INVARIANT FACE RECOGNITION USING MACHINE LEARNING TECHNIQUES

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Submitted by

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CANDIDATE'S DECLARATION

I, **Shubham Pachnanda**, Roll No – **2K21/AFI/05** student of M.Tech A.I (Department of Computer Science and Engineering),hereby declare that the project Dissertation titled "**INVARIANT FACE RECOGNITION USING MACHINE LEARNING TECHNIQUES**" which is submitted by me to the Department of Computer Science and Engineering, Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of degree of Masters of Technology, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma Associateship, Fellowship or other similar title or recognition.

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CERTIFICATE

I hereby certify that the Project Dissertation titled "**INVARIANT FACE RECOGNITION USING MACHINE LEARNING TECHNIQUES**" which is submitted by **Shubham Pachnanda**, Roll No – **2K21/AFI/05**, Department of Computer Science and Engineering ,Delhi Technological University, Delhi in partial fulfilment of the requirement for the award of the degree of Masters of Technology, is a record of the project work carried out by the students under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

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ABSTRACT

Face detection algorithms had to be updated due to updated security standards and other technological breakthroughs, such the pervasive usage of visual programs on communications networks. As a result, newer and more effective systems, such as low-level analysis, active shape models, feature analysis, etc., were developed in recent years. Face identification can be done in a variety of ways, including with knowledge- and appearance-based techniques, feature-invariant algorithms, and template-matching methods. Every individual has several photos taken, and their characteristics are identified, categorized, and stored in the database. The features of a face image are then compared to each category of faces that is stored in the records after identification of faces and extraction of characteristics. Several studies and techniques have been presented to address this categorization problem in the sections that follow. Face recognition has two general uses; the first is for identification, and the second is for verification. The models which is already proposed give low accuracy for face recognition. In this research work transfer learning model is proposed for face recognition. The proposed model is the combination of VGG-16 and CNN. The proposed model is implemented in python and results is analysed in terms of accuracy, precision, recall.

CONTENTS

LIST OF FIGURES 3
LIST OF TABLES 4
LIST OF ABBREVIATIONS 5
CHAPTER 1: INTRODUCTION 6
1.1 EVOLUTION OF FACE DETECTION RESEARCH 6
1.1.1 FEATURE-BASED APPROACH 7
1.1.2 IMAGE-BASED APPROACH 8
1.1.3 APPLICATIONS OF FACE RECOGNITION SYSTEM 8
1.2 GENERAL FACE RECOGNITION STRUCTURE AND PROCEDURE 10
1.2.1 TAXONOMY OF FACE RECOGNITION METHODS 11
1.3 CHALLENGES OF FACE RECOGNITION TECHNOLOGY 19
CHAPTER 2: LITERATURE REVIEW 20
CHAPTER 3: METHODOLOGY 34
3.1. PROBLEM FORMULATION 34
3.2. OBJECTIVES 34
3.3. RESEARCH METHODOLOGY 34
CHAPTER 4: RESULTS 37
4.1. DATASET DESCRIPTION 37
4.2 RESULTS 37
CHAPTER 5: CONCLUSION & FUTURE SCOPE 43
5.1. CONCLUSION 43
5.2. FUTURE SCOPE 43
BIBLIOGRAPHY 44

LIST OF FIGURES

Figure 1: Configuration of a General Face Recognition Structure

Figure 2: Working of All Steps on an Input Image

Figure 3: Face recognition system

Figure 4: Learning and classification

Figure 5: VGG16 Model Architecture

Figure 6: Proposed Model

Figure 7. Dataset Read

Figure 8: Input Image

Figure 9: Data Distribution

Figure 10: Sample Images

Figure 11: Prediction result

Figure 12: Prediction result

Figure 12: Performance Analysis

LIST OF TABLES

Table 1: Performance Analysis

LIST OF ABBREVIATIONS

ANN	Artificial Neural Network
CNN	Convolutional Neural Network
PDM	Point distributed models
LDA	Linear Discriminant Analysis
LBP	Local binary pattern
GAN	Generative Adversarial Network
SIAMS	Smart Inventory Access Monitoring System
SVM	Support vector machine

CHAPTER 1: INTRODUCTION

The development of sophisticated security systems utilizing biometric traits has been the subject of extensive research in the past few years. In short, a biometric system is a device that recognizes patterns that validates an individual's true identity by attesting to the truth of a certain bodily or psychological attribute that the user possesses. One of the most used biometric user authentication techniques is face recognition. A typical method for how an automatic face recognition system functions is to extract an array of attributes from an individual's face, such as geometric characteristics or information about the textures and shapes of all the different elements of a human face. Before applying a recognition algorithm, faces must first be recognized in a picture using some sort of detection mechanism. As a result, the identification of a face is the initial phase in a successful recognition procedure. In the 1970s, heuristic and anthropometric face detection algorithms made their debut. These techniques frequently failed because, in addition to being highly sensitive to shifts in lighting or image scale, they could only recognize faces in well-defined contexts, like high-contrast photographs with a white background [1].

The algorithm needed to be completely redone in order to recognise faces in complex situations.The need to adapt facial recognition algorithms arose as a result of emerging security demands and advancements in technology, like the ubiquitous integration of multimedia platforms in telecommunication networks. As a result, newer and more effective systems, such as low-level analysis, active shape models, feature analysis, etc., were developed in recent years. Face identification can be done in a variety of ways, including with knowledge- and appearance-based techniques, feature-invariant algorithms, and template-matching methods.

1.1 EVOLUTION OF FACE DETECTION RESEARCH

Simple heuristic and anthropometric approaches were utilized in the earliest face detection efforts, which date back to the early 1970s [2]. Due to several presumptions, such as a frontal face and a plain background—a common passport photos scenario—these techniques are mostly stiff. Any alteration in the imaging conditions would necessitate fine-tuning, if not a total redesign, for these systems. Despite these issues, until the 1990s, when usable facial recognition and video coding techniques started to become a reality, the increase of research interest remained stagnant. Numerous significant elements of face identification have attracted a lot of study attention over the last ten years. The use of motion, colour, and generalized information has led to the presentation of more reliable segmentation systems. Faces may now be picked out in cluttered surroundings at varying distances from the camera by using statistics and neural networks. Additionally, there have been several advancements made in the design of feature extractors, such the active contours and deformable templates, which can precisely find and track face characteristics.

Face detection methods can be divided into two main types because they each employ face knowledge differently and because they require a priori knowledge of the face [3]. The first category of approaches explicitly utilizes face knowledge and adhere to the traditional detection process, which derives low level features before knowledge-based analysis. At various system levels, the visible characteristics of the face, such as skin tone and face shape, are taken advantage of. These methods often manipulate measurements of the distances, angles, and areas of the visual characteristics extracted from the scene in order to perform face detection tasks. These methods are known as the feature-based approach since features serve as the major component. These methods account for almost all of the literature covered in this work since they have captured the majority of attention in face detection research going back to the 1970s. The methods in the second group tackle face detection as an overall recognition problem by taking use of recent developments in pattern recognition theory. Training methods are used to classify based on pictures illustrations of faces, for example 2D brightness arrays of values, into a facial category requiring the use of feature development or analysis. As opposed to the feature-based approaches, these relatively novel strategies incorporate face information indirectly into the framework through mappings and training operations.

1.1.1 FEATURE-BASED APPROACH

These methods account for almost all of the literature covered in this work since they have captured the majority of attention in face detection research going back to the 1970s [4]. The methods in the second group tackle face detection as an overall recognition problem by taking use of recent developments in pattern recognition theory. Without feature derivation or analysis, training techniques are used to categorize image-based illustrations of faces, such as 2D intensity arrays, into a face group. As opposed to the feature-based method, these relatively new techniques incorporate face information intuitively into the framework via mapping and training operations. With the purpose of recovering intricate and nonrigid aspects such tracking the lip and eye pupil, these dynamics—which vary from snakes, which were first shown in the latter part of the 1980s, to point distributed models (PDM)—have been developed.

1.1.2 IMAGE-BASED APPROACH

The unpredictable nature of facial appearance and contextual factors have caused problems with face detection using explicit modelling of facial traits. The majority of the latest feature-based methods are still restricted to head and shoulder and quasi-frontal faces, despite the fact that some of them have increased the capacity to deal with the unpredictability. Techniques that work in more adverse situations, like detecting several faces with cluttered backgrounds, are still needed. This necessity has given rise to a brand-new field of study where the problem of face detection is viewed as one of pattern recognition. The issue is described as being one of learning a face pattern from samples, which avoids the need to specifically apply face knowledge. This removes the possibility of modelling inaccuracy as a result of insufficient or erroneous face information [5].

A training strategy that separates samples into categories for face and non-face prototypes is used in the basic method for recognizing face patterns. Comparing these classes to a 2D intensity array (thus the name image-based) created from a source picture can reveal the presence of a face. The most straightforward image-dependent techniques entail template matching, however in terms of performance, these techniques fall short of the more complex techniques discussed in the following sections. The bulk of image-based approaches find faces using a window scanning method. Although practically all image-based systems implement the window scanning technique differently, in essence, it is merely a thorough examination of the input picture for potential face locations at all scales. Generally, the suggested approach and the requirement for a computationally efficient system determine the dimension of the scanning window, the subsampling rate, the step size, and the number of iterations [6].

1.1.3 APPLICATIONS OF FACE RECOGNITION SYSTEM

The major application areas of face recognition systems include:

i. Financial field: Currently, the financial industry, which is a key component of security, requires significant people and material resources in order to implement real-time monitoring of numerous moving targets in dynamic settings. Face recognition software can quickly solve this issue, and it has two benefits. The first is that it can be used to monitor business personnel on video, identifying anyone hiding their face and then verifying that person's identity using information from the public security system to gather proof and call the police to have the offender arrested. The second is the recognition of personnel in the service reservoir area. Because of the company's strict operating procedures, it is crucial to confirm the identities of all people entering and leaving the area, just as it is to identify people entering and leaving the company and goods entering and leaving the area. Because it might significantly affect every element of the business if a bad employee joins the organisation due to a poor monitoring mechanism. Face recognition can fill their needs in these places [7].

ii. Education field: The attendance system is particularly important in education since it can be used as evidence of a student's presence. Additionally, in some nations, a student's attendance decides whether they are eligible for a lecture final exam. The face recognition application for education is also desktop-based and was developed using the Python programming language, the Emgu CV library, and the SQLlite relational database management system. The feature surface method, which is employed in the processes of student attendance detection and face recognition, is implemented using the Emgu CV Library as a tool. And by using this strategy, children can develop positive habits while also assisting teachers in keeping an eye on their students. Therefore, if a face recognition system is used in a study of how youngsters interact, it will be advantageous in the following ways: Naturalness is one. Children's learning stress and costs are decreased by the recognition of the fundamental biometric aspects of the face and the interaction of the learning material with the acquisition feedback, which makes use of the natural interaction of the face.

iii. Transportation field: It takes a long time to physically check each passenger's identity on the platform because of the high volume of people using the passenger station, railway station and subway station. There are also instances where staff members make mistakes as a result of being overworked. Face recognition technology can be used to prevent the mismatch between the person, the certificate, and the ticket. In this instance, the gadget may be fixedly placed, the user's face and ID card can be confirmed simultaneously, and the comparison can be finished fast, saving both staff and client time [8].

iv. The public security field: Case detection is becoming more effective thanks to high-tech tools like big data platforms and face recognition. Public safety and the battle against terrorism also played a crucial part in maintaining national security. The public security agencies on the run from the image database can be identified using the Gabor transform, mathematical change, and double attribute. We can apprehend the fugitives by comparing the images. The method for comparing a face image with feature recognition is then demonstrated.

1.2 GENERAL FACE RECOGNITION STRUCTURE AND PROCEDURE

Given a photograph from a digital camera, the initial objective in image-based face recognition is to determine whether there is somebody inside, where their face is located, and who they are. The face recognition process entails three processes to achieve this goal: face detection, feature extraction, and face recognition as shown in Figure 1 [9].

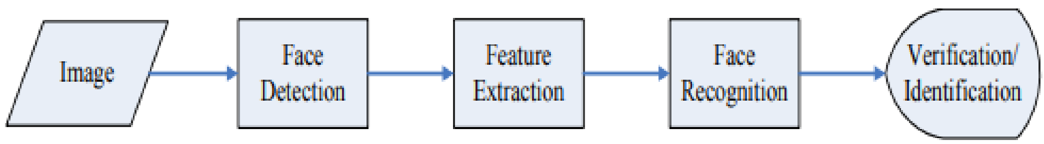

Figure 1: Configuration of a General Face Recognition Structure

i. Face Detection: The major goals of this step are to (1) identify the presence of human faces in a given image and (2) pinpoint their locations. The phase's anticipated outcomes are the patches that include each face in the input image. In an effort to make a potential system for recognizing faces more dependable and simpler to build, face alignment is carried out to rationalize the sizes and angles of these patches. Along with acting as the pre-processing for face recognition, face detection can be used for region-of-interest identification, retargeting, and other tasks.

ii. Feature Extraction: In the stage after face detection, face patches are taken away from photographs. First, the number of pixels in each patch is often over 1000, which is too many for a trustworthy recognition engine, making it difficult to use these patches directly for face recognition. Second, face patches may be extracted from various camera alignments, with various facial emotions and illuminations, and they may be cluttered and obscured by other objects [10]. To overcome these limitations, feature extractions are employed for information wrapping, dimension reduction, salience withdrawal, and noise cleansing. After finishing this step, a face patch is frequently transformed into a vector with specified dimensions or a group of fiducial points and places.

iii. Face Recognition: The final stage is to identify the identities of these faces after formulating each face's representation. A face database must be created in order to accomplish automated recognition. Every individual is photographed multiple times, and their physical characteristics are made note of, categorized, and stored in the database. Researchers next match a face image's characteristic to each category of faces stored in the database after conducting identification of faces and extraction of features. Several studies and techniques have been presented to address this categorization problem in the sections that follow. Face recognition has two general uses; the first is for identification, and the second is for verification. Face verification involves requesting the algorithm, given a picture of the face and a recognition believe for confirmation whether the assumption is valid or not. Face identification involves requesting the structure, provided a picture of the face, to determine the correct individual or identify the probable matches. An illustration of how these three procedures are applied to an input image is shown in Figure 2 [11].

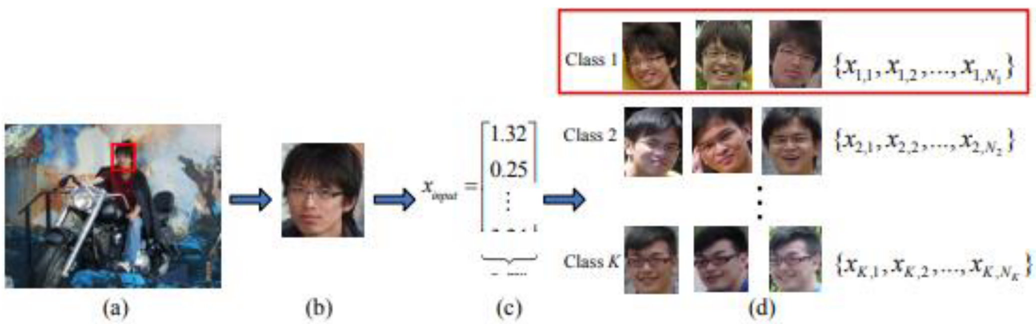

Figure 2: Working of All Steps on an Input Image

A sample of how the three processes are applied to an input image is shown in Figure 2. (A) The input image and the red rectangle represents the face detection result. (B) The removed facial patch (c) Following feature extraction, the feature vector (d) Using classification techniques, compare the input vector with the vectors kept in a repository to distinguish the most likely class (the red rectangle). The vector $x_{m,n}$ represents the n_{th} vector in the m_{th} class, and N_k represents the overall faces kept in the k_{th} class. This picture represents each face patch as a d-dimensional vector.

1.2.1 TAXONOMY OF FACE RECOGNITION METHODS

facial recognition software Face detection and face recognition are typically the two successive steps in a face recognition system. Face detection, which was described in the previous part, aims to extract the facial zone from the picture. The face section is then submitted to a face recognition tool for authentication. Fig. 3 depicts the framework of this procedure.

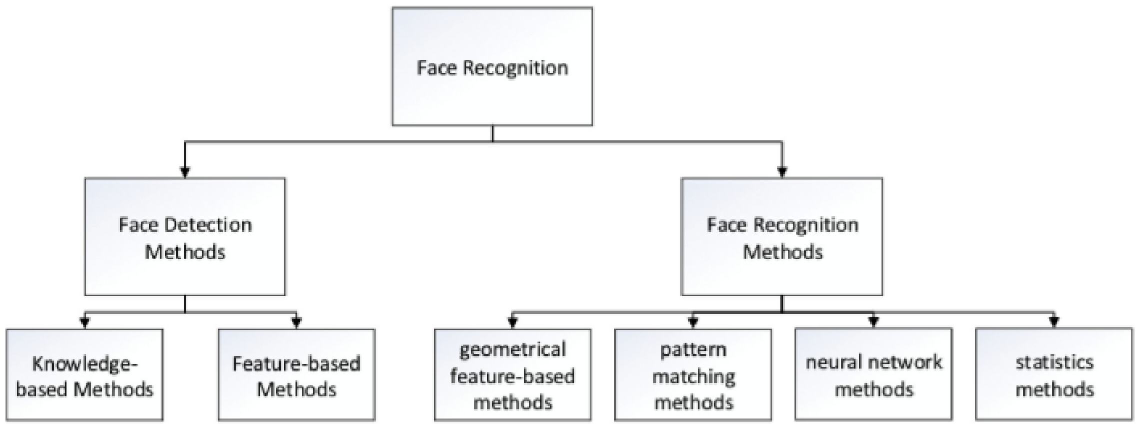

Figure 3: Face recognition system

a. Face detection: In order to find and separate the facial zone from the backdrop, face detection is a step that face recognition systems must do. In general, knowledge-based methods and feature-based methods can be used to categorise face detection [12].

i. Knowledge-based methods: The foundation of knowledge-based approaches is essentially a set of criteria developed by researchers based on their prior understanding of human faces, such as the distribution of face colours or the angle or distance between the eyes, nose, and mouth. The majority of these laws are simple and accessible. Mobile devices are used in a face detection system that operates in real-time. The system comprises layers for face detection and image pre-processing and is built using OpenCV, an on-demand machine vision software toolkit. Grayscale transformations are used for better processing, while Gaussian smoothing is used to reduce image noise. Additionally, the pre-processing layer contains binarization for recognizing features and contrast enhancement for smoothed image points' grayscale values. The system looks for Haar-like characteristics, which are intrinsic to OpenCV and are frequently employed in face identification software, in the face detection layer.

ii. Feature-based methods: Based on internal facial features and their geometric relationships, feature-based approaches identify the face region [13]. Feature-based approaches, as opposed to knowledge-based methods, look for constant features as a way of detection. Numerous strategies have been put forth by researchers that first identify face traits before determining whether this is a genuine face. With an edge detector, facial features including the brow, eyes, nose, mouth, and hairline are often extracted. The facial area can be represented by creating statistical models based on the extracted characteristics that describe the association between each feature. However, because these elements severely degrade the borders of the face, feature-based approaches are constantly vulnerable to light, noise, and occlusion.

b. Face recognition: Three types of face recognition techniques can be distinguished: early geometrical methods based on features and pattern matching techniques; neural network techniques; and statistical techniques.

i. Geometric feature-based methods: The early methods of face identification relied on a face's geometrical characteristics [14]. The goal of this type of procedure is to accurately record the dimension and location in relation to important facial features including the brows, eyes, nose, and mouth. After that, face contour data is added in order to categorise and identify the faces.

ii. Pattern matching approaches: The basic categorization techniques in the world of recognizing patterns are those that use pattern matching. Since face photos in a collection of images are regarded as the pattern, an association coefficient among the pattern and the new image can be produced to deliver the ultimate face recognition outcome.

iii. Neural network-based methods: In the 1940s, Warren McCulloch and Walter Pitts introduced the idea of artificial neural networks to the fields of mathematics and algorithms. Artificial neural networks are modelled after biological neural networks, which have several neurons. ANNs' neurons are essentially a collection of distinct functions, each of which is in charge of a specific task. The data that comes from the neuron before it is preprocessed by weighted connections that join the neurons. The ability of neural networks to retain scattered data that may be processed in parallel is a benefit when using them for face recognition. While a single neuron has a basic structure and only a few functionalities, a full neural network made up of many neurons is capable of achieving a variety of intricate tasks. The ability of the neural network to improve itself over repeated iterations is another important characteristic it possesses. Multi-level BP networks and RBF networks are the two most prevalent neural network techniques for face recognition.

iv. Statistics-based methods: Researchers who study facial recognition are interested in statistics-based techniques. A statistics-based approach aims to learn the statistical characteristics of a face, record them through learning, and then classify the face using the learned information. Figure 4 depicts the learn and classification process.

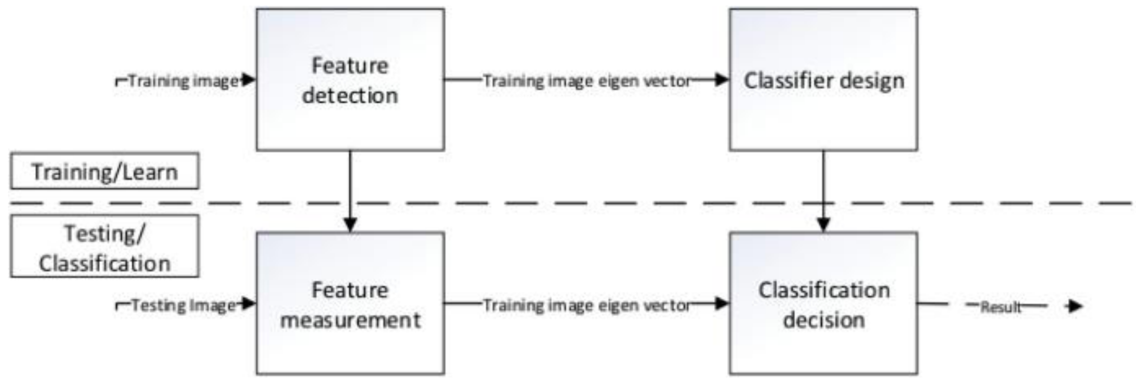

Figure 4: Learning and classification

The most common kind of statistics-based techniques is subspace analysis [15]. The main concept is to reduce the image of the face from a space that is highly dimensional to a region with fewer dimensions using a linear or non-linear modification. Some of the popular approaches in this category are described below:

a. Linear Discriminant Analysis (LDA): LDA represents a technique utilized in supervised learning to reduce the dimensions of data. It achieves this by minimizing the spread of data points belonging to the same category and maximizing the distinction between data points of different categories. Consequently, it projects data from a higher-dimensional space to a lower-dimensional one, resulting in the utmost level of discrimination between classes in the abridged space. When considering a data matrix $X = [x_1, \ldots x_n] \in R^{d\times n}$, consisting of n samples $\{x_i\}_{i=1}^{n}$ in a $\mathbb{R}^d$, the main focus is on extracting feature linearly. This process involves utilizing a linear transformation G, represented by a matrix in $\mathbb{R}^{d\times l}$, to convert each data point x_i, for $1 \leq i \leq n$ from the original d-dimensional space to a new vector x_i^L in an l-dimensional space. By employing this transformation, a constrained number of l features are created.

$$x_i \in \mathbb{R}^d \rightarrow x_i^L = G^T x_i \in \mathbb{R}^\ell (\ell < d). \quad (1)$$

Assume that the data matrix X has the following groupings:

$$X = [X_1, \ldots, X_k] \quad (2)$$

Where n_i is the sample size of the ith class, n_i is the sample size of the ith class, k is the number of classes, $X_i \in \mathbb{R}^{d \times n_i}$ is the data matrix made up of data points from the ith class, and $\sum_{i=1}^{k} n_i = n$. The following definitions apply to the three matrices known as within-class, between-class, and total scatter matrices in LDA [16]:

$$S_w = \frac{1}{n} \sum_{i=1}^{k} \sum_{x \in X_i} (x - c_i)(x - c_i)^T$$
$$S_b = \frac{1}{n} \sum_{i=1}^{k} n_i (c_i - c)(c_i - c)^T$$
$$S_t = \frac{1}{n} \sum_{i=1}^{n} (x_i - c)(x_i - c)^T \tag{3}$$

where c represents the global centroid and c_i is the centroid of the ith class. It is shown that $S_t = S_w + S_b$. Define the following three matrices:

$$H_w = \frac{1}{\sqrt{n}} [X_1 - c_1 (e^{(1)})^T, \ldots, X_k - c_k (e^{(k)})^T]$$
$$H_b = \frac{1}{\sqrt{n}} [\sqrt{n_1}(c_1 - c), \ldots, \sqrt{n_k}(c_k - c)]$$
$$H_t = \frac{1}{\sqrt{n}} (X - ce^T) \tag{4}$$

where the vectors $e^{(i)} \in \mathbb{R}^{n_i}$ and $e \in \mathbb{R}^n$ and are all ones. The three scatter matrices can therefore be written as follows [18]:

$$S_w = H_w H_w^T \quad S_b = H_b H_b^T \quad S_t = H_t H_t^T. \tag{5}$$

It follows from (1) and (2) that

$$\text{trace}(S_w) = \frac{1}{n} \sum_{i=1}^{k} \sum_{x \in X_i} \|x - c_i\|_2^2$$
$$\text{trace}(S_b) = \frac{1}{n} \sum_{i=1}^{k} n_i \|c_i - c\|_2^2. \tag{6}$$

It can be seen that the trace S_b computes the distances between each class centroid and the global centroid, and the trace S_w measures how close each data point is to its class centroid. G converts the three scatter matrices into an area with a smaller dimension.

$$S_w^L = G^T S_w G \quad S_b^L = G^T S_b G \quad S_t^L = G^T S_t G^T. \tag{7}$$

In the dimensionality-reduced space, LDA seeks to increase the distance between classes and decrease the distance within classes. This can be done by concurrently increasing trace S_b^T and decreasing trace S_w^L [17].

b. Independent Component Analysis (ICA): The estimation of the independent characterization of human faces is done using independent component analysis (ICA). Such representations have been supported as a general coding approach for the visual system by Atick and Redlich. Different human faces are known to correlate or depend on one another. It's crucial to separate the independent fundamental faces from the associated ones. A data matrix called X is used to represent the collection of human faces, with each row standing for a different face. The rows of a mixing matrix A can be used to express the correlation between rows of matrix X. Rows of the source matrix S are used to represent the independent fundamental faces. These independent faces are separated from a group of dependent ones by the ICA algorithm. It should be noted that ICA shares many similarities with the technique known as blind source separation (BSS), in which correlated and uncorrelated sources are separated without prior knowledge of the correlation between the source's components. Among many other image analysis issues, these methods have been used for 3D object recognition, sign recognition, and autonomous navigation. The batch method, however, is no longer sufficient for the emerging new trend in computer vision research, which calls for the gradual derivation of all visual filters from very lengthy real-time video streams online. The system must function while fresh sensory input is coming in for the online creation of visual filters.

High image dimensions cause a sharp increase in compute and storing difficulty. Hence, the concept of utilizing a genuine procedure to compute the primary independent components for observations (faces) arriving consecutively becomes quite effective. Each eigenvector or key element will be changed into a non-Gaussian component using the FastICA technique. It ought to be emphasized that a random vector is considered non-Gaussian if the pattern of its distribution is not a Gaussian distribution. if the source matrix S has Gaussian uncorrelated elements, then every element of the mixed matrix X will similarly be Gaussian but correlated.

$$X = A.S. \tag{8}$$

If the random variables to be estimated are Gaussian random variables, the FastICA technique cannot be solved. This is because S is always a non-Gaussian vector and the joint distribution of the elements of X will be totally symmetric, providing no unique information about the columns of A. A high-dimensional vector made up of $n \times m$ pixels will be used to represent each image x, which is represented by $a(n, m)$ matrix of pixels. It should be emphasised that the distribution of image intensities is non-Gaussian [18].

c. Principal component analysis: Data is frequently represented as vectors and matrices in computer science, especially in the context of Big Data. When it comes to photos, a higher resolution translates into a greater matrix size. Even if today's computers are capable of processing vast amounts of data in a short amount of time, efficiency must still be taken into account. Principal component analysis is a well-known and effective method for reducing the dimensionality of data via a linear transformation. The fundamental requirement is to maintain important information while lowering the data dimensionality. In statistics, the distribution and variation of a set of data are always examined using the mean value, standard deviation, and variance. Eqs below can be used to calculate these three values.

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

$$s = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}}$$

$$s^2 = \frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1} \tag{19}$$

Nevertheless, only one-dimensional data can be used with the mean value, standard deviation, and variance functions. The data in computer science is invariably multidimensional. Covariance is a novel measurement that expresses the relationship between data of multiple dimensions and must thus be included. As demonstrated in Equation, covariance can typically be used to characterise the association between two random variables.

$$cov(X, Y) = \frac{\sum_{i=1}^{n} X_i - \bar{X}(Y_i - \bar{Y})}{n-1} \tag{20}$$

As a result, as the dimension rises, it becomes necessary to calculate many covariances; for example, following equation illustrates how many covariances are required when working with n-dimensional data [19].

$$\frac{n!}{(n-2)! \times 2} \tag{21}$$

Thankfully, a matrix technique provides a flawless answer to this calculation. The definition of a covariance matrix is shown in Eq.

$$C_{n\times n} = (c_{i,j}, c_{i,j} = cov(Dim_i, Dim_j)) \tag{22}$$

A dataset with three dimensions (x, y, and z) is depicted by the covariance matrix in Equation [11].

$$C = \begin{pmatrix} cov(x,x) & cov(x,y) & cov(x,z) \\ cov(y,x) & cov(y,y) & cov(y,z) \\ cov(z,x) & cov(z,y) & cov(z,z) \end{pmatrix} \tag{23}$$

The diagonal of the covariance matrix, which is symmetric and displays the variance of each dimension, can be calculated. Through the use of above, one can determine the eigenvalues and eigenvectors of the covariance matrix once it has been created.

$$A\alpha = \lambda\alpha \tag{24}$$

Where A is the initial matrix, λ denotes one of its eigenvalues, and α denotes the eigenvector determined by eigenvalue λ. Eigenvalues are often arranged in descending order according to the significance of the eigenvector. Choosing the amount of knowledge to recall is a personal choice. In this situation, it is crucial to choose an appropriate threshold that allows useful information to be maintained while excluding less critical information.

1.3 CHALLENGES OF FACE RECOGNITION TECHNOLOGY

Face recognition technology has been used to identify genuine people, although there are still some issues.

i. Face recognition technology is still in its infancy, so there are issues like algorithm improvements and automatic image registration technology on the one hand, and hardware issues, algorithm complexity, algorithm recognition rate, facial light mode, expression, and random posture on the other. Because real-world populations are dynamic and there is a dearth of research into dynamic face recognition technology, the influence of practical use in the sphere of security for the public will be diminished [20].

ii. The criminal databases used by public security agencies to store suspects for arrest (database data based on sought or fugitives) information often only provide positive images, albeit it might be challenging to compare these images to actual face images that have been located.

CHAPTER 2: LITERATURE REVIEW

J. Yang, et.al (2023) suggested a curriculum learning loss function called HeadPose-Softmax for classifying the issue of a sample on the basis of its facial pose, and a new training method was adopted to recognize the deep face [21]. This approach considered that the samples were significant in accordance with dissimilar effort of every sample, and it assisted the model in deploying hard samples completely, learning the pose invariant attributes, and enhancing the accuracy while detecting multi-view face. This approach was capable of adjusting the relative position of the hard samples with regard to the pose angle of the face in the hard samples when the data was trained. The experimental results indicated that the suggested approach offered superior accuracy for recognizing the face.

A. -C. Tsai, et.al (2020) introduced a convolutional neural network (CNN) algorithm at which the training was done for enhancing the accuracy to recognize the face with the potential of capturing facial features [22]. The introduced algorithm helped in tackling the situation in case of occlusion in face. The face detection network (FDN) was implemented for computing all the face areas and facial landmark in the input image. The facial landmark was employed for aligning the face and the implemented network utilized it for recognizing the face. According to experimental results, the introduced algorithm offered an accuracy of 96.15% with the occlusion ratio (OR) 25% and 88.46% with 50% OR. Moreover, this algorithm led to enhance the accuracy in case of occlusion face.

G. C. Lee, et.al (2021) analysed that in an indoor environment, a surveillance camera was useful for covering an extensive region with multiple persons [23]. Hence, only lower resolutions of face images were obtained to recognize the face. A method was established to recognize the face in images of low resolution in which CNN was exploited in an inside scenario. The initial focus of this method was on detecting the face regions using the YOLOv3 model and recognizing face images with the help of the trained model. An indoor classroom was utilized for capturing the face images of higher resolutions. The testing results indicated that the established method was feasible.

X. Luan, et.al (2023) projected a new technique known as multi-level dynamic error coding (MLDEC) [24]. Initially, a multi-level pyramid model was constructed to provide complete and local sparse picture, for extracting the gallery dictionary patches so that a local gallery dictionary was generated. The generic dataset patches were extracted to create a variation dictionary for portraying the potential facial variations. Subsequently, a method of DEC was put forward based on an error function at diverse levels for mitigating the negative affect of disparities. Eventually, this technique emphasized on fusing the modified complete and local errors to classify the face. Experimental results exhibited that the projected technique had superior generalized capability to dictionary and its robustness was proved against facial variations under SSPP.

C. -F. Hsieh, et.al (2020) developed a technology of face recognition and combined with Line communication software for building an intelligent checkout system [25]. A YOLOv3-tiny-based system was constructed for recognizing the face. The face was recognized on the WIDER FACE database in order to train the method and the GoogLeNet was helped to enhance the accuracy to recognize the face. The result indicated that the developed approach assisted in enhancing the accuracy up to 7.57% as compared to GoogLeNet. Moreover, the combined approach had potential for transmitting the consumption details automatically.

U. Cheema, et.al (2022) designed a Deep Neighborhood Difference Relational (DNDR) model and Joint Discrimination Loss (JDL) to recognize disguised Heterogeneous face (HF) [26]. This model was implemented for computing the difference associations among cross-modality images in deep feature space and learning the associations among images having the same identity. For an input image pair, the designed model offered an output as identity representative embeddings of every image. The next task was to fuse the embedding distance and the match probability to increase the robustness for classifying the face at higher accuracy. The experimental results on public databases confirmed that the designed model was effective for recognizing the face.

Z. Chun-Rong, et.al (2020) emphasized on face recognition (FR) technology on the basis of deep learning (DL) [27]. The HOG feature was adopted for recognizing the images so that the face target was detected in the image. The impact of facial expression and posture was diminished by aligning the face. When the attributes for recognizing the face were extracted, the neural network (NN) was put forward for recognizing the face. The experiments were conducted to compute the presented approach. According to the results the presented approach was useful for enhancing the efficacy 1.5 times with the help of deep learning (DL) and it was proved adaptable to recognize the face.

W. Su, et.al (2023) formulated a new Hybrid token Transformer (HOTformer) approach for identifying the key facial semantics to recognize the face through atomic and holistic tokens [28]. This approach concentrated on producing the atomic tokens from small fixed-size areas for learning fine-grained core illustration and the holistic token from large adaptively-learned areas for capturing the coarse-grained contextual illustration. This approach was considered as a plug-and-play module. This module was inserted into convolutional networks (ConvNet) in a hierarchical way for creating a concise HOTformer-Net which effectively enhanced the accuracy for recognizing the face.

W. Kong, et.al (2022) presented a new Laplacian pyramid algorithm to recognize deep 3D face [29]. First of all, the 2D to 3D structure representation technique was adopted for fully associating the information of crucial points, and dense alignment was modelled. After that, the 3D critical point system was considered to developed a five-layer Laplacian depth network (LDN). 3D face depth images were mapped and re-constructed to recognize the face at superior precision. In the end, this algorithm was trained by embedding the MSRW into LF for enhancing efficacy to recognize the face. The results validated the robustness and adaptability of the presented algorithm in harsh, low light, and noise environments.

B. Tej Chinimilli, et.al (2020) recommended a face recognition (FR) based attendance system to attain lower false-positive rate (FPR) and a threshold to euclidean distance value [30]. Haar cascade was deployed to detect the face as it was robust algorithm and LBPH algorithm was adopted to recognize the face. This system worked robustly against monotonic grayscale transformations. The recommended system was quantified with regard to face recognition rate (FRR) and FPR considering a threshold to detect the unidentified individuals. The recommended system provided an accuracy of 77% for recognizing the face and FPR of 28%. This system was applicable to recognize the students even if they wore glasses or grown a beard

D. Yadav, et.al (2021) constructed a system for recognizing the face within the browser itself using serverless edge computing [31]. For the students, a simple web portal was put forward for navigating this plugin extension, at which the model was capable of capturing the attendance and updating in a dynamic way. The face was detected through TFD, and it was face recognized on the basis of Face Recognition Net (FRN). Various algorithms were implemented with these two models to recognize the student from their livestream, check whether they were authentic with their logged in IDs, and update the attendance.

Y. Ge, et.al (2022) discussed that a higher efficacy was required to recognize the masked face (MF) [32]. A Convolutional Visual Self-Attention Network (CVSAN) algorithm was devised in which self-attention (SA) was deployed for augmenting the convolution operator. For this, a convolutional feature map was associated for imposing the local attributes to a SA feature map so that the long-range dependencies were modelled. Moreover, a Masked VGGFace2 dataset was generated on the basis of an algorithm of detecting the face, for training the devised algorithm. The experimental results demonstrated that the devised algorithm performed more efficiently for recognizing the face as compared to the traditional methods.

D. Lin, et.al (2022) suggested an effective system to recognize the masked face (MF) [33]. At first RetinaFace model was put forward for detecting and aligning the masked face robustly. At second, a deep convolutional neural network (CNN) algorithm was presented to recognize the face and the ArcFace loss with a local consistency regularization (LCR) loss was alleviated for training this algorithm. It assisted the algorithm in simultaneously learning the globally discriminative face depictions of dissimilar identities jointly and their counterparts with synthesized facial masks. The experiments exhibited the supremacy of the suggested system and its applicability in a portable Jetson Nano device.

X. Zheng, et.al (2022) focused on analyzing in-depth the complicated physical-world conditions in case of facial attacks [34]. An innovative robust physical attack model recognized as dubbed PadvFace was investigated for dealing with these variations. Additionally, this analysis indicated the variation of the assault complications under diverse physical-world circumstances and an effectual CAA model was put forward for regularly adapting the adversarial stickers to environmental variations. Lastly, a standardized testing protocol was designed for computing the physical attacks accurately while recognizing the face. The experimental results revealed that the investigated model performed more robustly as compared to other approaches.

C. Yu, et.al (2022) intended a new meta-learning-based adversarial training (MLAT) algorithm to perform deep 3D face recognition (3DFR) on point clouds [35]. Primarily, this algorithm was employed for generating the adversarial samples of given 3D face scans in a dynamic way. Secondly, a meta-learning model was developed for avoiding the performance degradation occurred due to the generated adversarial samples. Therefore, this approach resulted in creating distinct and appropriate adversarial samples. Moreover, the meta-learning model was assisted in enhancing the accuracy of intended algorithm. The experimental results demonstrated that the intended algorithm offered an accuracy of 100% on BU-3DFE dataset, on 99.78% Bosphorus, 98.02% on BU-4DFE and 98.01% on FRGC v2.

Raman, et.al (2023) developed Multiscale Facial Action Regression System (MFARS) algorithm for recognizing the face [36]. In this, the mage features were segmented, the image pixel values were analyzed, and the face features functions were extracted. This algorithm employed Facial recognition (FR) system for retrieving information so that the images were recognized with enhanced sharpness. This procedure was consisted of diverse phases in which the image was completed, features were extracted, and finally the expression was classified. The simulation result confirmed that the developed algorithm offere superior accuracy for detecting the face.

X. Bai, et.al (2020) presented a face recognition (FR) based attendance method for recognizing the face [37]. The mobile platform and FR technology was employed for optimizing the manual attendance procedure. This method was employed for splitting the data into the FR method of check on work attendance information input, attendance sign-in and attendance record 3 function module. A notion was developed for detecting and classifying the face and analyzing the procedure of developing this system. The Android platform design was presented for evaluating the presented method. The experimental outcomes indicated that the presented method was feasible and recognized the face at higher accuracy.

Y. -X. He, et.al (2021) established the Harr feature model for detecting the face, and the EigenFace technique was presented for extracting the distinctive face information [38]. A technique was put forward for recognizing the face to simulate the actual condition. The image enhancement approaches, namely histogram equalization, Retinex, and Median filtering were implemented for processing the portraits. The ORL library and self-collected set was considered for computing the established approach. The experimental outcomes reported the superiority of established approach for recognizing the face.

L. Liu, et.al (2022) designed a novel technique on the basis of LBP algorithm for enhancing the depth belief network (DBN) to recognize 3D face [39]. At first, an analysis was conducted on both algorithms. At second, this technique emphasized on attaining LBP texture feature vector of 3D face image and employing it as input feature in second algorithm for capturing the local information of 3D face image. At last, a procedure of recognizing 3D face image and realized 3D face was executed on improved DBN. The FERET database was employed in the experimentation. Based on the results, the designed technique offered superior accuracy and least time in comparison with existing technique.

B. Huang, et.al (2022) devised a new Progressive Learning Loss (PLFace) to generate a progressive training model to recognize the face [40]. The initial task was to learn the feature illustrations of mask-free samples. Thereafter, this model focused on converging the mask-free cases and considered masked cases till the collection of masked sample embeddings in the center of the class. The entire procedure considered that normal samples were contracted and masked samples were gathered later on. The experimental results on benchmarks depicted the effectiveness of the devised model at higher accuracy and to maintain the efficacy of the performance of recognizing normal face.

M. Zhang, et.al (2022) formulated a method for lessening the negative impact of mask defects to recognize the face [41]. A cost-effective, precise technique of masked face synthesis called mask transfer (MT) was presented to augment the data. Afterward, an AMaskNet was put forward for augmenting the efficiency of recognizing the masked face. In the meantime, the entire method was optimized with the help of E2E (end-to-end) training method. In the end, MS method was helped to augment the efficiency in the inference phase. RMFRD, COX and Public-IvS datasets were utilized to compute the formulated method. The experimental outcomes exposed that the formulated method performed efficiently to identify the masked face.

S. Hangaragi, et.al (2023) presented a model in which a Face mesh model was applied to detect and recognize the face [42]. Several varied illumination and background situations were utilized for deploying this model. This model had potential for handling non-frontal pictures of individuals. The Deep Neural Network algorithm was trained on the images of Labeled Wild Face (LWF) dataset and images gathered in real-time. The testing indicated that in case of matching of face standards of the testing image with the standards of images used to train the data, this framework resulted in providing a name to the person or an output as unknown. According to the results, the presented model yielded an accuracy of 94.23% to recognize the face.

J. Li, et.al (2021) projected a new Fast FAce Recognizer (Fast-FAR) for enhancing the speed of Deep Convolutional Neural Network (DCNN)-based system to recognize the face [43]. The inexpensive features were employed for recognizing the identifiable face images in a precise way with an increase in computation. Meanwhile, the costly deep layers were utilized to process the samples of lower quality, larger pose variations or occlusions. The Reinforcement Learning Agent (RLA) model was presented for learning a decision policy which a reward function had determined. This policy helped to adaptively decide whether the face was recognized at a primary layer, or proceeded to the following layers. Hence, the FF cost was lessened for the informal faces. The constructed model was computed on LFW, AgeDB-30 and CFP-FP datasets. The results depicted that the constructed model led to mitigate the inference time by 14.22% on first dataset, 20.61% on second, and 7.84% on last.

A. Maafiri, et.al (2022) designed a novel technique named Local Binary Pattern and Wavelet Kernel PCA (LWKPCA) for recognizing the face robustly [44]. This technique emphasized on extracting the discriminant and vigorous information for diminishing the recognition errors. Initially, the RKPCA algorithm was employed. Subsequently, the Color Local Binary Pattern (LBP) and Wavelet Descriptor were adopted for extracting the features. The dimensionality of these attributes was alleviated using the projected technique. 2D-DWT and LBP was assisted in creating a new feature grouping scheme. The major focus was on investigating the finest representation of face image in a Discriminant Vector Structure (DVS). ORL, GT, LFW, and YouTube Celebrities datasets were employed for evaluating the projected technique. The experimental results exhibited that the accuracy of projected technique was computed 100% on first dataset, 96.84% on second GT, 99.34% on third, and 95.63% on last dataset.

H. -Q. Chen, et.al (2022) investiagted a method in which image super-resolution technology was implemented to pre-process the image along with a deep bilinear module for enhancing EfficientNet algorithm [45]. This method was utilized for fusing the SF domain attributes related to un-occluded regions of face, and classifying fused features. Moreover, the accuracy to recognize the mask face was augmented after maximizing the attributes of the un-occluded region. The results on RMFRD dataset indicated that the designed method attained an accuracy of 98% and fast speed. Moreover, based on the results on a real time system, the designed method provided 99% accuracy and this method was proved efficient and practical.

H. Qi, et.al (2023) intended a real-time technique for detecting the face on the basis of blink detection [46]. First of all, Local Binary Pattern (LBP) algorithm was exploited for extracting the features that resulted in removing the issue related to illumination changes to a certain extent. After that, ResNet model was fed with the extracted features, and an attention mechanism was employed for enhancing the process of extracting features. In addition, Bidirectional-Long Short Term Memory (BiLSTM) technique was deployed for extracting the temporal attributes of images from different angles so that more facial details were acquired. In the end, the face key point detection (FKPD) method was adopted for computing the eye EAR value and recognizing the real-time face against the fraud. The devised technique provided an accuracy of 99.48% on NUAA dataset, 98.65% on CASIA-SURF and 99.17% on CASIA-FASD.

H. B. Bae, et.al (2020) constructed a new model which had two modules: image translation module and the feature learning for generating an enhanced cross-modality matching system for heterogeneous datasets [47]. The initial one employed a PC technique, CycleGAN, and SN to preserve the contents and change the styles amid basis and destination domain. The latter one made the utilization of a training dataset jointly for adjusting the framework in the visual domain. Hence, the features of probe and gallery testing datasets were matched discriminatively and robustly. The CUFSF and the CASIA NIR-VIS 2.0 datasets were executed in the experimentation. The suggested model performed more effectively as compared to the traditional techniques.

G. Rajeshkumar, et.al (2023) introduced a new deep learning (DL) based Faster Region-based Convolutional Neural Network (R-CNN) that was combined with Internet of Things (IoT) for recognizing the face in the office [48]. A database was employed for collecting the images of existing employees and the NN was trained after pre-processing these images. Furthermore, VGG-16 algorithm was utilized for extracting the attributes from pre-processed images. The feature classification allowed the door to be opened in case a member of an organization approaching the door and remain locked for the unknown persons. A cloud was employed for storing the images of official and unofficial persons, and transmitting them to the office manager for monitoring. The results validated that the intended algorithm was effective to recognize the face at an accuracy of 99.3%.

A. -C. Tsai, et.al (2021) developed a mechanism in which Convolutional Neural Network algorithm was implemented with a pre-trained system for recognizing the face robustly and extract the facial features [49]. This mechanism helped in augmenting the accuracy to identifying the partially occluded face. Furthermore, the feature pyramids were adopted for lessening the number of network metrics and obtaining the scale invariance. The receptive field was exploited with the help of an image context module due to which the accuracy to detect the face was enhanced and memory consumption was alleviated. The experiment outcomes exhibited that the recommended algorithm was performed better to detect and for recognizing the occluded faces.

H. -I. Kim, et.al (2022) suggested a face shape-guided deep feature alignment (FSDFA) model to recognize the face misalignment robustly [50]. A face shape prior was considered for training the suggested model in which the alignment procedures were executed. The pixels were aligned to decode the aggregated feature whose extraction was done from a face image and face shape prior. The auxiliary operation was carried out for rebuilding the well-aligned face image. The association of aggregated attributes with the face feature extraction network due to the feature alignment procedure, resulted in training the robust face attribute for misaligning the face. The experimental results indicated that the suggested model was effective for recognizing the face.

Y. Wang, et.al (2022) analyzed the rudimentary principle and procedure of recognizing the face, and a Principal Component Analysis (PCA) and Support Vector Machine (SVM) algorithms based method was introduced [51]. This technique was assisted in recognizing the LFW dataset, and gridsearchcv helped in adjusting the parameters so that precision and recall were enhanced to recognize the face. The experimental results reported that the introduced method was effective for decreasing the dimension of face data as well as maximizing the recognition accuracy. Thus, this method was proved feasible for recognizing the face.

M. -T. Chiu, et.al (2021) presented two CNN algorithm for enhancing the efficacy to recognize RGB-D face [52]. The primary was DepthNet for estimating the depth maps from colored images to localize the face area accurately. The other was a new mask-guided RGB-D algorithm. The initial one was useful for augmenting a great dataset to a colored face dataset. Besides, the presented algorithm had potential for fully developing the depth map and segmentation mask information. The robustness of this algorithm was proved against pose variation as compared to earlier approaches. The experimental results indicated that the presented algorithm offered reliability for recognizing face.

L. Tan, et.al (2021) developed a face recognition (FR) technique [53]. The procedure of recognizing face had 3 portions in which the face was detected, illustrated and recognized. Then, an analysis was conducted on this technique, and PCA algorithm was put forward to recognize the face. Formerly, Visual Studio 2013 was employed for creating a FR system based on open CV was developed, and the face was detected and recognized, located, face feature was annotated, and then open the second photo was employed to recognize the face at last.

Simultaneously, the testing was done on every module and the entire procedure. The findings exhibited that the developed technique worked effectively.

V. R. Nagarajan, et.al (2021) designed a novel methodology for recognizing faces with pre-trained models using Genetic Algorithm and 2D Fast Fourier Transform in microcontrollers [54]. A hearty and memory-efficient model was suggested in which pre-trained systems were employed and doesn't need to retrain the data to identify the novel faces. The trained data is in the request for a couple of KBs and the feature vector size for every picture is in the request for a couple of KB. Thus, it was adaptable on lower end MCUs and Node Microcontrollers. The designed methodology was assessed on real time datasets. The testing results indicated the supremacy of the designed methodology over others.

Y. - C. Huang, et.al (2022) recommended a hearty masked face recognition system [55]. The matching is balanced on the grounds on attributes extricated from consistent face districts. The method comprises of CN and 2 FE methods. The first one groups an input face picture into a masked or simple face. The latter one extricates the attribute of a full face, and different purposes a directed perceptual misfortune to zero in the feature extraction on the non-blocked piece of the face. The system is tried on both manufactured and genuine data. The face check accuracy is worked on by 2.4% for LFW data set, 1.9% for the MFR2, and 5.4% for RMFD. The outcomes indicated that the recommended method further develops accuracy and preserved the data.

Y. Wang, et.al (2021) conceived a practical face recognition algorithm based on CNN method and TensorFlow deep learning structure is proposed for face multi-pose and occlusion recognition issues [56]. Right off the bat, a technique was laid out. The TensorFlow technique employed MTCNN system whose training was done on huge data set. Besides, CASIA-Webface dataset was utilized in the experimentation, and the LFW helped to train the system model. According to results, the developed system offered an accuracy of 98.78 % for recognizing the face as compared to others.

Efanntyo, et.al (2020) investigated a face recognition system to record attendance can lessen the event of direct contact and allow every individual to maintain a protected distance, including from the attendance gadget [57]. A MRF technique was employed for performing SSD and ResNet to extract attributes. Python was executed to simulate the investigated system and the results exhibited that this system offered higher accuracy to recognize the face. This assessment was done at distances amid the face and the camera and estimated at room at precision of 0.67. The method supports an attribute of transmitting a notification to each representative which can't join work on their booked business days.

G. Singh, et.al (2020) built entire strategy for authenticating any face data is sub-separated into two stages, in the primary stage, the face detection is done rapidly with the exception of those cases where the item is put very far, followed by this the subsequent stage is initiated in which the face is perceived as an individual [58]. Afterward, at that point, the entire cycle is rehashed consequently assisted to create an innovative framework. Essentially, there are two kind of strategies: Eigenface method and the Fisherface method. The Eigenface method fundamentally utilize PCA for augmenting the face layered space of the face attributes. The results reported the applicability of the built strategy.

S. Hao, et.al (2022) Face recognition under ideal circumstances is viewed as a very much tackled issue with progresses in deep learning. Recognizing faces under occlusion, in any case, actually remains a test [59]. A FFR-Net algorithm was designed to identify masked and normal faces the same. The rectification blocks were put forward to correct attributes separated via a cutting edge system for increasing the distance amid a masked face and normal one in the rectified feature space. The findings demonstrate the effectiveness of the designed algorithm to recognize the faces accurately.

M. Luo, et.al (2021) laid out a Face Augmentation Generative Adversarial Network (FA-GAN) to diminish the influence of imbalanced disfigurement trait conveyances [60]. We propose to decouple these qualities from the character representation with an original various leveled unraveling module. Besides, GCNs were put forward to recuperate geometric information for which the interrelations were discovered among local districts to ensure that the characters were preserved in process of augmenting the face data. Broad simulation results exhibit the adequacy and speculation capacity of the designed algorithm.

Z. Jianxin, et.al (2020) introduced a face recognition method of local occlusion based on the feature and meager representation of block-oriented gradient histogram (HOG) and local binary pattern (LBP) [61]. To begin with, a method portioned the face picture and separated both features from every block for gaining the oriented gradient histogram - local binary pattern joint attribute. Principal component analysis algorithm employed them into the feature subspace to lay out an occluded word reference, and at that point, characterized and recognized by meager representation remaking remaining later on. Contrasted and the conventional methods on 2 data sets, the introduced method provided higher accuracy for detecting the face.

T. Lindner, et.al (2020) designed face recognition and face detection system based on a single-board PC [62]. These Haar feature-based cascade classifier was contrasted and a MTCNN. The creators utilized FaceNet, that was used to map the face pictures onto a minimized Euclidean space. This system resulted in embeddings as feature vectors whose deployment was done in classifier. The training and testing of this approach was on an exclusive data set and. The designed approach offered accuracy of 97%. The objective was of conveying the chance to effectively adopt the approach on less energy-effective gadgets.

D. Montero, et.al (2022) extended an end-to-end approach for training face recognition models based on the ArcFace design, including different changes to the spine and misfortune calculation [63]. The method of augmenting the data was assisted in producing a masked variant of the original dataset and blend them to train the data. we change the picked network to yield likewise the probability of wearing a mask. Subsequently, the misfortune of recognizing the face and the mask-use misfortune are converged to make another capability called MTArcFace. The simulation outcomes exhibit that the extended approach outflanks the existing methods, while achieving comparable measurements on real world data set. Moreover, its accuracy was 0.9978.

A. R. Revanda, et.al (2020) laid out Generative Adversarial Networks (GANs) is a deep learning method that can make union pictures with great [64]. This examination expects to use the suggested algorithm to synthesize the face pictures as a type of augmenting the process to train the data. first of all, the LSR was employed in this algorithm to insert styles to the face picture with the help of LDA model. In the analysis, the misfortune esteem had the option to reach 15%. In the analysis of recognizing face, the expansion of face picture union had the option for augmenting the accuracy to recognize face up to 89%.

K. Eiamsaard, et.al (2021) recommended a system called Smart Inventory Access Monitoring System (SIAMS) that integrates an inserted system with face recognition into an inventory system [65]. The installed system is appended with a RGB camera. The first module leads to transmit identified face pictures to next module to recognize an individual as the individual's name or obscure class on the basis of DL method. The method accomplished cutthroat accuracy in standard assessment measurements to detect and recognize the face. The recovered information was utilized for discovering what is happening. The approach was extended with method of OD and individual tracking system to distinguish burglary progressively.

S. Hörmann, et.al (2021) total the faces directly in request to furthermore obtain a single representative face as an intermediate result, from which a more discriminative feature vector is extricated [66]. To defeat the restriction of a decent number of input pictures of the best in class in face collection, a change invariant U-Net design was equipped to process an erratic amount of edges, that was utilized in a GAN. Results show the viability of this approach on 3 famous data bases to recognize face. Our methodology beats existing methods on the YouTube Faces dataset, at accuracy of 0.9662.

V. Kumar, et.al (2021) fostered a framework of multi-face recognition for continuous checking, bringing about concurrent face following and recognition [67]. In the first place, the faces are recognized in the video frames utilizing VJ method. we plan a face skeleton based on YCBCR color space for recognizing and extracting the additional feature points. Formerly, at that point, HC feature points and SURF feature points are distinguished from every face, where initial ones are utilized to follow the faces in the video and the latter ones are utilized to separate facial attributes from the cropped faces., faces are all the while perceived by the prepared classifier (support vector machine). The tests propose that our technique is dependable, precise, and powerful.

X. Ke, et.al (2022) formed an original face recognition design called LocalFace to remove local face features [68]. To begin with, by examining the dispersion of huge attributes in face pictures, a productive FFPLF method and work on this strategy for developing a more viable face dynamic LFE conspire. Hence, a block-based random occlusion technique was developed for the impediments of the random face occlusion strategy to all the more likely reproduce the occlusion circumstance in genuine scenes. Eventually, a definite conversation was built on the CAtt technique which was more suitable to recognize face and grouping errands. Broad analyses on different benchmarks exhibit the prevalence of our LocalFace, and some portion of the exploratory outcomes accomplish SOTA results.

Y. Cho, et.al (2023) introduced Complementary Attention Learning and Multi-Focal Spatial Attention that unequivocally eliminates covered area [69] via preparing complementary spatial attention to zero in on two unmistakable locales: veiled districts and foundations. In our strategy, standard spatial attention and organizations center around exposed districts, and concentrate veil invariant attribute while limiting the deficiency of the regular Face Recognition execution. For traditional method, we assess the exhibition on 3 data sets. We assess the execution on the ICCV2021-MFR/Insightface track, and show the superior exhibition on the both datasets. Also, we exactly check that the introduced strategy is all the more definitively actuated in exposed locales.

CHAPTER 3: METHODOLOGY

3.1. PROBLEM FORMULATION

Face recognition technology is still in its infancy, so there are issues like algorithm improvements and automatic image registration technology on the one hand, and hardware issues, algorithm complexity, algorithm recognition rate, facial light mode, expression, and random posture on the other. Because real-world populations are dynamic and there is a dearth of research into dynamic face recognition technology. The face recognition technique has various phases which include face detection, classification and extraction of characteristics. In the past years, a variety of machine learning techniques have been put forward for classification. The machine learning techniques include SVM, Random Forest, KNN etc. It is analysed that techniques which are already been proposed give low accuracy. The hybrid machine learning algorithm needs to propose which give high accuracy for the face recognition.

3.2. OBJECTIVES

Below are the different goals: -

1. To research and evaluate many machine learning algorithms for face recognition.

2. To implement various machine learning algorithms for face recognition.

3. To proposed hybrid machine learning algorithm for face recognition.

4. To put the suggested algorithm into practise and evaluate it for accuracy, precision, and recall.

3.3. RESEARCH METHODOLOGY

The study presented a method to identify faces at various stages, which are as follows:

1. Preprocessing: The process of recognizing a face is just getting started. The platform accepts as input a collection of images created from a trustworthy source of information. The photos were gathered using Kaggle. Processing the pictures that are provided to achieve successful execution removes noise from the photographs.

2. Classification: - To prediction the face and age model of transfer learning is applied which is the combination of VGG16 and CNN model. The VGG16 is used as the base model over which CNN model is used for the training.

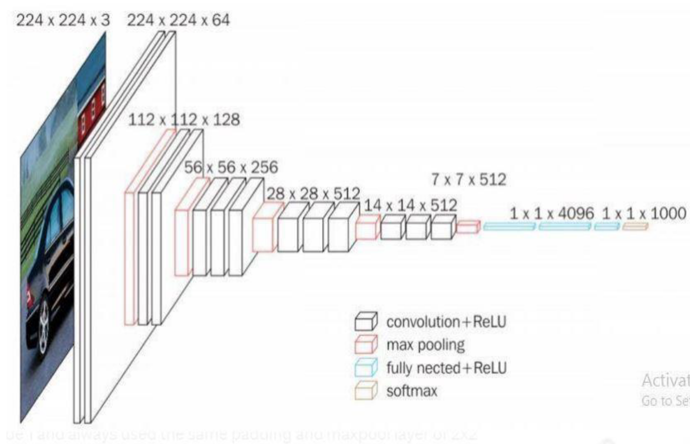

Figure 5: VGG16 Model Architecture

Following are the various specifications of VGG16 Model: -

1. The 16 in VGG16 stands for 16 weighted layers. 13 convolutional layers, 5 Max Pooling layers, 3 Dense layers, and a total of 21 layers make up VGG16, but only sixteen of them are weight layers, also known as learnable parameters layers.

2. VGG16 accepts an input tensor of size 224, 244 with three RGB channels.

3. The most distinctive feature of VGG16 is that it prioritized convolution layers of a 3x3 filter with stride 1 rather than a large number of hyper-parameters and consistently employed the same padding and maxpool layer of a 2x2 filter with stride 2.

4. The the design's convolution and max pool layers are positioned uniformly.

5. Conv-1 Layer has 64 filters, Conv-2 Layer has 128 filters, Conv-3 Layer has 256 filters, Conv 4 Layer has 512 filters, and Conv 5 Layer has 512 filters.

6. Three Fully-Connected (FC) layers, the third of which conducts 1000-way ILSVRC classification and has 1000 channels (one for each class), are added after a stack of convolutional layers. The first two FC layers each have 4096 channels. The soft-max layer is the last one.

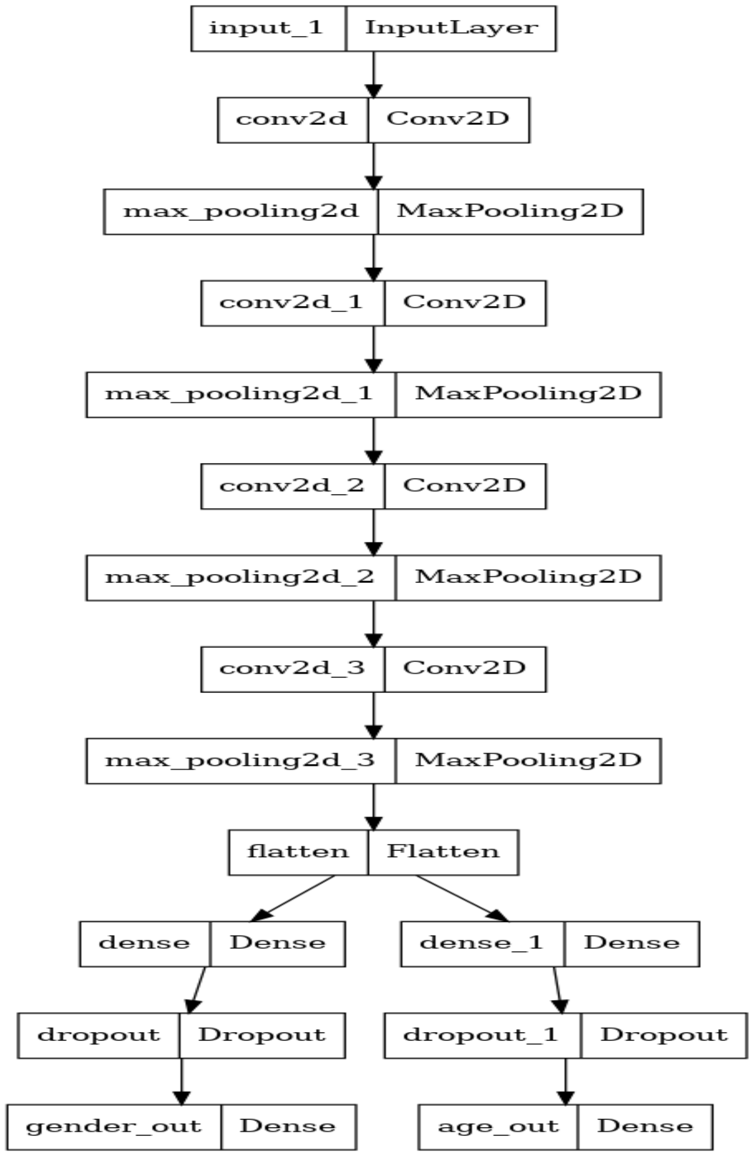

Figure 6: Proposed Model

CHAPTER 4: RESULTS

4.1. DATASET DESCRIPTION

UTK Face dataset is consisted of huge number of images with long age span within 0-116 years old. Around 20,000 face images having annotations of age, gender, and ethnicity are comprised in this dataset. The pictures are used for covering huge disparity in pose, face appearance, illumination, occlusion, resolution, etc. A number of tasks can be performed using this dataset such as to estimate the age, detect the face, localize the landmark etc.

4.2 RESULTS

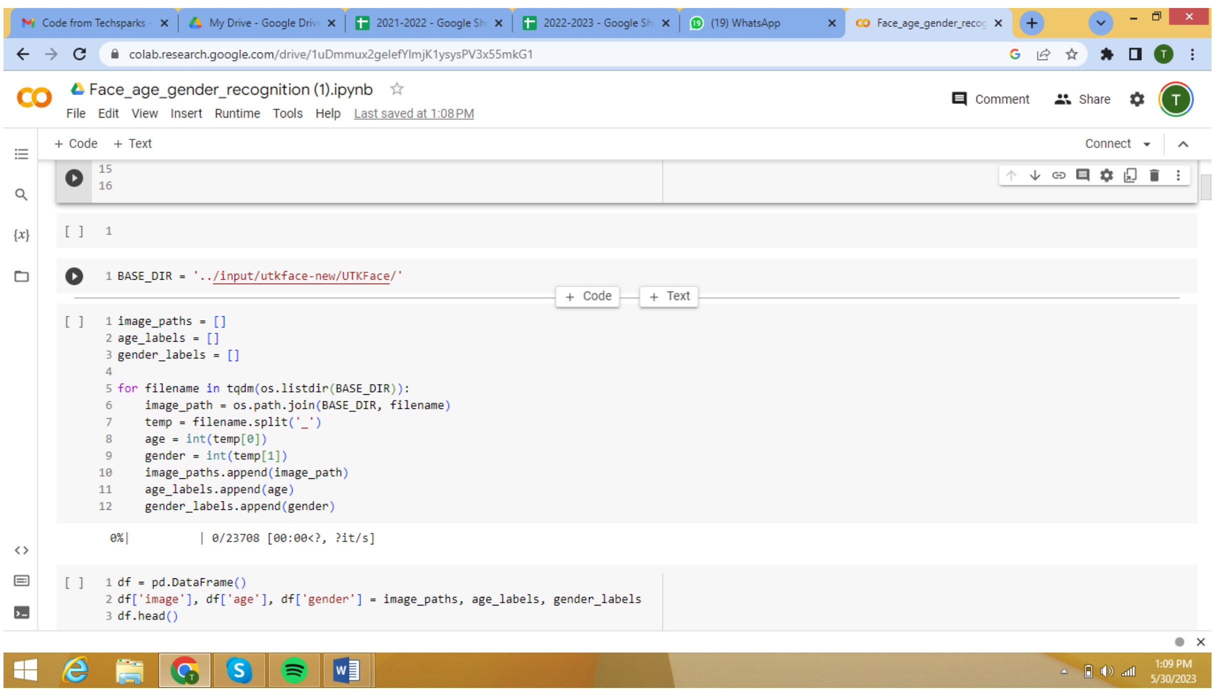

Figure 6. Dataset Read

As shown in figure 6, the dataset of UTK faces is used in the research work. The read of the directory is illustrated in the picture.

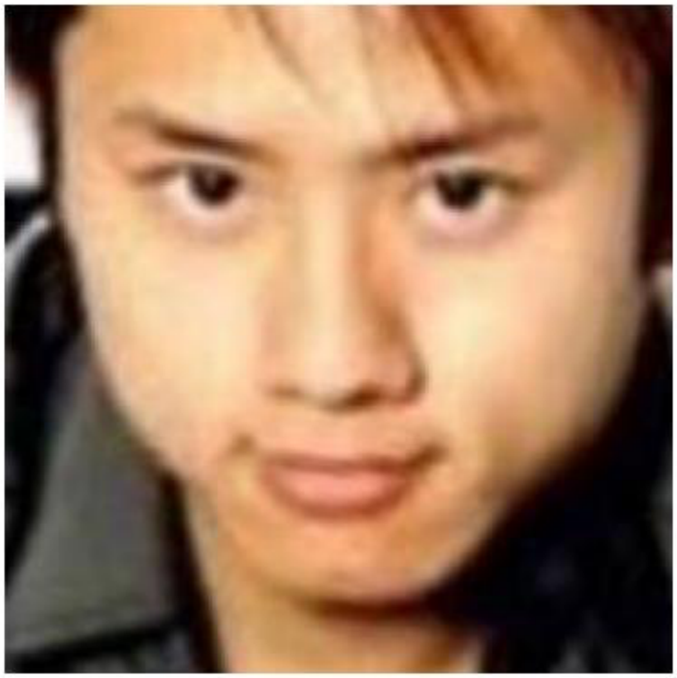

Figure 7: Input Image

As shown in figure 7, the dataset single sample image for the recognition.

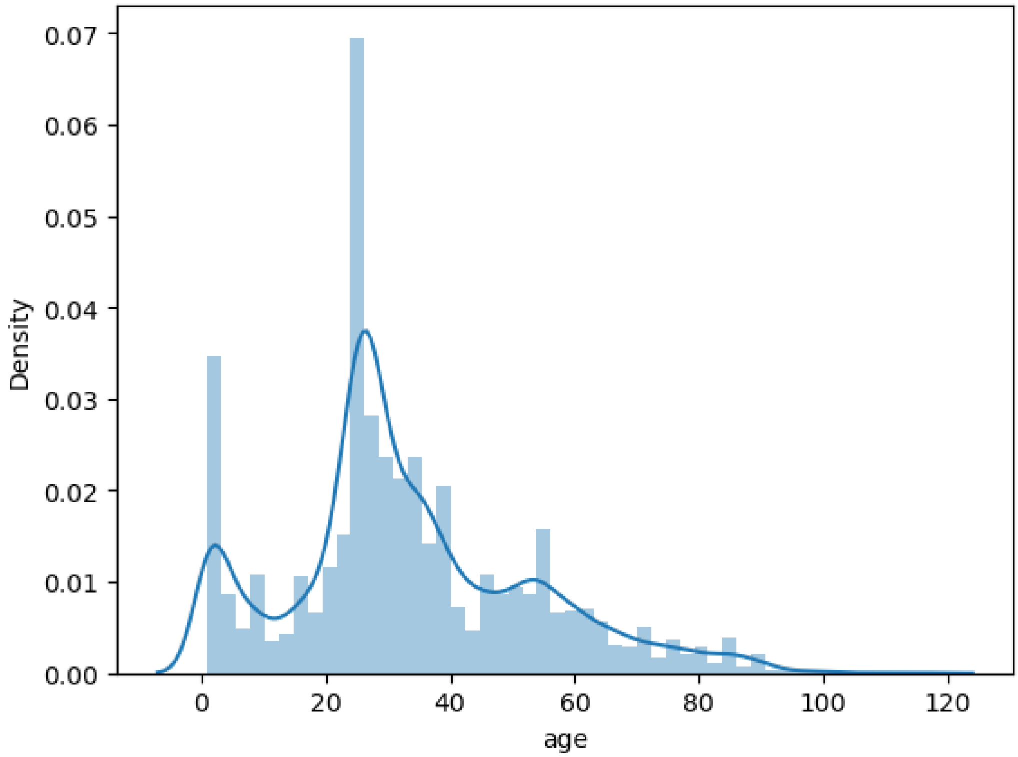

Figure 8: Data Distribution

As shown in figure 8, the age distribution of the various images in the dataset is described.

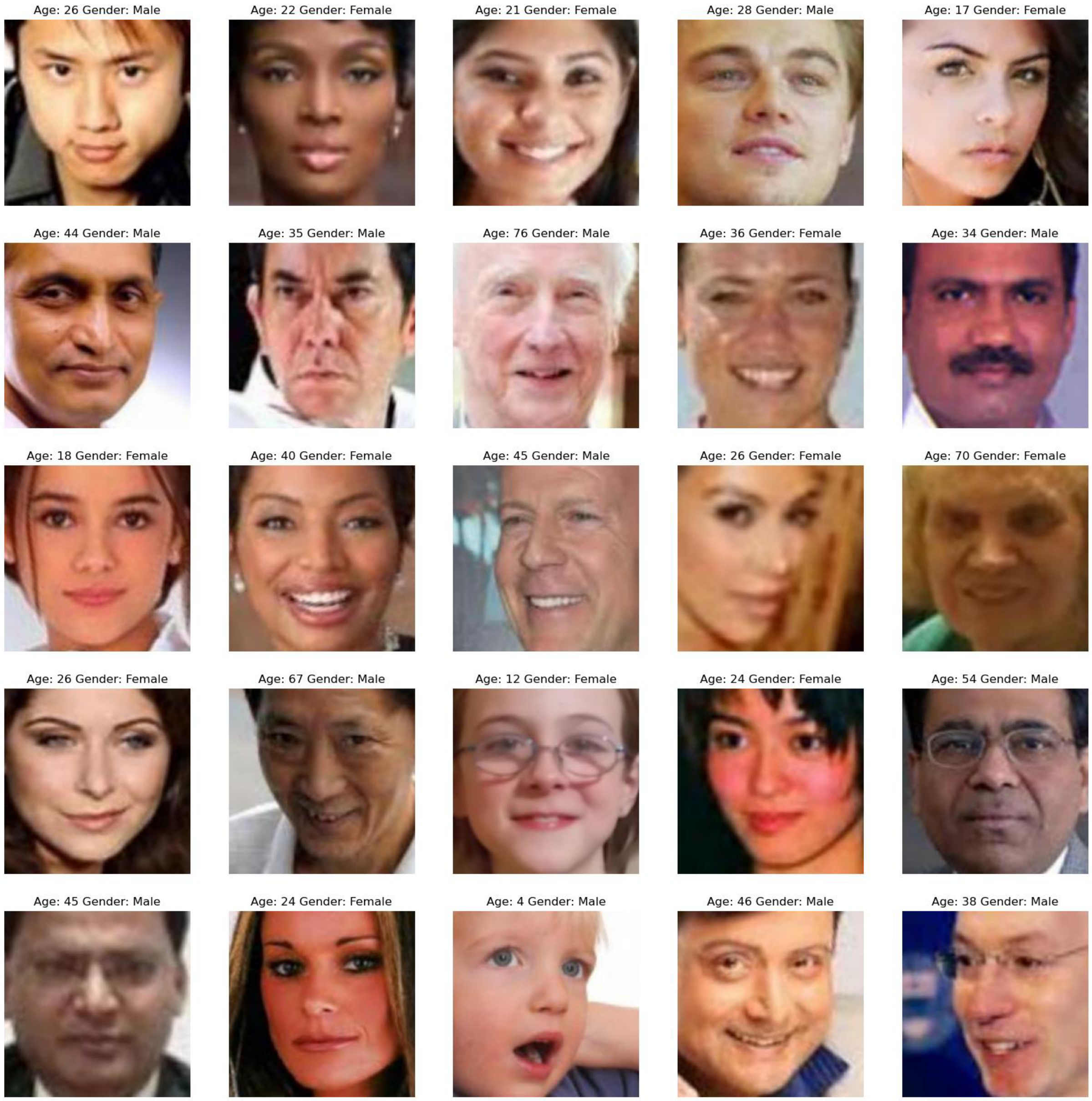

Figure 9: Sample Images

As shown in figure 9, the sample images of the dataset is described.

Figure 10: Prediction result

As shown in figure 10, the prediction of the model is illustrated which give result of female and age is 16.

Figure 11: Prediction result

As shown in figure 11, the prediction of the model is illustrated which give result of male and age is 95.

Table 1: Performance Analysis

Model	Accuracy	Precision	Recall
SVM	84.56 Percent	84 Percent	84 Percent
KNN	82.34 Percent	82 Percent	82 Percent
Proposed Model	92.34 Percent	92 Percent	92 Percent

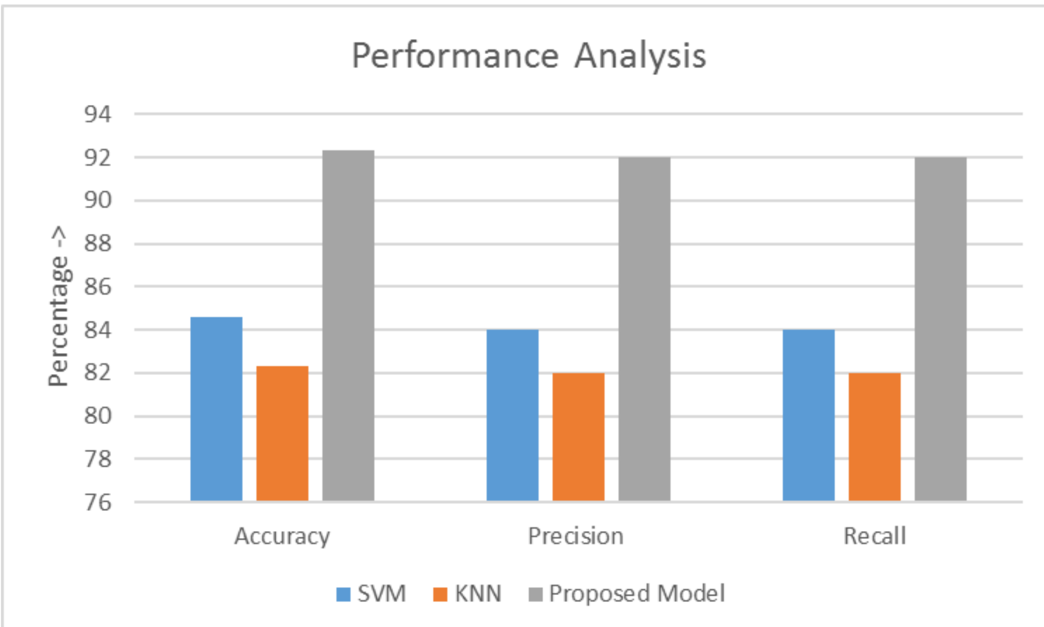

Figure 12: Performance Analysis

As shown in figure 12, the performance of proposed model is compared with SVM and KNN. It is analysed that deep learning model achieves accuracy of 92 percent which is 10 percent high than other models.

CHAPTER 5: CONCLUSION & FUTURE SCOPE

5.1. CONCLUSION

One of the most commonly used biometric user authentication techniques is face recognition. A typical method for how an automatic face recognition system functions is to extract a set of traits from an individual's face, such as geometric characteristics or information about the textures and shapes of all of the elements of an individual's face. Before applying a recognition algorithm, faces must first be recognized in a picture using some sort of detection technique. As a result, the identification of a face is the initial phase in a successful recognition procedure. These methods typically failed due to their extreme sensitivity to changes in lighting or image scale, as well as the fact that they could only identify faces in specific situations, such as pictures with a high contrast with a white backdrop. The face recognition model is proposed in this research work which is based on transfer learning. The proposed model is the combination of VGG-16 and CNN. The proposed model is implemented in python and results is analysed in terms of accuracy, precision and recall. The proposed model achieves 10 percent high accuracy as compared to existing models.

5.2. FUTURE SCOPE

The possible future scenarios are as follows:

1. The suggested model is expanded utilising additional training models.

2. The suggested framework may be contrasted with other facial recognition deep learning algorithms.

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LIST OF PUBLICATIONS

[1] S.Pachnanda and A. Bhat, "Advance Approaches Towards Invariant Face Recognition: A Survey", communicated and accepted at 7th International Conference on Intelligent Computing and Control Systems (ICICCS 2023).

[2] S.Pachnanda and A. Bhat, "Transfer Learning Model for Invariant Face Recognition", communicated and accepted at 5th International Conference on Advances in Computing, Communication Control and Networking (ICAC3N 2023**).**

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