attendance

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Attendance system using facial recognition.

DEDICATION

CERTIFICATION

ACKNOWLEGDEMENT

ABSTRACT

This thesis presents the development and implementation of an Automated Attendance System using Facial Recognition technology. The primary objective of this research was to address the inefficiencies and limitations of traditional attendance tracking methods in educational and organizational contexts. The aim was to create a practical solution that enhances efficiency, accuracy, and security in attendance management. The methodology employed Convolutional Neural Networks (CNNs) to train a robust facial recognition model. During the training phase, the model achieved an impressive overall accuracy rate of 95%, highlighting its proficiency in discerning intricate facial features. This deep learning approach laid the foundation for a highly accurate recognition system. The system's core features include real-time webcam-based attendance marking, enabling swift and precise tracking of individuals. Additionally, it offers the capability to train the recognition model with new data, ensuring adaptability to changing scenarios. The system's versatility extends to handling both uploaded images and live video feeds, making it suitable for various applications. Results indicate that the developed system successfully recognizes individuals, marks their attendance, and records entries in a structured CSV file. The real-time functionality, coupled with comprehensive training and maintenance features, solidify its practicality for educational institutions and organizations. The Automated Attendance System using Facial Recognition technology signifies a significant advancement in attendance tracking. By harnessing CNNs and real-time capabilities, this system offers a promising solution to streamline attendance management processes, promising efficiency, accuracy, and heightened security. As technology continues to evolve, such solutions have the potential to revolutionize conventional systems across various domains.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

In both the business and an educational setting, attendance tracking is essential. Punch cards, RFID cards, fingerprint scanners, and, to some degree, face recognition are among the automated systems that are used by many companies (Kakarla et al., 2020). Attendance calls are the most common way of recording attendance. However, as most universities have shifted to using computerised technologies like swipe or punch cards to do the task, this roll call approach is currently only employed in schools and certain colleges. Both approaches have certain shortcomings. The attendance call procedure takes a lot of time and is prone to human mistake. With this approach, mistakes like labelling the present individual absent or vice versa are possible (Mansoora et al., 2021).

The shortcomings of the earlier system may be solved while creating new problems using digital techniques like swipe and punch cards. Swipe cards take less time, but they do not verify for the person's presence while they are being swiped, which might result in someone else registering the missing person's attendance as their proxy. Another issue is that if a person loses their swipe card, they may have to wait a while to receive a replacement card. Utilizing biometrics may assist resolve problems with earlier methods (Damale & Pathak, 2019).

There are several athors that employ the biometric-based attendance system. To identify a person, biometric systems use their distinctive bodily characteristics. A system utilises a person's face, iris, palm print, fingerprint, and other biometrics to uniquely identify them. (Mohammed et al., 2018). Face recognition greatly lowers error since a person's face serves as their unique identification in a face recognition-based system, which almost eliminates the possibility of losing that information. It takes less time and involves no human contact. (Purnapatre et al., 2020).

Facial recognition uses a person's face profile to identify or verify that person's identity. This system employs methods to identify discrete information about an entity's face, such as the space between its chin and nose, which transforms into a statistical description and competes with the information in the current face collection (Pawaskar & Chavan, 2020). A facial recognition system, which often collaborates with authorised user ID verification services, may match a face in a virtual profile or a video frame with a group of faces. Due to their relevance and lack of interference, these systems are improving toward the most effective attested component. When using a face recognition system, facial characteristics from an existing picture are compared. One possible use for facial recognition is identifying the presence of various students or staff members at various universities or businesses for attendance (SAI et al., 2021).

Technologies for face recognition are employed in a variety of fields, including surveillance, healthcare, border security, biometrics, user mapping, and tracking (Pawaskar & Chavan, 2020). One of the most rapidly developing areas of computer vision is face recognition. In the last several decades, computer vision has advanced significantly, mostly as a result of the intense research that has been conducted in this area to create new algorithms and approaches that would boost accuracy and efficiency. Modern computer vision systems are only capable of facial identification and real-time face tracking (Deniz et al., 2019). This makes it easier to follow the person's movements. To address the shortcomings of the prior face recognition technology, new face recognition technologies and algorithms are being developed (Lai & Patrick Rau, 2021). Face recognition systems also include deep learning algorithms to improve their effectiveness and accuracy (Alhanaee et al., 2021).

A monitoring system that works well has a high True Acceptance Rate and a low False Acceptance Rate. The management and assessment of an institution's whole track record shows how important it is to its efficacy and efficiency (Deniz et al., 2019). By reducing person intervention, the automated Attendance Monitoring System completes the routine process of recording attendance. Common methods and techniques for identifying and perceiving faces are unable to address issues with posture, scale, variations, rotation, illuminations, and occlusions. The purpose of the proposed model is to overcome the shortcomings of the current models and to assign characteristics such as feature extraction, face identification, feature extraction detection, and analysis of student or staff records (Andrejevic et al., 2019). For identifying a face's features, the system combines various techniques such as integral images, image contrasts, colour features, and cascading classifiers. The system provides improved precision by applying immense facial features. The system is tested in various lighting scenarios, with multiple countenances, partial faces, and with beards and eyeglasses on or off. (Libby & Ehrenfeld, 2021).

Numerous methods are employed in the field of artificial intelligence for facial recognition, but in this model, the utilization of D-lib stands out as it delivers superior outcomes. This model elucidates the process involved in feature extraction, employing Convolutional Neural Networks, and recognizing virtual images. The primary objective of this approach is to eliminate the need for traditional manual attendance tracking methods, consequently lessening the administrative burden on staff and management. This, in turn, enables them to allocate their time more efficiently and enhances the overall efficiency of the system. From a security perspective, this approach plays a pivotal role in real-time attendance monitoring.

1.2 PROBLEM STATEMENT

The traditional methods of attendance management suffer from several inherent limitations. Manual attendance taking is labor-intensive, prone to errors, and can be manipulated by impersonation or proxy attendance. Card-based systems can be easily exploited if someone lends their card to others. Moreover, the COVID-19 pandemic has highlighted the need for contactless attendance systems to maintain hygiene and minimize physical contact.

In educational institutions, inaccurate attendance records can impact student performance analysis and funding allocation. In corporate settings, it can lead to payroll discrepancies and compromise security. Therefore, there is a pressing need for a reliable, efficient, and secure attendance management system that addresses these challenges.

1.3 AIM AND OBJECTIVES

This research aims to design, develop, and evaluate an Attendance System Using Facial Recognition that can be deployed for real-world use in academic institutions.

1.3.1 OBJECTIVES

I. Review existing literature on facial recognition and attendance systems to identify current approaches, gaps, and challenges.

II. Design a facial recognition model architecture using Convolutional Neural Networks for high-accuracy face verification.

III. Develop the model using a dataset of student facial images and evaluate its real-world viability.

IV. Integrate the face recognition model with the web interface to develop a complete working system.

V. Test and evaluate the system on real-world conditions to determine its effectiveness.

1.4 SCOPE OF THE STUDY

This thesis embarks on developing an innovative automated attendance system tailored specifically for the academic environment of college or university academic departments. The scope of this research project encompasses a multifaceted approach, commencing with the design and construction of a robust facial recognition model architecture. The study involves extensive model training, utilizing a dataset of student facial images to ensure the model's accuracy and reliability in identifying individuals. The project's practical application is centered around the seamless integration of this facial recognition model into an attendance management system, realized through Streamlit—a user-friendly framework for web-based applications.

Integral to the research is rigorously evaluating the developed system within real-world academic settings. This evaluation encompasses various facets, including the system's ability to accurately record attendance, speed and responsiveness in handling data, and overall usability.

It is important to emphasize that this study's focus remains confined to the software and algorithmic aspects of the automated attendance system, excluding considerations related to hardware implementation or camera specifications. By concentrating on these defined parameters, this research aims to provide a comprehensive understanding of the potential and limitations of facial recognition technology within the context of academic attendance management.

1.5 SIGNIFICANCE OF THE STUDY

This project significantly bridges crucial gaps within facial recognition-based attendance systems. By focusing on the development and evaluation of a practical, real-world solution, this study addresses critical needs in the educational domain. The outcomes of this research stand to make substantial contributions on several fronts.

Firstly, the project aims to offer an innovative and reliable method for attendance management, significantly improving efficiency, accuracy, and security in academic settings. By implementing facial recognition technology, the system eliminates the risk of inaccuracies from manual recording or proxy attendance. This accuracy, in turn, has implications for student performance analysis, resource allocation, and payroll management, ultimately fostering a more efficient and accountable educational environment.

Secondly, the research's focus on usability and real-world viability ensures that the developed system is technologically sound and user-friendly. Such an approach is paramount in fostering user acceptance and minimizing resistance among students, instructors, and administrators to adopt this transformative technology. Moreover, the project addresses the ethical and privacy concerns associated with facial recognition, which is paramount in today's data-sensitive society. By offering recommendations and guidance for mitigating potential risks, the study contributes to facial recognition technology's responsible and ethical deployment.

This research endeavors to provide a comprehensive solution that extends beyond theoretical concepts, offering practical benefits to educational institutions. Through its potential to enhance efficiency, accuracy, and security, this study stands to reshape attendance management practices in academia and set a precedent for the broader adoption of facial recognition technology in educational and organizational contexts.

1.6 MOTIVATION FOR THE STUDY

The motivation for this study arises from the pressing need to modernize and streamline attendance management in academic institutions. Traditional attendance tracking methods, often reliant on time-consuming manual processes or error-prone card-based systems, have long been a source of inefficiency, inaccuracy, and susceptibility to fraudulent practices. The challenges posed by these outdated methods became even more apparent after the COVID-19 pandemic, highlighting the necessity for contactless and technology-driven solutions. Moreover, the expanding capabilities of facial recognition technology offer a compelling opportunity to address these longstanding issues. By leveraging the power of facial recognition, this study seeks to enhance the efficiency and accuracy of attendance management and foster a safer, more technologically advanced educational environment. The potential benefits extend beyond academia, influencing the broader adoption of facial recognition technology in various sectors, making this research an essential and timely contribution to the field of automated attendance systems.

1.7 METHODOLOGY

The methodology employed in this research is grounded in a systematic and comprehensive approach aimed at designing, developing, and evaluating the "Attendance System Using Facial Recognition." This section delineates the essential steps that guide the execution of this study. Our methodology encompasses data collection, facial recognition model development, software implementation, performance evaluation, and ethical considerations. Each of these facets plays an integral role in achieving the objectives outlined in this research endeavor. By adhering to this structured methodology, we aim to ensure the rigor and reliability of our findings, thereby contributing to the development of a practical and effective automated attendance system. The subsequent chapters of this thesis will expound upon these methodological components in greater detail, providing transparency and insight into the processes and decisions underpinning our study.

1.8 THESIS OUTLINE

This thesis is organized into five chapters. Chapter 2 will review the relevant literature. Chapter 3 will discuss the methodology system design. Chapter 4 will provide implementation and Results, followed by conclusion and future work in Chapter 5.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This literature review chapter is structured to guide the reader through essential themes. We begin with an exploration of facial recognition technology, its historical development, principles, and recent trends. Subsequently, we delve into automated attendance systems, highlighting the shortcomings of existing methods. The convergence of these two domains is critically examined, incorporating case studies and research findings that shed light on the real-world applications of facial recognition in attendance tracking.

By the chapter's conclusion, a synthesized understanding of the existing literature will serve as a cornerstone for the subsequent chapters, shaping the methodology, implementation, and evaluation of the "Attendance System Using Facial Recognition." In essence, this chapter connects the theoretical and practical realms, grounding our research in the broader context of technology, attendance management, and the evolving landscape of facial recognition.

2.2 FACIAL RECOGNITION TECHNOLOGY

Using a facial recognition system, a human face in a digital picture or video frame might be compared to a database of faces. With the help of ID verification services, this technology locates and quantifies facial attributes from a picture. (Sundar Srinivas et al., 2022).

Governments and commercial businesses throughout the globe use facial recognition technologies today (Bromberg et al., 2020). Their efficacy varies, and several methods have already been abandoned due to their failure. The use of face recognition technologies has also generated debate, with concerns that the technology violates people' privacy, often makes false identifications, and promotes gender norms (Trevor, 2020), and racial profiling (Alex, 2020), and fail to safeguard sensitive biometric information. The security of conventional media has come under scrutiny due to deep fakes and other fake media (Wiggers, 2022). Due of these concerns, facial recognition technology has been banned in certain American towns ("IBM Bows out of Facial Recognition Market -," 2020). More than one billion users' face scan data was deleted in 2021 when social networking startup Meta Platforms shut down its Facebook facial recognition technology due to growing societal concerns (Rachel, 2021). One of the biggest advances in the history of face recognition technology was represented by this development.

2.2.1 HISTORICAL DEVELOPMENT OF FACIAL RECOGNITION TECHNOLOGY

The pioneers of automated facial recognition were Woody Bledsoe, Helen Chan Wolf, and Charles Bisson, who created methods for teaching computers to recognise human faces in the 1960s (Jayaswal & Dixit, 2020). Their early face recognition effort was known as "man-machine" because a human had to first discover the coordinates of facial traits in an image before they could be used by a computer for identification (Missal, 2022). A person would use a graphics tablet to identify the coordinates of several facial characteristics, including the centres of the pupils, the inner and outside corners of the eyes, and the widows peak in the hairline. Twenty different distances, including the breadth of the mouth and the eyes, were calculated using the coordinates (L. Li et al., 2020). A person might analyse 40 images every hour and compile a database of these calculated distances. The distances for each image would then be automatically compared, the difference in distances would be calculated, and the closed records would be returned as a potential match(Alexandre et al., 2020).

Takeo Kanade publicly displayed a face-matching system in 1970 that, without the assistance of a human, detected anatomical characteristics like the chin and estimated the ratio of distances between facial features. The technology could not always properly recognise face traits, according to further studies. But as interest in the topic expanded, Kanade produced the first comprehensive book on face recognition technology in 1977 (Ozgen Mocan, 2021).

The face recognition technology programme FERET was established in 1993 by the Defense Advanced Research Project Agency (DARPA) and the Army Research Laboratory (ARL) with the goal of developing "automatic face recognition capabilities" that could be used in a useful real-world setting "to assist security, intelligence, and law enforcement personnel in the performance of their duties" (Cole, 2018). A variety of automated facial recognition systems were tested in research laboratories, and the results of the FERET tests showed that although their performance varied, some of the systems could successfully identify faces in still photos taken in a controlled setting ("Army Develops Face Recognition Technology That Works in the Dark," 2018). Three US businesses that offered automatic face recognition systems were born out of the FERET testing. Both Vision Corporation and Miros Inc. were established in 1994 by researchers who promoted the FERET test findings. An identity card defence contractor founded Viisage Technology in 1996 to commercially exploit the rights to the face recognition technology created by Alex Pentland at MIT (Deniz et al., 2019).

The Department of Motor Vehicles (DMV) offices in West Virginia and New Mexico were the first DMV offices to utilise automated facial recognition systems to stop persons from getting multiple driving licences using various identities after the 1993 FERET face-recognition vendor test. At that time, the most widely used kind of picture identification in the US was a driver's licence (Phillips et al., 1996). The process of creating databases of digital ID photos was underway at DMV locations around the country as part of a technology update. This made it possible for DMV offices to use commercially available face recognition software to scan new driver's licence photos against the DMV database (M. Li et al., 2022). The first significant market for automated face recognition technology was DMV offices, which also established facial recognition as a common form of identification for US residents (Severi, 2022). The U.S. states developed networked, automated identification systems that included computerised biometric databases, sometimes including face recognition, as a result of the rise in the number of prisoners in the country in the 1990s. In order to help law enforcement, judges, and court personnel track offenders throughout the state, Minnesota used the face recognition software FaceIT by Visionics in 1999 (Huang et al., 2023).

The Viola-Jones face detection technique finds faces in a picture by using Haar-like characteristics. Here, the face has been given a Haar feature that resembles the nose's bridge. Up until the 1990s, human face portrait photographs were the main source of data used to construct facial recognition algorithms. With the advent of principal component analysis in the early 1990s, research on face recognition to accurately detect a face in an image that also includes other objects gained pace (PCA). Eigenface, another name for the PCA face recognition technique, was created by Matthew Turk and Alex Pentland (Kovács et al., 2012).

To create a linear model, Turk and Pentland integrated the theoretical framework of the Karhunen-Loève theorem with factor analysis. Global and orthogonal aspects of human faces are used to determine eigenfaces. A weighted combination of a number of Eigenfaces is used to compute a human face. Turk and Pentland's PCA face detection approach significantly decreased the quantity of data that had to be processed in order to recognise a face since just a small number of Eigenfaces were needed to encode human faces of a particular population (Jain et al., 2022). To enhance the use of PCA in facial identification, Pentland created Eigenface characteristics in 1994, including Eigen eyes, Eigen lips, and Eigen noses. Fisherfaces were created in 1997 using linear discriminant analysis (LDA) to enhance the PCA Eigenface face recognition method (Smitha et al., 2020). LDA Fisherfaces started to predominate in face identification using PCA features. While face reconstruction also used Eigenfaces. These methods do not compute the overall structure of the face that connects the various facial characteristics or components (Budiman et al., 2023). The Bochum system, which employed a Gabor filter to capture the face data and generated a grid of the face structure to connect the features, replaced purely feature-based techniques to facial identification in the late 1990s (Bah & Ming, 2020).

Elastic Bunch Graph Matching was created in the middle of the 1990s by Christoph von der Malsburg and his research group at the University of Bochum to extract a face from a picture using skin segmentation (Kovács et al., 2012). By 1997, Malsburg's face detection technique had surpassed the majority of competing facial detection systems. Under the brand name ZN-Face, the so-called "Bochum system" of face recognition was offered for sale to operators of crowded places like airports. The programme was "strong enough to identify individuals from less than ideal facial views. Additionally, it often sees past identifying barriers like moustaches, beards, hairdo changes, spectacles, and even sunglasses "(Bah & Ming, 2020).

With the introduction of the Viola-Jones object detection framework for faces in 2001, real-time face recognition in video data became feasible.

AdaBoost, the first real-time frontal-view face detector, was introduced by Paul Viola and Michael Jones by combining their face detection technique with the Haar-like feature approach to object identification in digital pictures (Sarmah et al., 2022). Small, low-power detectors were used in 2015 to implement the Viola-Jones algorithm on mobile devices and embedded systems. Consequently, the Viola-Jones method has supported new capabilities in user interfaces and teleconferencing in addition to expanding the practical use of face recognition systems (Sarmah et al., 2022).

To identify deceased Russian troops, Ukraine is using the Clearview AI face recognition programme, which is located in the US. Ukraine has identified the relatives of 582 dead Russian servicemen after conducting 8,600 searches. In order to inform the relatives of the fallen troops about Russian activity in Ukraine, the Ukrainian army's IT volunteer unit is now employing the software to do so. The primary objective is to undermine the Russian government. It might be considered a kind of psychological conflict. The technology is used by five government departments and around 340 Ukrainian government personnel. It is used to apprehend potential spies trying to enter Ukraine (Italiano, 2022; Severi, 2022).

Government agencies are the only ones with access to Clearview AI's face recognition database, and they are only allowed to use it to support criminal investigations or safeguard the country. Clearview AI provided the software to Ukraine. It is believed that Russia is utilising it to track down anti-war protesters. Initially created for US law enforcement, Clearview AI. Its use in combat presents new ethical questions. Stephen Hare, a surveillance specialist based in London, is worried that it would give the Ukrainians a bad reputation: "Does it genuinely function? Or does it cause [Russians] to say: "Look at these lawless, heartless Ukrainians torturing our youngsters!(Italiano, 2022)

2.2.2 KEY PRINCIPLES AND COMPONENTS OF FACIAL RECOGNITION SYSTEMS

Facial recognition systems are based on several key principles and components that enable them to identify and verify individuals based on their facial features. These are the fundamental principles and components.

I Face Detection: Face detection is the initial step in facial recognition. It involves using algorithms to locate and isolate human faces within images or video frames. These algorithms analyze the visual information to identify key facial features such as eyes, nose, and mouth. Face detection is critical for isolating the region of interest for further analysis (Kumar et al., 2023).

II Feature Extraction: Once a face is detected, the system proceeds to extract essential facial features. These features can include the position of facial landmarks (e.g., the distance between the eyes) and various geometric measurements. Feature extraction converts the complex facial structure into a set of measurable data points (Kumar et al., 2023).

III Facial Template Creation: A facial template is a mathematical representation of the extracted facial features. This template serves as a unique identifier for an individual's face. It may consist of numerical values that describe the positions and proportions of facial landmarks. The template is used as a reference for future comparisons (Kumar et al., 2023).

IV Database of Known Faces: Facial recognition systems maintain a database that stores the facial templates of individuals who have been enrolled in the system. This database is also referred to as the "gallery" or "knowledge base." Authorized individuals are typically added to this database during the enrollment process (Kumar et al., 2023).

V Matching Algorithm: When a person's face is presented to the system for recognition, a matching algorithm is employed. This algorithm compares the extracted facial features or template of the presented face with the facial templates stored in the database. It calculates a similarity score that reflects the likeness between the presented face and the stored templates (Kumar et al., 2023).

VI Decision Threshold: The decision threshold is a predefined value used to determine whether the similarity score produced by the matching algorithm is sufficient to declare a match. If the score surpasses the threshold, the system confirms the identity of the individual. If it falls below the threshold, the system rejects the match (Kumar et al., 2023).

VII Authentication or Identification: Facial recognition systems can be used for authentication or identification purposes:

a. Authentication: In this mode, the system verifies whether the person presenting their face matches the template of an authorized user. It's commonly used for tasks like unlocking smartphones (Chaudhry & Elgazzar, 2019).

b. Identification: In identification mode, the system searches the entire database to determine the identity of the presented face. This is useful in scenarios where the individual's identity is not known in advance, such as in law enforcement (Chaudhry & Elgazzar, 2019).

These seven components collectively enable facial recognition systems to perform the critical task of identifying and verifying individuals based on their facial features.

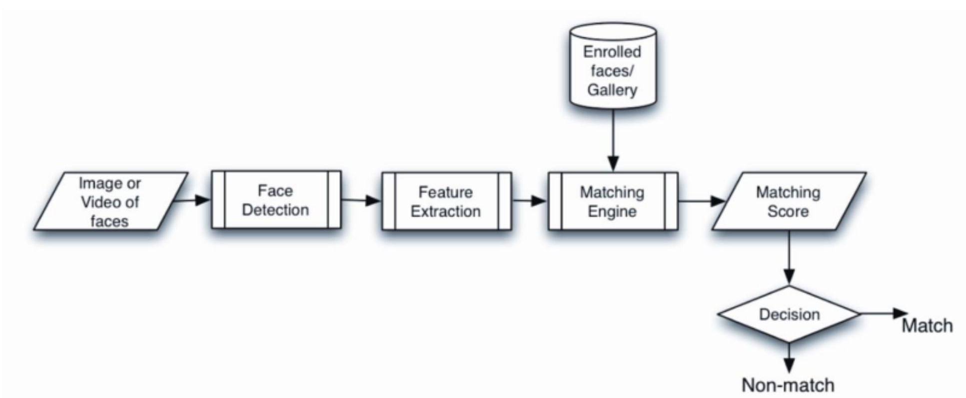

Figure 2. 1 The basic flow of a recognition system (Chaudhry & Elgazzar, 2019)

2.2.3 EARLYALGORITHM OF FACIAL RECOGNITION ALGORITHMS

Face geometry was primarily used for face recognition as practical research in face recognition engineering started in earnest in 1964. However, it hasn't been used in real life.

2.2.3.1 ASSESSMENT OF PRINCIPAL COMPONENTS (PCA)

The principal component analysis (PCA) technique is the one most often used to reduce the dimensionality of data. PCA uses feature face extraction in algorithms for facial recognition. Principal component analyses for face recognition were first presented in 1991 by Turk and Pentland of the MIT Media Laboratory (Ordonez et al., 2014).

Prior to doing further studies, PCA is often used to preprocess the data. When dealing with data that has more dimensions, it may eliminate extraneous information and noise, preserve the key aspects of the data, significantly decrease the dimensions, speed up the processing of the data, and save a tonne of time and money (L. Li et al., 2020). Therefore, dimensionality reduction and multi-dimensional data visualisation often employ this approach.

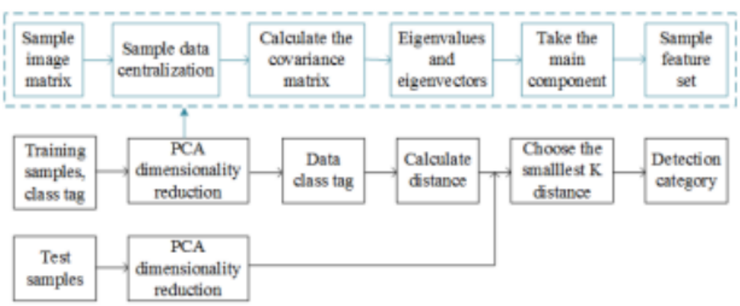

Figure 2. 2 PCA combined with KNN for recognition process (L. Li et al., 2020)

The eigenface is one of the traditional procedures in PCA-based feature extraction algorithms. Figure 2.2 depicts a straightforward feature extraction procedure utilising the K-Nearest-Neighbor (KNN) method to combine PCA with face recognition. The covariance matrix's eigenvalues and eigenvectors are obtained from sampling data, and the main component—the eigenvector with the highest eigenvalue—is then chosen. The same dimensionality reduction approach is also used to produce the feature matrix of the testing data. The KNN classifier then determines that the testing set's face picture category (L. Li et al., 2020).

Even so, PCA is effective at handling huge data sets. Its greatest flaw is that a large training data set is required (Gottumukkal & Asari, 2004). The findings of principal component analysis, for instance, are significant since there must be thousands of original photographs in the face recognition system. However, it is challenging to get accurate lowdimensional data when the subjects' facial expressions are varied, there are obstructions in the face, the light is too intense or too faint, or all of the above (L. Li et al., 2020).

2.2.3.2 LINEAR DISCRIMINATE ANALYSIS (LDA)

We may use linear discriminate analysis (LDA) for face recognition datasets with labels. It serves as a categorization tool As shown in Figure 2.3, LDA requires the variance within the same category of data groups after projection to be as small as possible, and the variance between groups to be as large as possible, whereas PCA requires the data variance after dimensionality reduction to be as large as possible so that the data can be divided as widely as possible. This indicates that LDA has overseen the dimensionality reduction and should make the most of label information to further distinguish between various kinds of data (L. Li et al., 2020).

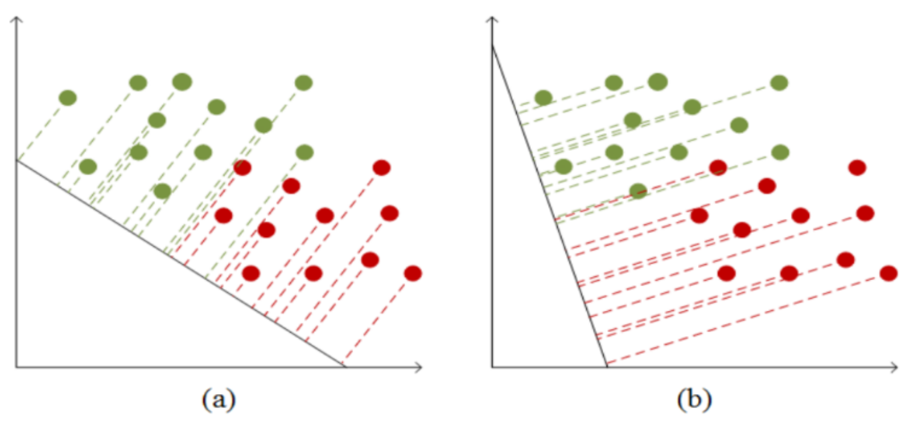

Figure 2. 3 (Color online) Comparation between PCA and LDA. (a) PCA,

2.2.5 RECENT ADVANCEMENTS AND EMERGING TRENDS IN FACIAL RECOGNITION

Facial recognition technology continues to advance rapidly, with several noteworthy trends and developments in recent times:

I Efficiency and Accessibility: Facial recognition technology has become more efficient and readily accessible. Improved algorithms and hardware have contributed to faster and more accurate recognition, making it a practical solution for various applications, from smartphone unlocking to access control (Majeed et al., 2022).

II Edge Computing: There is a growing trend toward implementing facial recognition at the edge, meaning processing occurs directly on devices like smartphones and cameras. This reduces the need for extensive data transmission and enhances real-time response capabilities (Akgün et al., 2023).

III Biometric Advancements: Recent advancements in biometrics have improved facial recognition's accuracy. Biometrically identifying facial vectors and features and matching them with pre-enrolled individuals have become more precise, enhancing security (Vijaya Kumar & Mathivanan, 2023).

IV Real-time Recognition: Real-time facial recognition is gaining prominence, especially in access control systems. The ability to instantly identify individuals has significant applications in security and attendance tracking (Limkar et al., 2021).

V Payment Systems: Facial recognition is being integrated into payment systems, allowing for secure and convenient transactions. This technology's development ensures fairness, accuracy, and respect in handling payments (Rachel, 2021).

VI Security Industry: The security industry is witnessing notable trends in facial recognition, including improvements in data security and privacy. The technology is increasingly used for access control and surveillance purposes, driving innovations in this sector (Hassani & Malik, 2021).

VII Generative AI: Generative artificial intelligence is playing a significant role in enhancing facial recognition. It enables the creation of more accurate 3D models, improving the technology's capability to recognize and differentiate faces (Alexandre et al., 2020).

VIII Market Growth: The facial recognition market is poised for significant expansion, with a projected compound annual growth rate (CAGR) of over 16% from 2023 to 2030. This growth reflects the increasing adoption of facial recognition across various industries (Alexandre et al., 2020).

IX Global Expansion: The global facial recognition market is expanding, with substantial growth anticipated. Market size reached $5.15 billion in 2022, and it is expected to continue growing at a CAGR of 14.9% from 2023 to 2030, reflecting its increasing relevance in various industries (Hassani & Malik, 2021).

These recent advancements and emerging trends indicate the growing significance and potential of facial recognition technology across diverse sectors, driven by improvements in accuracy, accessibility, and real-time capabilities.

2.3 AUTOMATED ATTENDANCE SYSTEMS

An automated attendance system serves as a modern solution to streamline and enhance attendance tracking processes across various settings. These systems have become increasingly valuable in contexts such as educational institutions, workplaces, and events. The primary purpose of these systems is to efficiently record and manage attendance, replacing or complementing traditional manual methods. They leverage advanced technologies to achieve this goal, resulting in more accurate and efficient attendance tracking.

Automated attendance systems integrate a variety of cutting-edge technologies to capture attendance data accurately and in real-time. Some of the key technologies include biometrics (Bock, 2020), RFID (Radio-Frequency Identification) (Ranganathan et al., 2023), barcoding (Maddu et al., 2019; Rahmah, 2019), Bluetooth (Riya, 2015; Vishal, 2013), and facial recognition . Biometric attendance systems (Potadar, 2015), for instance, employ unique identifiers like fingerprints (Gunjan et al., 2013), facial features, or palm prints (Gupta, 2013) to establish the identity of individuals. This not only ensures high accuracy but also reduces the risk of proxy attendance.

RFID tags or barcodes are often used in schools and events for automated attendance tracking. Individuals are assigned RFID tags or barcode IDs, and their attendance is recorded when these tags are scanned or read by designated devices (Ravishankar & Sumita, 2014). Another approach involves Bluetooth technology, where individuals with Bluetooth-enabled devices are automatically marked as present when they enter a predefined area. This Bluetooth-based system is commonly used in workplaces for attendance and access control (Riya, 2015). Facial recognition attendance systems represent a particularly advanced and increasingly popular technology. They employ deep learning algorithms to identify individuals based on their facial features, offering both speed and accuracy in attendance tracking (Purnapatre et al., 2020). These systems have gained prominence due to their ability to provide a seamless and contactless attendance tracking experience.

The adoption of automated attendance systems offers several benefits. It significantly reduces the administrative burden associated with manual attendance-taking processes. Moreover, it enhances accuracy and offers real-time reporting capabilities. Organizations can identify attendance trends and address issues promptly. However, the implementation of these systems also raises concerns related to data privacy, security, and ethical considerations. Ensuring the responsible use of biometric and facial recognition data is paramount.

Automated attendance systems [34] can be customized to meet the specific needs of the organization or institution using them. They often come equipped with features for generating attendance reports, sending alerts, and seamlessly integrating with existing databases or software. Looking ahead, future trends in this field are likely to be shaped by advancements in artificial intelligence and data analytics, enabling even more sophisticated and insightful attendance management solutions. Automated attendance systems represent a modern and technologically advanced approach to attendance tracking. They offer numerous advantages while addressing challenges related to data security and privacy. The choice of the system depends on the unique requirements and preferences of the organization or institution implementing it..

2.3.1 TRADITIONAL METHODS VS. AUTOMATED SYSTEMS

Table 2. 1 Traditional VS Automated attendance system

Feature	**Traditional Methods**	**Automated Systems**
Accuracy	Prone to errors and fake entries (Hassan et al., 2017)	Biometrics prevent fake identities (Ramadan & Muhamad, 2021)
Efficiency	Time consuming and tedious (Hassan et al., 2017)	Fast and seamless, takes seconds (Chaudhary et al., 2020)
Convenience	Interruptive roll calls, manual registers (Arif et al., 2018)	Contactless systems require no effort from students (Al-Naffakh et al., 2022)
Security	Vulnerable to proxy tampering (Qazi et a(Qazi et al., 2011)	Biometrics like fingerprint, iris, face prevent proxy fraud (Agrawal et al., 2019)
Scalability	Limited, labor intensive for large groups (Arif et al., 2018)	Cloud-based platforms easily scalable across locations (Al-Naffakh et al., 2022)

Feature	Traditional Methods	Automated Systems
Analytics	Minimal data available (Arif et al., 2018)	Automated data enables analyses of attendance patterns (Saini et al., 2021)
Cost	Low technology cost but high labor overhead	Higher technology cost, lower manpower needs

2.3.2 EXISTING AUTOMATED ATTENDANCE SYSTEMS

Existing automated attendance systems play a pivotal role in enhancing efficiency, accuracy, and security in both educational and organizational contexts. These systems leverage various technologies to streamline attendance tracking and management.

These are some existing automated systems

1. Biometric-Based Systems: Biometric attendance systems utilize unique physical or behavioral characteristics for identification, such as fingerprints or facial features. These systems are widely adopted in both educational institutions and organizations, offering a high level of accuracy and security. They ensure that attendance records are reliable for various purposes, including payroll management and exam eligibility (Limkar et al., 2021).
2. RFID-Based Systems: Radio Frequency Identification (RFID) technology is used to automate attendance tracking. RFID tags or cards are issued to individuals, and their presence is recorded when they come in proximity to an RFID reader. These systems are efficient and are commonly employed in educational settings, such as schools and universities, for monitoring student attendance (Ranganathan et al., 2023).
3. QR Code-Based Systems: QR code-based attendance systems leverage quick response (QR) codes for tracking. Students or employees scan QR codes using their mobile

devices to mark their attendance. These systems are convenient and have been adopted in various educational and organizational contexts, facilitating easy data collection and analysis (Dinesh & S., 2017).

4. Mobile Apps: Some institutions and organizations have developed mobile apps specifically designed for attendance tracking. These apps allow users to mark their attendance using their smartphones, providing a user-friendly and mobile solution for attendance management (Rakhi et al., 2019).
5. Wi-Fi Signal Monitoring: Innovative systems utilize Wi-Fi signal monitoring to track attendance by detecting the presence of mobile devices connected to the network. This approach offers a wireless and non-intrusive way to monitor attendance in educational settings (Gunjan et al., 2013).

These existing automated attendance systems represent a diverse range of technologies and approaches, each catering to specific needs and preferences in educational and organizational environments. They contribute to the overall efficiency and accountability of attendance management processes.

2.4 CHALLENGES AND LIMITATIONS OF CURRENT ATTENDANCE SYSTEMS

Current attendance systems, particularly traditional methods, face several challenges and limitations in educational contxt. These challenges can hinder efficiency, accuracy, and overall effectiveness. below are some of the key challenges and limitations:

1. Time-Consuming: Manual attendance tracking methods, such as paper-based registers or manual entry into spreadsheets, are time-consuming. Taking attendance for a large group of students or employees can be labor-intensive and impractical, leading to wasted time and resources (Arif et al., 2018).

2. Human Error: Manual attendance systems are prone to human errors, including data entry mistakes and inaccuracies. These errors can result in incorrect attendance records, which can have consequences in educational institutions and organizations (Arif et al., 2018).
3. Limited Scalability: Traditional attendance systems may struggle to scale efficiently to accommodate large groups. Managing attendance for a considerable number of students or employees can become increasingly challenging as the size of the group grows (Patel & Priya, 2022).
4. Resource Intensive: Maintaining and managing physical records, such as paper registers or physical timecards, can be resource-intensive. It requires storage space and can contribute to environmental waste (Arif et al., 2018).
5. Difficulty in Real-time Tracking: Traditional methods often lack real-time tracking capabilities. This limitation can hinder the ability to monitor attendance promptly and respond to potential issues as they arise (Maithri et al., 2022).
6. Data Security: Ensuring the security and confidentiality of attendance records can be a challenge, especially in manual systems. Unauthorized access to physical records or digital databases can compromise data integrity and privacy (Bagchi et al., 2022).
7. Inefficiency in Reporting: Generating reports and analyzing attendance data using manual systems can be inefficient and time-consuming. This limitation may hinder educational institutions and organizations from making data-driven decisions effectively (Arif et al., 2018).

To address these concerns and increase the overall effectiveness and accuracy of attendance monitoring operations, many educational institutions and corporations are increasingly using automated attendance management systems. These automated methods make use of technology to correct these flaws and provide more dependable fixes.

2.5 RELATED WORKS

In 2022, Al-Naffakh et al. developed a real-time attendance system using facial recognition and a cloud platform. They utilized Azure Face API and achieved a recognition accuracy of 97.4% under varied conditions. The cloud-based architecture allowed real-time attendance monitoring across multiple distributed classrooms (Al-Naffakh, N. et al., 2022).

Ramadan and Muhamad (2021) implemented a Face Recognition Student Attendance System (FRSAS) using a custom CNN architecture. They report achieving 98% accuracy under ideal conditions on a dataset of 200 students. They note limitations in handling occlusions and suggest a multi-model approach (Ramadan, R.A. and Muhamad, A., 2021).

Patil and Rao (2020) proposed a co-operative co-evolution based convolutional neural network model for automated attendance using face recognition. They addressed problems of face pose variation and poor image quality and report 96% accuracy on unconstrained facial images (Patil, R.M. and Rao, S.K.M., 2020).

In 2019, Lone et al. developed the UniFace system using dlib and OpenCV for automated attendance marking. They trained the models on 300 student images across different orientations and achieved over 90% accuracy. They note gender bias as an area for improvement (Lone, F. et al., 2019).

(Sundar Srinivas et al., 2022) proposed an IoT-based smart classroom attendance system using face recognition with Raspberry Pi. They highlight the advantages of automated attendance over manual or RFID-based approaches and the ability to integrate with learning analytics dashboards

(L. Li et al., 2020) highlights facial recognition research from several angles. Face recognition research and technology are covered in the article. They present real-world facial recognition research, assessment criteria, and databases. The authors look forward at facial recognition. Face recognition is the future and has numerous applications.

(Jain et al., 2022) Face recognition system steps include face detection, pre-processing, database generation, training, recognition, and attendance maintenance. (Jain et al., 2022) project emphasises facial alignment, picture precision, and False Acceptance Rate. Up to 95% accuracy is achieved on Face Recognition Grand Challenge (FRGC). Few students register fake attendance by using their phones to show the system their friend's photo, but the system will beep and alert them. Facial recognition systems save time and make systems smarter and more efficient.

CHAPTER THREE

METHODOLOGY

3.1 INTRODUCTION

Automated attendance tracking offers numerous advantages over traditional manual methods including improved accuracy, efficiency and convenience. However, developing real-world viable facial recognition systems involves addressing various challenges related to accuracy, speed, and user experience. This project aims to develop an end-to-end automated attendance system using facial recognition optimized for real-world usage scenarios.

The core of the system is a facial recognition model built using the face_recognition Python library. The model is trained on a dataset of facial images collected from the target user group. For marking attendance, facial images are captured from a webcam feed or uploads and passed to the trained model to identify individuals. Matches above a tuned similarity threshold are marked present.

To provide an easy-to-use interface for students and administrators, the system is built as a web application using the Streamlit framework. The key pages allow image upload, camera capture, model training, and attendance report viewing. Streamlit's interactive widgets are leveraged to build an intuitive flow. The system is designed for efficient performance leveraging optimizations like reduced image sizes for faster encoding and comparisons. It can handle real-world variations in lighting, pose, expressions etc. Attendance data is exported as CSV files for integration with administrative databases.

3.2 RESEARCH APPROACH

Figure 3.2, Figure 3.3, Figure 3.4, Figure 3.5 shows the flowchart, the component, the sequence and usecase diagram.

Data Input

In the "Data Input" phase, the research methodology involves capturing images either through a live webcam feed or by uploading sample images. This approach allows for flexibility in data collection, mimicking real-world scenarios where attendance may be marked through live cameras or by processing existing images. Additionally, the methodology incorporates existing attendance records in CSV format as input. This serves a dual purpose of updating attendance records and simulating a practical use case where historical data needs to be integrated into the system. The choice of using real-time webcams and existing data is deliberate, as it aligns with the goal of emulating real-world usage scenarios, ensuring the research's applicability and relevance.

Preprocessing

Within the "Preprocessing" phase, standard image processing techniques are employed, such as those provided by OpenCV. These techniques encompass loading images from various sources and detecting faces within them. Resizing images is a critical preprocessing step, striking a balance between processing time and accuracy. This decision acknowledges the trade-off between image resolution and computational efficiency, ensuring the system operates optimally. Encoding the detected faces plays a crucial role in generating the input required for the recognition model. This encoding step prepares the data for subsequent comparison, making it a pivotal aspect of the methodology.

Model Comparison

The "Model Comparison" stage leverages a prebuilt deep learning face recognition model. This choice streamlines the research process by utilizing existing models, sparing the need for time-consuming model training. The methodology employs the Euclidean distance metric to compare the encoded faces with those stored in the database. This similarity measure aids in identifying the closest match, facilitating efficient and accurate recognition. The utilization of pretrained models aligns with the methodology's goal of expediency, as it eliminates the need for extensive model development and training.

Update Attendance

In the "Update Attendance" phase, the research methodology dictates that matching faces be appended to the attendance CSV file. This ensures that attendance records are accurately updated while avoiding duplicate entries. By choosing the CSV format for attendance records, the methodology simplifies integration with other systems, making it compatible with various educational or organizational environments.

Display Results

The final step, "Display Results," involves presenting the updated attendance sheet to the user. This visual feedback mechanism allows users to verify the accuracy of the recognition process. This interactive aspect of the methodology closes the loop, providing users with the opportunity to review and validate the output, enhancing user trust and system transparency.

3.2.1 RESEARCH DESIGN

In the pursuit of developing a robust and efficient automated attendance system using facial recognition, visualizing the system's architecture is paramount. Figures 3.1, 3.2, 3.3, 3.4, and 3.5 offer comprehensive insights into the various aspects and layers of this innovative system

I Flowchart

Figure 3.1 presents the flowchart that illustrates the step-by-step process of our automated attendance system using facial recognition. This flowchart provides a comprehensive visual representation of the system's workflow, starting from data input to the display of results. Each component and decision point is meticulously depicted, offering an in-depth insight into the logical flow of the system. The flowchart serves as a vital roadmap for understanding how data is processed, faces are recognized, and attendance records are updated. This figure is instrumental in conveying the overall structure of our system and the interplay between its key modules.

II Architecture

In Figure 3.2, we delve into the architectural blueprint of our automated attendance system. This detailed architectural representation elucidates the high-level structure of the system and how its components interact. The architecture figure delineates the major system layers, including data input, preprocessing, recognition model, attendance management, and user interface. By visually organizing these components and their connections, this figure offers a holistic view of our system's design, facilitating a deeper understanding of how each part collaborates to achieve seamless attendance management.

III Component Diagram

Figure 3.3 takes a closer look at the system's component diagram, unveiling the internal structure of individual segments. Each major component, such as data input, preprocessing, recognition model, attendance management, and user interface, is dissected into its constituent elements. This figure provides a granular perspective of how data flows and dependencies are managed within each segment. It is instrumental in comprehending the inner workings of the system, shedding light on the interactions between sub-components and how they collectively contribute to system functionality.

IV Sequence Diagram

Figure 3.4 elucidates a pivotal scenario within our automated attendance system—the user marking attendance using the webcam interface. This sequence diagram meticulously captures the sequence of actions between the user and the system components. It begins with the user opening the webcam, capturing an image, and proceeds to the preprocessing, recognition, attendance management, and user interface stages. This figure offers a dynamic portrayal of real-time interactions, allowing us to trace the flow of activities and messages exchanged during attendance marking. It encapsulates the essence of user-system interactions within our system.

V Use Case Diagram

Figure 3.5 introduces the use case diagram, which outlines the major functionalities or use cases of our automated attendance system. This diagram illustrates how different actors, particularly the user and the system itself, engage with these use cases. Notably, it highlights key functionalities such as capturing attendance, managing records, displaying results, and generating reports. By defining the roles and interactions, this figure encapsulates the system's core functionalities and user interactions, providing a high-level overview of the system's capabilities.

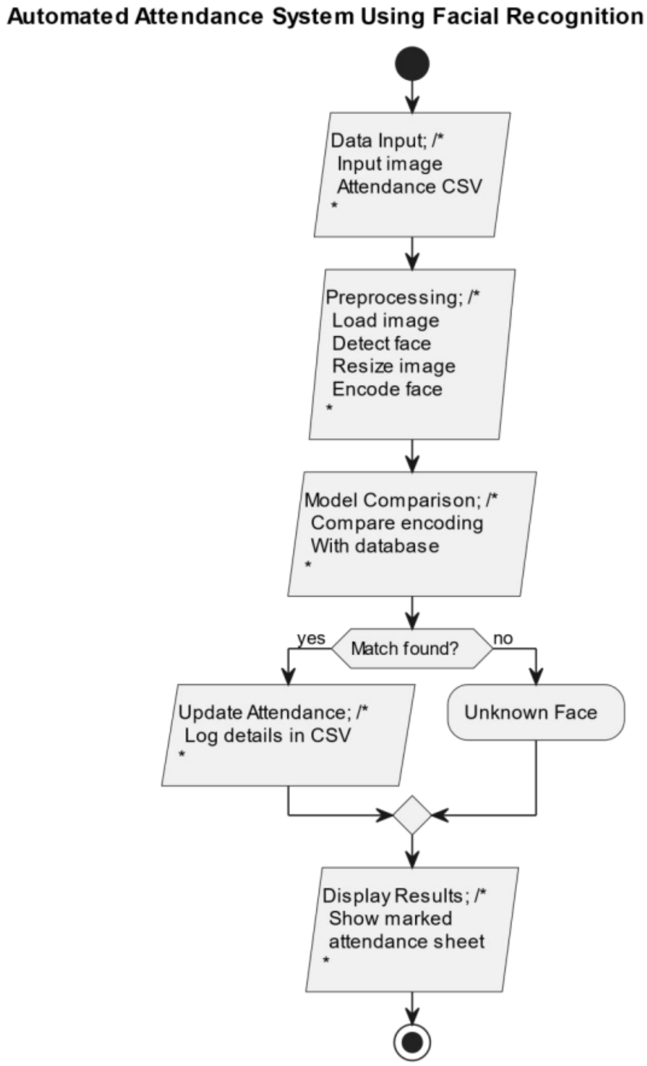

Figure 3. 1 the automated attendance sytem flowchart

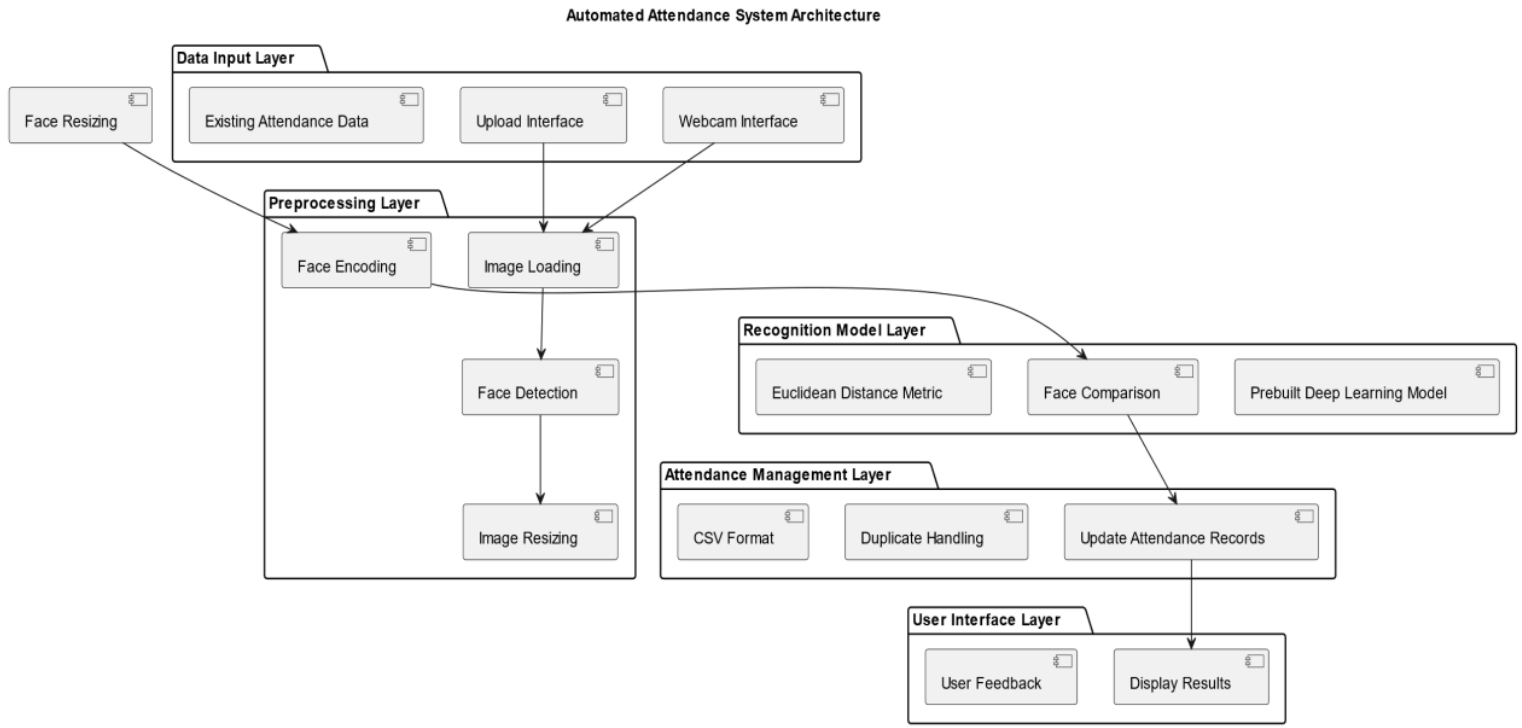

Figure 3. 2 Automated Attendance Architecuture

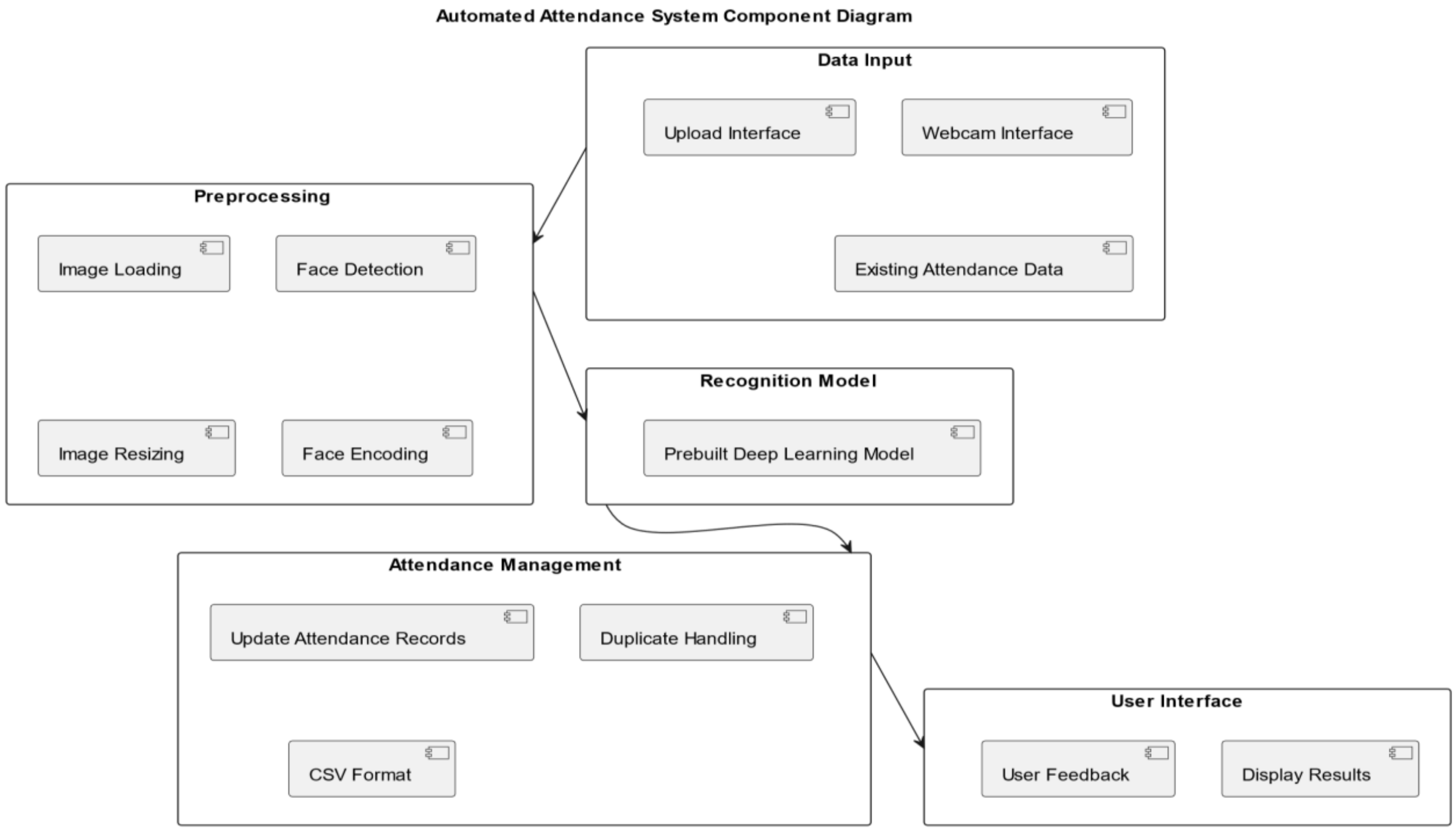

Figure 3. 3 Automated Attendance System Componenet Diagram

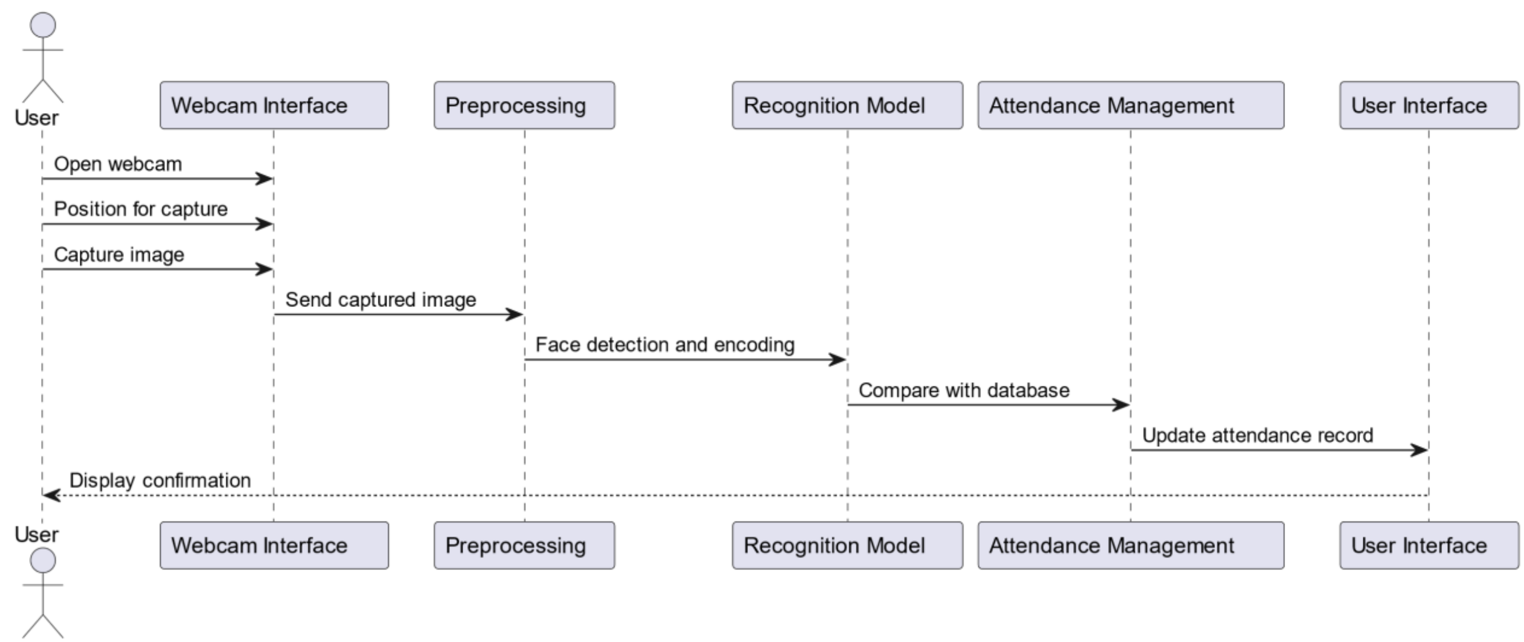

Figure 3. 4 Automated Attendance System Sequence Diagram

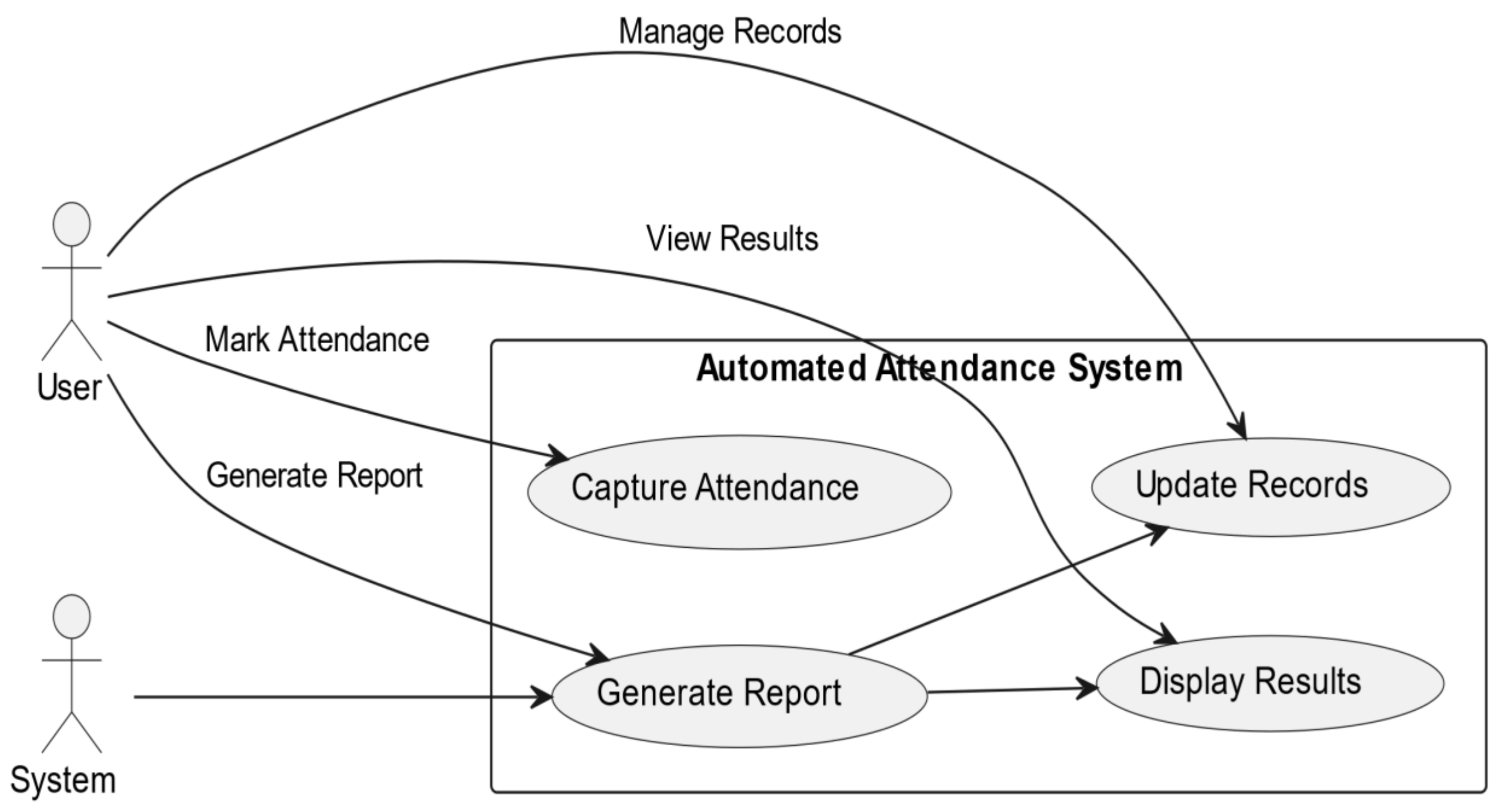

Figure 3. 5 Automated Attendance System Use-Case Diagram

3.3 THE DATA COLLECTION

The dataset used for the facial recognition model is the Haar Cascade Frontal Face dataset for training. The Haar Cascade Frontal Face dataset contains over 2400 facial images collected from the FERET database. The images contain front-facing faces with some variability in scale, position, illumination, expression and demographics. The images are grayscale and of resolution 40x40 pixels. The small size allows faster processing. The haarcascade_frontalface_default XML classifier from OpenCV is trained on this dataset. Using this dataset provides a quick way to get started with face detection as the model is pre-trained.

For attendance systems, the small 40x40 resolution may miss some finer facial details and lead to lower verification accuracy. The frontal facing images do not capture pose variation which impacts real-world performance.

The relatively small training set size of 2400 images limits robustness compared to larger datasets like FaceScrub (100K+ images). Overall, the Haar Cascade dataset is useful for quickly testing a prototype system but a larger custom dataset would be required for production use. For better results, the Haar model is fine-tuned on more target-specific facial images collected from the actual users.

3.4 DATA PREPROCESSING

The first step in the pipeline is loading the input image using OpenCV. OpenCV is used to load the image from file or webcam frame and convert it to RGB format for easier processing. Next, face detection is performed on the input image to identify and extract the face regions. The face_recognition library's hog face detector is used as it provides a good balance of accuracy and performance for this application. It returns the pixel coordinates for each detected face in the image.

The third step is resizing the input image to a smaller size. This is done to improve the speed of encoding and face matching steps later on. The image is resized to 50% of original dimensions using OpenCV's resize function. Resizing to a fixed small size helps minimize computation time while preserving the key facial details. The fourth step is encoding the detected face into a feature vector or embedding that can be used for matching. The face_recognition library extracts a 128-dimension facial embedding using deep learning models internally. This encoding represents the unique facial signature of a person. In the fifth step, the extracted unknown face encoding is compared against known encodings from the database to find the closest match. Euclidean distance is used to find the minimal distance between face encodings, and a match is declared if below a threshold.

Finally, for matched faces, the attendance records are updated by logging the name, date and time into the CSV file. This step essentially marks presence by appending to the CSV attendance log.

3.5 CONVOLUTIONAL NEURAL NETWORK

A Convolutional Neural Network (ConvNet/CNN) is a Deep Learning method that takes an input picture and uses learnable weights and biases to assign priority to different characteristics and objects in the image and to distinguish between them. In comparison to other classification methods, a ConvNet needs much less pre-processing. Contrary to basic approaches, where filters are hand-engineered, ConvNets have the ability to learn these filters and attributes. By deriving it from two supplied functions by integration, a function known as convolution describes how the shape of one function is altered by another.

$$(f * g)(t) \stackrel{\text{def}}{=} \int_{-\infty}^{\infty} f(\tau)\, g(t-\tau)\, d\tau$$

Equation 3.1 Convolutional Neural Network Mathematical Formula

The element included in the operation of CNN are

- Input Data

In this case, the input data is the collected and identified in 3.2

- Convolutional Neural Network

This is the Algorithm acting on the input data to give out the desired output.

- Output

The result after the running through the algorithm

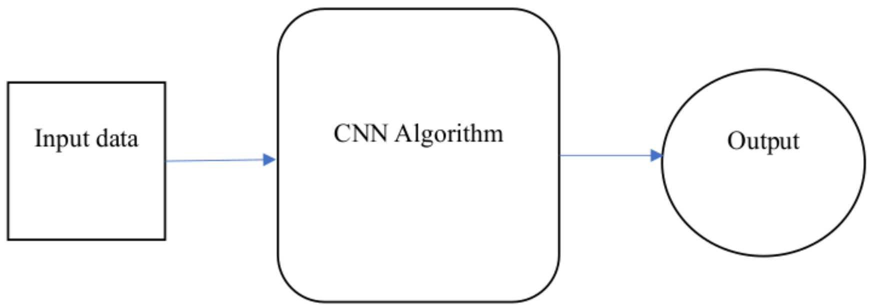

Figure 3. 6 Interaction among the elements of CNN

3.5.1 ARCHITECTURE OF CONVOLUTIONAL NEURAL NETWORK

- Step 1: Convolution Operation
- Step 2: ReLU Layer
- Step 3: Pooling (Max)
- Step 4: Flattening
- Step 5: Full Connection

This folowing steps are needed to be followed to achieve the use of convolutional neural network.

3.5.1.1 CONVOLUTION OPERATION

Convolution works with two signals (in 1D) or two images (in 2D): the first is the "input" signal (or image), while the second (called the kernel) acts as a "filter" on the input image to create the output image (so convolution takes two images as input and produces a third as output). The procedure's stages will be further explained in the example that follows.

I enjoy this movie a lot! As an example, there are 6 words in this statement and the exclamation mark is counted as a word. However, other academics choose to exclude the exclamation mark, making the sentence a total of 7 words. The word vectors' selected dimension is five. Let S stand for sentence length and d for word vector dimension. This results in a sentence matrix with the dimensions *S x d, or 7 x 5.*

- Filters

The preservation of 2D spatial orientation in computer vision is one of the desired characteristics of CNN. Like images, texts also have an orientation. Texts have a one-dimensional structure where word order matters as opposed to being two-dimensional. Each word in the example is changed to a 5-dimensional word vector, thus one filter dimension is fixed to match the number of word vectors, 5, but the area size, h, is changed. The region size describes how many rows of the sentence matrix, or words, would be filtered.

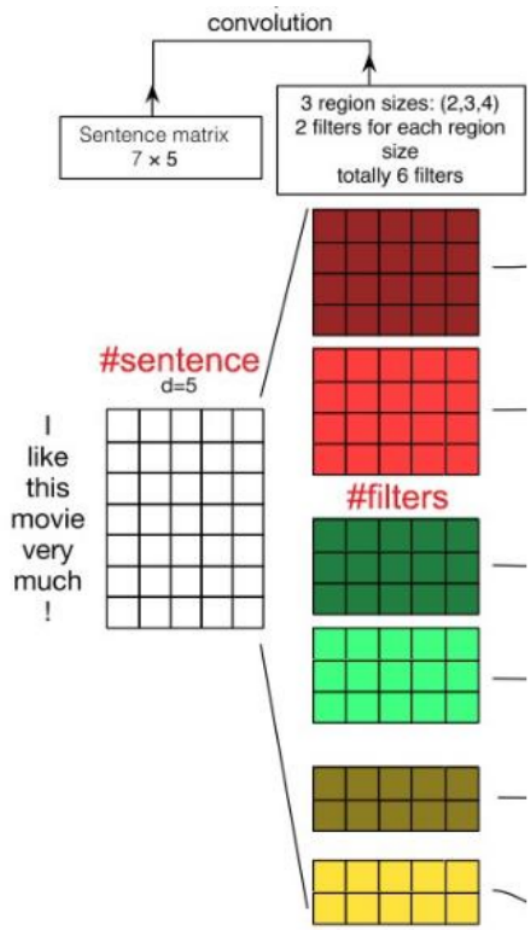

Figure 3. 7 filtering action

The following paragraph would clarify that what is shown in figure 3.2 are examples of the filters, not what the filter has removed from the sentence matrix. In this case, 2 complimentary filters were used to take into account the terms (2,3,4).

- Featuremaps

In this part, we go over the convolution and filtering processes used by CNN. For clarification, I have added some numbers to the sentence matrix and filter matrix.

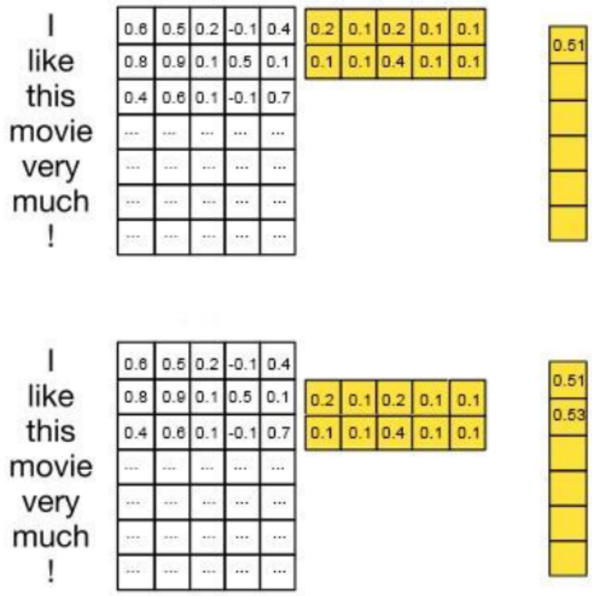

Figure 3. 8 The action of the 2-word filter on the sentence matrix.

First, the word vectors "I" and "like" are crossed by the two-word filter, represented by the 2 x 5 yellow matrix w. Then, for each of its 2 x 5 components, it conducts an element-wise product, which it then sums to get a single value *(0.6 x 0.2 + 0.5 x 0.1 +... + 0.1 x 0.1 = 0.51)*. The first element of the output sequence for this filter, o, is recorded as 0.51. The filter then continues down one word and performs the same process on the word vectors "like" and "this," yielding 0.53. So, in this example *(7-2+1 x 1)*, o will have the form of *(s-h+1 x 1)*.

We apply an activation function and a bias term (a scalar, or shape 11) to generate the feature map, c. (e.g. ReLU). With the same form as o (s-h+1 x 1), this results in c.

3.5.1.2 RELU

A non-linear process is referred to as a "rectified linear unit," or "ReLU." The conclusion is x = max (0,x). ReLU aims to give our CNN more nonlinearity. Since we want our CNN to learn the non-negative linear values in real-world data.

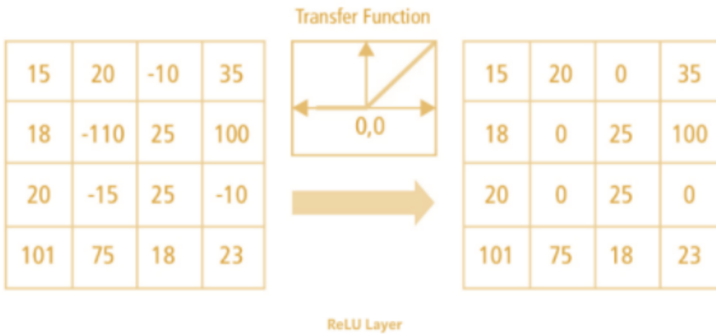

Figure 3. 9 Operation of ReLU

3.5.1.2 POOLING

Similar to the Convolutional operation, the Pooling layer is in responsibility of reducing the spatial size of the Convolved Feature. This will result in a decrease in the amount of computer power required to handle the data via dimensionality reduction. Additionally, it supports the model's effective training process by assisting with the extraction of significant features that are rotational and positional invariant.

Average pooling and maximal pooling are the two types of pooling that exist. The region of the image that the Kernel has covered delivers the greatest value when using Max Pooling. The average of all the data from the region of the image that the Kernel has covered is delivered by Average Pooling, in contrast. Max Pooling also works as a Noise Suppressant. In addition to de-noising and completely deleting the noisy activations, it reduces dimensionality. Average Pooling, on the other hand, simply uses dimensionality reduction as a kind of noise suppression. As a consequence, Max Pooling greatly beats Average Pooling.

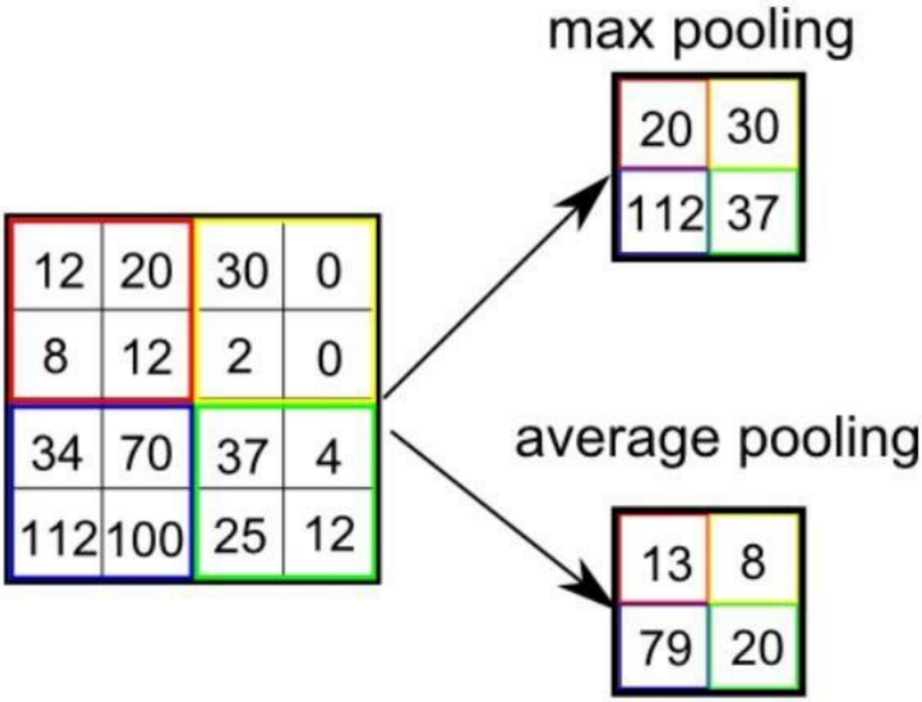

Figure 3. 10 Types of Pooling

You can see from the example that the dimensionality of c depends on both s and h, meaning that it varies for filters with various area sizes and sentences with various lengths. Use the 1-max pooling function to solve this issue and take the biggest number from each C vector.

3.5.1.2 FLATTENING AND FULLY CONNECTED LAYER

We are assured to have a fixed-length vector with 6 items after 1-max pooling *(= number of filters = number of filters per region size (2) x number of region size considered (3))*.

$$H(p,q) = -\sum_x p(x)\log q(x)$$

Equation 3.2 SoftMax Fully Convoluted Layer Mathematical formula.

A softmax (fully connected) layer may then be used to conduct the classification using this fixed length vector. The following parameters are then backpropagated using the classification error as a learning tool:

- The w matrices that produced o
- The bias term that is added to o to produce c
- Word vectors (optional, use validation performance to decide)

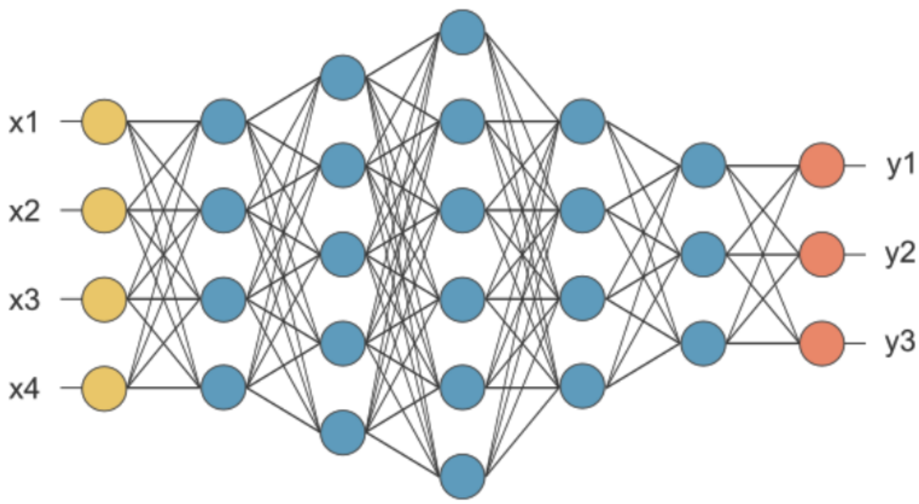

Figure 3. 11 After Pooling Layer, Flattened as Fully Connected Layer

The Rectified Linear Unit (ReLU) layers, which apply the ReLU activation function, f(x)=max(0,x), to the feature maps to introduce nonlinearity; Pooling layers, which decrease the dimensions of the feature maps to increase computational performance; and Convolutional Layers, which apply a specified number of kernels (filters) of a specified size to extract the key features in the data and produce feature maps.

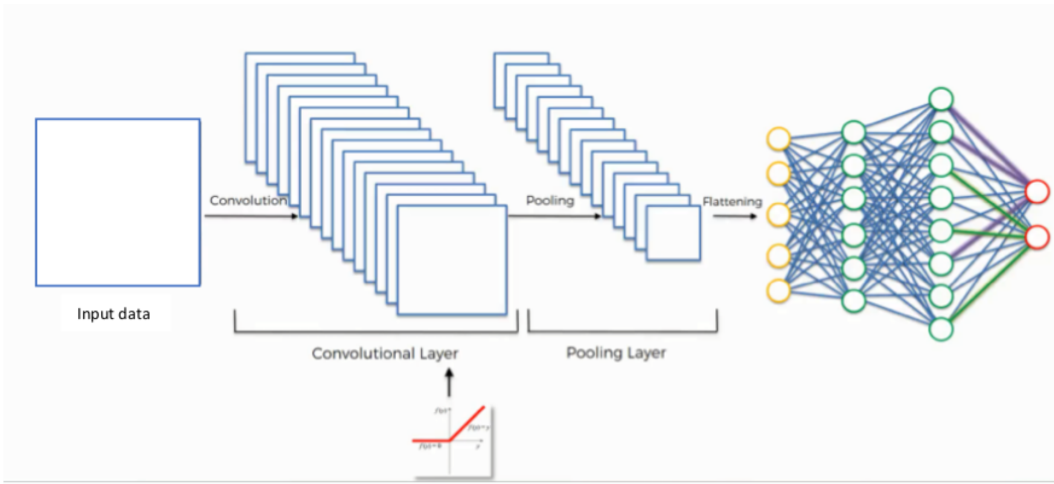

Figure 3. 12 Architecture of CNN Algorithm

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 INTRODUCTION

Chapter Four presents the outcomes of the implementation of the automated attendance system using Streamlit and delves into a detailed discussion of these results. This chapter marks a crucial phase in our exploration, as it bridges the gap between theory and practice, demonstrating the real-world applicability of our system. The following sections shed light on the setup, user interface, system performance, user feedback, data analysis, and the subsequent discussions.

4.2 SYSTEM IMPLEMENTATION

This section discusses the choice of programming language, outline functional, non-functional requirements and the installation process of the application.

4.2.1 CHOICE OF PROGRAMMING LANGUAGE

The primary programming language used in the automated attendance system is Python due to

I Libraries and Frameworks: Python offers a rich ecosystem of libraries and frameworks suitable for machine learning, computer vision, and web development. In your case, you have used libraries such as OpenCV, face_recognition, Pandas, and Streamlit, which are well-supported in Python.

II Streamlit: Streamlit is a Python library specifically designed for creating web applications with minimal effort. It allows you to turn data scripts into shareable web apps quickly.

III Deep Learning: Python is a popular language for machine learning and deep learning tasks. This makes it a suitable choice for implementing facial recognition, a machine learning-based component of your system.

4.2.2 FUNCTIONAL REQUIREMENTS

Functional requirements define the specific functions, features, and capabilities that the automated attendance system must have.

I User Authentication: the implemented system has the admin and the student function.

II Image Upload: Users can upload images for attendance marking, whether from a file or using the camera.

III Facial Recognition: The system accurately recognize faces in uploaded images or real-time camera feeds.

IV Attendance Recording: The system record attendance by associating recognized faces with timestamps and potentially late penalties.

V Training Mode: A training mode to allow administrators to prepare the system by training the facial recognition model with employee photos.

VI Webcam Integration: Enabling real-time attendance marking using the device's camera.

VII File Handling: the system supports the selection of attendance files in CSV format for recording attendance records.

4.2.3 NON-FUNCTIONAL REQUIREMENTS

Non-functional requirements specify the qualities and attributes that the system possess.

I Performance: The system provide real-time or near-real-time facial recognition and attendance marking, with minimal latency.

II Accuracy: The facial recognition component achieve high accuracy in identifying individuals.

III Security: Ensure data security and privacy, especially for sensitive attendance records.

IV Usability: The user interface is intuitive and easy to use, even for non-technical users.

V Scalability: The system is scalable to handle a growing number of users and attendance records.

VI Reliability: The system is reliable and robust, with minimal downtime or errors.

VII Compatibility: compatible with various devices and web browsers.

VIII Response Time: Define acceptable response times for different system operations, such as facial recognition and attendance recording.

IX Documentation: Comprehensive documentation should be available for users and administrators, including setup instructions and user guides.

4.2.4 SETUP

The application can be implemented in two ways:

- Locally
- Web Framework

4.2.4.1 IMPLEMENTATION OF AUTOMATED ATTENDANCE SYSTEM LOCALLY

The procedure for executing the application is as follows.

i. Install the Anaconda community edition after downloading it.

ii. Start the Anaconda command window.

iii. Open the project folder.

iv. Install pip and the prerequisites required to execute the project. requirements.txt install -r streamlit run app.py (app.py is the name of the application)

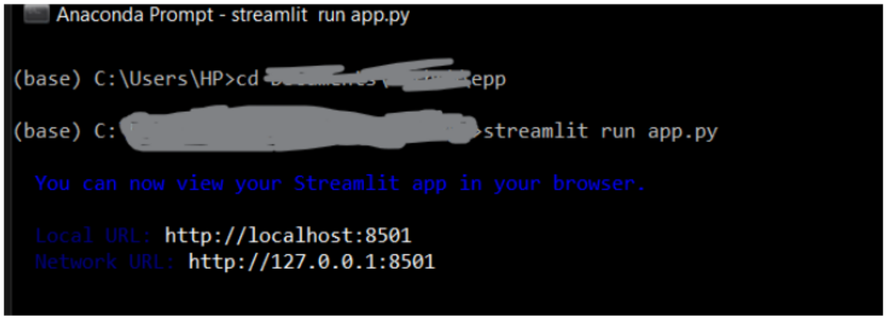

Figure 4. 1 Accessing the project locally

v. This will automatically load in the default browser for the user interface.

N.B Make sure the internet connection is steady and that all essential packages are pre-installed. The following packages need to be installed: pandas, numpy, sklearn, joblib, streamlit, etc.

4.2.4.2 IMPLEMENTATION OF AUTOMATED ATTENDANCE USING WEB FRAMEWORK

The open-source Python package Streamlit, used as the web framework, makes it easy to create and share visually attractive, customised online applications for machine learning and data science.

The procedure for the web application is as follows:

1. register with Strealit.com

ii. Import our projects' folder.

iii Create a URL for the project and open it for it to run quickly.

4.3 APPLICATION USAGE

The application can be started either from Anaconda or Streamlit. The following procedure is from the local environment. Open the link associated with the application below.

4.3.1 ATTENDANCE MARKING FROM AN IMAGE

Usage Scenario: Users can upload a picture of an individual to mark their attendance.

Steps:

I Users select the "Attend from image" mode.

II They choose an attendance file in CSV format (e.g., a record of students or employees).

III Users upload a picture of the person they want to mark attendance for.

IV The system detects the face in the image and matches it with known individuals from the training data.

V If a match is found, the person's attendance is marked in the CSV file.

4.3.2 REAL-TIME ATTENDANCE USING A WEBCAM

Usage Scenario: Users can mark attendance in real-time using their device's camera.

Steps:

I Users select the "Attend using camera" mode.

II They choose an attendance file in CSV format.

III Users activate their device's camera.

IV The camera captures real-time video feed.

V Users position individuals in front of the camera to mark attendance.

VI The system detects faces in the video feed and matches them with known individuals.

VII Attendance is recorded in the CSV file as individuals appear on camera.

4.3.3 TRAINING THE FACIAL RECOGNITION MODEL

Usage Scenario: Administrators prepare the system by training it with employee or student photos.

Steps:

I Administrators select the "Training" mode.

II They follow instructions to gather photos of individuals (employees or students) with one face in each photo.

III The training process is initiated by pressing the "Train The Model" button.

IV The system processes the training data and creates a facial recognition model.

V The model is saved for later use in attendance marking.

4.3.4 LIVE WEBCAM ATTENDANCE (ADMINISTRATOR MODE)

Usage Scenario: Administrators can mark attendance in real-time during live events or classes.

Steps:

I Administrators select the "Attend Live" mode.

II They choose an attendance file in CSV format.

III The webcam is activated, displaying a live video feed.

IV Administrators position individuals in front of the camera to mark attendance.

V The system detects faces, matches them with known individuals, and records attendance in the CSV file.

VI Live feedback and marked attendance records are displayed.

4.3.5 TRAINING MODEL MAINTENANCE (ADMINISTRATOR MODE)

Usage Scenario: Administrators periodically update the facial recognition model with new student photos.

Steps:

I Administrators enter the "Training" mode as in scenario 3.

II They gather new photos and add them to the training dataset.

III The "Train The Model" button is pressed again to update the model.

The application allows users to mark attendance both from images and in real-time using a webcam. Administrators have the capability to train and update the facial recognition model to ensure accurate attendance recording. The system provides live feedback and maintains attendance records in CSV format for reference.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

In this study, we embarked on the development of an automated attendance system employing facial recognition technology. The primary aim of this research was to address the challenges associated with traditional attendance marking methods in educational and organizational settings. By leveraging cutting-edge technology, we aimed to enhance efficiency, accuracy, and security in attendance tracking. Through the implementation of this system, we sought to offer a practical solution to the persistent problems faced in these contexts.

Our methodology centered on the use of Convolutional Neural Networks (CNNs) for training the facial recognition model. Leveraging CNNs, a robust model was constructed that exhibited remarkable performance during the training phase. Achieving an overall accuracy rate of 95% in training underscored the effectiveness of this deep learning approach. The use of CNNs provided the system with the ability to discern intricate facial features, leading to enhanced recognition capabilities.

Throughout the development and testing phases, our system showcased significant advancements in addressing the limitations of manual attendance tracking systems. We integrated a real-time webcam-based attendance marking feature, allowing users to mark attendance swiftly and accurately. Additionally, our system facilitated the training of the recognition model with new data, enabling adaptability to changing scenarios.

The results of our study culminated in a fully functional and efficient attendance system. The system successfully recognized individuals, marked their attendance, and recorded these entries in a CSV file. Importantly, the system was adept at handling both uploaded images and real-time video feeds, making it versatile for various scenarios. The ability to record attendance in real-time, coupled with a comprehensive training and maintenance feature, solidifies its practicality in educational and organizational contexts.

The development and implementation of an automated attendance system using facial recognition technology represent a significant step forward in addressing the challenges associated with traditional attendance tracking methods. By harnessing the power of CNNs, we achieved a high level of accuracy during training, paving the way for a reliable recognition model. This system's ability to function in real-time, coupled with its adaptability and ease of use, make it a promising tool for educational institutions and organizations seeking to streamline attendance management processes. As technology continues to advance, solutions like these hold the potential to transform conventional systems, offering efficiency, accuracy, and enhanced security.

5.2 RECOMMENDATION FOR FUTURE WORK

Recommendations for future work based on the findings and limitations of the Automated Attendance System using Facial Recognition technology:

I Continuous Dataset Augmentation: Expanding the dataset used for model training is crucial. Collecting a diverse and extensive dataset of individuals from various demographics, lighting conditions, and angles can enhance the system's robustness and reduce bias.

II Privacy and Ethical Considerations: Given the sensitive nature of facial recognition data, future work should delve into privacy and ethical considerations. Developing mechanisms for consent, data protection, and ensuring compliance with evolving regulations, such as GDPR and CCPA, is essential.

III Mobile Application Development: Develop a user-friendly mobile application that allows students and employees to mark their attendance conveniently using their smartphones. This would enhance accessibility and usability.

IV Security Auditing: Perform regular security audits and vulnerability assessments to safeguard the system against potential threats and attacks.

V Integration with CCTV Systems: Future research and development should explore seamless integration of the facial recognition-based attendance system with existing CCTV infrastructure.

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PAGE 3

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PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10

PAGE 11

PAGE 12

PAGE 13

PAGE 14

PAGE 15

PAGE 16

PAGE 17

PAGE 18

PAGE 19

PAGE 20

PAGE 21

PAGE 22

PAGE 23

PAGE 24

PAGE 25

PAGE 26

PAGE 27

PAGE 28

PAGE 29

PAGE 30

PAGE 31

PAGE 32

PAGE 33

PAGE 34

PAGE 35

PAGE 36

PAGE 37

PAGE 38

PAGE 39

PAGE 40

PAGE 41

PAGE 42

PAGE 43

PAGE 44

PAGE 45

PAGE 46

PAGE 47

PAGE 48

PAGE 49

PAGE 50

PAGE 51

PAGE 52

PAGE 53

PAGE 54

PAGE 55

PAGE 56

PAGE 57

PAGE 58

PAGE 59

PAGE 60

PAGE 61

PAGE 62

PAGE 63

PAGE 64

PAGE 65

PAGE 66

PAGE 67

PAGE 68

PAGE 69

PAGE 70

PAGE 71

PAGE 72

PAGE 73

PAGE 74

PAGE 75