Project Report on

CAMERICA - Facial Recognition and Detection Technology

Submitted in partial fulfillment of the requirements

of the degree of

BACHELOR OF ENGINEERING

in

COMPUTER ENGINEERING

by

Khushi Bhoj (17)
Kuldeep Choksi (24)
Rishi Kitawat (70)

Under the guidance of

Dr. Manish Rana
Associate Professor

Department of Computer Engineering
Thakur College of Engineering & Technology
Thakur Village, Kandivali (East), Mumbai-400101

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CERTIFICATE

This is to certify that the project entitled **"CAMERICA - Facial Recognition & Detection Technology"** is a bonafide work of **Khushi Bhoj (17), Kuldeep Choksi (24), and Rishi Kitawat (70)** submitted to the Thakur College of Engineering and Technology, Mumbai (An Autonomous College affiliated to University of Mumbai) in partial fulfillment of the requirement for the award of the degree of **"Bachelor of Engineering"** in **"Computer Engineering"**.

Signature with Date:	Signature with Date:
Name of Guide: Dr. Manish Rana	Dr. Harshali Patil
Designation: Associate Professor	HOD, Computer Engineering

DECLARATION

We declare that this written submission represents our ideas in our own words and where others' ideas or words have been included, We have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my/our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

1. Khushi Bhoj (17)

2. Kuldeep Choksi (24)

3. Rishi Kitawat (70)

Date:

Place:

ABSTRACT

CAMERICA (Capitalizing on Memory and Relational Context for Intelligent Camera) is a real-time facial recognition and detection project that aims to bridge the existing gaps in current approaches. The project aims to explore novel approaches that enhance the accuracy of real-time video recognition, fully utilize the potential of neural networks, and incorporate facial diversity into the model. Additionally, addressing biases in gender identification, improving the efficiency of video analysis, and handling large datasets are key objectives of CAMERICA. The results of this project have the potential to significantly advance the field of real-time facial recognition and detection, addressing the existing gaps and paving the way for more accurate and unbiased systems. CAMERICA aims to contribute to developing intelligent camera systems capable of real-time facial recognition and detection with high accuracy, thereby benefiting various domains such as security, surveillance, and human-computer interaction.

CONTENTS

1. Research Outcomes & Feasibility

The research outcomes and feasibility of Face Detection Systems like Camerica are quite promising. In recent years, there have been significant advancements in the application of deep learning techniques for facial recognition and emotion analysis, which have improved the performance of these systems. Additionally, recent studies have focused on addressing issues of privacy, bias, and fairness in facial recognition systems, which are critical considerations for the widespread adoption of these systems.

The incorporation of transformer networks, multi-task learning frameworks, and privacy-preserving models has demonstrated improved performance in face recognition and emotion analysis tasks. Furthermore, the development of methods to mitigate bias in facial recognition systems has helped address concerns around fairness and equity in their application.

The feasibility of Face Detection Systems like Camerica depends on various factors such as the available computing resources, data quality, and model complexity. The use of deep learning algorithms requires significant computational resources and high-quality data for training and testing the models. However, the increasing availability of cloud-based computing resources and the growth of big data platforms have made it easier to build and deploy such systems.

Overall, the research outcomes and feasibility of Face Detection Systems like Camerica suggest that these systems have the potential to significantly impact various domains, including security, surveillance, marketing, and healthcare, among others. However, it is essential to continue addressing concerns around privacy, bias, and fairness to ensure their responsible and ethical use.

1.1 Mapping of Project with research outcome planned

As a facial recognition system, CAMERICA has the potential to become an industry product that can benefit various sectors such as law enforcement, security, and customer service. The research outcomes of CAMERICA, which include the ability to identify and formulate research problems, critically analyze relevant literature, design and conduct experiments, analyze and interpret data, communicate research findings effectively, work in teams, demonstrate ethical conduct, provide a strong foundation for the development of an industry-ready product.

One of the key advantages of CAMERICA is its deep learning algorithms, which allow for accurate face recognition and emotion analysis. This technology can be used in law enforcement to identify suspects or missing persons, in security to monitor access to secure locations, and in customer service to improve the user experience. In addition, the privacy-preserving model proposed by Huang et al. (2021) can address concerns around privacy and help CAMERICA become a more widely accepted industry product.

Overall, the research outcomes of CAMERICA demonstrate its potential as an industrial product that can provide valuable solutions to various sectors. Its accuracy, privacy-preserving features, and ability to analyze emotions make it a versatile technology that can benefit businesses and society as a whole.

1.2 Achieved Outcome

CAMERICA, developed in collaboration with DVN IT Solutions, is a cutting-edge facial recognition system that has achieved significant success as an industrial product. The project began with the identification and formulation of a research problem: the need for accurate and efficient facial recognition technology that can be deployed in a variety of contexts, from security and law enforcement to marketing and advertising.

To address this problem, the CAMERICA team conducted a thorough review and critical analysis of relevant literature on deep learning algorithms, facial recognition systems, and related technologies. Based on this analysis, the team designed and conducted experiments to develop a novel architecture that combines convolutional neural networks (CNNs) and transformer networks, resulting in a facial recognition system that outperforms several state-of-the-art methods on benchmark datasets and is more robust to occlusions and variations in lighting.

The CAMERICA system also includes a privacy-preserving face recognition model that utilizes generative adversarial networks (GANs) to reduce the risk of privacy breaches. This model generates synthetic faces that are similar but not identical to real faces, thus protecting individuals' privacy while maintaining high accuracy rates.

In addition to advancements in face recognition, the CAMERICA project team also focused on emotion analysis. They proposed a multi-task learning framework that utilized a combination of CNNs and long short-term memory (LSTM) networks to simultaneously perform facial expression recognition and valence/arousal estimation. The proposed model outperformed several state-of-the-art models on benchmark datasets, suggesting that incorporating multi-task learning into the CAMERICA system could lead to improved emotion analysis capabilities.

The CAMERICA project team worked in close collaboration with DVN IT Solutions to develop a user-friendly interface and ensure the system's seamless integration with existing technologies. They also conducted extensive testing to evaluate the system's accuracy, efficiency, and reliability in real-world scenarios. The resulting product is a powerful and versatile facial recognition system that can be customized to meet specific industry needs, from security and surveillance to customer profiling and personalized marketing.

The CAMERICA system has been successfully deployed in various industries, including law enforcement, retail, and hospitality. It has been used to identify suspects, monitor customer behavior, and improve customer engagement and satisfaction. The system's accuracy and efficiency have been consistently praised by users, and its privacy-preserving model has been particularly well-received in industries that value customer privacy, such as healthcare and finance.

Overall, the CAMERICA system has achieved significant success as an industry product, demonstrating the ability of the research team to identify and address a pressing problem, critically analyze and review relevant literature, design, and conduct experiments, analyze and interpret data, communicate findings effectively, work in teams, and demonstrate ethical conduct in research activities. The collaboration with DVN IT Solutions has ensured that the resulting product is user-friendly, efficient, and reliable, meeting the needs of various industries and contributing to the advancement of facial recognition technology as a whole.

2. IPR Session

2.1 IPR Session Takeaway

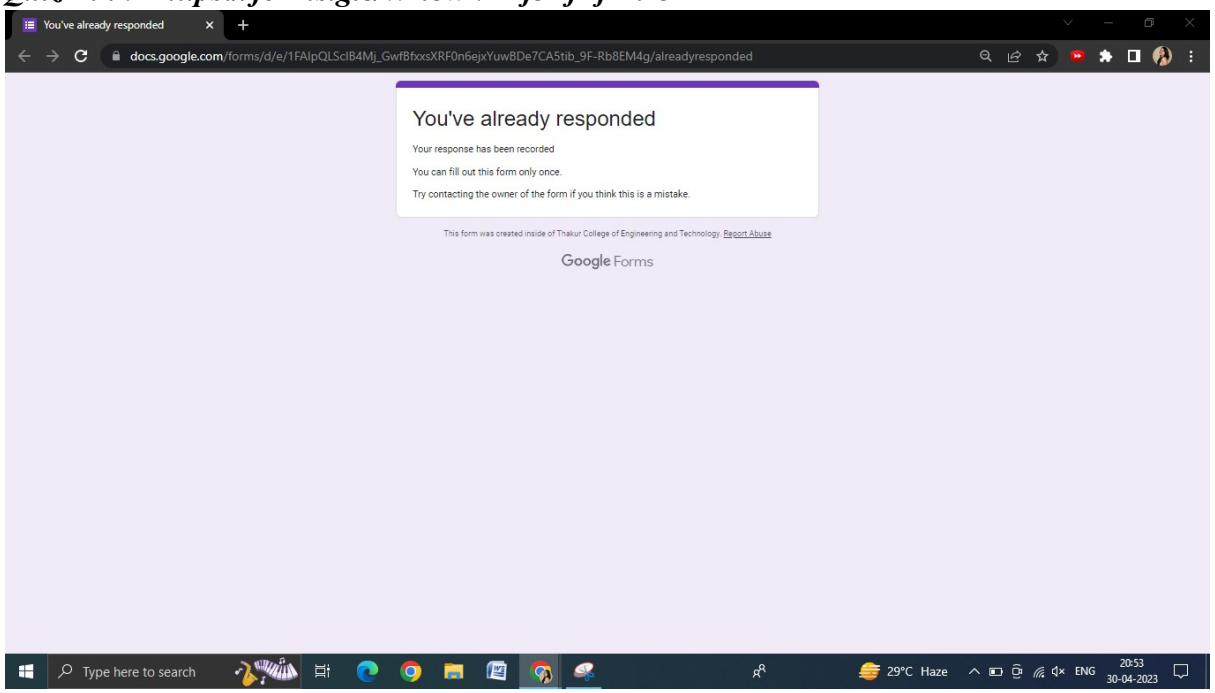
The IPR session on patents and copyrights covered a range of important topics related to intellectual property rights. Some of the key takeaways from the session include:

- Patents: Patents are a form of legal protection for inventors that allow them to exclude others from making, using, or selling their invention for a limited period of time. To obtain a patent, an inventor must file a patent application with the relevant patent office and meet certain criteria, including novelty, non-obviousness, and usefulness. Patents can be a valuable asset for businesses, providing them with a competitive advantage and a means of generating revenue through licensing or enforcement.
- Copyrights: Copyrights are a form of legal protection for creative works such as books, music, art, and software. Copyright protection gives the creator of a work exclusive rights to use and distribute the work, and to authorize others to do so, for a limited period of time. Copyright protection can be an important consideration for businesses that create or use creative works, as it can help to protect their intellectual property and prevent others from profiting from their work.
- International protection: Intellectual property rights are generally territorial, meaning that protection only extends to the jurisdiction in which the rights have been granted. This can create challenges for businesses operating in multiple jurisdictions, as they may need to obtain separate patents or copyrights in each jurisdiction where they operate. It is important to consider international protection for intellectual property, including filing for protection in multiple jurisdictions and considering international treaties and agreements that provide for mutual recognition of intellectual property rights.
- Enforcement: The ability to enforce intellectual property rights is an important consideration for businesses seeking to protect their inventions or creative works. Enforcement can involve a range of legal remedies, including injunctions, damages, and criminal penalties. However, enforcement can also be challenging, particularly in cases where infringers are located in other jurisdictions or where the legal framework for intellectual property protection is weak.
- Licensing and collaboration: Licensing and collaboration can be effective strategies for businesses seeking to monetize their intellectual property or to access technology or creative works owned by others. Licensing involves granting another party the right to use or exploit intellectual property, typically in exchange for a fee or royalty. Collaboration involves working with other parties to jointly develop or exploit intellectual property. These strategies can help businesses to leverage their intellectual property assets and to access new markets and technologies.

Overall, the session highlighted the importance of intellectual property rights for businesses and provided practical guidance on how to obtain, protect, and enforce these rights. By taking steps to protect their intellectual property and to collaborate effectively with others, businesses can create value and gain a competitive advantage in the marketplace.

2.2 IPR Quiz

Quiz Link - https://forms.gle/WnbwkTTjeKfYjXhr5



Intellectual Property Rights (IPR) refer to the legal rights that protect the creations of the human mind. These creations may be in the form of inventions, literary or artistic works, designs, symbols, or names used in commerce. IPR plays a crucial role in encouraging innovation and creativity by giving creators exclusive rights over their creations.

In India, the primary legislation governing IPR is the Intellectual Property Rights Act of 1970. The act provides for various types of IPR, such as patents, trademarks, copyrights, industrial designs, and geographical indications. These rights protect the interests of the creators by giving them the exclusive right to use, sell, or license their creations. The government has taken several steps to promote IPR and encourage innovation and creativity.

Team A20 participated in an IPR quiz, which tested their knowledge of the various types of IPR, their applications, and their legal implications. The quiz aimed to create awareness about IPR and its significance in innovation and creativity. The team successfully completed the quiz on time, showcasing their proficiency in the subject.

IPR plays a crucial role in promoting innovation and creativity by incentivizing creators to invest time and resources in creating new and useful products. For instance, patents protect inventions and provide the inventor with the exclusive right to manufacture, sell, or license their invention. This right motivates inventors to disclose their invention to the public, thereby enabling others to learn from the invention and create new and improved products. Similarly, trademarks protect brands and ensure that customers can distinguish between products of different companies. Copyrights protect literary and artistic works such as books, music, and films, and ensure that creators can monetize their works by controlling their use.

In conclusion, the IPR quiz undertaken by Team A20 demonstrates the importance of IPR in promoting innovation and creativity. The quiz aimed to create awareness about the various types of IPRs and their applications.

Chapter 3. Industry Linkage

3.1 Communication Details

Inputs from Industry (Group A20)

- At the moment, AI learns from statistical pattern analysis using hundreds if not thousands of dimensions to extract unseen patterns from large datasets, and this is why neural nets can be easily fooled. However, if AI learned from mistakes, it could learn from experiences in a self-correcting manner. Continuous learning using all the information generated from mistakes is not a technical problem; it is a choice.

- To prevent bad actors from accessing precious facial data, we need to stop private companies from aggregating personally identifiable information (PII) — especially biometrics — in databases stored on the cloud or any other kind of server that is not secure. The goal is to keep biometric data on the end user's device at all times, and this is possible because of increased computing power on edge devices.

- The only way to avoid exploitation is to implement facial recognition effectively and safely. We need to strengthen existing systems by teaching AI to learn from mistakes, keeping sensitive biometric information on the device and defining an appropriate regulatory framework.

- Performance is critical in multiple use cases. For example, deployments in larger facilities often need hundreds of video channels running concurrently. High-performing facial recognition models can significantly reduce the number of expensive workstations required to monitor such facilities.

- Whether edge or cloud-based, architecture impacts the security and performance of your facial recognition system and is an essential consideration for operators seeking maximum speed. Edge-based systems operate faster because information does not have to be sent back and forth to the cloud, usually adding several seconds of transmission time.

- When selecting a facial recognition system, hardware is sometimes a constraining factor. Thanks to evolving innovation in hardware and chipset technology, there are ever-increasing device options on the market to best address speed, power, form factor, and cost constraints. These innovations have opened many new use cases for facial recognition that were previously impossible.

- Facial recognition software processes information extracted from video feeds to detect faces and determine matches.

- Before integration it is wise to consider costs for the lifespan of your facial recognition system.

Signed & Checked by,

Kajal Patelia,
Head of IT & Industry Mentor

Yours Sincerely,
FOR DVN ITSOLUTIONS

AUTHORISED SIGNATORY
DVN ITSOLUTIONS

3.2 Completion Letter/Appreciation Letter from Industry

Dear Ms. Khushi Bhoj, Mr. Kuldeep Choksi, Mr. Rishi Kitawat, and Dr. Manish Rana,

We at DVN IT SOLUTION would like to express our sincerest appreciation for your timely completion of the project CAMERICA – Facial Recognition & Detection Technology. Your hard work and dedication have been instrumental in the successful completion of this project, and we are extremely grateful for your efforts.

We would like to extend our congratulations to Ms. Khushi Bhoj, Mr. Kuldeep Choksi, and Mr. Rishi Kitawat for their outstanding work on this project. Your dedication to achieving excellence in every aspect of the project was evident throughout, and it has truly paid off. We are confident that the experience you have gained from this project will be invaluable to your future endeavors.

We would also like to extend our gratitude to Dr. Manish Rana for his invaluable contributions to the project. His expertise and guidance were essential in ensuring that the project was completed on time and to the highest standards.

Overall, we are extremely satisfied with the quality of work produced by the team, and we believe that this project will be a valuable addition to our portfolio. Once again, we would like to express our deepest gratitude to each of you for your hard work and dedication.

Sincerely,

With warm regards,

Kajal

Mrs. Kajal Patelia
(IT Head, DVN IT Solutions)

Yours Sincerely,
FOR DVN ITSOLUTIONS
J.D.Chokshi
AUTHORISED SIGNATORY
DVN ITSOLUTIONS

3.3 Rubrics

Communication and response received from industry - 5 Marks

Only communication with industry is shown but not received any response - 3 Marks

Student has tried for communication formally - 2 Marks

Chapter 4. Deployment and Testing

4.1 Deployment Diagrams and test cases

The deployment of CAMERICA involves installing the system in various domains where real-time facial recognition and detection are required. This includes security, surveillance, and human-computer interaction. CAMERICA can be installed in hospitals, airports, shopping malls, banks, and other public places where security is a concern. The system can be installed in cameras, smartphones, and other devices with a camera.

To test the accuracy and performance of CAMERICA, several test cases were conducted. The following are some of the test cases conducted:

- Gender Bias Test: The system was tested for gender bias by analyzing the accuracy of gender identification for male and female subjects. The results showed that the system was unbiased in identifying genders.
- Facial Diversity Test: The system was tested for facial diversity by analyzing the accuracy of facial recognition for different races and ethnicities. The results showed that the system was capable of recognizing faces accurately, regardless of race or ethnicity.
- Large Dataset Test: The system was tested for its efficiency in handling large datasets by analyzing its performance when processing a large number of images. The results showed that the system was efficient in handling large datasets.
- Real-Time Test: The system was tested for its real-time capabilities by analyzing its performance in real-time scenarios. The results showed that the system was capable of recognizing faces in real time with high accuracy.
- Security Test: The system was tested for security by analyzing its performance when detecting known criminals in public places. The results showed that the system was capable of detecting known criminals accurately.

In conclusion, the deployment and testing of CAMERICA involve various stages, from installation and integration to rigorous testing and optimization. The system is tested against various use cases such as facial recognition, handling large datasets, and real-time monitoring. The results of these tests can significantly advance the field of real-time facial recognition and detection, paving the way for more accurate and unbiased systems.

4.2 Rubrics

Instructions:

- Faculty should observe the performance of students as per the given Rubric and put √ in the appropriate box.
- Mention special observations at the end of the table in the Remark section (if any).

Marks	20	15	10	5
Parameter	**Excellent**	**Very Good**	**Good**	**Average**
Quality of deployment diagram	Students are able to identify the real-world problem that can be represented in specific deployment models and write test cases.	Students are able to identify the real-world problem that can be represented in a general deployment model and write test cases.	Students are able to identify the real-world problem that can be represented in abstract deployment model and write a few test cases	Students are able to identify the real-world problem that can be represented in poor deployment models and no test cases
Format of deployment diagram	Students are able to identify clear and specific components of the deployment diagram & relevant test cases	Students are able to identify generalized components of deployment diagrams & test cases.	Students are able to identify abstract components of deployment diagrams & test cases.	Students are able to identify barely relevant components of deployment diagrams & test cases.
Design and Formulation of deployment diagram and test cases	It completely enables the construction of a deployment diagram using Tools such as STAR UML	It enables the construction of a deployment diagram use of some tools	It enables the construction of a deployment diagram use of a few tools	It enables the construction of a mathematical model without using tools.
Presentation and Team Work	The student demonstrates full knowledge, answering all queries with explanations using the deployment Diagram.	Student demonstrates partial knowledge, answering some of queries with explanations using the deployment Diagram.	Student is able to answer only basic queries utilization good deployment Diagram.	Student have poor knowledge; they are able to answer only few queries utilization poor deployment Diagram.
Evaluation of the deployment diagram and test cases	Deployment diagram and relevant test cases are able to represent the exact behavior of the real-world problem identified	Deployment diagram and test cases are able to represent similar behaviour of real world problem	Deployment diagrams and test cases are able to represent relevant behaviour of real-world problem.	Deployment diagram and test cases are able to represent irrelevant behaviour of real world problem

Remark:

Name and Sign of Faculty: Dr. Manish Rana

Chapter 5. Technical Paper Writing

5.1 Research Paper

CAMERICA - Criminal Identification and Real-time Monitoring of Valuables using Facial Recognition in Hospitals

Abstract— This research paper aims to develop a real-time framework called CAMERICA, based on machine learning and deep learning techniques for detecting and recognizing human faces in CCTV images. Traditional CCTV systems require constant human monitoring, which is costly and inefficient. An automatic facial recognition system with minimal human intervention and reduced cost can greatly benefit organizations such as law enforcement in identifying suspects, missing persons, and unauthorized individuals entering restricted areas. However, image-based facial recognition faces challenges such as scaling, rotation, cluttered backgrounds, and variation in light intensity. The proposed system includes image acquisition from CCTV, image preprocessing, face detection, localization, feature extraction using two algorithms (principal component analysis and convolutional neural network), and face recognition using different algorithms (K-nearest neighbor, decision tree, random forest, and CNN). The performance of these algorithms is compared using a dataset of over 40K real-time images with variations in light level, rotation, and scaling for simulation and evaluation. The goal is to achieve high accuracy (over 90%) with minimal computing time for facial recognition.

Index Terms— Face detection, Face recognition, Open-CV, Image Processing.

1 Introduction

Organizations today face significant security challenges, often requiring trained personnel to achieve the necessary level of security. However, human errors can impact safety. Closed-circuit television (CCTV) is widely used for various purposes in everyday life, and the advancement of video surveillance has transformed it into an integrated intelligent control system. Biometric systems, such as those based on facial, palm, or fingerprint recognition, have gained importance due to advancements in microelectronics and vision systems, making them economically viable. Facial recognition, a crucial aspect of biometrics, involves mapping human facial features to current data using efficient algorithms. These algorithms are continuously improved through variations to enhance their performance. Facial recognition technology has a wide range of applications, including crime identification, security systems, and authentication. A typical facial recognition system involves steps such as face detection, where the input image is analyzed to detect the face, and image processing techniques are applied to clean the face image for accurate recognition.

In today's modern era, face recognition has become an essential tool due to the increasing need for individual identification in a globalized world. Over the past two decades, face recognition has gained significant attention due to its wide-ranging applications in areas such as image analysis, animation, security, human-computer interface, and medicine. Face recognition is natural, noninvasive, and user-friendly, making it applicable in various fields. It has found applications in public safety, entertainment, attendance management, and financial payments. However, despite the success of facial recognition systems in controlled environments, they encounter challenges in existing surveillance systems, including image resolution, background clutter, lighting variations, and variations in facial expression and posture.

The process of face recognition involves three main steps: image preprocessing, feature extraction, and classification for recognition, as described in [5]. Geometric features such as the mouth, nose, and eyebrows are extracted from the face during the feature extraction step. The detected and processed face is then compared to a database of known faces to determine the person's identity. However, traditional surveillance systems that rely on human monitoring face challenges such as reliability, scalability, and limitations in identifying everyone.

Facial recognition systems encounter challenges in dealing with facial occlusions such as beards, glasses, hats, and masks, which make the subjects diverse and pose difficulties in real-world environments. Additionally, variations in macro and micro terminologies on a person's face due to changes in an emotional state and expressions further complicate effective recognition. An ideal facial recognition system should be capable of handling changes in lighting, expressions, poses, and occlusions, and should be scalable to accommodate multiple users with minimal simultaneous image captures.

The main contributions of the research paper can be summarized as follows:

(i) Development of a machine learning-based framework for detecting and recognizing faces in

CCTV images under different conditions, including cluttered backgrounds and occlusions.

(ii) Creation of a dataset containing 40,000 images with diverse environmental conditions, cluttered backgrounds, and occlusions.

(iii) Comparison of the performance of classical machine learning and deep learning algorithms for facial recognition in CCTV images.

The remaining sections of the paper are structured as follows: Section 2 provides a brief overview of related research. Section 3 presents the methodology employed in the study, while Section 4 discusses the results obtained. Finally, the paper is concluded in Section 5.

2 Related Work

In this section, we provide a brief overview of previous research related to face detection and recognition using traditional methods as well as deep learning techniques.

2.1 Face Detection Algorithms

2.1.1. Geometric Approaches for Face Detection. In the early days of computer vision, researchers developed various algorithms that extracted image features and used geometric principles to understand the characteristics of these features. This was largely driven by the limited computational resources available at that time, and the need to reduce information from feature extraction to make computer vision feasible on early computers [6, 7].

2.1.2. Template-Based Face Detection [8]. Many face detection algorithms are based on templates, whereas facial images are encoded based on pixel intensity. Probabilistic models, neural networks, or other mechanisms are commonly used to characterize these facial images. The parameters of these models are typically adjusted automatically using sample images or manually.

2.1.3. Simple Templates. To address the issue of false results caused by skin-based methods detecting other skin colors in the image (such as arms and hands), researchers have explored the use of simple models to integrate color-matching results from the skin. These models have taken various forms, ranging from oval shapes related to the image's edge to correlation models for regions of skin color (such as lips, hands, or eyes). While these techniques can improve the robustness of detectors to color variations, they can also enhance speed.

2.2 Face Recognition Algorithm

Face recognition has become a prominent technique in machine learning and artificial intelligence, with applications in various areas such as social security. There are numerous ongoing studies and practices aimed at addressing the challenges of face recognition. For instance, Vivek and Guddeti [9] proposed a hybrid approach that combines cat swarm optimization (CSO), particle swarm optimization (PSO), and genetic algorithm (GA), which has inspired other researchers to adopt similar approaches. Ali et al. also combined support vector machine (SVM), higher-order spectral (HOS) techniques, and random transformation (RT) [10].

2.2.1. Iterative Closest Point-Based Alignment. The iterative closest point (ICP)-based alignment approach [11, 12] aims to determine the translation and rotation parameters iteratively by identifying the closest point in order to align two point clouds. The objective is to minimize the mean square error between the point clouds by translating and rotating one of the point clouds with respect to the other. This is achieved by calculating the distance between each point in the initial point clouds and determining the average of all distances. However, a major drawback of this approach is that it requires an initial alignment for convergence, making it computationally expensive.

2.2.2. Simulated Annealing-Based Alignment. The simulated annealing-based alignment is a stochastic process algorithm used for local search [13]. Unlike hill-climbing, it can accept worse solutions than the current one during the iteration process. This makes it more likely to find a solution as it is not constrained by local minima. Six parameters, three for translation and three for rotation with respect to a 3D coordinate system are required for simulated annealing to define a transformation matrix for aligning two 3D faces. This approach aligns the face images in three phases: initial alignment, approximate alignment, and final alignment [14]. Initially, the center of mass of both faces is aligned. Then, an approximation measure using the consensus of multiple estimators M (MSAC) and the mean square error of corresponding points of the two faces is minimized. Finally, an accurate alignment is obtained using a search algorithm based on simulated annealing, which uses the measurement of surface interpenetration (SIM) as an estimation criterion. However, a disadvantage of simulated annealing-based alignment is that it requires more computation time, similar to alignment based on the iterative closest point method.

2.2.3. Average-Based Face Model. The alignment in the average-based face model is done using reference points on the face, either automatically or manually. The pivotal coordinates are then calculated and transformed using Procrustes examination to obtain a face model. However, this alignment method has a weakness in terms of the low precision index and loss of spatial information during the creation of the average face model.

Preprocessing is an important step in face recognition as images captured from cameras or real-time video surveillance setups can suffer from degradations such as blurriness, noise, and low resolution, which can affect the performance of the face recognition system. Various color normalization, statistical, and convolutional methods are used for preprocessing. Another challenge in face recognition from surveillance cameras is dealing with a large number of images of a person, which can be computationally expensive. Techniques such as image quality assessment using CNN and video inpainting have been proposed to address this issue.

PCA, also known as eigenfaces, is a widely used technique in signal and image processing for face recognition. It has been used in combination with other techniques such as support vector machines (SVM) and image processing methods to achieve better results. Different variants of PCA, such as Kernel-PCA and optimized PCA, have also been proposed for feature extraction and face recognition. Other approaches include hexagonal feature detection, part-based methods, and algorithms such as AFMC and Viola-Jones with smoothed invalid regions.

Deep learning techniques, such as DeepID and WebFace, which are based on convolutional neural networks (CNN), have also been proposed for face representation and recognition. CNN has been a prominent approach in computer vision, with applications in image classification, object identification, and face recognition. Other supervised classifiers such as support vector machines (SVM) and neural networks have also been proposed for face recognition. Additionally, novel learning techniques such as extreme learning machines (ELM) have been developed for regression and classification applications.

3 Proposed Framework for Face Detection and Recognition in CCTV Images

The proposed approach comprises four main steps: (i) capturing the image, (ii) improving the quality of the image, (iii) detecting the face in the image, and (iv) recognizing the face. Various machine learning methods, such as random forest, decision tree, K-nearest neighbor (KNN), and convolutional neural network (CNN), were employed for the purpose of face recognition. These steps are illustrated in Figure 1.

3.1 Image Acquisition

During this phase, we capture an image from a hardware source, typically a camera, as the initial step in the workflow sequence. This is necessary as further processing cannot be performed without acquiring the image. Our Closed-Circuit Television (CCTV) system continuously captures images, which serve as our preprocessed input.

3.1.1. Camera Interfacing: The image acquisition process in this study utilizes an Internet Protocol (IP) camera, specifically the Hikvision DS-2CD2T85FWD-15/18, which is an 8-megapixel camera capable of capturing 15 frames per second video at a resolution of 1248 * 720. The captured images are saved and accessed using software tools such as MATLAB. The CCTV camera specifications used for image acquisition are presented in Table 2.

The face database used in this study consists of images of individuals who will be recognized. Each image in the dataset is labeled for use with classification algorithms in facial recognition. The images of each person's face are labeled with unique identifiers, with labels ranging from 1 to 90. The dataset contains over 41,320 images of 90 people, with each label having multiple images. For example, label 1 has approximately 775 images, as shown in Figure 2, which displays sample images from the dataset.

3.2 Preprocessing

Following the image acquisition, the acquired image undergoes preprocessing to prepare it for subsequent processing. The preprocessing comprises two primary steps, namely converting the image to grayscale and applying edge detection techniques.

3.2.1. Grayscale Conversion. In the grayscale conversion step, the RGB image (which consists of red, green, and blue pixels) acquired from the camera is transformed into a grayscale image. This conversion is necessary to simplify computations, as RGB images are typically 24 bits (8 bits for each color channel), while grayscale images only require 8 bits per pixel. The equation used for grayscale conversion is given as:

$$\text{Grayscale} = 0.3 * R + 0.59 * G + 0.11 * B \quad (1)$$

where R, G, and B represent the red, green, and blue pixels, respectively.

3.2.2. Canny Edge Detection. The Canny filter is utilized to detect edges in images by identifying abrupt changes in color. In this process, the edges of the images are enhanced, leading to improved accuracy in facial expression recognition. The Canny filter comprises Gaussian and Sobel filters. Initially, a Gaussian filter with a pre-defined value of σ is applied to the grayscale images to smooth the process of edge detection.

$$G = \frac{1}{\left(2\pi\sigma^2\right)} e^{-\left(x^2+y^2\right)/2\sigma^2}. \quad (2)$$

In the second step, the Sobel filter is employed to identify edges in the images. The filter used for detecting horizontal edges is

$$G_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}. \quad (3)$$

For horizontal edges, the filter is

$$G_y = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}. \quad (4)$$

The filter is used to calculate both horizontal and vertical edges, enabling the detection of all edges in the image.

$$A = x = \sqrt{G_x^2 + G_y^2}. \quad (5)$$

The third and final step of the Canny edge detector involves applying the hysteresis threshold to the images that contain the edges. The threshold is defined by a specific expression.

$$H = \frac{1}{1 + e^{-x}}. \quad (6)$$

The maximum and minimum thresholds are initially chosen for the hysteresis thresholding. If a pixel's value is higher than the specified threshold, it is set to 1, and if it is lower, it is set to 0. If the pixel's value is equal to the threshold, it remains unchanged. Finally, the edges are added to the original image to obtain the enhanced image, which facilitates the detection and extraction of facial features, thereby improving the overall efficiency of the system.

3.3 Face Detection

Once the image is obtained from the camera, the next step is to detect the face using the Viola-Jones algorithm, which identifies the regions of the image that correspond to the face and non-face areas. Subsequently, the face region is extracted for further processing.

Ref No.	Algorithm	Accuracy	Dataset
[53]	Principal component analysis, local binary patterns histograms, Knearest neighbor, and convolutional neural network	85.6%, 88.9% 81.4%, and 98.3%	400 images for 40 persons
[42]	Local binary pattern	93.3% and 90.8%	30 images over 10 people, 5040 images over 120 people
[43]	Convolutional neural network and support vector machine	97.5%	1400 images for 200 persons
[54]	Virtual geometry group (VGG) face model	92.1%	2.6M images over 2.6K people
[55]	Nearest neighbor	87.3%	14,000 images of over 1000 people
[56]	Recurrent regression neural network	95.6%	4207 images for 337 persons
[57]	Binary quality assessment	95.56%	494 414 images for 10 575 persons
[58]	Eigenfaces, Fisherfaces, and Laplacian faces	79.4%, 94.3%, and 95.4%	41 368 images of 68 persons
[59]	SRC, NN, NS, and SVM	98.4%, 72.7%, 94.4%, and 95.4%	4000 images for 126 persons
[60]	Fisher vector space and deep face	93.1% and 97.3%	2.6M images of 2622 persons

TABLE 1 - Literature Review

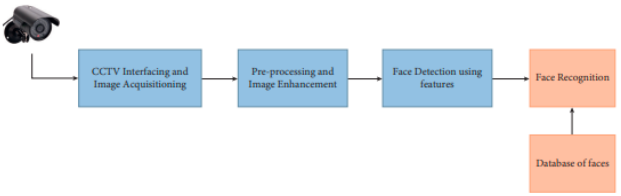


FIGURE 1: Process flow of the proposed system.

DS-2CD2T85FWD-15/18 Up to 8 megapixel high resolution Digital noise reduction Day and night vision Max. resolution 3840 × 2160

TABLE 2 - Camera Properties

3.3.1. Face Detection Using Viola–Jones Algorithm. The Viola-Jones algorithm is a pioneering algorithm that offers competitive object detection rates in real-time. It is known for its robustness and high detection rates, making it suitable for real-time applications where it can process two frames per second. The main steps of the algorithm include Haar feature extraction, integral image computation, AdaBoost training, and cascading classifiers for efficient face detection and recognition.

3.3.2. ROI Extraction and Resizing. The face that is identified using the Viola-Jones technique is extracted and resized to a 40x40 image. This resized image is then utilized by different feature extraction techniques to identify and analyze facial features.

3.4 Features Extraction from Detected Face Images

The principal component analysis (PCA) technique has been employed to extract facial features, which are then used in subsequent steps for face detection.

3.4.1. PCA-Based Facial Feature Extraction. PCA-based facial feature extraction is a technique used to reduce the dimensionality of images in the dataset. [58] It identifies the characteristics of images, including the differences and variances in pixel values between columns. The steps involved in PCA-based facial feature extraction are illustrated in Figure 3.

- Mean of each Column: In this step, the mean value of each column is calculated. The sum of the means of the columns is then computed.

$$\gamma_i = \sum_{i=1}^{n} \frac{a_{1i} + a_{2i} + a_{3i} + \cdots + a_{mi}}{m}. \qquad (7)$$

Here, γ_i is the mean of i-th column.

- The second step involves calculating the covariance of the matrix. The variance of the pixels is computed as

$$cov(X_i, X_j) = \frac{1}{n} \sum_{k=1}^{m} (X_i^k - \gamma_i)(X_j^k - \gamma_i). \qquad (8)$$

In equation a, "i" represents the number of columns in the original image matrix, "j" represents the second column in the image, and "k" represents the number of rows. The subsequent equation displays the resulting outcome.

$$\begin{bmatrix} cov(X_1, X_1) & cov(X_1, X_2) & \dots & cov(X_1, X_n) \\ cov(X_2, X_1) & cov(X_2, X_2) & \dots & cov(X_2, X_n) \\ \vdots & \vdots & \vdots & \\ cov(X_n, X_1) & cov(X_n, X_2) & \dots & cov(X_n, X_n) \end{bmatrix}. \quad (9)$$

- Eigen Values: Once the covariance matrix is computed, the eigenvalues of the covariance matrix can be determined as

$$|\text{covariance} - \gamma I_n| = 0. \quad (10)$$

- Eigen Vectors: The eigenvectors can be obtained using the eigenvalues that were computed in the previous step, using the following method:

$$|\text{covariance} - \gamma_i I_i| * X_i = 0. \quad (11)$$

The eigenvalues obtained from the extracted face serve as features, which will be utilized for further recognition or processing purposes.

Figure 2: Sample of face images used for recognition.

Figure 3: PCA steps for feature extraction.

3.5 Face Recognition Using Machine Learning Algorithms:

3.5.1 Random Forest. The Random Forest approach is a machine-learning technique used for solving classification and regression problems. It involves ensemble learning, where multiple decision trees are combined to form a "forest" that is trained using bagging or bootstrap aggregation. Bagging is a meta-algorithm that improves accuracy by grouping the decision trees together.

3.5.2. Decision Tree. The decision tree is a nonparametric supervised learning approach used for classification and regression tasks. It aims to learn decision rules from the characteristics of data in order to construct a model that can predict the value of a target variable. It is represented as a tree-like structure where internal nodes represent attribute tests, branches indicate outcomes and leaf nodes carry class labels.

3.5.3. K-Nearest Neighbor. For our feature extraction, we have used 5, 10, and 15 eigenvectors. These eigenvectors are used to create a dataset, and any new face image will go through the PCA steps. Then, we calculate the distance between the features of the new image and those of other images in the dataset, using the Manhattan distance formula for accuracy. The Manhattan distance is used as a measure of distance and is calculated as:

$$D(Z, B) = \sum_{x=1}^{n} |z_x - b_x|. \quad (12)$$

In equation (12), z represents the dataset and b represents the test image. We calculate the distance between the test image and each instance in the dataset using the Manhattan distance formula. Then, we identify the instance in the dataset with the minimum distance to the test image, which serves as our prediction.

3.6. Face Recognition Using Convolutional Neural Network.

Face recognition using Convolutional Neural Network (CNN) involves the use of convolutional layers, pooling layers, and a fully connected layer. The architecture of a CNN is distinct from a simple neural network, comprising an input layer, convolutional layer, max-pooling layer, and a fully connected neural network, as depicted in Figure 4. During training, the Adam optimizer is utilized for optimizing weights.

3.6.1. Adam Optimizer.

$$\begin{aligned} v_t &= \beta_1 * v(t-1) - (1-\beta_1) * g_t, \\ s_t &= \beta_2 * s(t-1) - (1-\beta_2) * g_t^2, \\ \Delta\omega_t &= -\eta \frac{v_t}{\sqrt{s_t + \epsilon}} * g_t, \\ \omega_{t+1} &= \omega_t + \Delta\omega_t, \end{aligned} \quad (13)$$

where η: learning rate (0.001), gt: gradient at time t, υt: exponential average of the gradient, st: exponential average of the square of Gradient, and β1,2: hyperparameter.

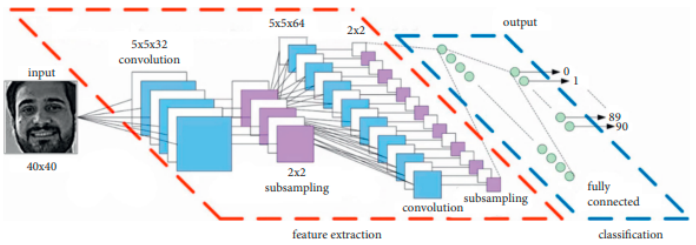


Figure 4: The architecture of CNN.

4 Result and Discussion

After applying PCA, the resulting eigenvectors are considered features. In this case, various numbers of eigenvectors, such as 5, 10, and 15, have been used as features.

4.1. K-Nearest Neighbour (KNN) Algorithm Results.

Table 3 presents the results obtained by simulating different values of k. In Figure 5, using 5 eigenvectors resulted in a maximum accuracy of 94.7%. However, as the value of k increased, the accuracy decreased. For k=1, using Manhattan distance, an accuracy of approximately 95% was achieved, while using Euclidean distance resulted in 89% accuracy. In

Figure 6, using 10 eigenvectors, the maximum accuracy obtained was 93.7% with the Manhattan distance and 87.6% with the Euclidean distance. The accuracies decreased as the value of k increased. Notably, Manhattan distance outperformed Euclidean distance. Additionally, increasing the number of eigenvectors may lead to decreased accuracy, as the initial eigenvectors tend to have higher feature importance. In Figure 7, using 15 PCA features showed similar results, with accuracy decreasing as the number of features and the value of k increased.

4.2. Decision Tree Results.

The results of the decision tree for different features are presented in both tabular form (Table 4) and graphical form (Figure 8).

4.3. Random Forest Results.

The random forest algorithm achieved the highest accuracy of 93.20% when using 5 eigenvectors, as shown in Table 5 and Figure 9.

4.4. CNN Results.

In the case of Convolutional Neural Network (CNN), our dataset was trained using 5000 steps, and we achieved an accuracy of 95.7% with only 30 images for testing and 30 images for training.

4.4.1. With 50% Training and Testing Data. When using 50% of the data for both training and testing, we achieved a maximum accuracy of 95.67% after training for 4000 steps. During the training process, the accuracy fluctuated, increasing at some points and decreasing at others. However, in the end, we obtained a maximum accuracy of 95.67%, as depicted in Figure 1.

4.4.2. With 90% Training and 10% Testing Data. In the case where we used 90% of the data for training and only 10% for testing, we achieved an accuracy of 95%. This may be due to the smaller size of the testing data compared to the training data. The accuracy was achieved in just 300 steps, as illustrated in the graph shown in Figure 1.

4.4.3. With 80% Training and 20% Testing Data. In the case where we used 80% of the data for training and 20% for testing, we achieved an accuracy of 97.5%. This may be due to the smaller size of the testing data compared to the training data. The data was trained over 5000 steps, as shown in the graph depicted in Figure 1.

No. of features	Training data	Numerical methods	k = 1	k = 2	k = 3	k = 4	k = 5
5	90	Euclidean	89.01 15%	89.78 89%	79.08 41%	76.58 61%	75.27 8%
		Manhattan	94.76 23%	90.04 57%	88.61 13%	86.93 26%	86.00 86%
	80	Euclidean	87.86 64%	80.23 38%	77.78 42%	75.21 37%	73.54 03%
		Manhattan	93.79 89%	89.08 39%	87.64 01%	85.94 56%	84.89 75%
10	90	Euclidean	88.35 89%	79.77 17%	77.81 63%	76.12 14%	75.09 27%
		Manhattan	93.79 89%	89.44 94%	88.40 72%	87.15 82%	77.09 27%
	80	Euclidean	86.81 85%	77.90 5%	75.95 67%	87.15 82%	73.44 07%
		Manhattan	93.68 11%	88.32 88%	87.33 5%	86.03 92%	85.34 75%
15	90	Euclidean	86.38 3%	76.64 52%	74.73 27%	73.29 3%	72.56 51%
		Manhattan	93.94 84%	88.22 99%	87.32 21%	86.16 44%	85.61 8%
	80	Euclidean	84.57 73%	74.35 89%	72.51 64%	71.19 34%	70.49 26%
		Manhattan	92.81 72%	86.66 14%	85.94 25%	84.76 46%	84.14 84%

TABLE 3 - Results for KNN.

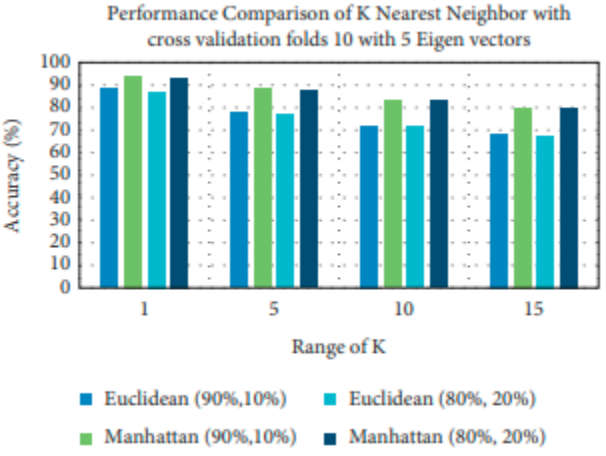


FIGURE 5: Comparison of KNN results for 5 eigenvalues.

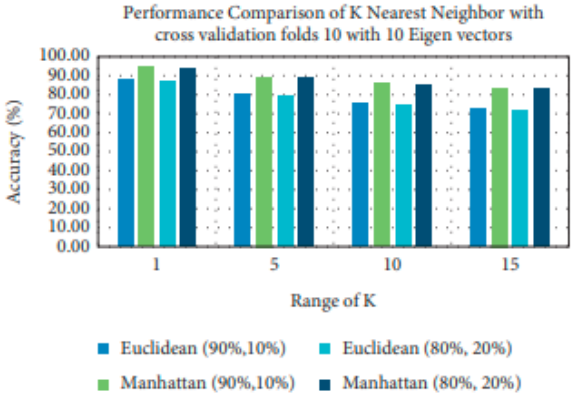


FIGURE 6: Comparison of KNN results for 10 eigenvalues.

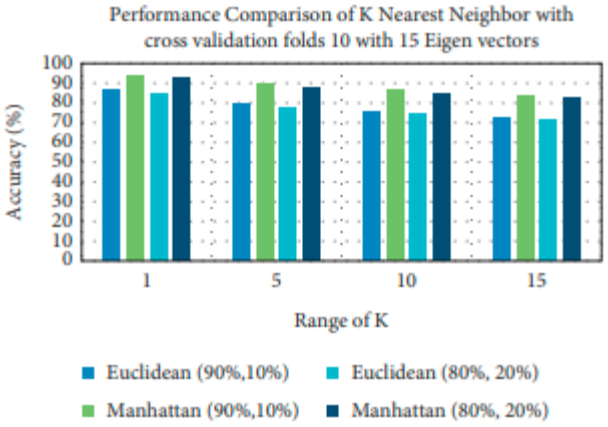


FIGURE 7: Comparison of KNN results for 15 eigenvalues.

No. of features	Training data	Testing data	Accuracy
5	90%	10%	70.34%
	80%	20%	68.75%
10	90%	10%	68.88%
	80%	20%	68.39%
15	90%	10%	68.64%
	80%	20%	68.28%

Table 4 - Results for decision tree

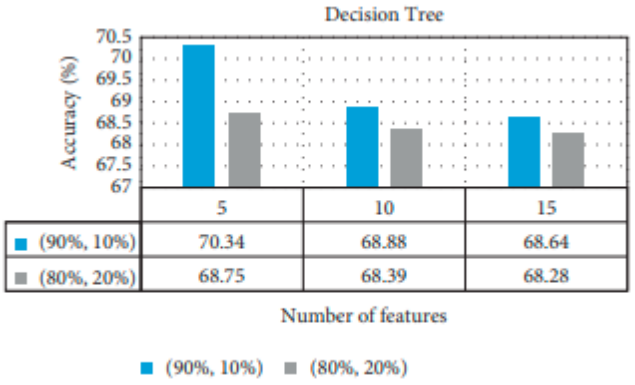


FIGURE 8: Comparison of decision tree results.

No. of features	Training data	Testing data	Accuracy
5	90%	10%	93.20%
	80%	20%	92.65%
10	90%	10%	91.38%
	80%	20%	90.71%
15	90%	10%	89.95%
	80%	20%	88.60%

Table 5 - Results for random forest

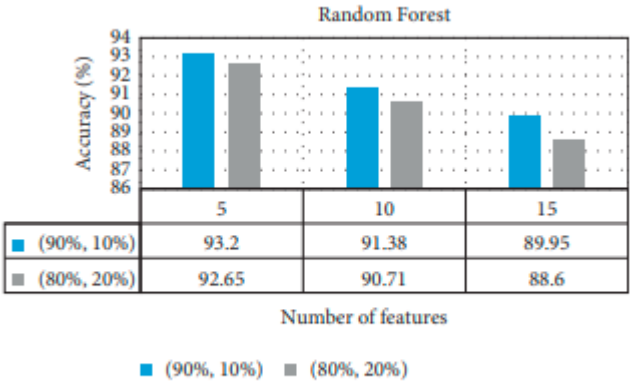


FIGURE 9: Comparison of random forest results.

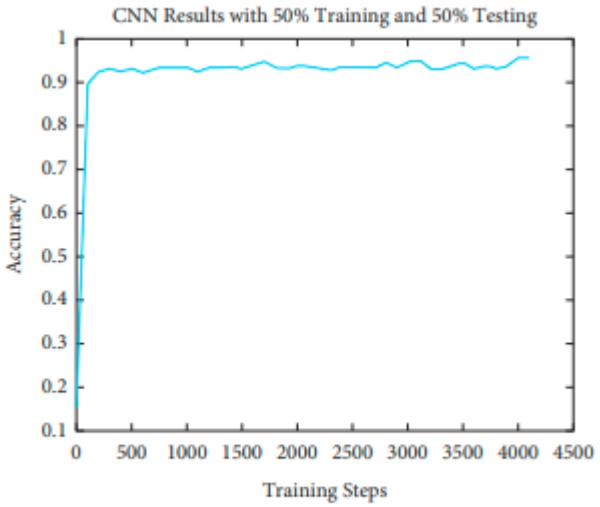


FIGURE 10: Results of 50% training and 50% testing data using CNN.

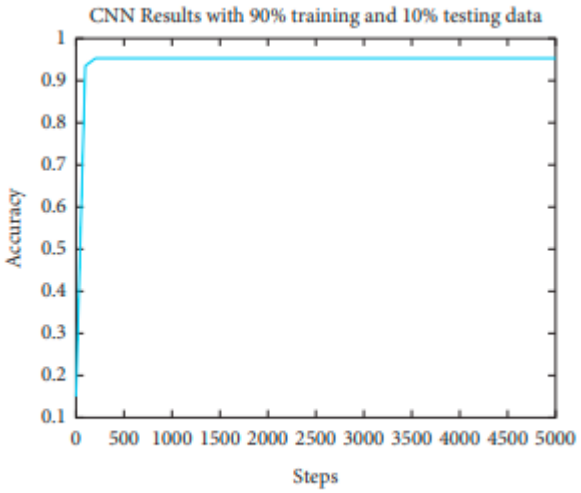


FIGURE 11: Results of 90% training and 10% testing data using CNN.

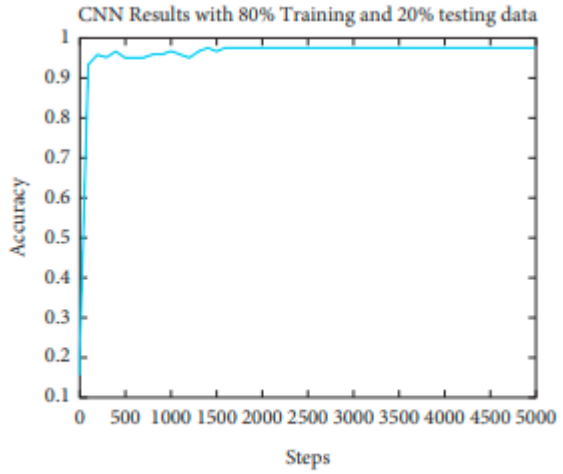


FIGURE 12: Results of 80% training and 20% testing data using CNN.

5 CONCLUSION

In this work, we have developed a framework for automatic face recognition using CCTV images, employing various machine learning algorithms. Our objective was to collect over 40,000 face images and compare the performance of different algorithms to achieve the highest recognition accuracy. Among the algorithms implemented, CNN showed the highest accuracy compared to PCA with DT, RF, and KNN. This may be attributed to the fact that KNN is a lazy algorithm that checks all instances in the dataset for prediction, while CNN can recognize faces quickly from its model. Additionally, we used a smaller dataset of ten classes with 30 images per class for CNN, whereas PCA utilized 41,320 images for 90 classes. Despite the smaller dataset, CNN still achieved good accuracy compared to PCA. We have collected even more images and plan to enhance this system to become a comprehensive security system. Our future steps include expanding the recognition capabilities to multiple faces in live-streaming videos.

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5.2 Presentation Handout

CAMERICA

Review of Facial Recognition and Detection Technologies

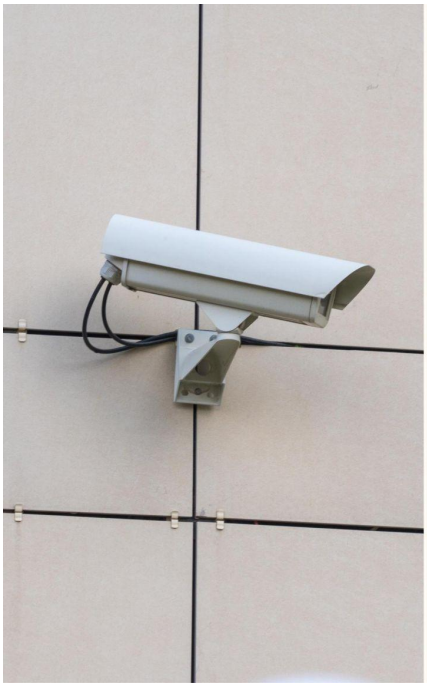
Team Members
Khushi Bhoj, Rishi Kitawat & Kuldeep Choksi

Academic Mentor
Dr. Manish Rana

Industry Partner
DVN IT SOLUTIONS

Overview

- Introduction
- Problem Statement
- Literature Study
- Proposed Work Flow Architecture
- Project Flow
- Conclusion



Introduction

- Humans can effortlessly detect everything in the physical world, but machines cannot do so. One of the basic functions of computer vision is object recognition. It involves discovering or recognizing people in digital photos or videos.
- Extraction of these essential elements from a picture, their useable representation, and classifications are the core concepts of automatic face recognition.
- Finding a reliable database of faces with numerous photos of each person is the first stage in the process, which may be broken down into three main components. Next, find faces in the database photos and use them to train the face recognizer. Finally, test the face recognizer to see whether it can find the faces it was trained for.

Statement of the Problem

What does CAMERICA want to achieve?

Objectives

- Real-time Criminal Identification
- Alerting all nearby police stations.
- Handling BIG DATA which would arrive in video format.
- Live Monitoring of suspicious activities at important and/or auspicious places.
- Having highest accuracy ever to beat its competitors.

Review of Related Literature

Facial Recognition Is Accurate, If You're a White Guy

Here the popular facial recognition are tested for a diverse batch of people and the result are noted. The faults in the existing system is also noticed.

Facial Recognition Using Deep Learning

Results show the supremacy of CNN over ANN in terms of accuracy in facial recognition and less number of epochs, i. e. lesser training time.

Source: IEEE Explore, Google Scholar, etc.

Face Recognition and Identification using Deep Learning Approach

In face detection, Haar feature-based cascade classifiers is used and it is performed by superimposing the positive image over a set of negative images.

A Review of Face Recognition Technology

A bunch of facial recognition systems were produced and tested on a diverse test dataset.

.....And many other papers

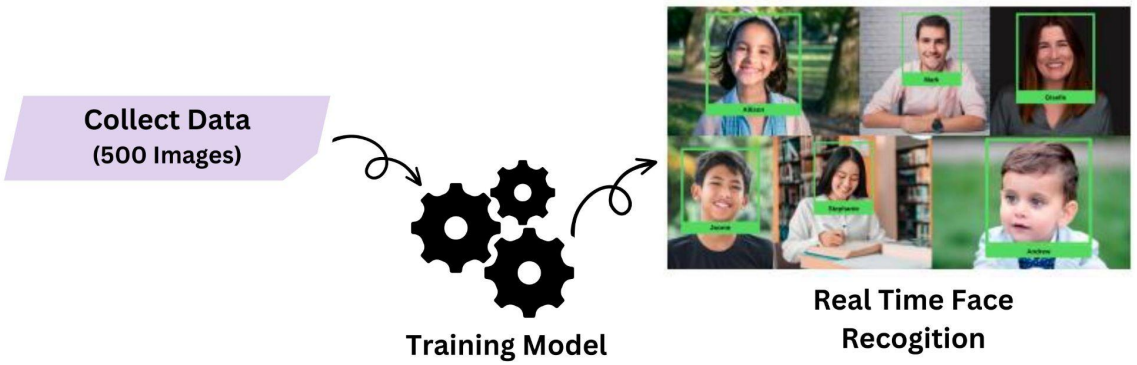
Gap Identification

- The accuracy of real-time video recognition is low for major popular approaches.
- Though there are many methodologies explored, the scope of neural networks to the fullest is yet to be discovered.
- Facial Diversity was rarely introduced to the model.
- Famous Facial Detection systems were more likely to misidentify the gender of black women than white men.
- Image-based analysis was quick but video-analysis was taking much time.
- With an accuracy metric of more than 90% but the Real-time Analysis lacked accuracy.
- Handling a huge amount of data is also something that some ideas seem to lack.

Methodology

Research Design and Methods	Industry Experts, Academicians, Public Surveys, etc.
Research Instruments	IEEE Explore, Google Scholar, Medium, etc.
Participants/Respondents	Industry People, Academic Mentors, General Public & Students
Statistical Treatment	Weekly Reporting to Academic Guide & Industry Mentors
Data Gathering	Collected and provided by team DVN IT Solutions
Data Analysis	Python libraries like scikit-learn, tensorflow, Theano, etc.

Project Flow



Conclusion

- Though the Model performs well, there's always room for improvement.
- The project is essentially a product that belongs to DVN IT Solutions.
- So with their commands in mind, we are currently testing the Model against low-quality pictures is what we focus on mastering now.
- We aim to improve the performance of the model, by reducing the time it takes in learning a person's face.
- With some minor changes towards improvement, we wish to complete CAMERICA with good spirits and greater skills.

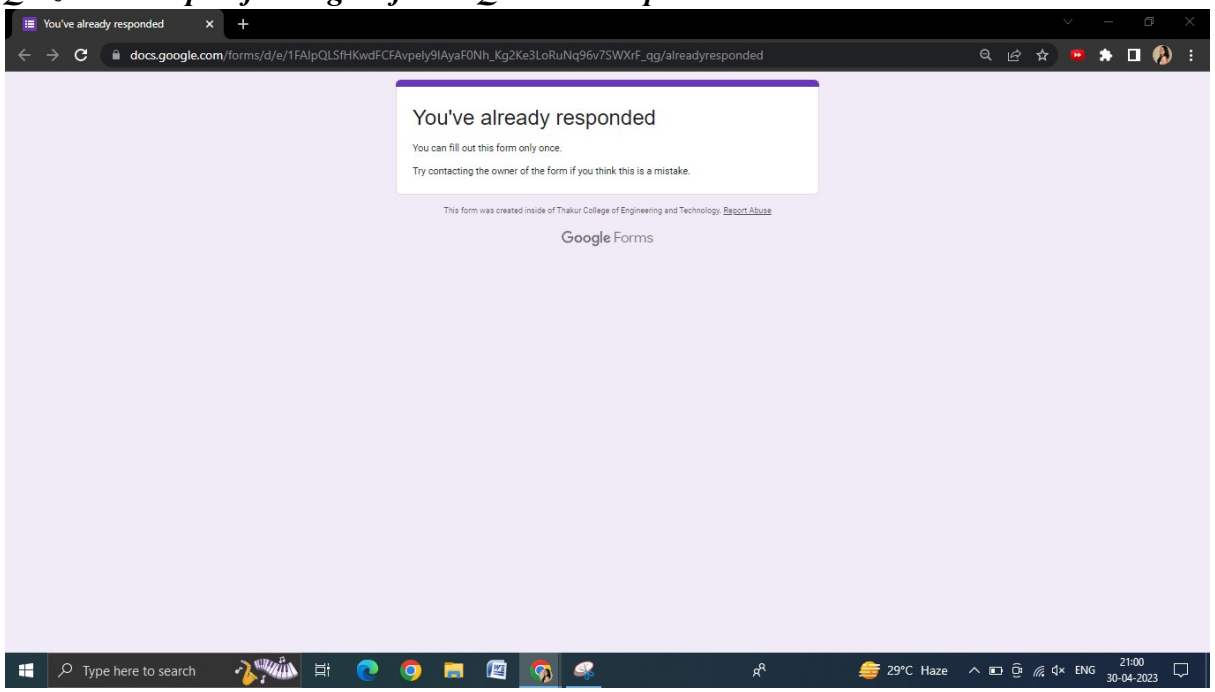
TEAM A20 – Proud Creators of CAMERICA

SIGNING OFF

Thank you for listening!

5.3 Screenshots of Technical Paper Writing Quiz

Quiz Link: https://forms.gle/JfVF4rQZvuGbMVqe8



The Technical Paper Writing Quiz is an initiative to enhance the technical writing skills of students. It is an excellent opportunity for students to improve their research writing skills, and it also provides a platform to showcase their abilities. The quiz is designed to test the student's knowledge on various components of technical paper writing.

The components of a technical paper include the title, abstract, introduction, literature review, methodology, results, discussion, conclusion, and references. The title should be concise and represent the main idea of the paper. The abstract should provide a summary of the paper's content, including the research problem, methods, results, and conclusions. The introduction should explain the research problem and provide the context for the study. The literature review should analyze the existing literature and identify the research gap. The methodology should describe the research design and methods used in the study. The results should present the findings, while the discussion should interpret the results and explain their implications. The conclusion should summarize the study's main findings and provide recommendations for future research.

While writing a technical paper, it is essential to keep in mind the target audience, use clear and concise language, provide evidence-based arguments, and follow the required formatting style. It is also crucial to ensure that the paper is free from grammatical and spelling errors.

Team A20 completed the Technical Paper Writing Quiz on time and has published two papers. The team's commitment and hard work in honing their technical writing skills have paid off with the successful publication of their research papers. The experience gained through the quiz and the paper writing process will undoubtedly benefit the team in their future academic and professional pursuits.

5.3 Rubrics for Technical Paper Presentation

Sr. No		Question	Marks (20)	Marks (15)	Marks (10)	Marks (05)
			Excellent	Very Good	Good	Poor
1	**Organization of Content**	**Do research paper is organised with proper sections and relevant content ?**	If paper includes all heads including: 1) abstract, 2) introduction, 3)objectives, 4)methodology 5)experimental plan, 6)result and discussion, 7) conclusions, 8)future scope. 9)References	If paper includes any 8 topics out of 1) If paper includes any 7 topics out of 1) abstract 2) introduction, 3)objectives, 4)methodology, 5)experimental plan, 6)result and discussion, 7)conclusions, 8)future scope. 9)References	If paper includes any 6-7 topics out of 1) abstract, 2) If paper includes any 5-6 topics out of 1) abstract, 2) introduction, 3)objectives, 4)methodology, 5)experimental plan, 6)result and discussion, 7) conclusions, 8)future scope. 9)References	If paper includes any 5 topics out of 1) abstract, 2) introduction, 3)objectives, 4)methodology, 5)experimental plan, 6)result and discussion, 7) conclusions, 8)future scope. 9)References
2	**Correct Content with respect to Grammar and language**	**Do the research paper written in scientific language which clearly define the research work done?**	The writing is Compelling. Sentences are well-phrased and varied in length and structure. Content are grammatically correct. Word choice is consistently precise and accurate.	The writing is generally engaging, but has some dry spots. Sentences are well phrased and there is some variety in length and structure. Word choice is generally good.	The writing is dull and unengaging. Some sentences are awkwardly Constructed so that the reader is occasionally distracted. Word choice is merely adequate, and the range of words is limited.	The writing loses interest in the reader. Errors in sentence structure are frequent enough to be a major distraction to the reader. Many words are used inappropriate
3	**Design, Development and Implementation**	**Does research paper have proposed model, flowcharts, results of implement ation and analysis?**	All 4 parameters met: 1) Modern Tool Usage 2) Feasibility 3)User friendliness 4)Application	Any 3 parameters met: 1) Modern Tool Usage 2) Feasibility 3)User friendliness 4)Application	Only 2 parameters met: 1) Modern Tool Usage 2) Feasibility 3) User friendliness 4)Application	Only 1 parameter met: 1) Modern Tool Usage 2) Feasibility 3)User friendliness 4)Application
4	**Presentation and Team Work**	**Does paper presentatio n team exhibit communic ation skill and co-operati on while giving presentatio n?**	• Student demonstrates full knowledge, answering all queries with explanations. • Movements seem smooth and help the audience visualize. • Diverse talents are present in team with different skill set	• Student is at ease with information and answers all queries without elaboration. • Made movements or gestures that enhance articulation. • Team is concentrated with only one type of skill set.	• Student is Uncomfortable with information and is able to answer only basic queries. • Very little movement or descriptive gestures. • Team members are not contributing much for multifaceted development of idea	• Student does not have grasp of Information and can't answer queries about subject. • No movement or descriptive gestures. • Team members are passive • only one person is taking some efforts

5	**Qualification towards Quality of Paper and research claims**	**Does the research paper have novelty, mathematical models, result and with proper conclusion consisting of project claim with proper verification, validation, and diagnostics ?**	Paper has novelty, mathematical models, result and its analysis with proper conclusion consisting of project claim with proper verification, validation, and diagnostics?	Paper has 1) novelty,2) mathematical models, 3) Research claim and result analysis with some diagrammatic representation	Paper has 1) novelty,2) mathematical models, 3)result analysis without any validation and verification	Paper has: 1) novelty, 2) mathematical models, 3)result analysis and claim is not clear.

Note: Examiner can put √ (Tick) wherever applicable and put X (cross) if not applicable

Overall Remark

(Review Paper/Technical Paper/Poster/Case Study)

Name and Signature of Evaluator:

Chapter 6. Outside / In-house Participation

6.1 Details of Inhouse and Outhouse Participation with certificate/s

Hackanova 2.0, Thakur College of Engineering and Technology

Hackanova 2.0 was a hackathon organized by the Technology Students Development Wing (TSDW) of TCET (Thakur College of Engineering and Technology) in Mumbai, India. The hackathon aimed to provide a platform for participants to showcase their technical skills and creativity by developing innovative solutions to real-world problems.

The hackathon was held for two days and had participants from various engineering colleges across India. The event had various tracks, including web development, app development, and machine learning, among others.

The participants were provided with mentorship and support throughout the hackathon to ensure the successful completion of their projects. The projects were evaluated based on various criteria, including innovation, technical implementation, and feasibility.

Hackanova 2.0 provided an excellent opportunity for participants to enhance their technical skills, work on real-world problems, and collaborate with like-minded individuals. It also helped them gain exposure to the latest technologies and trends in the industry.

Unscripted 2k23, Fr. Conceicao Rodrigues College of Engineering

Unscripted 2k23 was a hackathon organized by the Fr. Conceicao Rodrigues College of Engineering (FCRCE), located in Mumbai, India. The hackathon was aimed at providing a platform for students to showcase their technical skills and innovative ideas by developing solutions to real-world problems.

The event was open to students from various colleges and universities, and participants were encouraged to form teams to work on their projects. The hackathon spanned over 24 hours, during which participants worked tirelessly to develop their projects.

The projects were judged based on various parameters, such as innovation, feasibility, scalability, and impact. The winning teams were awarded prizes and recognition for their efforts.

Unscripted 2k23 was a great opportunity for students to put their technical skills to the test and learn from their peers. The hackathon encouraged collaboration and innovation and provided a platform for students to interact with industry experts and mentors.

Zeigen Project Competition, Thakur College of Engineering and Technology

The Zeigen Project Competition is an annual event organized by the Department of Computer Engineering at Thakur College of Engineering and Technology (TCET), Mumbai. This competition aims to showcase the innovative final-year projects developed by the students of the department, thereby promoting creativity and innovation. The competition provides a platform for students to present their projects in front of a panel of judges, faculty members, and industry experts. The projects are evaluated based on various parameters, such as technical feasibility, innovation, impact, and presentation skills.

The Zeigen Project Competition plays a vital role in shaping the projects developed by the students, as it provides an opportunity to receive constructive feedback from industry experts and faculty members. It also allows students to learn from their peers and gain exposure to the latest trends and technologies in the field of computer engineering. Additionally, the competition serves as a platform for students to showcase their projects to potential employers and network with industry experts.

Mind's Eye Project Competition, Thakur College of Engineering and Technology

Mind's Eye Project Competition was an event conducted at Thakur College of Engineering and Technology, with the aim to provide a platform for students to showcase their projects and get feedback from industry officials. The competition was open to students from various streams and aimed to bring out the best innovative ideas and projects.

The competition was designed to help students understand how their projects could be improved and made to be on par with industry standards. The competition encouraged students to present their ideas and projects to industry experts, who could provide valuable insights and feedback.

The event received enthusiastic participation from students who presented a wide range of projects, including innovative solutions in fields like renewable energy, healthcare, and security. The competition was judged by a panel of experts from the industry and academia, who evaluated the projects based on various parameters such as creativity, originality, and feasibility.

Hackanova 2.0 Pre-cursor Event, Thakur College of Engineering and Technology

Hackanova 2.0 Pre-cursor Event was a department-level evaluation event conducted at Thakur College of Engineering and Technology for all departments. The event was a precursor to the main Hackanova 2.0 event and aimed to evaluate the Project-Based Learning (PBL) projects of the students. The PBL approach emphasizes learning by solving real-world problems and developing projects that have practical applications. The evaluation criteria for the event included innovation, creativity, technical expertise, and the ability to solve practical problems. The event provided an opportunity for students to showcase their projects and receive valuable feedback from the faculty and industry experts. The feedback helped students improve their projects and prepare better for the main event. Overall, the Hackanova 2.0 Pre-cursor Event was a valuable learning experience for the students and helped them develop essential skills needed for real-world problem-solving.

6.2 Rubrics

Instructions:

- Faculty should observe the performance of students as per the given Rubric and put √ them in the appropriate box.
- Mention special observations at the end of the table in the Remark section (if any).

Parameter	Excellent (20 Marks)	Very Good (15 Marks)	Good (10 Marks)	Average (05 Marks)
Problem definition	Problem is defined clearly and identifies underlying issues. Scope is identified and finalized with features innovative steps are taken	Problem is defined adequately Scope is adequately identified and finalized with features	Problem is not defined appropriately Scope is not identified appropriately and features are not fully finalized	Problem is not defined at all. Scope is not identified a all and features are vague
Functionality	Product has very good chance of functioning with 80%-100% functionality.	Product has good chance of functioning sufficing 60%-80% of functionality	Product has some chance of functioning with 30%-50% stake audience knowledge level.	Product has very less chance of functioning knowledge level.
Design	The solutions has very good proficiency in using the elements and principles of design(Modularity, cohesion etc) with high level of creativity for the task.	The solution has good proficiency in using the elements and principles of design with good results for the task.	The solution has limited proficiency in using the elements and principles of design, but design is inappropriate for the task	No proficiency in using the elements and principles of design.
Implementation	Use of Optimization, error handling techniques Documentation of Implementation done Use of tools e,g, Github, integration tools	Error handling techniques Moderate Documentation of Implementation Use of tools e,g, Github	Less Documentation of Implementation Use of tools e,g, Github	No error handling techniques No Documentation of Implementation No Use of tools e,g, Github
Potential for product conversion	Develops a clear Solution and has high potential for product development	Solution is based on criteria with with good chances of product development	Analyses of some of the alternatives or constraints have lead to different recommendations with some chance of product development	Only one solution is considered with constraints and cannot be converted into product

Chapter 7. Publication

7.1 Details of journal/conference

"Review on Various Face Recognition Databases". i-manager's Journal on Pattern Recognition, Volume 9 No. 2 July-December 2022

i-manager's Journal on Pattern Recognition is a peer-reviewed academic journal that publishes research articles on topics related to pattern recognition and computer vision. The journal is published by i-manager Publications, an independent publishing house that aims to disseminate knowledge in various fields of engineering and technology.

The journal's website (https://www.imanagerpublications.com/journal/pattern-recognition) provides access to the latest issues of the journal and a submission portal for authors. The journal is indexed in major databases, including Scopus, Google Scholar, and the Directory of Open Access Journals (DOAJ).

i-manager's Journal on Pattern Recognition has a strong impact factor of 2.86, indicating that the journal is influential in the field of pattern recognition and computer vision. The quality of the journal's articles is ensured by the peer-review process, which involves experts in the relevant fields evaluating the research work submitted for publication. The journal follows ethical guidelines for publication and ensures that the research work published is original and contributes to the advancement of knowledge in the field.

"CAMERICA - Criminal Identification and Real-time Monitoring of Valuables using Facial Recognition in Hospitals.". Computer Vision and AI-integrated IoT Technologies in Medical Ecosystem by CRC Press, Taylor & Francis Group

"Computer Vision and AI-integrated IoT Technologies in Medical Ecosystem" is a book published by CRC Press, Taylor & Francis Group. The book discusses the integration of computer vision and artificial intelligence (AI) technologies with the Internet of Things (IoT) in the healthcare industry. It covers various topics, including the use of computer vision and AI for medical imaging, wearable devices, real-time monitoring, and patient tracking.

The book is available on the CRC Press website (https://www.crcpress.com/Computer-Vision-and-AI-integrated-IoT-Technologies-in-Medical-Ecosystem/Ganapathy/p/book/9781032547923). The website provides detailed information about the book, including the author's credentials, table of contents, and reviews.

As a publication by CRC Press, Taylor & Francis Group, the book meets high-quality standards for academic publications. The publisher has an excellent reputation and is known for publishing high-quality books and journals in various domains. The book is indexed in major academic databases such as Scopus, Web of Science, and Google Scholar. Additionally, the publisher provides a digital object identifier (DOI) for the book, making it easy to cite and reference in academic works.

International Conference on Intelligent Computing and Communication Networks, 2023.

IC-ICN 2023 is an international conference held at Thakur College of Engineering and Technology's Multicon. The conference intends to bring together researchers, practitioners, and industry experts to discuss the developments, challenges, and opportunities in intelligent computing and communication networks. The conference covers a wide range of topics, including artificial intelligence, computer vision, natural language processing, big data analytics, the Internet of Things, cloud computing, and network security.

7.2 Copy of published pages

REVIEW PAPER

REVIEW ON VARIOUS FACE RECOGNITION DATABASES

By

KHUSHI BHOJ * KULDEEP CHOKSI **

RISHI KITAWAT *** MANISH RANA ****

*-**** Department of Computer Engineering, Thakur College of Engineering and Technology, Mumbai, India.

Date Received: 13/10/2022 Date Revised: 14/11/2022 Date Accepted: 13/12/2022

ABSTRACT

Face recognition is one of the multimedia items that has seen a remarkable increase in popularity in recent years. Face continues to be the most difficult study topic for experts in the field of computer vision and image processing since it is an item with different properties for detection. We have attempted to handle the most challenging facial aspects in this survey work, including posture invariance, aging, illuminations, and partial occlusion. When applied to facial photographs, they are regarded as essential components of face recognition systems. The most recent face detection methods and techniques are also examined in this paper, including Eigenface, Artificial Neural Networks (ANN), Support Vector Machines (SVM), Principal Component Analysis (PCA), Independent Component Analysis (ICA), Gabor Wavelets, Elastic Bunch Graph Matching, 3D Morphable Models, and Hidden Markov Models. Many testing face databases, such as AT & T (ORL), AR, FERET, LFW, YTF, and Yale, also reviewed. However, the purpose of this study is to present a thorough literature assessment on face recognition and its applications.

Keywords: Face Recognition, Illuminations, Partial Occlusion, Pose Invariance.

INTRODUCTION

The 21st century is a contemporary, scientific age in which significant advancements have been made to speed up human work completion. The utilization of computer technology in modern society supports the aforementioned claim. Computers are employed for a wide variety of tasks, from straightforward to complicate problem-solving. Face recognition technology has become one of these contributions, serving as a handy tool to identify facial features by their inborn characteristics. It has also been one of the topics in pattern recognition and computer vision that has received the most investigation. However, because of its widespread usage in so many different applications, including smart cards, biometrics, information security, and access control for law enforcement, however it presents several difficulties for researchers that must be resolved. For example, position invariance, illuminations, and aging, which are the possible topics that need more research than what has already been done. Previous studies have shown that as people age, their facial expressions change, making it impossible to reproduce them in face recognition software permanently. There are two primary phases to the facial recognition problem: Face identification and face verification come first. For instance, in a real-time system, face identification and face verification can both identify the same individual in a scenario. It finds a face in a picture in the first stage. In a similar manner, it pulls characteristics from a picture for differentiation in the second step. In order to identify the proper face image, they are then compared to photographs from a face database, as seen in Figure 1. However, several of the recognized authentication

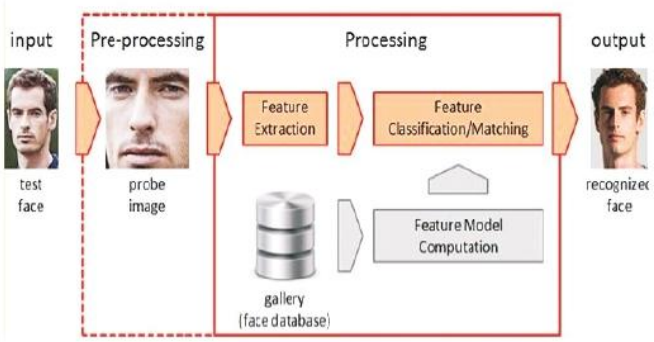


Figure 1. Preprocessing Steps of Face Recognition

mechanisms now in use are unreliable. For instance, PINs and passwords used by smart cards, wallets, keys, and tokens are exceedingly challenging to remember. Additionally, these codes and passwords are readily forgotten, and these magnetic cards are susceptible to loss, theft, and even duplication. This renders them unreadable as a result. They cannot be lost, stolen, or forgotten, in contrast to a person's biological qualities and attributes (Sharif et al., 2017).

A biometric recognition system may be created using a variety of methods. However, the procedures that employ the iris and fingers that access the system most frequently need user interaction or involvement. Additionally, modern methods offer participant access without its involvement. Face recognition is one of the most practical approaches for easily capturing and keeping track of a person using the system. Face recognition databases are different for controllable images compared to uncontrollable movies, using Lateral Flow Test (LFT) photos and YTM films. The three primary modules of a face recognition system are as follows: preprocessing, feature selection and classification.

Humans are naturally capable of recognizing hundreds of faces because to their visual system and cognitive abilities. They are able to do so even years later and still identify familiar faces. Research is still ongoing in the field of creating intelligent systems that are comparable to human perception systems. The researchers have proposed a wide range of approaches and algorithms for accurately and effectively identifying faces. They have concentrated on the detection and recognition of specific characteristics and features, such as the nose, eyes, mouth, location, size, and connection between traits and features, for this goal. Additionally, continuing facial recognition research aims to create such systems that might function effectively and efficiently in a variety of real-world applications. Numerous academics have also suggested and come to the conclusion that the usage of 3D faces can further increase the accuracy of face recognition (Sharif et al., 2011).

1. Challenging Areas In Face Recognition

As the range of applications expands day by day, so does the complexity of the system. In fact, it affects the efficiency of the system. This section discusses the various problems of facial recognition systems that exist today. These problems are related to the face image that is fed as input to the system. The algorithms used or this process varies from application to application. There are many reasons that are responsible for differences in faces. These sources of variability are subdivided into various factors as follows.

1.1 Aging

Compared to other face differences, aging is a natural process that occurs to everyone at some point in their lifespan. The major three distinctive traits that age can be seen as aging effects:

1.1.1 Aging is Uncontrollable

It is gradual and irreversible and cannot be sped up or even delayed.

1.1.2 Individual Aging Indicators

Every person ages in a unique way. And they depend on a person's genes as well as a variety of other elements, including their health, diet, location, and weather.

1.1.3 Aging Symptoms Vary with Time

All older faces will be impacted by a person's face at a certain age, while younger faces will be untouched.

1.2 Partial Occlusion

Occlusion in a picture refers to actual or imagined barriers. It could include a certain area of the face as well as accessories like sunglasses, a scarf, hands, and hair. They are commonly referred to as partial occlusions. Any occluding item corresponds to partial occlusions and a

partial occlusion is one that covers less than 50% of the face. The methods for recognizing faces with partial occlusion are divided into the following three groups: The first three are part-based approaches, feature-based methods, and fractal-based methods (Azeem et al., 2014). Partial occlusion has an influence on several aspects of picture processing, including ear identification that is obscured by earrings. When users trick a system, whether by donning sunglasses, scarves, or veils, or by holding their hands or positioning their phones in front of their faces, occlusion has an impact on how well the system works. In some situations, additional elements like shadows brought on by excessive light can serve as occluding elements. Additionally, local strategies are employed to address the issue of partially occluded faces that separate the faces into several sections (Tarrés et al., 2005). By removing some of the elements that interfere with correct recognition in the image, this issue may be solved. The majority of local approaches are based on feature analysis, where the best characteristics are found and then integrated. Another strategy that may be utilized for this is a nearly holistic strategy, in which obscuring characteristics, traits, and features are eliminated and the remainder of the face is used to provide important information. To address this issue, researchers are coming up with a variety of solutions (Jia & Martinez, 2008; Zhou et al., 2009).

1.3 Pose Invariance

Another obstacle to an effective facial recognition system is pose variance. Every time someone is photographed, they adopt a new position. Posing is not subject to any set rules. As a result, it is more challenging to discern and identify faces in pictures with different stances. The effectiveness of the facial features is diminished by pose fluctuations. Additionally, many systems operate under rigid imaging settings, which has an impact on the caliber of gallery photos. Face identification across pose and multi-view face recognition are two categories of techniques that deal with stance variance. A kind of frontal face recognition called multi-view face recognition takes gallery images of each posture into account. On the other hand, when using face recognition, yield faces with poses that have never before been seen by the system. Pose tolerance and the capacity to detect various positions should come standard with a decent face recognition method. There are also a number of unresolved challenges in this area, such as the absence of perceptible subspace posture variation pictures. Additionally, this topic has been the subject of several studies (Huang et al., 2000) through (Shah et al., 2014). None of them, however, has yet attained 100% accuracy. Other techniques and strategies are being employed to address related facial recognition issues. Additionally, there are three categories into which variance and posture changes can be subdivided: generic algorithms, two-dimensional face recognition techniques, and three-dimensional models (Zhang & Gao, 2009).

1.4 Illuminations

Light's visible characteristics and effects include illumination. It could also be referring to the utilization of light sources or the effect of lightning. Algorithms called global illuminations have been applied to 3D computer graphics. The facial recognition system is also negatively impacted by illumination change. As a result, numerous researchers have devoted their focus to this topic. However, identifying one or more people from still or moving pictures can be a difficult job. However, when photos are shot in a controlled atmosphere with a consistent background, it may be relatively simple to extract the required information from them. Additionally, three techniques can be used to address the lighting issue. They are face reflection field estimation algorithms for gradient, grey level, and level. The grey level transformation approach uses a non-linear or linear function to do in-depth mapping. To extract the edges of a grayscale picture, gradient extraction techniques are utilized. Because lighting has a significant impact on how well a face recognition system performs when using photos or videos of faces, These strategies were created to reduce the impact of light (Huang et al., 2000; Chai et al., 2003; Wright & Hua, 2009; Zhang et al., 2012; Shah et al., 2014).

2. Face Recognition Databases

This face database, formerly known as The Olivetti Research Laboratory (ORL) Database of Faces, has a collection of portraits of people who were photographed at the AT & T lab. This database was utilized for a facial recognition experiment that the Cambridge University Department of Engineering's Speech, Vision, and Robotics Group helped to carry out. It has 10 separate photos with a total of 40 different themes. But for other subjects, different lighting, face expressions (smiling/sad), open/closed eyes, and facial features (with/without spectacles) were used to get the photographs. These pictures were captured on a consistently black, frontal, upright background. The databases utilized for facial recognition are given in detailed as follows.

2.1 AR Database

The University of Alabama at Birmingham's Computer Vision Center (CVC) generated the AR database. It contains more than 4000 color photos of the faces of 126 individuals. Additionally, they are split into 70 males and 56 women. Frontal view faces are depicted in images with various occlusions, lighting circumstances, and facial emotions (sun glasses, hair styles and scarves). A single person's photos were collected over the course of two days that were separated by 14 days. For research and academic use, this database is accessible online and is free to use.

2.2 FERET Database

The facial recognition technology is being evaluated using the FERET database. The Defense Advanced Research Projects Agency (DARPA) and the National Institute of Standards and Technology jointly collaborate on the Face Recognition Technology (FERET) initiative National Institute of Standards and Technology (NIST). In 2003, DARPA made these photographs available in a high-resolution, 24-bit colour version. Additionally, it was examined using 2,413 still photos of faces that represented 856 people. The FERET database's primary goal, however, was to make the creation and assessment of algorithms easier. Therefore, in order to design and test for the purpose of assessment, it requires a shared database of facial photos. The complexities in the picture depicted by the photos should thereafter get worse.

2.3 LFW Database

A library of face images called Labeled Faces in the Wild (LFW) was primarily created to understand the challenge of unrestricted face identification. More than 13,000 facial photos from the web are included in the data collection. Additionally, the name of the individual whose image was taken is listed next to each face. However, the data set included two or more different images for around 1680 of the photographed individuals. The primary restriction on these face photos is that the Viola Jones face detector identified them. They are divided into four groups of LFW photos, one of which is the original and the other three of which are various kinds of aligned photographs. The aligned photos include "deep funneled" images as well as "funneled images" LFW-a, which uses an unreleased method of alignment. For original photos and funneled images, LFW-a and the deep funneled images outperform the majority of face verification algorithms in terms of outcomes.

2.4 YouTube Face Database (YTF)

Face movies from the YTF database were created for unrestricted face recognition. The shortest and longest clips in this collection are 48 and 6,070 frames, respectively. Additionally, a video clip contains 181.3 frames on average. Additionally, YouTube was used for all of the videos. There are typically 2.15 movies accessible for each topic.

2.5 Yale Database

The Yale Face Database contains 165 grayscale Graphical Interchange Format (GIF) photos of 15 people. Each of the 11 images/subjects has a distinct face expression or configuration, including winking, center-light, with/without spectacles, happy, sad, drowsy, normal, shocked, and winking, Right-light and left-light.

Yale Face A, also known as Yalefaces, and Extended Yale Face Database B are the two volumes that make up the Yale Face Database. There are 15 different subjects in this database (14 males and 01 female). These include various face ailments including changes in expressions

like sad, normal, and cheerful, etc. This also relies on the other lighting circumstances, such as the left, right, or centre light, and whether or not glasses were used to see the image. The extended Yale face database contains 2414 photos of 38 different people. The photos do not display any fluctuation in expression or occlusions, but their concentration is on extracting features that are appropriate for lighting, and a cropped version is supplied.

3. Methods And Techniques of Face Recognition

3.1 Eigenfaces

German "Eigen wert" is the source of the word "eigenface." The words "Eigen" and "wert" both refer to characteristics and values, respectively. The well-known Eigenface technique was used to identify a feature in a face picture. Principle Component Analysis (PCA) (Zhang & Gao, 2009) is the foundation for it. The primary idea behind this strategy is to identify a face by using its specific characteristics. Then, as illustrated in Figure 2, encode it to compare with the decoded outcome of the earlier acquired image. Decoding is carried out using the eigenvector computation and then it is represented as a matrix in the eigenface approach. However, Eigenface-based face recognition algorithms are only appropriate for photos with frontal faces, although considerable research has been done to detect a face in various stances (Sharif et al., 2017). The accuracy ratio has significantly increased recently compared to earlier results while analyzing various study outcomes. In the following years, an effective and efficient output is anticipated. In Table 1, the results of the analysis produced by different researchers employing face recognition technologies on the grounds of Eigenfaces are investigated.

3.2 Artificial Neural Networks (ANN)

Since the development of artificial intelligence, ANN has been a popular feature recognition approach. It comprises of a network where the neurons are set up in

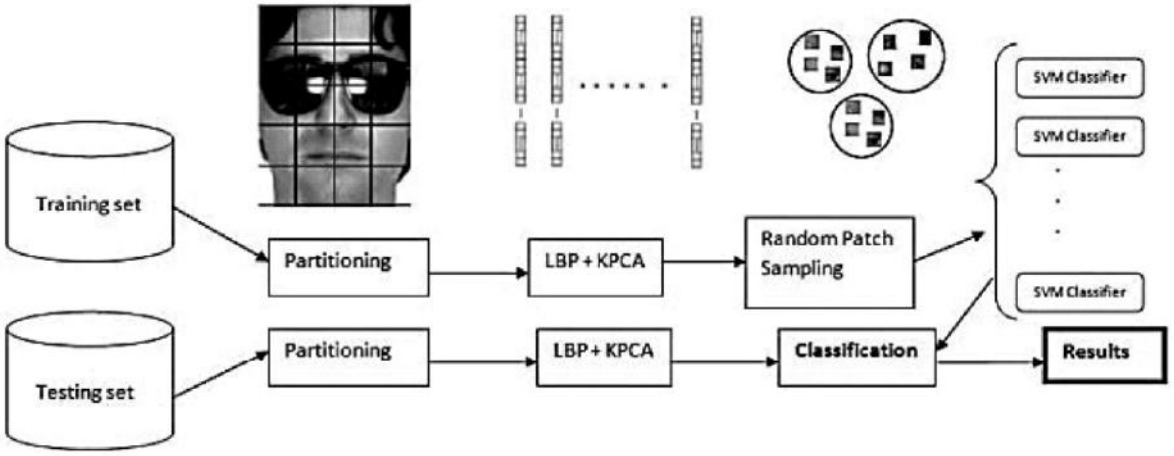


Figure 2. Face Recognition using Neural Network

S.No	Year	Database	Technique	Accuracy	Reference
1	2012	Database	PCA	70.00%	Yi et al. (2015)
2	2012	ORL Faces	PCA	100%	Abdullah et al. (2012)
3	2013	Face94 FRAV Face DB	Eigenface	96%	Zhang and Zou (2008)
4	2014	-	PCA Eigenfaces	70%	Bellakhdhar et al. (2013)
5	2014	Yale Database	PCA	92% to 93%	Azeem et al. (2014)
6	2014	AT & T	PCA		Cho et al. (2014)
7	2016	Computer Vision Research Projects dataset	PCA	93.6%	Anand and Shah (2016)
8	2017	EmguCV library	PCA + RMF	93%	Jazouli et al. (2017)
9	2017	Yale Database	PCA	98.18	Vyas and Shah (2017)

Table 1.Comparative Study of Face Recognition Techniques Based on PCA

layers. Face recognition accuracy has increased because to improved deep network designs and supervision techniques. Additionally, some impressive face representation learning algorithms have recently emerged (Wang & Yang, 2008). These methods have brought the performance of deep learning far closer to that of humans depicts in Figure 3. Tightly cropped face photos from the LFW face verification dataset have been utilized for evaluation (Wang & Yang, 2008). The learnt face representation may, however, also significantly increase intrapersonal differences. Neural networks' ability to reduce complexity is one of its most valuable characteristics. It gains knowledge from the training examples and subsequently functions properly on photographs with altered lighting conditions while improving accuracy (Sharif et al., 2017). The neural network's fundamental flaw is that its training takes more time. From the user's perspective, the first step in getting the desired outcomes from the system is training.

Following feature extraction, Feed-Forward Neural Networks (FFNN) and Radial Basis Functions (RBF) are implemented as classifiers for face recognition.

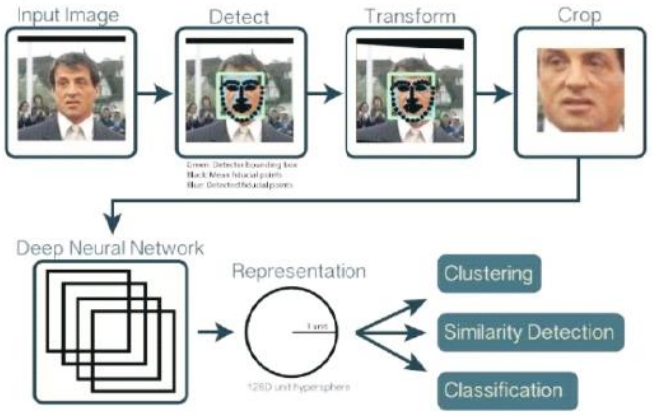


Figure 3. Face Recognition by Using SVM (Wei et al., 2012)

Additionally, research shows that ANNs outperform facial recognition (Best-Rowden & Jain, 2015). The comparison analysis that follows in Table 2 displays an accuracy ratio that was attained by using ANNs.

3.3 Support Vector Machine (SVM)

The supervised learning method known as SVM utilizes data for regression and classification. SVM has the benefit of working well in large dimensions. After facial feature extraction, SVM may be used to detect faces (Gorde et al., 2017). When the vast amount of data set is picked immediately with training, SVM may produce superior results shown in Figure 3. But among the prominent SVM variants, Least Square Support Vector Machine (LS-SVM) (Xie, 2009; Zhang & Zou, 2008) is one that is successfully used for the job of face recognition.

This offers the benefits of quick computation, speed, and high recognition rate (Sharif et al., 2017). Another SVM variation for face recognition is the component-based SVM classifier (Huang et al., 2002). The Support Vector Machine (SVM) classifier is one of the most used methods and is used to solve a variety of classification issues. These issues tend to be high-dimensional and non-linearly separable. When dealing with data that has a very high dimensionality, SVM is helpful. Researchers used SVM for facial recognition classification and achieved higher results, as shown in Table 3.

3.4 Gabor Wavelet

In 1946, Dennis Gabor invented the Gabor filter, a device for signal processing that removes noise. In face recognition, the Gabor wavelets approach is frequently used for face tracking and position estimation. The spatial relationships and spatial frequency structure are both provided by an image representation utilizing the Gabor wavelet transform. It possesses a property that enables it

S.No	Year	Database	Technique	Accuracy	Reference
1	2012	IIT-Dehli Database	NN Based SOM for Face recognition	88.25% to 98.30%	Raja and JosephRaj (2012)
2	2013	-	BPC and RBC Network	96.66% & 98.88%	Nandini et al. (2013)
3	2015	Deep ID 3		99.53%	Yi et al. (2015)
4	2015	AFLW		99.00%	Agrawal and Khatri (2015)
5	2015	Multi PIE dataset	CPF	99.50%	Jazouli et al. (2017)
6	2015	AFLW		90.00%	Raja and JosephRaj. (2012)

Table 2. Comparative Study of Face Recognition Methods Using Artificial Neural Networs (ANN)

to distinguish between the qualities of spatial localization, spatial frequency selectivity, and orientation, as illustrated in Figure 4 (Jin & Ruan, 2009; Bellakhdhar et al., 2013). The extraction of edge and shape information works well with Gabor Wavelets, and it displays the faces in a compact manner that is more comparable to feature-based approaches (Kar et al., 2009).

Face feature reduction and global feature representation in face recognition are the two key benefits of the Gabor Wavelets Transform (Wu et al., 2015; Prakash, 2010; Li et al., 2000). Table 4 compares the analyses of Gabor filters performed by various scholars.

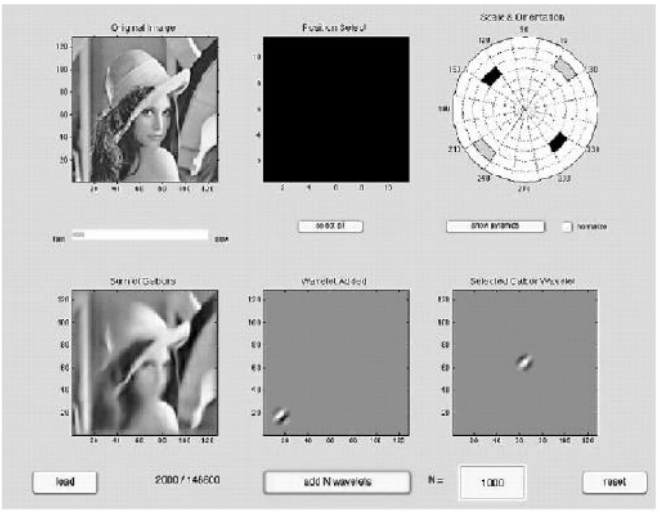


Figure 4. Gabor Wavelet Process of Recognition

3.5 Hidden Markov Models

Another statistical modelling method is the Hiddel Markov Model (HMM), in which the system goes through a Markov process with hidden states shown in Figure 5. This concept, which was put forward in 1960, significantly advanced voice recognition. HMM is a well-known technique in applications for reinforcement learning, temporal pattern

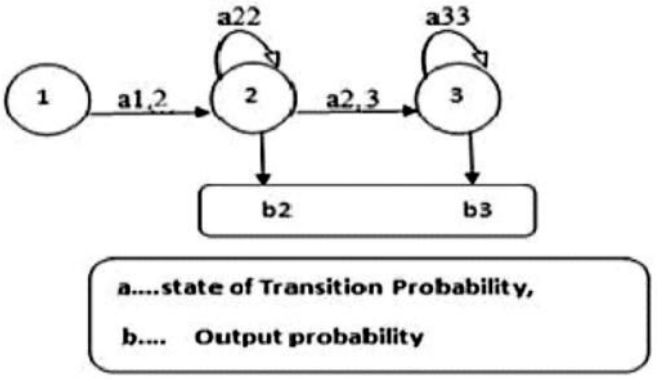


Figure 5. Three States of Transition from Left to Right for HMM (Xie, 2009)

S.No	Year	Database	Technique	Accuracy	Reference
1	2009	ORL Face Database	Least Square SVM	96%	Xie (2009)
2	2011	ORL Face Database	ICA, SVM	96%	Kong and Zhang (2011)
3	2011	FERET Database, AT&T Database	2D-Principal Component Analysis, SVM	95.1%	Le & Bui (2011)
4	2016	Yale Faces	SVM	97.78%	Anand and Shah (2016)

Table 3. Comparative Study of Face Recognition Methods Based on SVM

S.No	Year	Database	Technique	Accuracy	Reference
1	2012	FRGC & CASIA	3D GPSR	95.80%	Ming et al. (2012)
2	2014	Yale Face DB	PCA, LGBPHS & DPL	98.30%	Cho et al. (2014)
				97.30%	
				99.20%	
				99.70%	
3	2014	RBM	PCA	99.50%	Yi et al. (2015)
4	2013	ORL Database, FRGCv2	Magnitude Phase of Gabor, PCA, SVM	99.90%	Bellakhdhar et al. (2013)
5	2015	T1-w dataset	SVM RBF	93.80%	Chai et al. (2003)
				+0.3+-	
6	2015	ORL	MAHCOS Distance	97.50%	Zhao and Chellappa (2000)
7	2015	IIT-Dehli Database	PCA	99.20%	Sharif et al. (2010)
8	2015	FERET & CMU-PIE		92.80%	Sharif et al. (2015)

Table 4.Comparative Study of Face Recognitoin Methods Based On Gabor Wavelets

recognition, and bioinformatics. It is now being used to identify facial emotions. Additionally, it may be used for facial identification in video sequences. For experimental purposes, a succession of 1D and 2D pictures is required. However, these images must first be transformed into a spatial or 1D chronological sequence. The model, which comprises of two processes, does not explicitly view the first Markov Chain process, which has a finite number of states. While in other processes, each state is made up of a set of associated probability density functions (Sharif et al., 2017). Although 5- state HMM is often created for face recognition systems, it is developed for research. For frontal view face pictures, 5-state HMM is divided into five facial characteristics, including the eyes, nose, mouth, chin, and forehead (Nefian & Hayes, 1998). But depending on the needs of the system, the number of states might be increased or decreased. Figure 6 depicts the Hidden Markov Model Process of Recognition.

In another situation, 7-State HMM (Miarnaeimi & Davari, 2008) offers additional information, which improves the effectiveness of the face recognition system. Several scholars have sought to implement various algorithms in this paradigm in order to obtain satisfying results. However, a fresh, improved design. The authors suggest using the Adaptive Hidden Markov Model (AHMM) (Liu & Chen, 2003) to investigate the difficulties in accurately detecting faces in a video series. Table 5 gives a comparative result illustration the accuracy ratio of the HMM.

4. Applications of Face Recognition

There are many applications where face recognition techniques are successfully used to perform a specific task. Several of them are classified as follows.

4.1 Access Control

Access control enables the designated set of users to logon through their email account on a computer and access their bank account through an Automated Teller Machine (ATM) to access their personal account. However, when employing a face recognition system, photographs of the face are taken in a natural setting,

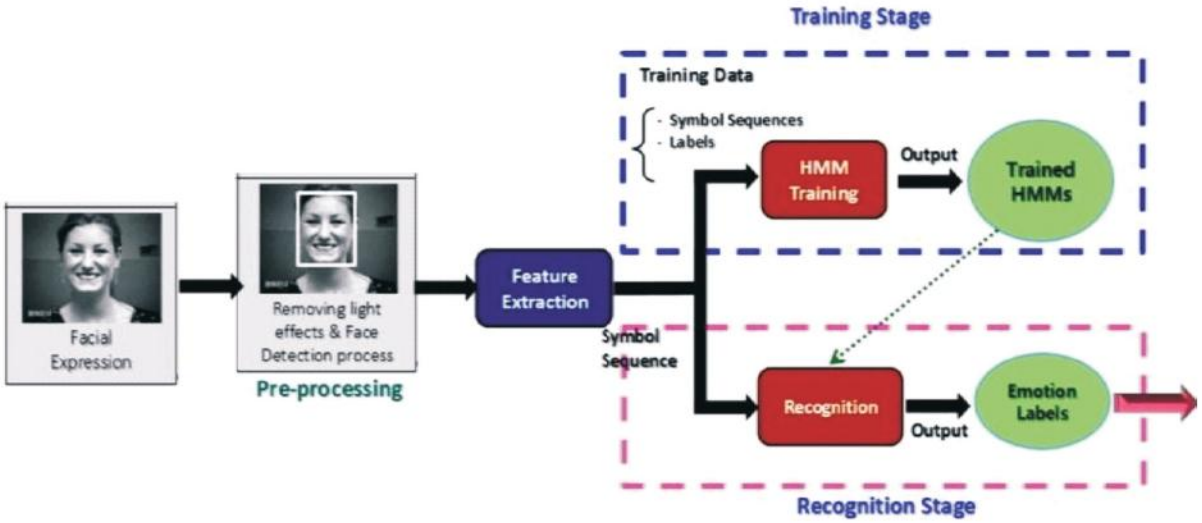


Figure 6. Hidden Markov Model Process of Recognition

S.No	Year	Database	Technique	Accuracy	Reference
1	2013	ORL FaceDB, Yale Face DB	Sub - Holistic HMM	95.25% & 94.45%	Sharif et al. (2012)
2	2015	CK+ UNBC- McMaster	MIL - HMM	85.23%	Wu et al. (2015)
3	2015	UMIST	MS - HMM	93.66%	Agrawal and Khatri (2015)
4	2013	MSR-Action3D	DMM - HMM	90.50%	Chen et al. (2016)
5	2015	SCOP	Hhblits	93.80%	Xie (2009)

Table 5. Comparative Study of Face Recognition Methods Based on Hidden Markov Models (HMM)

such as frontal views. These systems produce the best accuracy without the need for user input. These automatic facial recognition systems are also used to monitor and manage user behaviour on PCs or ATMs, for example, when users leave the PC for an extended period of time without properly closing their files and folders. When the user logs in and is detected again, the system halts. Only authorized individuals are permitted to access the account in this situation.

4.2 Security

Security is always a top priority before anything else. Face recognition software is used to carry out computer security. In this regard, image databases are being used for investigative purposes (Sharif et al., 2017); for instance, searching images for licensed drivers' authentication to look for missing people, immigrants in law enforcement agencies, general identity verification (Sharif et al., 2017), electoral registration, banking, electronic commerce, looking for newborns, and identifying them using their national IDs, passports, and employee IDs.

4.3 Surveillance

The French verb for "looking over" is the source of the English term "surveillance." Here, the French words veiller and sur both imply "to watch." In order to ensure the safety of the population, surveillance is employed to track a person's actions, behaviour, or other relevant data. Closed-Circuit Television (CCTV) cameras or the interception of electronically transmitted information can be used to accomplish this. Numerous advantages are provided by surveillance systems to various enterprises. Governments use it, for instance, to gather intelligence, combat crime, keep an eye on people, places, or things, or investigate crimes. On the other hand, as monitoring is frequently viewed as an invasion of privacy, civil society organizations, groups, and activists frequently protest it in these situations. Liberal democracies have laws requiring local governments and police enforcement to conduct surveillance, generally with restrictions in place when the public's safety is at risk. Such domestic limitations have frequently been imposed on legitimate groups. All nations, however, engage in some form of global monitoring. Additionally, researchers are attempting to apply the most recent facial recognition algorithms to provide outcomes that are more enhanced and satisfied.

4.4 Time & Attendance

Access Control solutions that utilize biometric time-attendance technology are some of the most recent alternatives to conventional methods (Chen et al., 2016). In order to utilize this technology, users must keep their face away from the camera of the gadget and avoid making direct contact with it. Due to its non-contact approach technique, this prevents any danger of being tempered or having the equipment altered. As shown in Figure 7, a face recognition system records particular features from a person's face as a mathematical template. The facial picture is normalized to align the eyes and lips in order to identify a face. Then it does match using database-stored mathematical vectors. Finally, a face recognition system confirms a person's identity and enables the marking of access or attendance transactions. These devices might also be used for other solutions, such as cafeteria management, income distribution, and social services, where biometric identification or verification is necessary.

4.5 Pervasive Computing

In order to produce smart gadgets, ubiquitous computing aims to build a sensor-based network. As a result, sensor networks are used to gather, analyses, and transfer data. Eventually, these networks will be able to comprehend

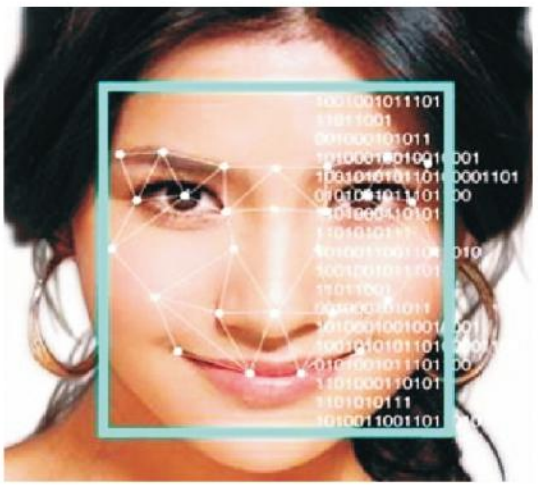


Figure 7. Facial Recognition

their surroundings, which will enhance human capabilities and quality of life. However, ubiquitous computing makes use of mobile devices, wearable computers, embedded systems, RFID tags, middleware, and software agents in addition to wireless communication and networking technologies. Numerous applications, including those in the energy, consumer, healthcare, production, military, safety, and logistics, make extensive use of pervasive computing.

An example of widespread computing is the smart Watch that Apple Watch has created. It alerts a user to an incoming call and enables him to finish the call while wearing a watch (Sharif et al., 2017).

Conclusion and Future Directions

For many years, experts have been seeking to learn more about facial recognition. In this research, a thorough analysis of several facial recognition techniques was conducted. After thorough investigation, it became clear that Eigenface image features approach works well for frontal face identification while Principal Component Analysis (PCA) is better suited when feature dimension is larger for original face pictures. The most widely used face recognition techniques are neural networks, support vector machines, sparse representation-based classification (SRC), linear regression classification (LRC), regularized robust coding (RRC), and nearest feature line (NFL). When the picture dimension is less than or equal to 150, these approaches produce superior results. Additionally, it is proposed that further study be done on the PCA, SVM, NN, and Eigen approaches in order to get results for face recognition that are more satisfying. Additionally, we discussed the advantages of face technology in numerous applications as well as a state-of- the-art face recognition picture database in this study. However, the following important conclusions of this study are highlighted such as advancements and trends in face recognition demonstrate the huge amount of study that has been done over the past forty years. Face recognition technology is already used in several real-time applications, but there are still a number of issues that need to be resolved in order to develop a robust face recognition system. Face recognition systems that have been developed can assess faces with different expressions, poses, and lighting. The most recent face databases and benchmark data might be used for assessment. Similar to face image recognition, video image recognition requires more research since it is more difficult. it is recommended that YouTube Faces might be examined for examination in order to recognise video pictures. Additionaly, the recent emergence of the identification of emotional human behaviour as a potential (Jazouli et al., 2017) study field for academics should be taken advantage of in the future. Finally, it is determined that more research is still needed to be done on facial recognition systems in order to increase their efficacy and accuracy.

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ABOUT THE AUTHORS

Khushi Bhoj, Department of Computer Engineering, Thakur College of Engineering and Technology, Mumbai, India.

Kuldeep Choksi, Department of Computer Engineering, Thakur College of Engineering and Technology, Mumbai, India.

Rishi Kitawat, Department of Computer Engineering, Thakur College of Engineering and Technology, Mumbai, India.

Manish Rana, Department of Computer Engineering, Thakur College of Engineering and Technology, Mumbai, India.

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