FACENET to recognize the individual faces and generates the attendance sheet and share the report through mail to the respective departments and staff members. Facial recognition turns out to be a viable option because of its high accuracy along with minimum human intervention. This system is aimed at providing a significant level of security and reducing manual errors [16]. In this research, Z. Yang et al. (2020) propose an

enhanced model of face recognition, which is based on MTCNN and integrated application of FaceNet and LBP method. The work described in this article using LBP parallel FaceNet to improve the illumination robustness of the model only consists of MTCNN and FaceNet. Experiments show that the enhanced model is very effective in improving illumination robustness [17]. K. Sanath et al(2021), RFID and Face Recognition based Smart Attendance System proposes a model which marks the attendance ofan employee using RFID and facial recognition alongwith a temperature check. In addition, it captures the facial expression of the employee to detect the emotion for counseling if required. Some limitations encountered in this proposed system include if the whole face of the employee captured for facial recognitionis not visible, then the facial recognition will work successfully because the training set containsall such images but emotion classification will fail because detection of the entire face is necessary for emotion recognition. [18].

Rita Goel et al.(2021), A Study of Deep Learning-Based Face Recognition Models for Sibling Identification. This study investigates the use of state-of-the-art deep learning face recognition models(FaceNet, VGGFace, VGG16, and VGG19)to evaluate their capacity for discrimination between sibling faces using various similarity indices. The experimental results show that the accuracy of the chosen deep learning models to distinguish siblings basedon the full-frontal face and cropped face areas vary based on the face area compared. It is observed that VGGFace is best while comparing the full frontal faceand eyes, the accuracy of classification being more than 95 % in this case. However, its accuracy degrades significantly when the noses are compared, while FaceNet provides the best result for classification based on the nose. Similarly, VGG16 and VGG19 are not the best models for classification using the eyes, but these models provide favorable results when foreheads are compared [19].Mrunal Aware et al.(2021), proposed Attendance Management System using Face-Recognition, The proposed system is designed in the TKINTER platform and supported with a script of PYTHON as well as an SQL database. The algorithm used in the system is based on image comparison based on the encoded values of the face from the image from the database with the image recorded by the system in run time. The system has output in the form of an excel sheet[20].

Tippavajhala Sundar Srinivas et al.(2021), presents a Face Recognition based Smart Attendance System Using IoT, The system has been implemented using Raspberry Pi 3 Model B V1.2, Webcam,

OpenCV, Haar cascade, and python. Haar cascade, one of the finest face detection algorithmic programs is used to confirm the standard of the system. The system results in Time-saving, more efficient, Real-time, Precise, Automatic reports in a spreadsheet, and online updating easy[9].S. Kangwanwatana et al.(2022), presents Improve Face Verification Rate Using Image Pre-Processing and FaceNet, a method that does not require retraining each time there is a new person not in the database using a pre-trained FaceNet model. Improvement of the face verification rate is done, in this research paper using image pre-processing on the inputted images, such as using MTCNN to select out the face, face alignment, and brightness adjustment. From testing with Caltech's Faces 1999 (Front)dataset, the proposed method shows an improvement in accuracy [21].

2.2 Existing system limitations

The above studies and most others have contributed to improving the Face recognition model or/and face recognition attendance using IoT devices. Thus, most of them used to capture the image using the phone or the camera manually by ignoring the errors or intervention of human beings in attendance and the hygienic issue during the transmission of disease. Some of the projects mentioned above Tippavajhala Sundar Srinivas et al.(2020), K. Sanath et al.(2021), etc. tried to tack the solution to fight against the COVID-19 pandemic transmission. The projects have limitations because the majority of them were carried out on populations from rich nations, without necessarily taking into account the less privileged populations of developing nations like my own country. Due to those issues why I proposed to take attendance using real-time video streaming face recognition using IoT devices without human intervention to fight against the transmission of the disease.

Table 1: Related papers and their limitations addressed by the recent works

No	Authors& year	Project title	Scope	Limitations
1.	G. Anitha et al.(2020)	Face Recognition based attendance using MTCNN and FaceNet	The proposed system is a mobile application, that used MTCNN to detect faces and FaceNeT to recognize individual faces and generates the attendance sheet, and shares the report through mail to the respective departments and staff members. Facial recognition turns out to be a viable option because of its high accuracy along with minimum human intervention. This system is aimed at providing a significant level of security and reducing manual errors.	Use a mobile phone and record the attendance into an excel sheet which is not accessible online and The system doesn't protect its users against infectious environment
2.	Tippavajhala Sundar Srinivas et al(2020)	Face Recognition-based Smart Attendance System Using IoT,	The system has been implemented using Raspberry Pi 3 Model B V1.2, Webcam, OpenCV, Haar cascade, and python. Haar cascade one of the finest face detection algorithmic programs is used to confirm the standard of the system. The system results in Time-saving, more efficient, Real-time, Precise, Automatic reports in a spreadsheet, and online updating easy	Use Different technologies and devices and the system is inaccessible online, and no emailing system is used .
3.	F. Hamami, I. A. Dahlan, S. W. Prakosa,	Implementation of Face Recognition Attendance Monitoring	proposed to employ deep learning algorithms based on the Convolutional Neural Network (CNN). Through the CCTV data streaming, faces are captured and matched with the database. Furthermore, it is marked and	The system is not IoT based and has no email delivery

	and K. F. Somantri(2020)	System for Lab Surveillance with Hash Encryption	stored in the database. This system prototype is developed by big data technology to tackle this complexity of data. The recognized faces can be monitored in real-time monitoring. Eventually, real-time reports are delivered through the web and android devices with API after the data transmission is secured with hash encryption.	to workers in this case.
4	K. Sanath et al.(2021),	RFID and Face Recognition based Smart Attendance System	Proposes a model which marks the attendance of an employee using RFID and facial recognition along with a temperature check. Also, it captures the facial expression of the employee to detect the emotion for counseling if required.	The system use photos, not accessible online, providing a contagious environment with human intervention.
5.	Mrunal Aware et al.(2021)	Attendance Management System using Face-Recognition	The proposed system is designed in the TKINTER platform supported with a script of PYTHON as well as SQL database. The algorithm used in the system is based on image comparison based on the encoded values of the face from the image from the database with the image recorded by the system in run time. The system has output in the form of an excel sheet.	No email system and no displaying statistics and not IoT based.

2.3 Research Contribution

Many of these studies use a large number of IoT-based frameworks to track employee attendance are carried out in developed countries and not in favor of the poor population in developing countries. My contribution research focuses on designing and prototyping a system to monitor the attendance of the employees without contact and real-time using a machine learning approach and able to attain more improvement by using devices with high quality and performance which will be a less expensive system with more accuracy.

CHAPTER 3 : METHODOLOGY

This section describes the technologies, methods, and materials that will be used in the research. The system's main goal is to coordinate and enhance the training and placement attendance process. By offering an automated and dependable system, manual process errors can be reduced. Increase privacy and security health, eliminate fake attendance, and send out attendance records regularly.

3.1 Background Knowledge

- **Transfer Learning**

A model created for one task is used as the basis for another using the machine learning technique known as transfer learning. Machine learning is a branch of artificial intelligence (AI) and computer science that uses data and algorithms to imitate how humans learn, gradually improving its accuracy.The primary idea behind transfer learning is to use what has been learned in one task to enhance generalization in another[22]. Transmission of a network's learned weights from "task A" to a new "task. B", transfer learning is mostly employed in computer vision. It can be used for classification, regression, and clustering problems.

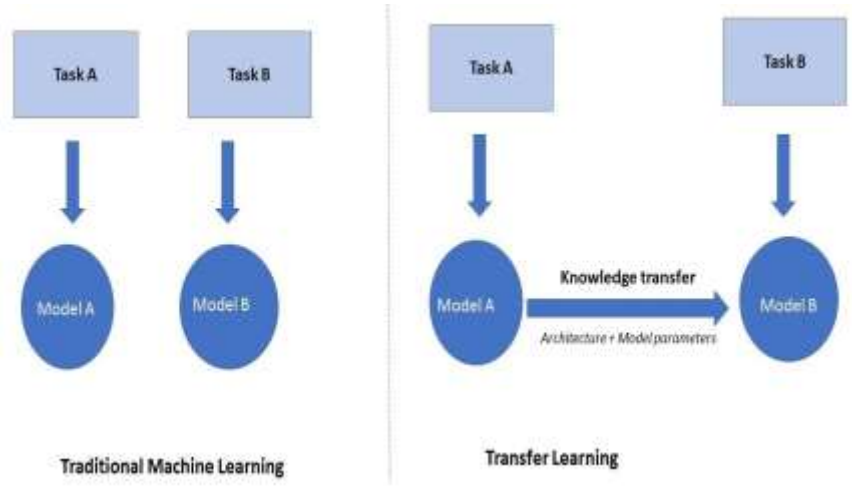

Figure 3-1: Traditional machine learning vs Transfer Learning (source: 21)

Recently, convolutional neural networks (CNNs) achieve remarkable progress in a variety of computer vision tasks, such as image classification [23] and face recognition [24]. Inspired performance of CNNs in computer vision tasks, some of the CNN-based face detection approaches have been proposed in recent years. Li et al.(Li et al. 2015)[25] use cascaded CNNs for face detection, but it requires bounding box calibration from face detection with the extra computational expense and ignores the inherent correlation between facial landmarks localization and bounding box regression.

- **Convolutional neural networks (CNNs)**, a subclass of artificial neural networks that have gained prominence in several computer vision applications, are gaining popularity in several fields, including image processing. Using a variety of building pieces, including convolution layers, pooling layers, and fully connected layers, CNN is designed to automatically and adaptively learn spatial hierarchies of features through backpropagation. The CNN model of stringed neural networks proposed by LeCul et al. in 1989 [26] opened up a new research direction in detecting patterns in images as well as in videos. A convolution neural network consists of an input and an output layer, as well as multiple hidden layers.

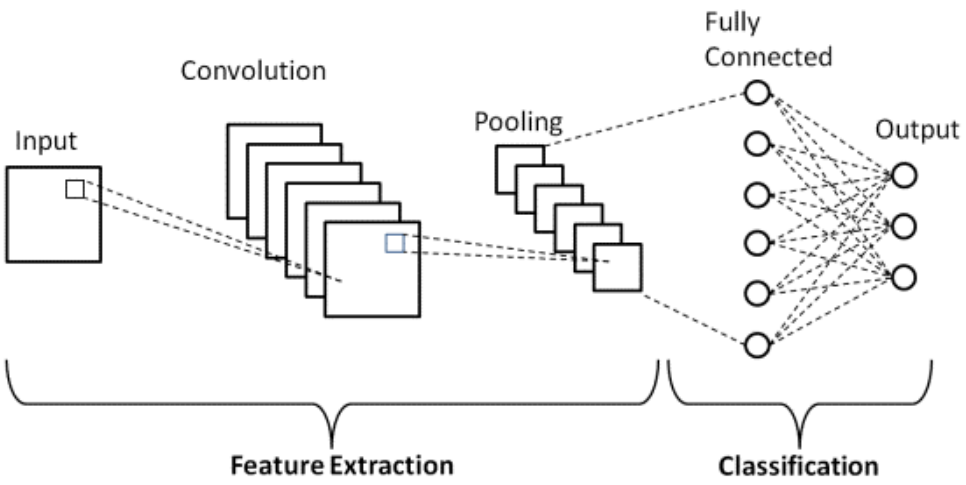

Figure 3-2: CNN architecture 2source:[27])

CNN's hidden layers usually consist of a series of complex layers that can vary with convolution [28]. The trigger function is usually ReLU layers, and then following by additional convolutional parts such as layers of convolution, pooling, and fully connected layers. Therefore, they are called hidden layers because of their inputs, and the active functions and final convolution operators obscure the output.
Numerous author teams have studied face detection algorithms. MTCNN, short for multi-tasking, deeply layered model, was proposed by Zhang et al in 2016 [29], proposed a multi-tasking, deep layered model called MTCNN [30]. Firstly, the candidate window is created through the quick proposal network (P-Net). Secondly, the candidate areas in the next phase are refined through network refinement (R-Net). Thirdly, the output network (O-Net) creates the final bounding box and the position of the main landmarks of the face as shown in figure 3. As a result, the accuracy is approximately 82.1% high, perhaps 95.9%, and the maximum FPS with GPU is 100.

- **MTCNN**

MTCNN or Multi-Task Cascaded Convolutional Neural Network is a neural network, which detects faces and facial landmarks on images. It was publishedin 2016 by Zhang et al.[29]. One of the most widely used and reliable face-detection technologies availabletoday is MTCNN. It consists of 3 neural networks connected in a cascade. This model can recognize numerous face detection benchmarks and landmark locations including the eyes, nose, and mouth while maintaining real-time performance since it has three levels of convolutional networks (P-Net, R-Net, and O-Net)[16,17,26,29,30].

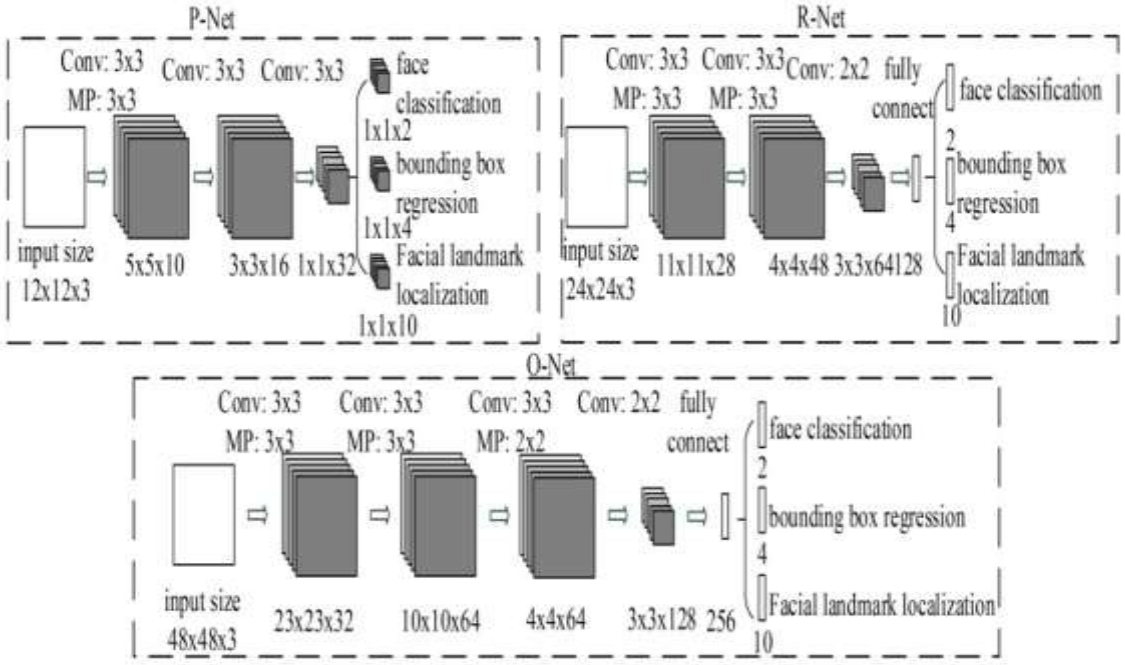

Figure 3-3: The architectures of P-Net, R-Net, and O-Net, where "MP" means max pooling and "Conv" means convolution. The step size in convolution and pooling is 1 and 2, respectively.

Stage1: The proposal Network (P-Net)

This Proposal Network is used to obtain candidate windows and their bounding box regression vectors.

Bounding box regression is a popular technique to predict the localization of boxes when the goal is detecting an object of some pre-defined class, in this case, faces. After obtaining the bounding box vectors, some refinement is done to combine overlapping regions. The final output of this stage is all candidate windows after refinement to downsize the volume of candidates.

Stage2: The Refine Network(R-Net)

All candidates from the P-Net are fed into the Refine Network. The R-Net reduces the number of candidates, performs calibration with bounding box regression, and employs non-maximum suppression (NMS) to merge overlapping candidates. The R-Net outputs whether the input is a face or not, a 4-element vector, which is the bounding, box for the face, and a 10-element vector for facial landmark localization.

Stage3: The Output Network (O-Net)

This stage is similar to the R-Net, but this Output Network aims to describe the face in more detail and output the five facial landmarks' positions for eyes, nose, and mouth.

The multi-task cascaded convolutional neural network (MTCNN) is used to achieve rapid face detection and face alignment while keeping real-time performance and being easy to integrate with Keras.

The Three Tasks of MTCNN

The Network's task is to output three things: face/non-face classification, bounding box regression,and facial landmark localization [16, 26, 29, 30].

1. **Face classification**: this is a binary classification problem. For each sample *xi*, uses cross-entropy loss:

$$L_i^{det} = -\left(y_i^{det}\, log(p_i) + (1-y_i^{det})(1 - log(p_i))\right) \quad 3.1$$

Equation *3.1* where p_i is the probability produced by the network that indicates sample *xi* being a face. The notation $y_i^{det} \in \{0,1\}$, denotes the ground-truth label.

2. **Bounding box regression**: the learning objective is a regression problem. For each candidate window, the offset between the candidate and the nearest ground truth is calculated. Euclidean loss is employed for sample x_i [29]:

$$L_i^{box} = \left\|\hat{y}_i^{box} - y_i^{box}\right\|_2^2 \quad 3.2$$

Equation 3.2 where $\hat{y}_i^{box}$the regression target is obtained from the network and y_i^{box} is the ground-truth coordinate.

3. **Facial Landmark localization**: the localization of facial landmarks is formulated as a regression problem, which minimizes the euclidean loss[29]:

$$L_i^{landmark} = \left\|\hat{y}_i^{landmark} - y_i^{landmark}\right\|_2^2 \quad 3.3$$

In Equation 3.3 Where $\hat{y}_i^{landmark}$ is the facial landmark's coordinate obtained from the network and $y_i^{landmark}$is the ground-truth coordinate for the i-th sample.

There are five landmarks: left eye, right eye, nose, left mouth corner, and right mouth corner.

- **FaceNet**

FaceNet is a deep neural network used for extracting features from an image of a person's face. It was published in 2015 by Google researchers Schroff etal. paper titled "FaceNet: A Unified Embedding for Face Recognition and Clustering" [31]. FaceNet uses a deep convolutional network trained to precisely optimize the embedding itself, instead of intermediate bottleneck layers as in previous deep learning approaches. It is a robust and efficient face

recognition system, and the general nature of the extracted face embeddings provides the approach to the rangeof applications.

The model is a deep convolutional neural network trained via a triplet loss function that encourages vectors for the same identity to become more similar (smaller distance), whereas vectors for different identities are expected to become less similar (larger distance). The focus on training a model to create embeddings directly (rather than extracting them froman intermediate layer of a model) was an important innovation in this work.

FaceNet takes an image of the person's face as input and outputs a vector of 128 numbers, which represent the most important features of a face. In machine learning, this vector is called embedding. FaceNet takes a person's face and compresses it into a vector of 128 numbers [19, 20, 30]. Ideally, embeddings of similar faces are also similar. The FaceNet with improved loss function is used to realize face verification and recognition with high accuracy. FaceNet is the backbone of many open-source systems such as FaceNet using Tensorflow, Keras FaceNet, DeepFace, and Open Face.

FaceNet directly learns a mapping from face images to a compact Euclidean space where distances directly correspond to a measure of face similarity.

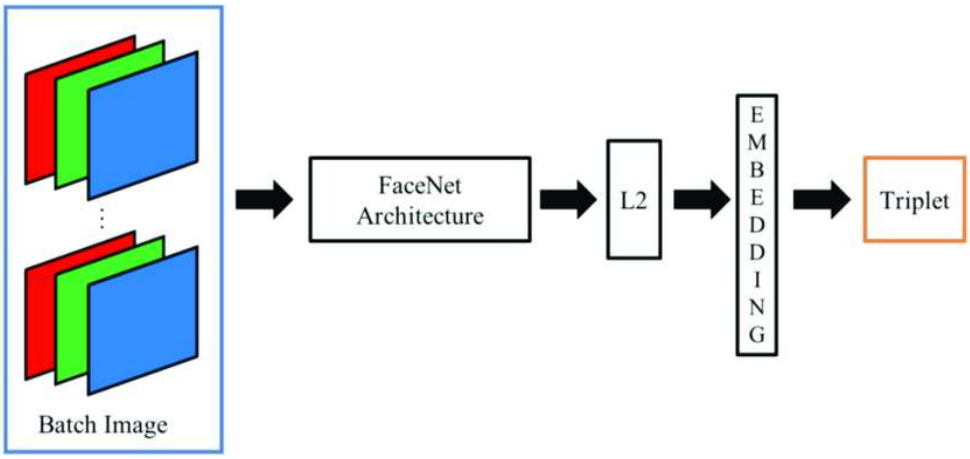

Figure 3-4: Model structure. Our network consists of a batch input layer and a deep CNN followed by L2 normalization, which results in face embedding. This is followed by triplet loss during training [31].

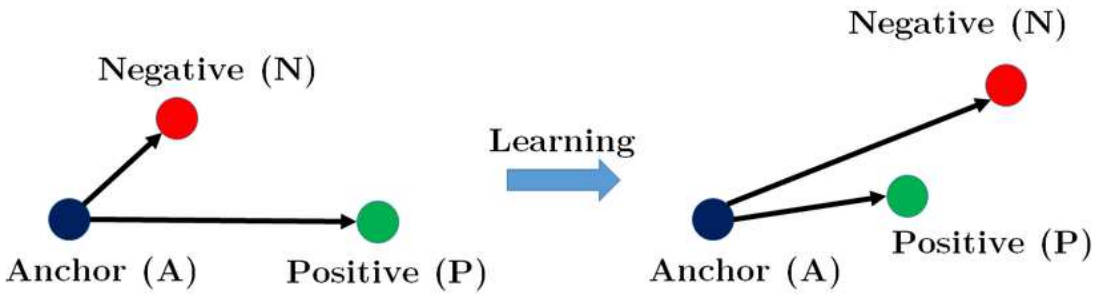

Figure 3-5: The Triplet Loss minimizes the distance between an anchor and a positive, both of which have the same identity, and maximizes the distance between the anchor and a negative of a different identity (source:[31]).

3.2 Face detection

Face detection is a method for detecting and locating human faces in digital pictures and videos. The system uses Multi Task Cascade Neural Network (MTCNN) [29, 30]. The network uses a cascade structure with three networks (P-Net, R-Net, and O-Net). First, the image is rescaled to a range of different sizes (called an image pyramid); Stage 1- the first model 'Proposal Network or P- Net' proposes candidate facial regions. Stage 2 -the second model 'Refine Network or R-Net filters the bounding boxes. Stage 3 - the third model 'Output Network or O-Net' proposes facial landmarks. Pre-processing is performed during the training phase, after the detection of faces in images. It is a procedure for improving the image's features. The suggested approach crops and resizes recognized faces from dataset photos before converting them to grayscale images. The processed photos are saved in a separate folder for each person. During the testing phase, the discovered faces from the live capture are fed into the FaceNet model for face recognition. Experimental results had always been demonstrated that while keeping the reliability of real-time performance, MTCNN consistently outperforms the sophisticated conventional methods across the most challenging benchmarks.

3.3 Face recognition

- **Keras FaceNet**

FaceNet Keras is a one-shot learning model. It fetches 128 vector embeddings as a feature extractor. It is even preferable in cases where we have a scarcity of datasets. It consists of high accuracy even for such situations[32]. So, I used the pre-trained Keras FaceNet model (88 megabytes) provided by Hiroki Taniai which is the best for the deep learning model and ready for use is around 0.994 of LFW [33]. It fetches 128 vector embeddings as a feature extractor. The

provides a script for converting the Inception ResNet v1 model from TensorFlow to Keras. It was trained on the MS-Celeb-1M dataset and expects input images to be color, to have their pixel values whitened (standardized across all three channels), and to have a square shape of 160×160 pixels.

3.4 Face Recognition Approach

The face recognition approach is a method of identifying or confirming an individual's identity using their face. Facial recognition systems can be used to identify people in photos, videos, or in real-time. The facial technology systems can vary, but in general, they tend to operate as follows:

- Face detection: The camera detects and locates the image of a face, either alone or in a crowd. The image may show the person looking directly ahead or in profile.
- Normalization/Face analysis: an image of the face is captured and analyzed, the software reads the geometry of your face and most of the Facial technology relies on 2D rather than 3D.

  Key factors include the distance between your eyes, the depth of your eye sockets, the distance from forehead to chin, the shape of your cheekbones, and the contour of the lips, ears, and chin. The aim is to identify the facial landmarks that are key to distinguishing your face.

- Feature extraction: The face capture process transforms analog information (a face) into a set of digital information (data) based on the person's facial features. Your face's analysis is essentially turned into a mathematical formula. The numerical code is called a faceprint.
- Face recognition/Face matching: Your faceprint is then compared against a database of other known faces.

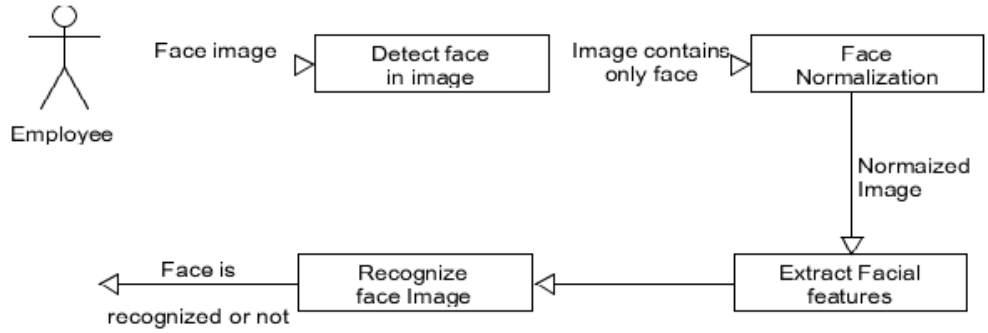

Figure 3-6: Face recognition approach

3.5 System Architecture

The system architecture is the conceptual design that defines the structure and/or behavior of a system. An architectural description is a formal description of a system, organized to support reasoning about the structural properties of the system. It defines the system components or building blocks and provides a plan from which products can be purchased and systems developed, which will work together to implement the overall system.

Figure 3-7: System Architecture, the sensing unit, and the microcontroller connected to the DigitalOcean cloud system are the main components of the architecture, via the internet. The HQ camera with a 16mm lens, buzzer, LED, cooling fan, and servo motor connected to the raspberry pi 4 model B is from the edge devices. Raspberry pi connected to the internet will process the data collected from the camera, then transfer them to the cloud. The processed data is accessed via a web server. MTCNN assists in detecting and locating faces in frames by constructing a bounding box around their extent, and FaceNet extracts features from images. As a result, it compares the new faces to existing encoded images, adds a rectangle-bounding box to the frame, and sends the results to the web to record attendance in the dashboard.

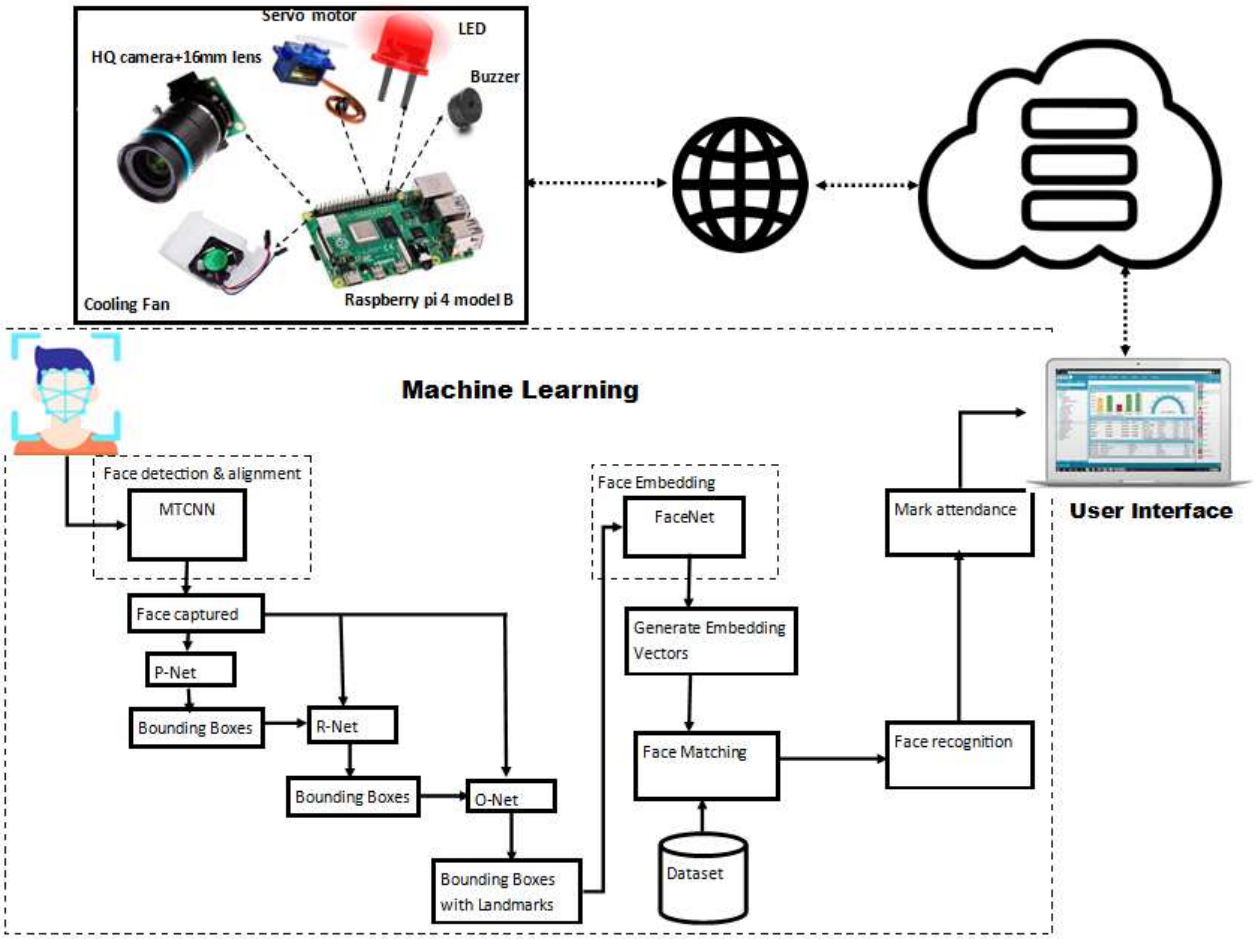

Figure 3-7: System Architecture

3.6 Working Principle of the System

Here are going to look systematically at how the system will work.

1. Person registration

The admin registered the new employees with the photo via a dashboard. The MTCNN detect images, FaceNet process the images, and store extracted features of the employees. Here in the dashboard, the admin can be adding multiple images from different angles, environments and conditions, orientations, locations, and brightness into the system to be able to increase accuracy.

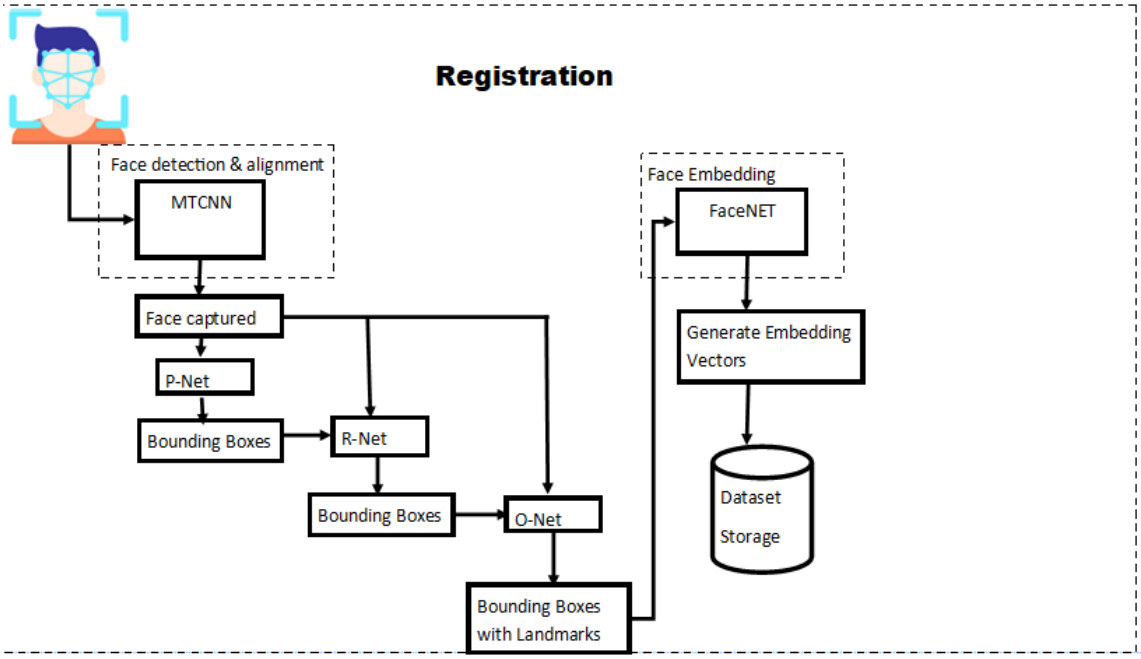

Figure 3-8: Registration phase

2. Frame Capturing Phase

In this phase Raspberry pi, a High-Quality Camera with a lens of 16mm 10MP telephoto connected to the Raspberry pi 4 Model B captures real-time video and then splits it into frames with the software OpenCV library.

3. Face detection and Recognition phase

The system uses the MTCNN to detect the face area in the frame; it detects as many faces as present in the given live-streaming videos and delivers their bounding-box coordinates. After getting the bounding box of a face in an image, it is easier to crop the face part of the image and use it. I use a pre-trained FaceNet model to build the database of embeddings corresponding to the existing face image dataset.

Mainly 2 functions are used in the face recognition approach:

- face_encoding: retrieves all images stored at a person's images locations, resizes and normalizes them. It then uses MTCNN to detect the face in each image and crops the image where the face is located the image is then encoded using the FaceNet model and stored in the encodings.json file.
- face_comparison when an image is passed from the picamera, the face_comparison takes the image, in addition, passes it into MTCNN to detect every face in it. For every face in it, the function crops the face section and encodes it using FaceNet. The encoding of each face is then compared to all the encodings in encodings.json using the cosine rule with a tolerance of 0.3, the function returns the image which holds the highest similarities in the encodings.json. Using cv2, the name is then added to the image and returned.

4. Marking attendance phase

In this phase the attendance is marked, if the person in the uploaded frame matches the encoding stored in the database, then the attendance is marked present and saved in the database. However, if any employees do not attend during the morning time, the system will check, generate, and send the email to the employee. Then in the time set the camera will rotate 180^{0} to take the afternoon attendance after a certain time also the system will send the email to those who didn't sign out. The system administrator has the ability to edit via the dashboard in the event of an informed leave or absence in order to avoid confusing the system.

3.7 Proposed System Requirements

The system is made up of both hardware and software components. The hardware components have been grouped into categories based on their functions.

❖ **HARDWARE COMPONENTS**

- The main components of the prototype system are:

1. **Raspberry pi High-Quality camera module**: Sony IMX477 sensor released in 2020, used for data acquisition. It has 12.3 megapixels with a 7.9mm diagonal image size, 7.9 mm sensor diagonal, and 1.55 µm × 1.55 µm pixel size with videos up to 1980×1080 pixels. It used a Hoya CM500 infrared filter, which blocks visible light and only allows infrared light to pass through into the lens and camera. By adding a 16mm C-mount telephoto lens on it, it provides superior low-light performance. This HQ Camera with a lens will help to build a CCTV Camera, which will capture images up to 4056 x 3040 pixels through live streaming, which is a preprocessed input [34].

Figure 3-9: Raspberry pi HQ camera

2. **16mm 10MP Telephoto lens**: It has a resolution of 10MP and uses a 16mm ultra-wide angle focal length high definition telephoto lens. It capture every tiny detail and multi-field angle option which brings the beautiful world into your vision and has a wide field of view (FoV): 1″ 44.6° × 33.6° … 2/3″ 30.0° × 23.2° … 1/1.8″ … 24.7° × 18.6° … 1/2″ 21.8° ×16.4°and a variety of uses, like CCTV applications. It takes a High-quality picture with a more zoomed-in view making it perfect for close-up capture [35].

Figure 3-10:16mm lens 10MP Telephoto

Figure 3-11: Field of view of HQ camera

3. **Raspberry Pi 4 Model B**: it is the latest product in the popular Raspberry Pi range of computers and is the sixth generation of Pi, is a series of small single-board computers (SBCs) developed in the United Kingdom by the Raspberry Pi Foundation in association with Broadcom[36]. It offers a high-performance 64-bit quad-core processor, dual-display support at resolutions up to 4K via a pair of micro-HDMI ports, hardware video decode at up to 4Kp60, with 2GB of RAM, dual-band 2.4/5.0 GHz wireless LAN, Bluetooth 5.0, Gigabit Ethernet, USB 3.0, and PoE capability (via a separate PoE HAT add-on. It used to process the image captured by the raspberry pi HQ camera and transfers data to the web server for analysis.

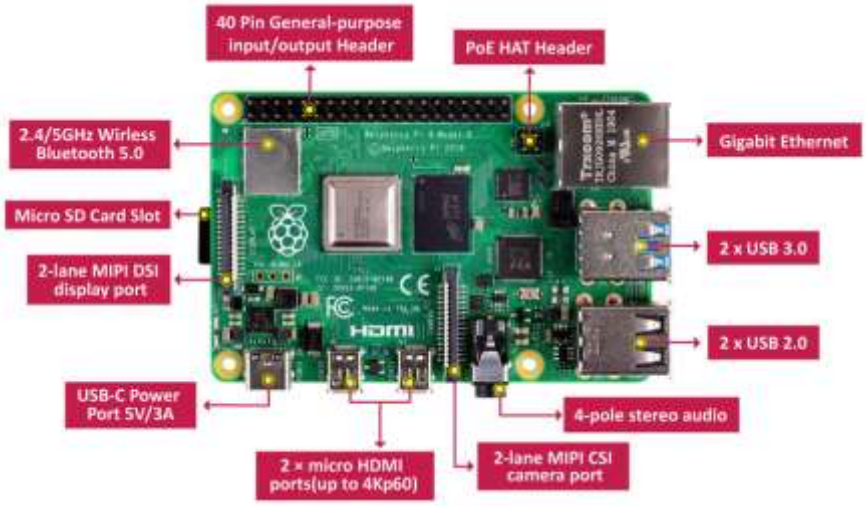

Figure 3-12: Raspberry pi 4 Model B

- **Other components:**

No	Hardware	Description & Role	View
1.	**MG90 micro servo engine/motor servo**	a closed-loop mechanism that incorporates positional feedback to control the rotational or linear speed and position [37]. It is an electronic device, which will help to rotate and push part of the camera with great efficiency and high precision. It has an operating voltage of 4.8 V to 6 and an operating temperature: of 0 ° C ~ + 55 ° C. It is set to rotate the camera at 180ºC.	 *Figure 3-13: Motor servo*
2.	**Buzzer**	An audio signaling device that can convert audio signals into sound signals. It is usually powered by DC voltage [38]. It has a frequency range is 3,300Hz, operating temperature ranges from – 20° C to +60°C, operating voltage ranges from 3V to 24V DC, the sound pressure level is 85dBA or 10cm and the supply current is below 15mA. It gives the sound in case the camera rotates in the time set.	 *Figure 3-14: Buzzer*
3.	**Jump wires**	a smaller and more bendable corrugated cable, which is used to connect antennas and other components to network cabling, electrical wires with connector pins at each end, which is used to connect two points in a circuit without soldering [39].	 *Figure 3-15: Jump wires*

4.	**SD card**	stands for Secure Digital card, is a proprietary non-volatile flash memory card format developed by the SD Association for use in portable devices, it is used to read and write large quantities of data,16GB which helps to store the operating system[36].	 *Figure 3-16:SD Card*
5.	**Pi 4 charger/Raspberry pi Power supply**	a Micro USB plug and produces a voltage perfectly regulated as suited to power the Raspberry Pi 4 with a nominal power of 15W, is a 5-feet cable with an integrated noise filter with output: 5V DC / 2.5A and regulated Input: 100 - 240VA[36].	 *Figure 3-17: Raspberry pi Power Supply*
6.	**LED**	is utilized to signal conditions based on the embedded system situations which indicate if the system is on.[40].	 *Figure 3-18: Light Emitting Diode*
7.	**Resistor**	a device having resistance to the passage of an electric current [41]. It is used for current limiting. I used the 380 Ohm to get the necessary light.	 *Figure 3-19:Resistors*

8.	**Raspberry pi Cooling fan**	active cooling to keep your system from overheating. It is powered by 5V [32].	 *Figure 3-20: Cooling Fan*

❖ CLOUD PLATFORM

DigitalOcean, Inc. is an American cloud infrastructure provider headquartered in New York City with data centers worldwide. DigitalOcean provides developers, startups, and SMBs with a cloud infrastructure-as-a-service platform. The system is hosted on this platform to be accessible everywhere and anytime with 1GB of RAM and 25GB of SSD storage, Data engine of the system from cloud services such as data storage, security, privacy, and execution of the instruction.

❖ SOFTWARE REQUIREMENTS

- **Web server**: A web server is a software or hardware that responds to client requests via the World Wide Web using HTTP (hypertext transfer protocol) and other protocols. A web server's primary responsibility is to show website content by storing, processing, and distributing WebPages to users. **Fast API** acts as a Web server that provides SMTP (simple mail transfer protocol) and FTP (file transfer protocol) for email, file transmission, and storage, in addition to HTTP. FastAPI is a modern, high-performance web framework for backend API. It is used to build web APIs. It is used to receive the requests and frames process the data, create accounts, login, deploy, and authentication of web and for storage.
- **VS 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. It streamlined the code editor with support for development operations like debugging, task running, and version control. It aims to provide just the tools a developer needs for a quick code-build-debug cycle and leaves more complex workflows to fuller featured IDEs, such as Visual Studio IDE.
- **Thonny python IDE** is a beginner-friendly Python IDE (Integrated Development Environment) that allows users with little to no programming knowledge to start their first step

on the road of mastering the Python programming language used in Raspberry pi. It is simple to use and has built-in Python. For the beginner in Python, Thonny provides a clean, vanilla interface.

- **PiCamera python Library**: an excellent Python library designed to provide easy access to imaging capabilities on Raspberry Pi. It used to capture videos from the camera then customize the settings of the HQ camera and send it to the web.
- **Python Schedule Library** used to schedule a task in a very minimalistic and user-friendly way at a particular time every day. It set time in 24 hours format, which is when a task should run.
- **RPIO Library** is an advanced GPIO module for the Raspberry Pi. Package rpio provides GPIO access on the Raspberry PI without any need for external libraries.
- **SQLAlchemy** is a Python library for implementing SQL databases without using the SQL language itself. It used to create a database-using python. This library used as an Object Relational Mapper (ORM) tool that translates Python classes to tables on relational databases and automatically converts function calls to SQL statements.

CHAPTER 4 : SYSTEM ANALYSIS AND DESIGN

A system's architecture is a high-level description of the entire system that specifies its essential pieces and functions, as well as the rules that each element must follow to communicate and collaborate. The Internet of Things is founded on embedded systems as well as other technologies such as pervasive systems and sensor networks. The Internet of Things (IoT) is a system in which "things" are linked together via a network (via Internet protocol) to collaborate and carry out tasks while interacting with the physical and digital worlds. A real-time face recognition system was developed using the IoT architecture paradigm.

In this section, the embedded system level design is presented; first, the system architecture is outlined followed by the system IoT Layers architecture design, Schematic diagram, and database diagram. In the end, the system functionalities will be presented using system flow charts, and Use case diagrams.

4.1 The System Architecture

4.1.1 IoT Layers Architecture

Figure 4-1 IoT architecture, this is how the real-time face recognition attendance works accordingly as per it has been designed/developed. It describes hardware or software systems as well as represents the workflows and processes. This 4 layers architecture is divided into 4 main components/layers Device connectivity/physical layer, Network layer, Data processing, management layer, and application layer.

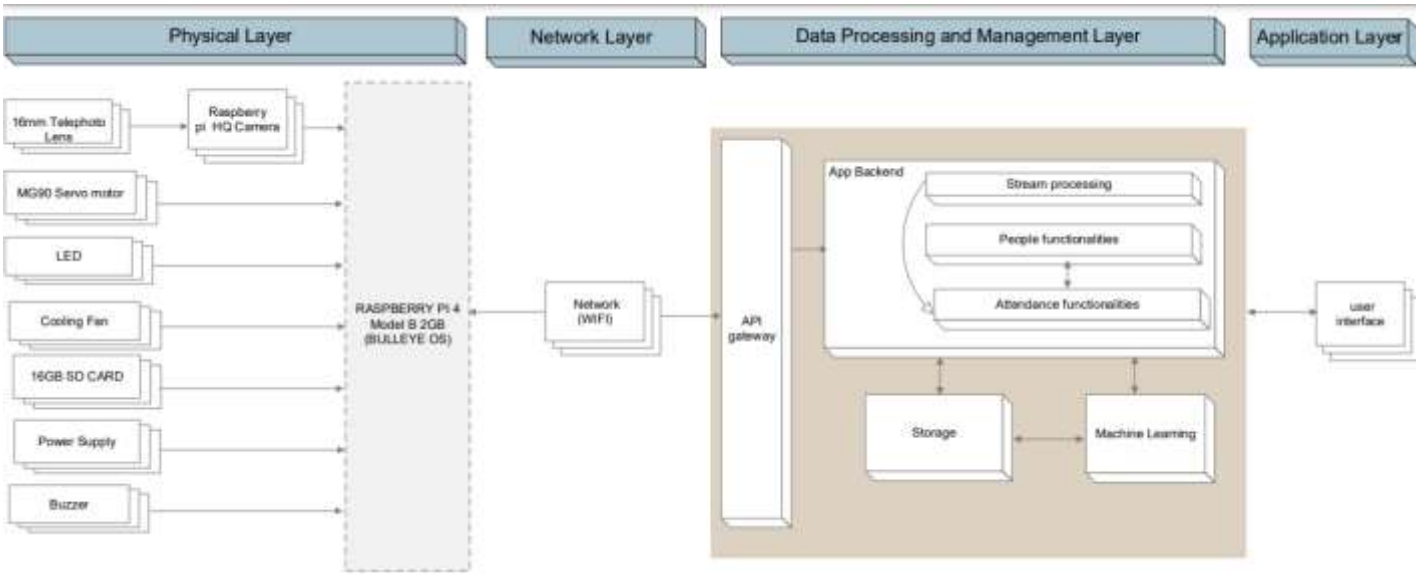

Figure 4-1: IoT architecture

1. Device connectivity/Physical Layer: this part consists of different IoT components with different technologies, which are interconnected together to perform the main goal of this research. Raspberry pi 4 Model B is used as a control unit, raspberry pi HQ camera, LED, and fan which are connected and controlled by a raspberry pi.
2. Network layer: used WIFI as a communication network to link the Control unit with the cloud server
3. Data processing and management Layer: this is the data engine of the system from cloud services such as data storage, security, machine learning, and execution of the instruction.
4. Application layer: This Layer consists of a web application interface that helps the admin to manage and monitor the system for data analysis. It allows the admin to manage and monitor the attendance of the employees and generate reports. This is Web App and a personal computer or smartphone. In this layer, the SMTP protocol is used to send your email.

4.1.2 Schematic Diagram

The schematic diagram is the representation that shows the functionality and connectivity between elements of the system.

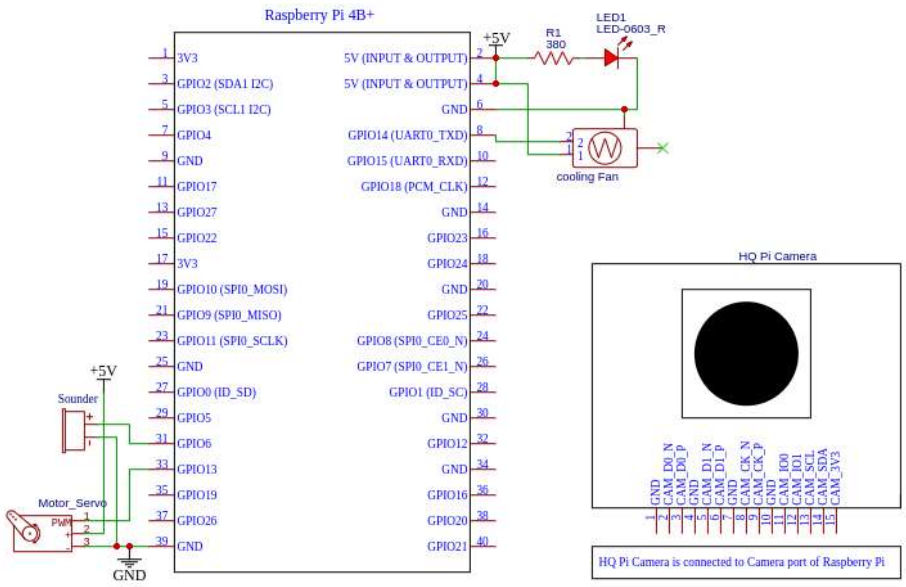

Figure 4-2: Schematic Diagram

4.1.3 Database Diagram

Database diagrams display the database's structure and the connections between its elements graphically. For a data source, a schema, or a table, you can create a diagram. Consider using primary and foreign keys to establish relationships between database objects.

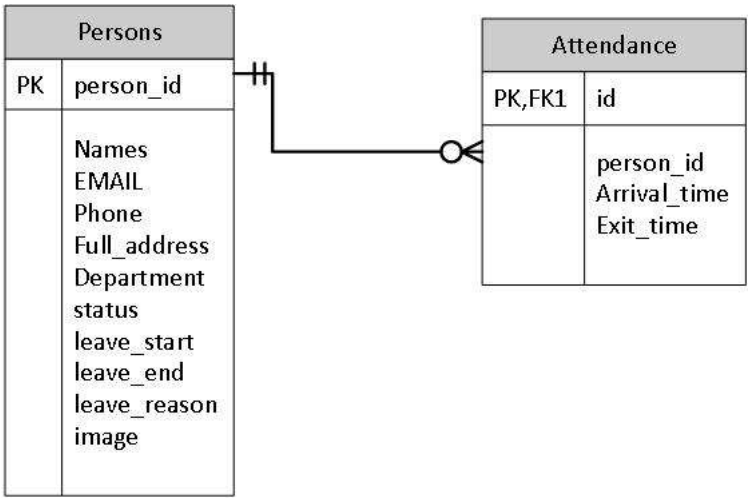

Figure 4-3: Database diagram of the system

4.2 System Functionality

This part explains the flow of both instruction and data in the system and how it functions. It includes the system flow chart and uses case diagrams.

4.2.1 Use Case Diagram

In the Unified Modeling Language (UML), a use case diagram can summarize the details of your system's users (also known as actors) and their interactions with the system. The use cases diagram is used to show the main actors for the system and the related actions they perform. The different actors like Employee who provides the necessary information to be recorded into the system and receives the emails. Admin of the system has access to login, record the info, update, view the live streaming of attendance Employee and log out. Web server to check and recognize faces, store and mark attendance according to time set , and be able to sends the emails to the absent employees, and embedded system captures images, sends frames to the web server and rotates the camera at time set as shown in Figure 4-4 below.

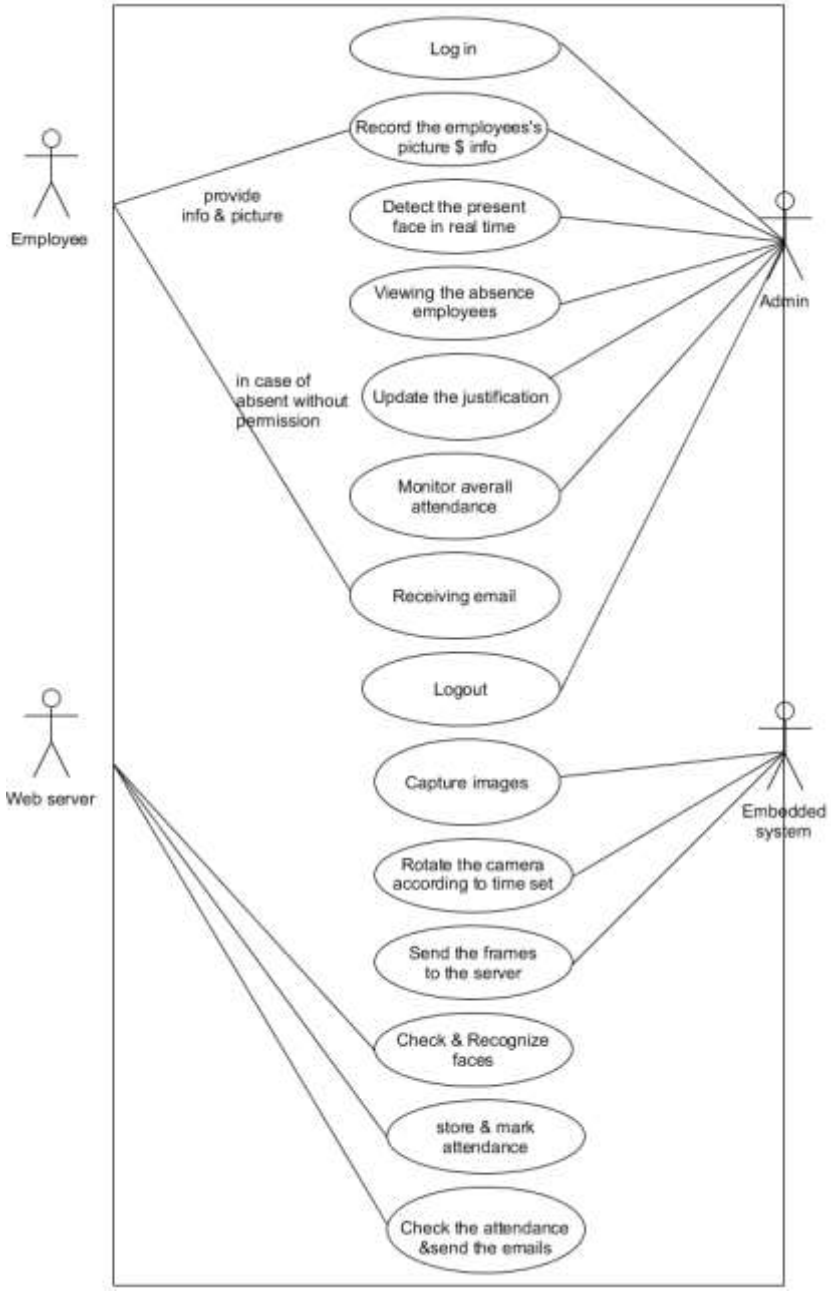

Figure 4-4: Use case diagram

4.2.2 Flowchart Diagram

A flowchart is a graphical representation of steps, which helps to clearly illustrate a process from a beginning to an end. The flow charts describe the flow of data and instructions in the embedded system connected to the web server.

- Figure 4-5: Embedded system connected to the web server below After initialize the embedded system, the system checks the time, captures images and then sends the frames to the server. The web server receives the frame and makes the faces comparison with the embedding vectors stored into database, and then marks the attendance according to the time set and the status of each individual employee.

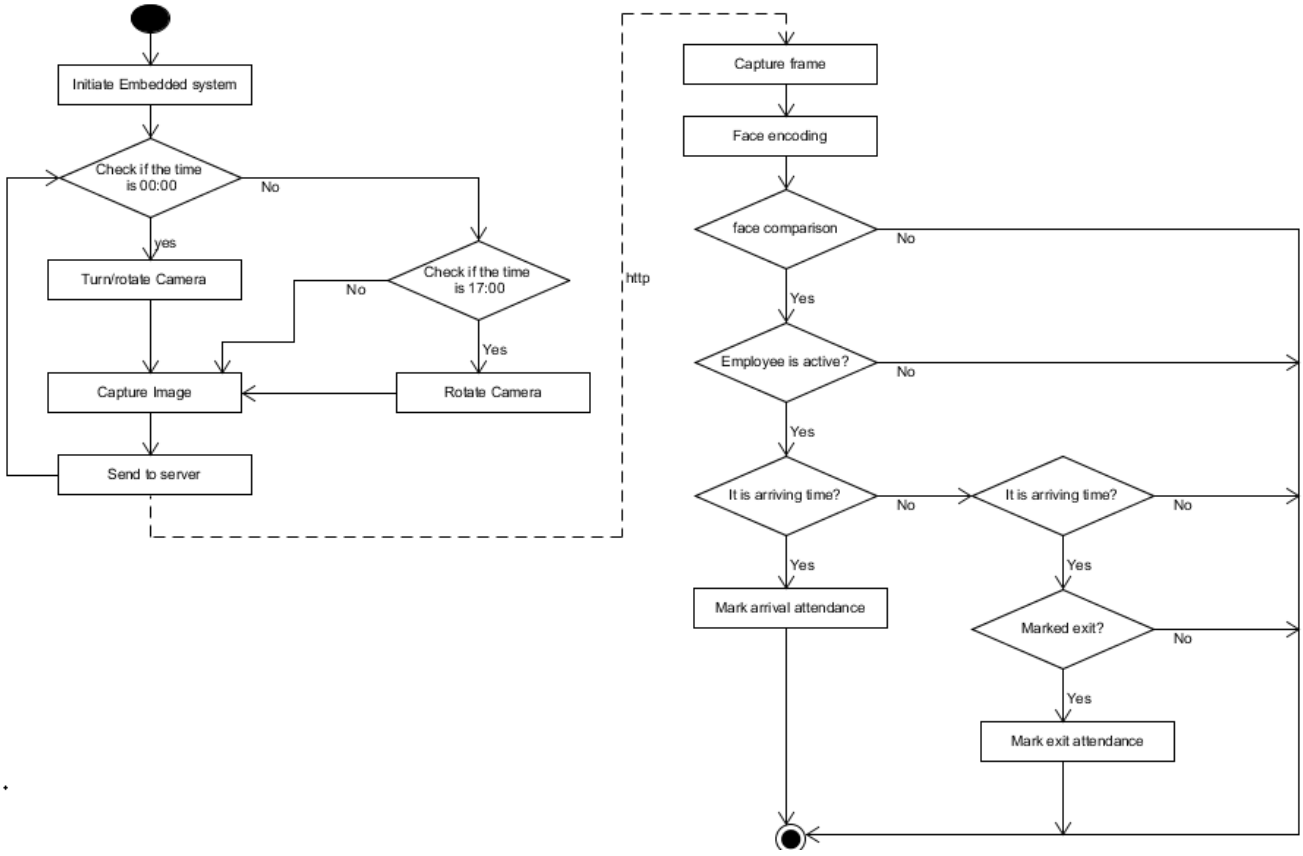

Figure 4-5: Embedded system connected to the web server

- The system checked the attendance list of the employees in morning time at 8:30 AM and evening time at 5:30 PM then able to send the emails to the absent employees as shown in Figure 4-6.

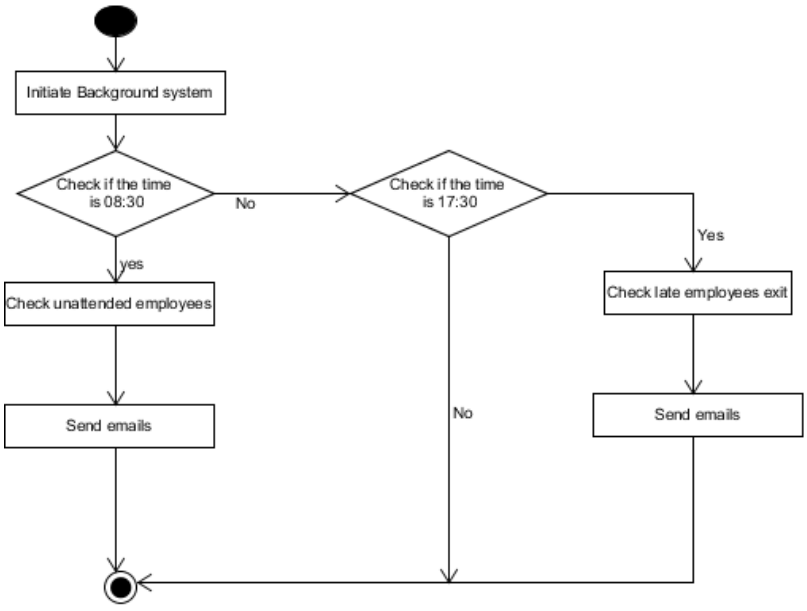

Figure 4-6: Flowchart of sending emails

CHAPTER 5 : EXPERIMENT AND RESULT ANALYSIS

5.1 Introduction

This section consists of face recognition attendance results obtained from images taken a by camera sensor collected from live streaming and the statistic reports are generated based on attendance taken.

5.2 Experiment

5.2.1 Machine Learning Approach

The images is added into a file called images; every person you want to recognize must have a dedicated directory with the image in it and its corresponding names.

MTCNN help us to detect the face in frames and locate it by drawing the bounding box around their extent and FaceNet to extract features from the image. Thus, it compares the new faces with other encoded images, adds a rectangle-bounding box to the frame, and sends the results to the web for marking the attendance into the dashboard.

Table 2: Describe the functions used in the proposed system and its executed results

Test data	Expected Result	Observed Result	Pass/Fail
Cv2.imread() Cv2.imwrite()	Use the CV2 function to read and write the images to corresponding files.	Read and write images	Pass
PiCamera()	use the capture() function from the camera object to take a Videos.	Camera started	Pass
face_encoding()	Retrieves all images stored at a person's images locations, resizes, and normalizes. Then using MTCNN detects the face in	Detected and extracted images features, then stored them in encodings.json file	Pass

	the frame and crops where the face of a person is located, then extracting features using the FaceNet Pre-trained model.		
Face_comparison()	A new image with a person is then turned to its encoding, using FaceNet and compared to other encodings stored in encoding.json using the cosine rule with a tolerance of 0.3.	Face matching	Pass

The results show that the system was successfully implemented with the expected results. The figure below is the face encoded from the saved photos in the file .Json which is s plain text written in JavaScript object notation.

0.1475059688091278, -0.032912783324718475, 0.13536131381988525, 0.009178878739476204, -0.02542356587946415, -0.03663301467895508, -0.06766160577535629], "adeline":
[0.09080983698368073, 0.038561876863241196, -0.09523240476846695, -0.03089103475213051, -0.01946841925382614, -0.11623012274503708, 0.03380464017391205,
-0.04027588292956352, -0.2868429720401764, 0.009923738427460194, -0.03844491019845009, 0.017262013629078865, -0.016239434480667114, 0.08999078720808029,
0.1333954632282257, -0.04845647141337395, 0.14983029663562775, -0.12417373806238174, -0.05395587533712387, -0.14922921359539032, -0.06588133424520493,
-0.10105916112661362, 0.06290063261985779, -0.038801465183496475, 0.09951246529817581, 0.12229879945516586, 0.05707470327615738, 0.14594928920269012,
-0.018815018236637115, -0.06272302567958832, 0.0915747657418251, 0.08915816992521286, -0.006603484507650137, 0.1170022040605545, 0.028568806126713753,
-0.026023302227258682, -0.007896128110587597, 0.05938410013914108, -0.015894971787929535, 0.15645229816436768, -0.22734470665454865, 0.10272036492824554,
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0.16461870074272156, 0.17832234501838684, -0.11255958676338196, -0.038450367748737335, -0.004373373463749885 6, -0.11911530047655106, -0.029135342687368393,
-0.11441680043935776, -0.01426237728446722, -0.147673100233078, 0.02534649893641472, -0.08205818384885788, 0.013851713389158249, 0.049927808344364166,
-0.043906766921281815, 0.09487254172563553, -0.0548759289085865, -0.06821861118078232, 0.14015023410320282, 0.09778027981519699, 0.03135014325380325,
-0.04362429678440094, -0.10373758524656296, -0.0995674803853035, 0.16310307383537292, -0.14189456403255463, 0.039250511676073074, 0.01830003596842289, 0.0654211938381195
0.011834066361188889, -0.16616307199001312, 0.11017125099897385, 0.005183114670217037, -0.05766391381621361, 0.024772947654128075, 0.033773452043533325,
-0.07300447672605515, 0.16271425783634186, 0.03300707787275314, 0.0372735820710659, -0.0015088528161868453, -0.011066391132771969, 0.05143006518483162,
0.07227129489183426, -0.07829277217388153, -0.013867120258510113, -0.07281674444675446, -0.05233587324619293, -0.03033389337360859, 0.005550680682063103,
0.1163531243801117, 0.07826099544763565, 0.015555071644484997, -0.125584676861763, 0.03527001664042473, -0.049452029168605804, -0.000962174846790731, 0.08698161691427231
0.14323730766773224, -0.0910324677824974, -0.03639427199959755, 0.0011337363393977284, -0.05021083727478981, 0.087821878492832 18, 0.038280095905065536,
-0.07622894644737244, -0.04571082442998886, 0.052227433770895004, -0.012266135774552822, 0.11470835655927658, -0.16500154137611 39]}

Figure 5-1:Image encoded with 128 vector embeddings

5.3 Results

The system consists of two parts: the embedded system and the cloud platform. Both parts are essential for the system, and employees can obtain notification in case of delay or absence.

5.3.1 Embedded system

After designing the full circuit, I implemented the circuit. I did a test of my prototype to check if it is working. This is a prototype of the system which consists of a raspberry pi HQ camera with a 16mm telephoto 10MP lens, LED, Servo motor, and buzzer connected to the Raspberry pi 4 Model B with 2GB of RAM.

Figure 5-2: Embedded system

5.3.2 Results display on the dashboard

- The implemented system will keep data in the cloud, and many analysis can be accessible by inserting a username and password into the login form below:

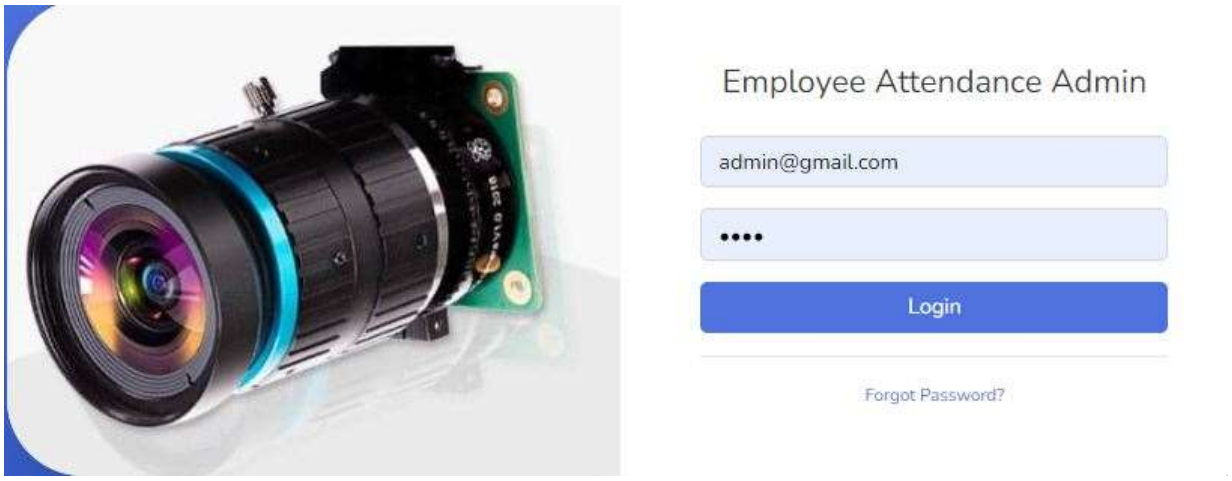

Figure 5-3:Login page

- In addition, a web interface was created enabling the authorities to display data in the dashboard. After gaining access, by clicking on add employee button; you will be able to register the new employees with full details.

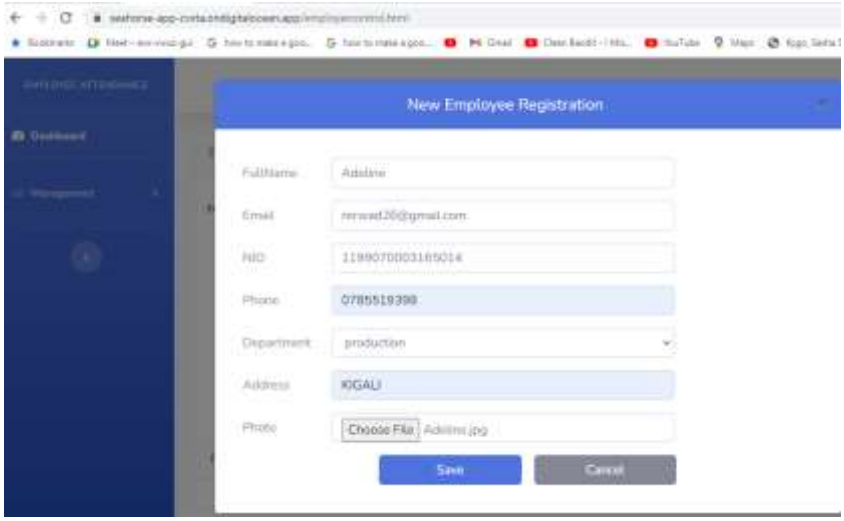

Figure 5-4: How to register new employees in the system

- After saving the employee's details, you can view in employee list file and able to filter accordingly.

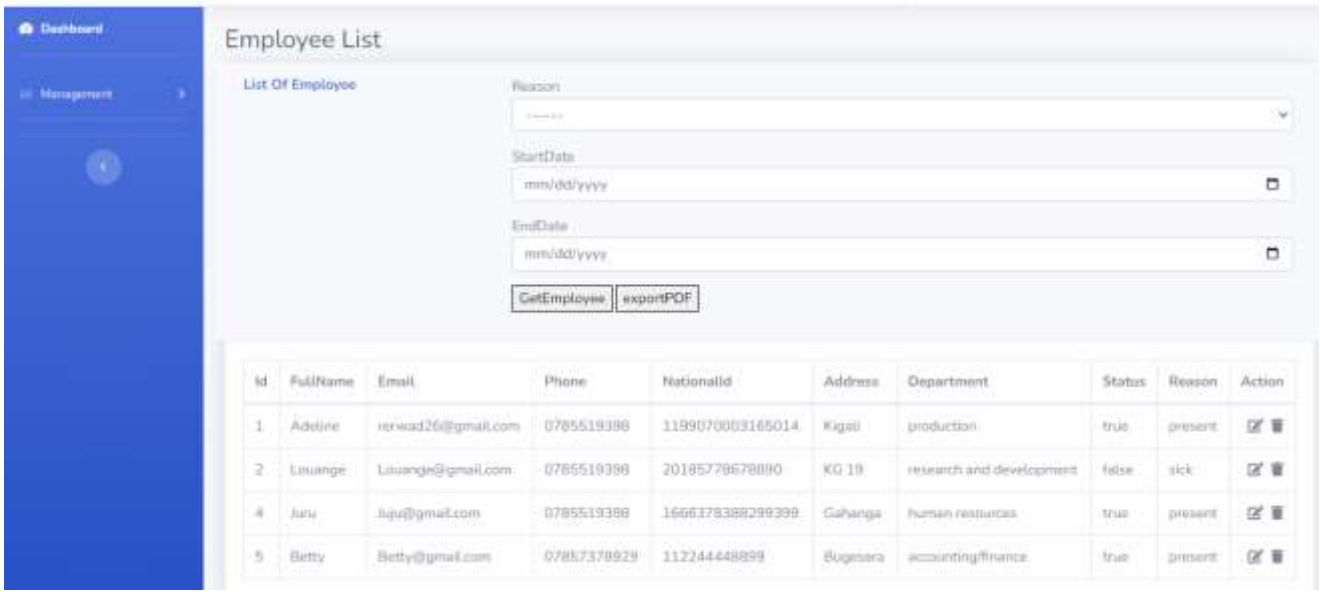

Figure 5-5: List of the employees

- After saving the new employees, the new face is compared with other encoded images and then display if the images captured are known with corresponding names or unknown.

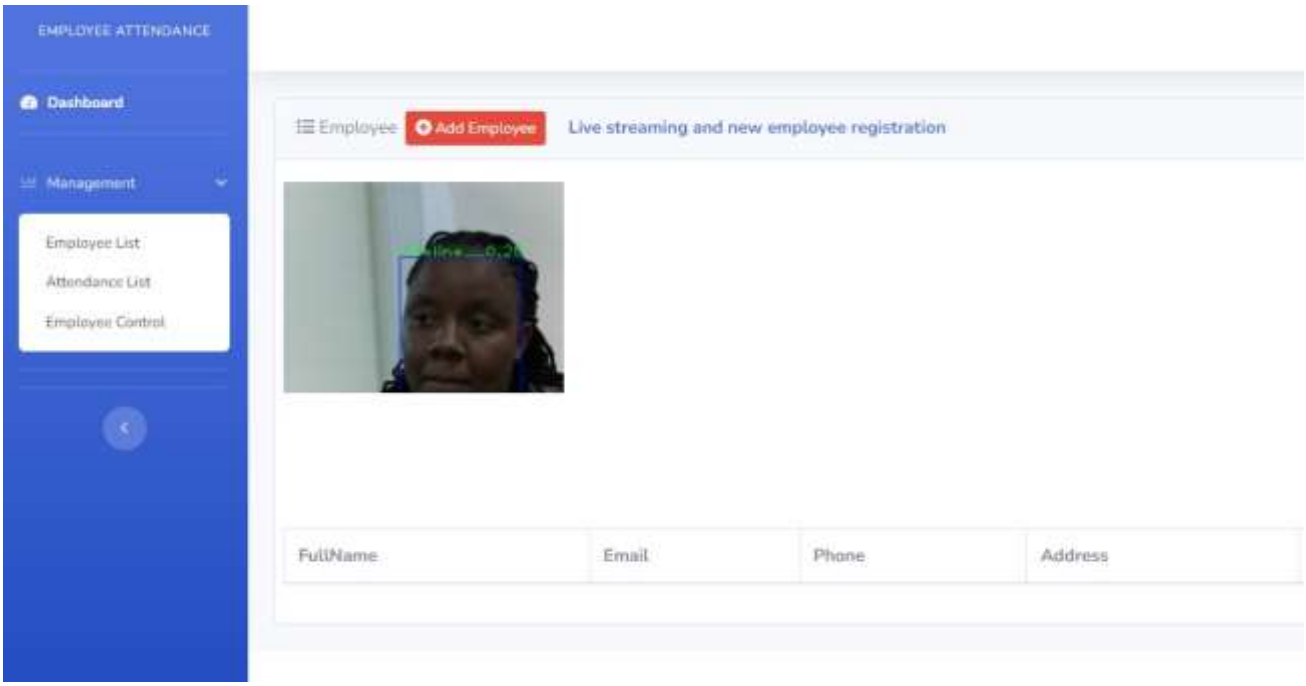

Figure 5-6: Image comparison /matching with encoded images through live streaming

- Figure 5-7 shows the dashboard, which graphically groups together all the information concerning the attendance made.

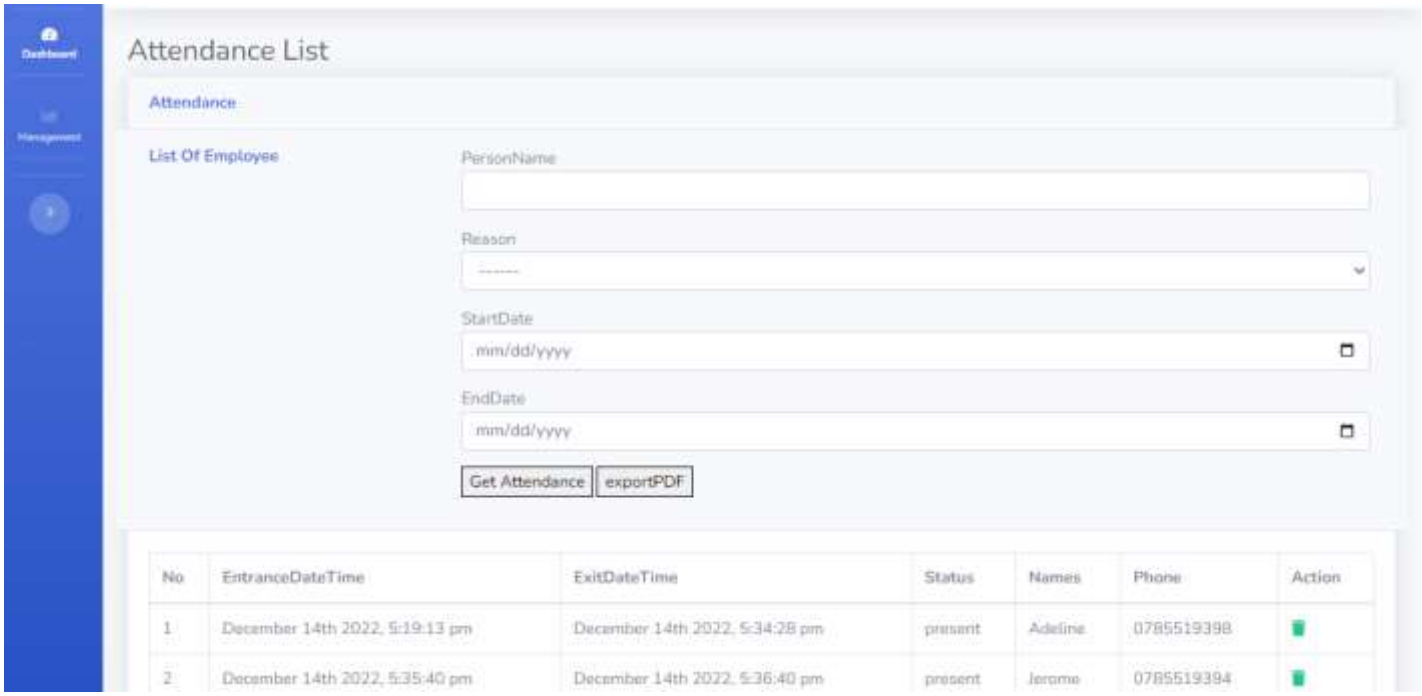

Figure 5-7: Employees attendance List

- Figure 5-8 shows the dashboard, which graphically groups together all the information concerning the attendance made.

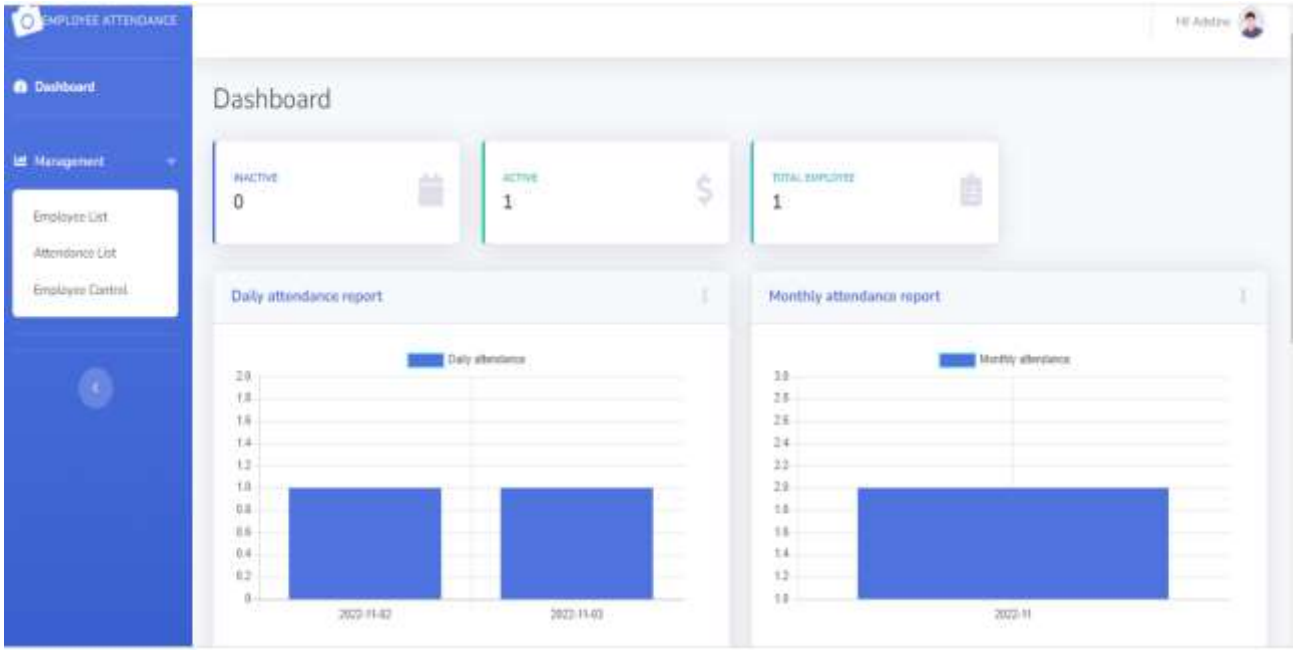

Figure 5-8: Dashboard picture

- **Error! Reference source not found.** shows how the system is capable of sending an email to t he employee if he or she is absent or late for work.

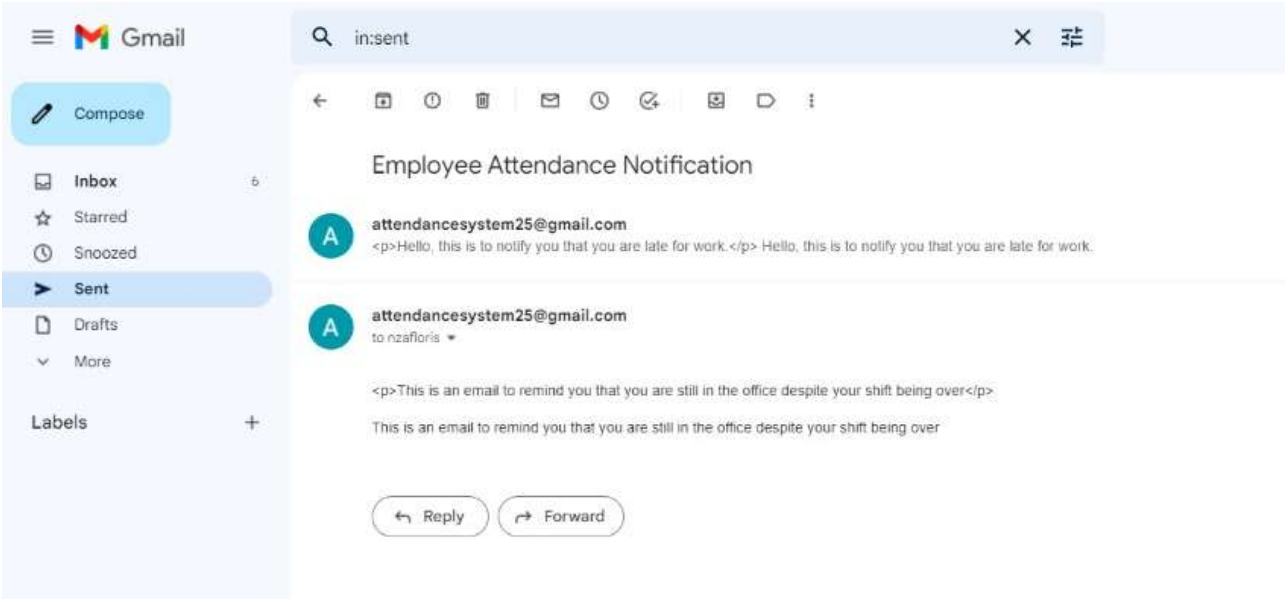

Figure 5-9: The output of email alert

CHAPTER 6 : CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

This project presents a simple yet efficient approach to calculating attendance in any institution /organization by employing facial recognition techniques to avoid the propagation/ mitigation of Transmission disease in general. The project was implemented using IoT tools with Machine Learning, which leads me to the success of the project, The system also successfully recognizes and marks the attendance of the detected employees, and sends the emails to the corresponding employee successfully. After carrying out the necessary test, it was observed that the aim of the work was achieved with an efficient, time-saving, and easy-to-operate system, which will benefit both institutions and employees simultaneously. The goal of this study is to eliminate errors and human intervention in spreading COVID-19 during attendance records by using real-time face recognition with machine Learning to protect the well-being of society. The outcome demonstrates our system's ability to address the issues raised in Chapter 2. To run efficiently, the system should use the cloud with the following specifications 16GB RAM, Geforce RTX , 3080 GPU for the server, and 15GB GPU memory.

6.2 Recommendations

Based on the Design and implementation of a real-time face recognition attendance using machine learning, I have been experiencing a lot of opportunities and challenges during this process as follows:

- Due to the instability of the network, continuous live steaming transmission maybe only possible in a few circumstances. Significant delays in data transfer to the web.
- I suggest that the camera should be put into the place with enough brightness for detection and recognition.
- Due to the project's restricted budget, the better option to develop this project is to deploy two cameras: one to record the entrance time and the other to track the exit date.
- Data augmentation is very important to increase the system's accuracy.
- I recommend institutions to adopt and use face recognition for attendance to prevent and mitigate the transmission of diseases.

- I recommend UR especially in the ACEIoT department to focus more on practical to increase the knowledge of students.
- I inspire UR especially in the ACEIoT students to focus more on face recognition in their projects to look at how it can be improved and used in daily life.
- Future studies could improve on the operational paradigm, which collects videos and sends them to the cloud for further processing, decision-making, and data storage via an IoT-enabled system. This project could benefit from edge data processing rather than cloud processing to reduce latency time between raw data transmission, data processing, and decision-making. It will also be linked to the payroll management system to automatically record financial transactions.

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