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Automatic Human Face Detection and Recognition Based On Facial Features Using Deep Learning Approach

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Abstract

In recent years, there has been an increased emphasis placed on the identification of face traits in studies. The human face is the most significant characteristic that may be used in the process of identifying a person. Even the most genetically identical twins may be distinguished from one another by a few key facial characteristics. Therefore, to discern one from the other, a human face identification and detection system that is based on facial traits is necessary. This study suggests a technique for automated human face identification and recognition based on facial characteristics that are achieved via the use of deep learning. It would seem that deep learning, with its high rate of accuracy, would be an appropriate method to use while carrying out face recognition. Face detection and identification may be accomplished using a process known as deep learning. According to the results of the study, it is possible to conclude that the approach that was suggested is superior to other ways in terms of accuracy, precision, recall, and f1-score.

Keywords: Detection and recognition, deep learning, facial features, human face, CNN.

I. Introduction

Face searching for proof of identity in each application, the monitoring of bank self-service cash machines, face decryption for mobile phones, and Alipay's new face-brushing technology are just a few examples of the growing prevalence of face detection and recognition as a result of scientific and technological progress. Everyone has to be able to "pass" face recognition software. The constant evolution of technology has brought face detection and identification closer to everyday life. Face detection and recognition technology add a fun element to technology while also making life simpler and faster. Through the use of high-tech technology to secure the security of our belongings and identities and to achieve the connection between technology and life, it is an essential element of our lives. Examples of such operations include unlocking the phone, paying for the face, and intelligently identifying. With the rapid advancement of artificial intelligence in recent years, facial recognition has grown in popularity. A person's face is one of the most readily identifiable features that can be used to differentiate between individuals.

Face recognition is a form of personal identification that works by comparing a picture of a person's face with a database of that person's other identifying information. The human face recognition process can be broken down into two distinct phases: the first is known as face detection, and it occurs very quickly in humans, except for circumstances in which the object is situated at a close range. The second phase is known as face introduction, and it is this phase that recognizes a face as belonging to a specific individual. Eigenface and Fisherface methods are two examples of popular types of approaches that may be found in today's established face recognition patterns. The process of determining whether a previously detected object is a known or unknown face is referred to as "facial recognition." The issue of face recognition and the problem of face detection are frequently confused with one another. The geometric (feature-based) method and the photometric (view-based) approach are the two most common ones taken to solve the challenge of face recognition.

One of the most significant aspects of a photograph or moving picture is its subject matter, and the human face is frequently featured. Within a system that is capable of automatic face recognition, the first step, regardless of how cluttered or simple the background is in a picture or video, is to segment the face. The efficiency of the facial feature extraction procedure has a significant impact on the synthesis performance for model-based video coding. To put it another way, these applications require a trustworthy mechanism for identifying the face's regions and pinpointing its features. In this research, an effective technique for extracting facial features from a cluttered image and detecting faces is presented.

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Facial recognition technology has been present since the 1970s, and after decades of refinement, it is now considered fully mature. The standard method of face detection analyses visual cues including the face's shape and coloring. The facial characteristics of a person may be identified by using traditional face recognition algorithms, which often use landmarks or features extracted from a photograph of the person's face. As can be seen in Figure 1, an algorithm may take into account the position, size, and shape of facial features such as the eyes, nose, cheekbones, and jaw. This information may then be used to find images with the same characteristics. These algorithms may be difficult to understand, demanding of resources, and be sluggish to execute. Furthermore, they may be off if the faces contain noticeable emotional expressions, since this may significantly alter the size and positioning of the landmarks.

Figure 1 Abstract humane face into features.

Recently, improvements have been made to the administration of face recognition systems, which has resulted in this technology becoming more helpful in a variety of different situations, including security and the operations of businesses.

1.1 Face detection

The process of finding faces in an image is referred to as face detection. If faces are found in the image, face detection will return the image location and surrounding area of each face. To recognize faces, image windows need to be divided into two categories: the first category must contain faces, which must be distinguished from the background (clutter). It is not easy since, even though different faces have similarities, there might be significant differences between them in terms of age, skin color, and facial features. Partial occlusion and disguise are additional factors that add complexity to the situation already brought on by varying illumination, picture quality, and geometry. As a result, the ideal face detector would be able to detect a face in any setting, independent of the illumination or background. The first step is a classification job that takes an image as input and returns a binary value of yes or no to indicate whether or not the picture includes faces. Whether or not this picture includes any identifiable human faces is indicated by this value. In the second stage, known as "face localization," a picture is fed in as input, and, in return, a bounding box and label are outputted to indicate the position of any faces within the image (x, y, width, height).

1.2 Face Recognition

The process of using a person's face to identify them based on an image of their face that has been trained on data from a dataset is known as facial recognition. One of the most effective biometric methods for identifying a person is face recognition. It has advantages over other biometric techniques in that it may be used without the user's involvement and has non-intrusive features. Surveillance, smart cards, entertainment, law enforcement, data security, picture database analysis, non-military usage, and human-computer interactions are just a few of the many applications of face recognition technology. The input for face recognition is a digital still or moving picture, and the output is the processed data of the person or thing shown in the input. There are two possible stages to the facial recognition process. Acquiring face pictures through scanning, improving image quality, cropping, filtering, edge detection, and feature extraction are all part of the initial phase of image processing. The second component is a facial recognition method that combines genetic algorithms and artificial intelligence with other methods. Figure 2 illustrates the three processes that make up the face recognition system's process: face detection, feature extraction, and classification.

Face detection is the first step in face recognition. As previously stated, face detection is the process by which a computer searches an input image for an object that resembles a face. The goal of face detection is to identify whether a face is present in the image. If the face is real, the output will show where it is and how big it is. The next stage is to find and extract facial features. Face features include the chin, ears, eyebrows, eyes, nose, and lips. In the final phase, the result is compared to the database to identify the face.

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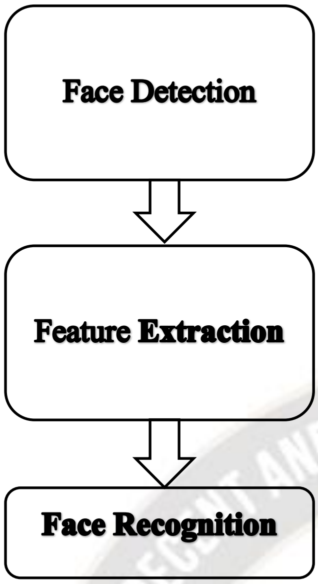

Figure2. Process in face recognition.

The process of automatically identifying, then validating, a person from either an image or a video is included in face recognition. Although facial recognition has been the subject of much research, there are still difficulties to be solved, including:

- Misalignment
- Pose Variation
- Illumination Variation
- Expression Variation

Many strategies must be evaluated to increase the precision and accuracy of face recognition.

- **Feature-based approach**

The term "feature-based approach" is used to describe a method for processing input images that involves first identifying and extracting unique features within the image, like the eyes, mouth, and nose, and then computing the geometric relationship between the points of the face to transform the input face image into a geometric feature vector. The geometric feature performs an analysis of the geometric relationship between facial features. A method known as the elastic bunch graph uses dynamic link structures as its foundation. The use of fiducial points results in the production of a graph for each face. Each point in the graph represents a node in a fully connected graph, and the nodes are labeled according to the response of the Gabor filter.

Features-based and brightness-based approaches to HFR are two popular strategies. Figure 3 illustrates how the feature-based strategy uses distinguishing features and facial indicators including the eyes, nose, mouth, and borders. Just the extracted portion of the image is used during the calculation to make it simpler. The brightness-based strategy accounts for and combines every facet of a picture. This approach also goes by the names of image-based or holistic. The complexity and assessment time of the brightness-based solution is higher in comparison to other methods because the entire picture must be evaluated.

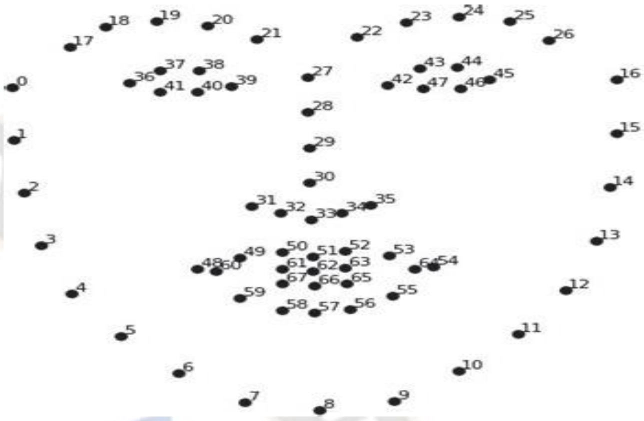

Figure 3: 68 landmarks present on the face (Lukas et al. 2016)

- **Deep Learning**

The creation of artificial neural networks is what led to the development of deep learning. Training of MLPs (Multi-layers Perceptrons), in which a linear layer is produced from the input of the network connection to that of the output. Practice in training MLPs. This is done from the beginning. After that, G. Thomson 2018 came up with a brand new concept that came to be known as deep learning. Deep learning is new model training, as demonstrated in Figure 4.

Deep learning can produce a good approximation of a complicated function by increasing the number of hidden layers; hence, it can produce astonishing results in face recognition. It is a subset of machine language that is responsible for teaching computers to mimic the natural behaviors of humans. As a result, we have decided to use deep learning for the implementation of this work.

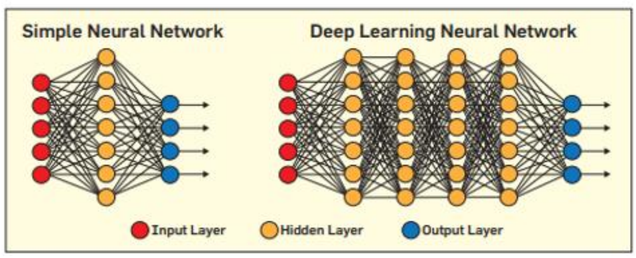

Figure4. Simple neural network vs deep learning neural network

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- **CNN**

Convolution neural networks have recently achieved significant advancements in computer vision. The system has also come a long way in terms of object recognition. Because of the ever-increasing price of computers and the mountain of data required to train a neural network, this technology is now beginning to gain traction. Convolutional neural network (CNN) models feature kernels that can identify an image's boundary or contour. To create and achieve the necessary qualities, this model's weights are placed in an array of values. Every CNN model allots space to decide how an image should be controlled to be identified.

CNN is a type of artificial neural network that uses computing to do tasks similar to those performed by the human brain. Neurons in CNN can be trained to be more efficient. CNN and Artificial Neural Networks vary in that CNN is utilized mostly in the field of pattern identification in images.

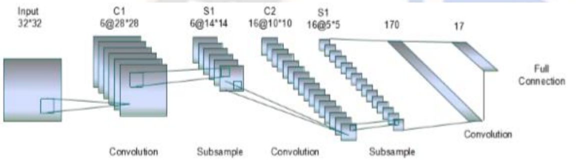

Figure 5.Convolution neural network (CNN) model stages

- **Approach**

The three sequential steps of the proposed study are face detection, face recognition, and face classification. A video camera is utilized in the first phase to record a human face and pinpoint its precise location using bounding box coordinates for the face detected in real-time. In this step, we do face detection with the open CV library and the Haar cascade detection method. Face recognition is achieved by combining the Haar cascade features with the Viola Jones method. Image types include shapes, objects, and landscapes. Faces are identified, features are extracted, and the data is stored in preparation for face recognition. The CNN model, as seen in above figure 5 makes use of VGG 16 to match a face from the database and identify it with its name. Faces from the database are identified, and then they are compared to identify or detect the face using embedding vectors. The distribution platform processes face detection, identification, and classification using software from Jupiter and Python. The picture is included in the Dlib database and other libraries. Face detection comes first, followed by recognition using database features and matching with training and testing databases for CNN models. The identified human face is finally categorized based on facial features such as the eye, ear, mouth, etc. in real-time.

II. Review of literature

Ullah, Rehmat, et al. (2022) created a framework for automatic face recognition based on CCTV photos. Collecting more than 40,000 face photographs to compare algorithm performance to get the greatest recognition accuracy is one of the goals of this effort. They have used many algorithms and achieved great accuracy for CNN. In comparison to PCA with DT, RF, and KNN, CNN is substantially more trustworthy. KNN is a sluggish algorithm that examines every instance in the dataset for prediction while CNN quickly recognizes from its model.

Teoh, K. H., et al. (2021) created a deep learning-based face detection and identification system in this paper. To train this face recognition system, the CNN method of face recognition was used. The accuracy of image recognition is 91.7%, and the accuracy of real-time video recognition is 86.7% when using a massive number of face photos to train a classifier. A small number of variables determine the accuracy of the system. When the light intensity is low, the accuracy drops significantly. The recognition process's main component is the classifier. Classifiers perform better with longer training. To train a robust classifier, images must be in a range of circumstances.

Lu, Peng, et al. (2021) proposed a new method for human face identification on tiny datasets. Face picture adjustments like flip, shift, scaling, and rotation expands the small dataset. An inventive CNN may accomplish facial recognition using the remarkably enhanced face dataset. Several studies show that the enlarged dataset works and the new strategy outperform some of the most popular face recognition systems.

M Rajamanogaran et al. (2021) suggested that by leveraging contactless involvement, the test produced a more accurate framework. Artificial intelligence (AI) is needed to construct smart robots. Using machine learning, algorithms can be designed and altered based on user experience. These artificial neurons mimic genuine neurons' actions to create a neural system. Artificial neural networks (ANNs) can solve real-time issues.

Hussain et al. (2020) suggested real-time face detection, recognition, and classification. Results reveal seven states for classified expressions. The functionality is tested using Anaconda and Python 3.5. Utilizing the Jones and Haar Cascade Algorithm for Face Detection In addition, KDEF and VGG 16 were used as part of a convolution neural network model for face recognition and classification.

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Python uses dlib and other libraries. The 88%-accurate CNN model validates performance measurements.

Sutabri et al. (2019) researched an automated attendance system for university students utilizing face recognition based on deep learning; this study indicates an attendance system for students that uses facial recognition. The system can identify a student's face via the use of a Convolutional Neural Network to detect a face, a Dlib's CNN or deep metric learning for facial embedding, and a K-NN for face categorization. The system uses student ID numbers, dates, and times to record attendance. The present manual attendance procedure will be replaced by this technology, which automates it.

Qu, Danyang, et al. (2018) proposed a CNN-based automation system to increase classifier performance, Haar-like features and AdaBoost are used to extract face areas from the original photos. The results of this study show that doing face recognition in advance increases the performance of a classifier. The accuracy for the original photographs is 69.53%, while the accuracy for face images is 92.09%. The classifier is trained using a CNN with 10 layers, including 5 convolution layers and 2 pooling levels. After testing different optimizers, the suggested method achieves 93.16% accuracy, a substantial improvement over existing methods.

Yan, Kewen, et al. (2017) introduced a convolution neural network (CNN)-based face recognition technique. The network contains nine layers in total. The Caffe is used in the screening and evaluation phases of the training process. When comparing the recognition rates of the ORL face database to the AR face database, the former has a testing set recognition rate of 98.95%, while the latter has a whole database recognition rate of 99.82%. The network also has good robustness and excellent convergence.

III. Research Methodology

The procedures involved in facial recognition are depicted in flowchart form in Figure 6. It is necessary to have an input that can be identified and validated to do facial recognition. Because of this, an image sensor or, more commonly, a camera needs to be configured such that it can record or capture images. The program that is being utilized ought to be suitable for the camera. The following stage involves the image that is being input. The input may consist of still photos, recorded video, or video captured in real-time. Following the provision of the input, it will be necessary to identify faces within the photographs or videos. When the classifier has been properly educated, it may then be put to use to begin the recognition process. It is possible to recognize one or more people in either a video or a picture with this technology. A diverse collection of Python scripts, each tailored to a specific kind of recognition, is made available here. The Python script will import the classifier that was learned in the phase before it to carry out the recognition for the individual. This can be done either from a picture or from the camera.

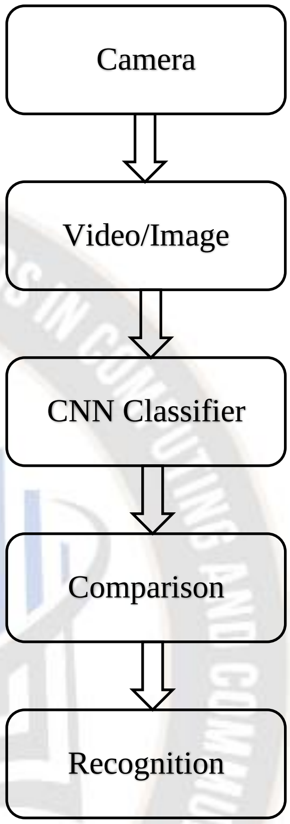

Figure6. Flow chart of face recognition

Face recognition employs cascade classifiers based on the Haar feature set, with the Haar Cascade serving as the frontal face classifier of choice. Simply said, a Haar Cascade is a classifier used to extract the target entity directly from the input. This detection occurs in reverse, with the object being detected first. To generate a Haar Cascade, one must superimpose a positive picture on top of a cascade of negative images. The training is often carried out on a server and consists of several different stages. The use of images of high quality and an increase in the number of stages at which the classifier is trained both contribute to the achievement of better outcomes.

The system classifier part is built on top of TensorFlow, which is the framework that is being used. The process of recognition involves training the classifier and using it. The training procedure takes a significant amount of time to produce a more accurate classifier. The training runs need to be longer in duration for the classifier to become more accurate. The proposed system for facial recognition has a

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training period that lasts for a total of three days. If the training is permissible to continue for a longer period, the amount of loss can be lowered even further, which will increase accuracy.

Accuracy

The accuracy of the system will be evaluated by the recognition of a human face that has been captured several times in a variety of settings. The primary objective of this evaluation is to determine how the level of illumination influences the precision of the system. Using a confusion matrix, the accuracy is checked and confirmed. The reasoning for this computation is as follows in equation 1.

$$Accuracy = \frac{TN+TP}{TOTAL} x100\% \quad (1)$$

Where TN represents the true negative while TP is denoted as the true positive.

IV. Proposed Functional Design

Figure 7 provides an illustration of the proposed system as well as its operational aspects. Each of the individual functional building components is responsible for a distinct operation. The image is taken using an HP 3000 camera, and then it is pre-processed even further so that it can be fed into the neural networks. The collected image is modeled using network architecture to construct and train the dataset for identification and feature classification.

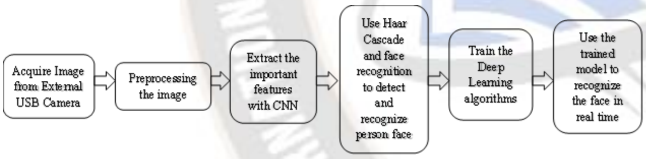

Figure7. Block diagram of Recognition classification and Face detection

1.3 Flowchart and Design Specifications

Figure 8 depicts the real-time face detection, recognition, and classification that were performed on the images. After the image has been transformed into a binary pattern and described as a feature vector, it is encased in a box and then stored in a database. Finally, the database is updated with the new information. The facial features are analyzed and categorized as eye, lip, and mouth before the images are trained to resemble the original input image. There are a total of seven steps that are involved in the training process. These stages are shown in the following table loading the dataset, pre-processing the data, supplementing the data as a feature vector, developing and compiling the design model, training and storing the feature vector, and verifying the test model.

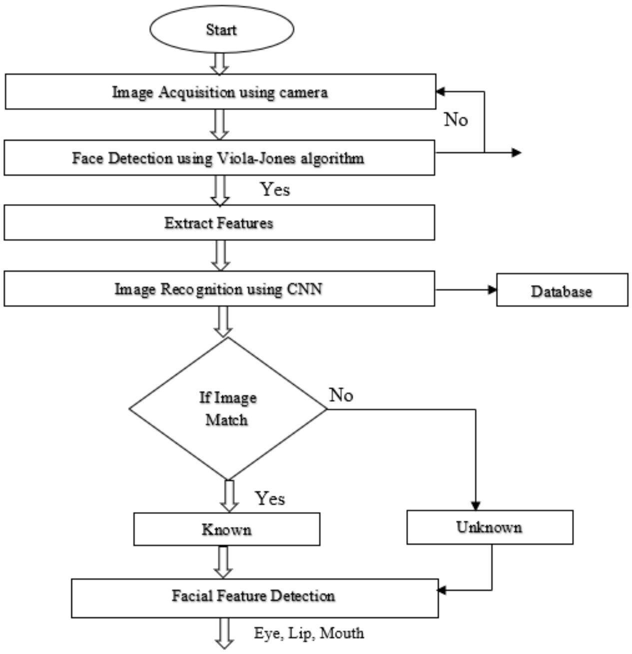

Figure8. Face detection and recognition flow chart

The task involves something called a local binary pattern histogram, or LBPH to convert the collected image into a binary vector. This processing aids the famous Jones algorithm, which can be used to recognize people by their faces. Pixels from the image are saved with a threshold that has been established for the facial feature vector. These vectors, together with their weights, are combined to construct a network architecture model for the categorization of facial expressions using the VGG 16 CNN model, as illustrated in figure 9. In most cases, VGG 16 is educated using the picture net database, which has 16 layers of the network arranged into 1000 categories. The optimal level of pooling is reached by piling up 3x3 convolution layers in ascending order. The 4096 nodes that make up the softmax classifier are connected to these network connections.

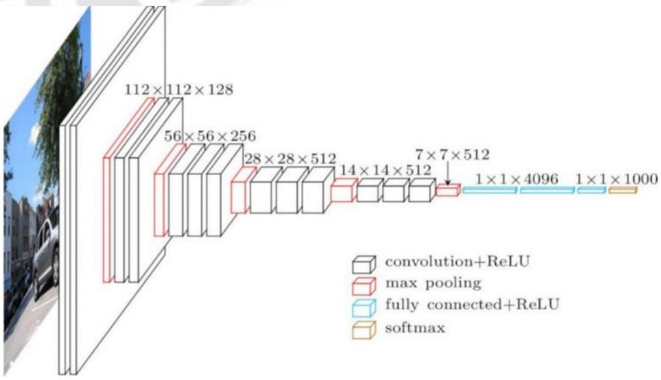

Figure9. VGG 16 net model

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V. Result and analysis

Multiple results illustrate the discrepancy between the proposed model and previous research models. In addition, further findings are demonstrating the efficacy of the proposed model in terms of accuracy, precision, recall, F1 score, and confusion matrix.

Result 1: The result illustrates the accuracy comparison graph between the proposed model and earlier research models. From figure 10, the decision tree classifier attained low accuracy as compared to the random forest and CNN. CNN models have attained high accuracy as compared to random forest classifiers. This result demonstrates that our proposed model obtained maximum and more accuracy as compared to other models. Figure 10 shows the comparative bar graph.

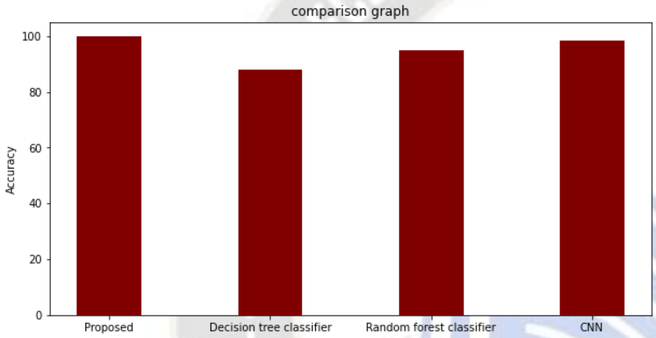

Figure 10: Accuracy comparison graph between the proposed model and earlier research models

Result 2: The result illustrates the F1- score comparison graph between the proposed model and earlier research models. From figure 11, CNN attained a low f1-score as compared to the random forest and decision tree classifier. The random forest classifier has attained a high F1 score as compared to CNN and decision tree classifier, while our proposed model is having F1- score than other models. Figure 11 shows the comparative bar graph.

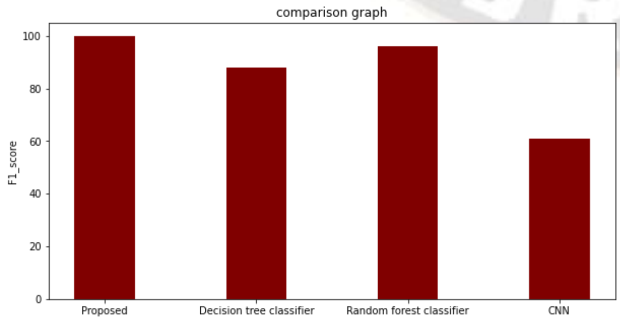

Figure 11: F1-score comparison graph between the proposed model and earlier research models

Result 3: Figure 12 illustrates the loss comparison graph between the proposed model and earlier research models. From Fig.12, the decision tree classifier has obtained maximum loss as compared to the random forest and CNN model. This result demonstrates that our proposed model is having less loss than other models as shown below.

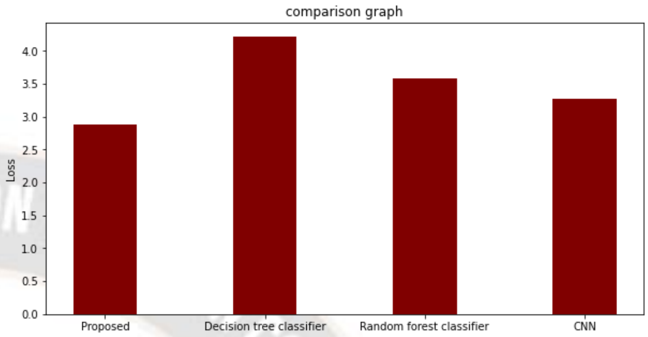

Figure 12: Loss comparison graph between the proposed model and earlier research models

Result 4: Figure 13 illustrates the precision comparison graph between the proposed model and earlier research models. From Fig.13, the CNN model achieved low precision as compared to other models. Random forest classifier has attained the maximum precision as compared to CNN and decision tree classifier. This result demonstrates that our proposed model is having more precision than other models as shown below.

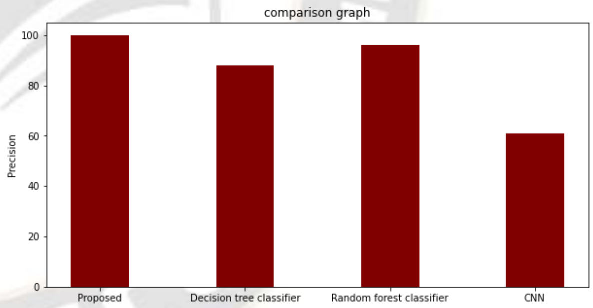

Figure 13: Precision comparison graph between the proposed model and earlier research models

Result 5: Figure 14 illustrates the recall comparison graph between the proposed model and earlier research models. Random forest classifier has high recall as comparison to CNN, while the CNN model has attained low recall as compared to another model as shown below. This result demonstrates that our proposed model is having more recall than other models.

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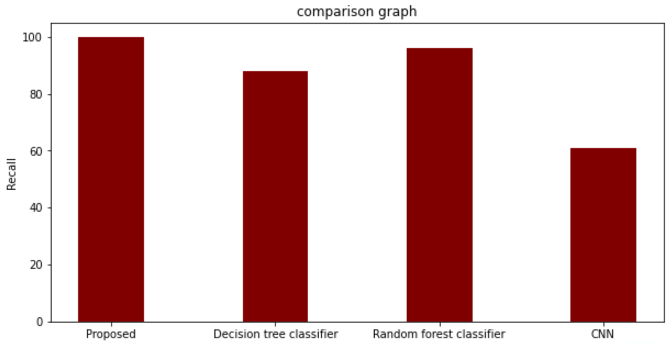
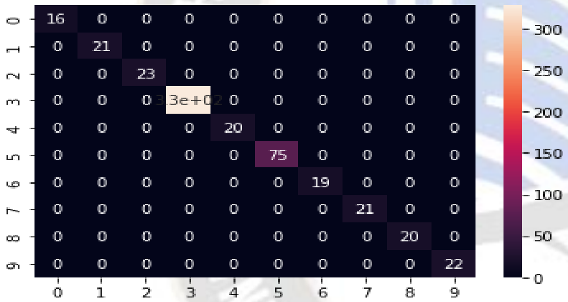


Figure 14: Recall the comparison graph between the proposed model and earlier research models

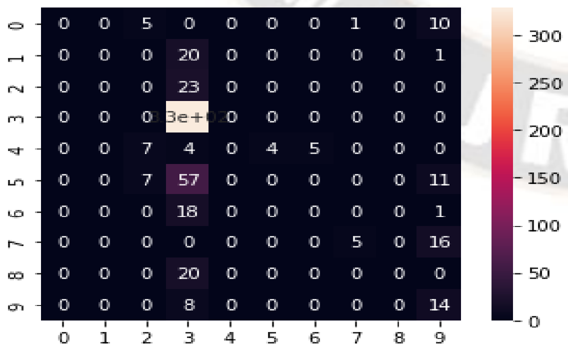
Result 6: The result illustrates the confusion matrix comparison graph between the proposed model and earlier research models. This result demonstrates that our proposed model is having better confusion matrix values than other models. Table 1 shows the comparative bar graph.

Table 3: Confusion matrix comparison of the proposed model and previous research models

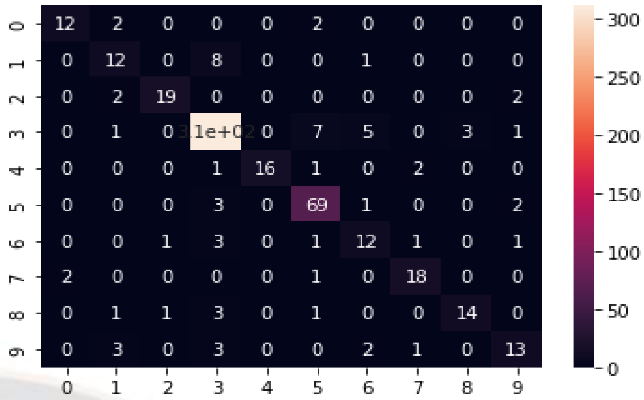
Proposed model



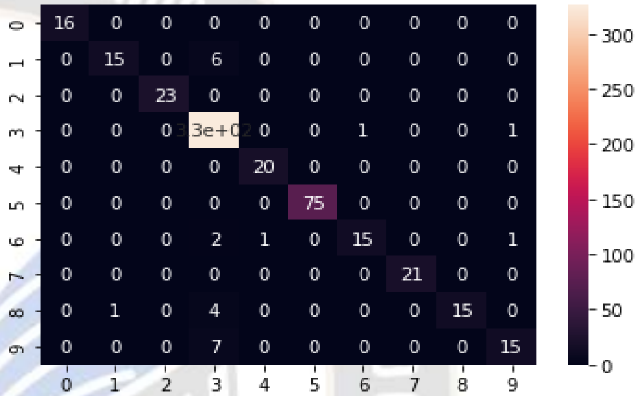
Previous research models



CNN model confusion matrix



Decision tree classifier



Random forest classifier

Accuracy, precision, recall, F1 score, confusion matrix, training loss graph, and training accuracy graph provide further evidence supporting the effectiveness of the suggested model.

Result 1: Figure 15 illustrates the training loss graph of the proposed model. This result demonstrates that our proposed model is having less loss than other models. Figure 15 shows the training loss graph of the proposed model as shown below.

Figure 15: Training loss graph of the proposed model.

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Result 2: Figure 16 demonstrates the training accuracy graph of the proposed model. This result demonstrates that our proposed model is having more accuracy than other models. Figure 16 shows the training accuracy graph of the proposed model.

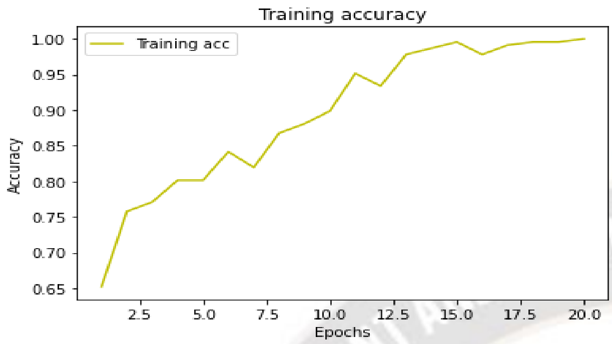

Figure 16: Training accuracy graph of the proposed model.

Result 3: Figure 17 illustrates the confusion matrix of the proposed model. This result demonstrates that our proposed model is having better confusion matrix value than other models. Figure 17 shows the training accuracy graph of the proposed model.

```
Confusion Matrix

[[ 16   0   0   0   0   0   0   0   0   0]
 [  0  21   0   0   0   0   0   0   0   0]
 [  0   0  23   0   0   0   0   0   0   0]
 [  0   0   0 328   0   0   0   0   0   0]
 [  0   0   0   0  20   0   0   0   0   0]
 [  0   0   0   0   0  75   0   0   0   0]
 [  0   0   0   0   0   0  19   0   0   0]
 [  0   0   0   0   0   0   0  21   0   0]
 [  0   0   0   0   0   0   0   0  20   0]
 [  0   0   0   0   0   0   0   0   0  22]]
```

Figure 17: Confusion matrix of the proposed model.

Result 4: Figure 18 presents a demonstration of the suggested model's accuracy, recall, F1-score, and precision value. This result suggests that the model that we have provided has the best value compared to other models. The suggested model's accuracy, recall, F1-score, and precision value are all shown in Figure 18.

```
Accuracy: 1.00

Precision: 1.00
Recall: 1.00
F1-score: 1.00
```

Figure 18: Accuracy, recall, F1-score, and precision value of the proposed model.

Result 5: Figure 19 shows the classification report of the proposed model. This result demonstrates that our proposed model is having best value than other models. The classification report shows the support value, precision, recall, and F1-score of some sample input image data, and this data is classified after the training process and gives the best value in every iteration. Figure 19 shows the classification report of the proposed model.

Classification Report

	precision	recall	f1-score	support
Aaron_Guiel	1.00	1.00	1.00	16
Aaron_Pena	1.00	1.00	1.00	21
Aaron_Tippin	1.00	1.00	1.00	23
Aaron_Sorkin	1.00	1.00	1.00	328
Abbas_Kiarostami	1.00	1.00	1.00	20
Abba_Eban	1.00	1.00	1.00	75
Abdel_Aziz_Al-Hakim	1.00	1.00	1.00	19
Aaron_Peirsol	1.00	1.00	1.00	21
Aaron_Patterson	1.00	1.00	1.00	20
Aaron_Eckhart	1.00	1.00	1.00	22
accuracy			1.00	565
macro avg	1.00	1.00	1.00	565
weighted avg	1.00	1.00	1.00	565

Figure19: Classification report of the proposed model

VI. Conclusion and future scope

In this work, we use a deep learning approach to designing and building a system for recognizing and identifying people by their faces. The whole process of creating this face recognition system is outlined, beginning with data training and ending with the implementation of the suggested method of face recognition. The reliability of the system is mostly unaffected by external variables. This model is trained using a CNN-based technique with a high sample size of photos for each candidate. This has resulted in a massive dataset and increased precision. Examining the data, it becomes clear that the ambient lighting affects the identification procedure. When the lighting is poor, the recognition system is more likely to make mistakes. To fix this, additional low-light-quality training photos should be used to create the face classifier. This study's findings indicate that, compared to the decision tree, random forest, and CNN models, face recognition on images provides the highest accuracy. The parameters such as recall, precision, and f1-score of the proposed method are higher as equated to existing methods. A confusion matrix is generated and the confusion matrix of the suggested method is better as equated to existing methods. To further improve the recognition rate in uncontrolled environments, this work may be expanded to discover a strategy for selecting optimal features from extracted features and also an improved classification model.

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