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A Biometric Recognition Method Using Deep CNN

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Abstract: ***Face is perhaps the first biometric trait of a person that catches one's eye and it remains in memory for a long due to its uniqueness created by almighty. Recognizing a person using his/her face, is very natural to us and we do not need any special training for identification. But computers are programmed for analyzing things and making predictions almost in similar fashion that our brain does. Then, the recognition takes place by using some techniques and trainings. The recognition system which uses biometric properties is itself a secure and trusted technique but use of neural networks make it highly accurate and add more worth to it. A CNN model works in a fully supervised or guided environment and performs all the tasks in a robotic manner. The convolutional layer which lies in CNN model performs the complex calculation and extracts all the unique and useful features without any human involvement. I preferred to adopt Transfer learning in my work, by importing a pre-trained CNN model and I found 97.5% accuracy in recognition when I tested the model with my test samples.***
Keywords: Biometrics, Convolution, AlexNet, Feature Extraction, Transfer Learning.

I. INTRODUCTION

Biometrics recognition refers to a technique where an individual's authenticity is verified using his biological or behavioural traits. Biometrics based systems have evolved as the most secure and the most trusted method for computerized identification. Remembering several passwords for different accounts is really a tough job and there are chances of forgetting passwords. Some people may intentionally steal other's passwords to harm a person or organisation. Today, almost all of the countries have adopted biometric based identities for its citizens. The AADHAR card program of India is actually a biometric based identities of its citizens which is valid in getting all the citizen-centric services. As, people are being more technology dependent, there is also a jump in smart techniques of cyber crimes which has troubled the big companies by increasing the risk of data theft.

Sir, Alan Turing has first time given the concept of "thinking machines" [1] and then after years, the term "Artificial Intelligence" was first time coined in 1956 [2] . As the research and exploration started on Artificial Intelligence, the world came to know the miracles of it and now it seems to have changed the meaning of impossibility. Today, AI driven technologies has entered in or lives everywhere, for example- driverless cars, Alexa assistance, recommendations we get in Netflix, video suggestions in youtube, online shopping advertisements on the basis of our searching, spam filters used in e-mail, conversational bots, etc. The social media sites are using Machine learning technique of AI for understanding the pattern of their visitors.

Biometric based method for authentication is quite secure but tempering of AI makes it more complex for intruders by converting the biological/ behavioural properties into mathematical codes. Deep learning technique, a branch of AI, has completely changed our perception about machines and brought a revolution in the field of computer vision. This technique uses Neural Networks as its backbone and performs identification and classification very fast and with commendable accuracy.

In my paper, I have used a pre-trained model of CNN for extracting features and recognizing on the basis of learning. Pre-trained models are heavily trained on a vast amount of data with a good classification ability.

II. LITERATURE REVIEW

Kai Guo et al. [3] carried a CNN based facial recognition by applying score fusion of both visible light image and near-infrared images. So, they obtained a more efficient model for real life applications in comparison to other traditional approaches. They also came to a conclusion that the result achieved in the experiment, is independent of any changes in illumination. H. Khalajzadeh et al. [4] selected CNN for extracting features, which encompasses a hierarchical structure. This hierarchy based network was tested on the face data obtained from three databases, i.e., Yale, ORL and JAFFE database. It resulted in higher accuracy with reduced overall time taken in training. Lawrence and Giles et al. [5] gave a concept of hybrid CNN for carrying out facial recognition. In order to reduce the problem of dimensionality of the image samples, they used self-organizing map neural network. They took LeNet-5 CNN for extraction of features. They conducted the experiment using 400 images gathered from 40 persons. They found this method suffering from high complexity because recognition was performed using two different neural networks. Brunelli and Poggio et. al. [6] came with two approaches for face recognition system. In first approach, the calculation was based on the geometrical shapes and size of the facial features, such as height and width of nose, position of mouth with respect to nose and chin shape.

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This approach yielded 90% recognition accuracy. His second approach was performed using template matching scheme and an accuracy of 100 % was achieved. Suleman et. al. [7] carried a work on face recognition using smart glasses by using Deep CNN method. In this method, He proposed Haar-like features for detecting faces and finally he achieved a detection rate of 98% using 3099 features.

III. CONVOLUTIONAL NEURAL NETWORK (CNN)

A Deep learning model, composed of more than one layers and which accomplishes a convolution operation on some of the layers, is named as Convolutional Neural Network (CNN). CNN has been designed by having inspiration from working of neurons in human brain and follows the similar approach for recognizing images. CNNs have been designed to carry out feature extraction and classification tasks in the field of Computer vision. Earlier, before the emergence of CNN, features were extracted using traditional methods which used to take a lot of time and may require some human mediation also. But CNN has emerged with a fully supervised, accurate and time saving abilities. The CNN has a revolutionary feature of weight sharing which makes it to perform better on various image transformation operations, such as rotation, translation and scaling [8].

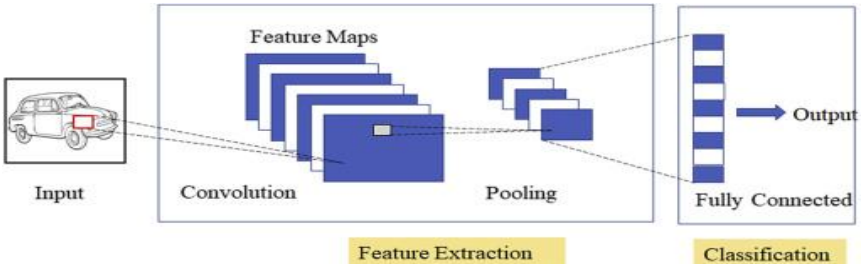


Figure 1: A Convolutional Neural Network [9].

The layers of CNN are categorized into following three types-

1) *Convolution Layer:* This is the layer where all the important calculations take place. Convolution is performed between an input image and a filter. Filter, also named as kernel is a feature detector with fixed size and is always smaller than the image samples. This filter acts in a sliding manner and moves across an image in a repetitive way and hence a dot product of filter and the particular section of the image is calculated. This element-wise multiplication is done until the entire image is scanned and the filter reaches to the bottom right corner of the image. In this way, the final output is obtained in the form of a feature map.
2) *Pooling Layer:* Pooling layer comes after convolutional layer. Its main job is dimension reduction. Pooling operation brings down the no. of pixels present in a feature map hence the overall dimension of feature map is decreased. Pooling layer also deals with the over fitting problem that the most of the neural networks have to deal with. This layer makes images translation and rotation invariant. There are mainly two types of pooling operations are performed- Max Pooling and Average Pooling which works on maximum and average value respectively.
3) *Fully Connected Layer:* As its name, all the neurons of one layer is connected with all the neurons on other layers. This is the last CNN layer which takes flattened inputs from its previous layers and applies Softmax activation function. The Softmax activation function transforms output in terms of probability of the input images which belongs to the corresponding output labels.

IV. METHODOLOGIES

I wanted to design a recognition system which must be based on facial traits of a person. For this, I went through the following procedures -

1) I have used face image samples received from Faces 95 dataset which is freely available.
2) I made proper labelling of all the face images used in my experiment before proceeding.
3) I adopted Transfer Learning approach of Deep Learning in my work as I had a few dataset.
4) Facial features extraction has been carried out using AlexNet, a pre-trained model of CNN.
5) I classified the image dataset used in my experiment into training and testing data.
6) The imported AlexNet model has been trained by feeding the facial images to it.
7) The classification of the images took place after training.
8) Then, I tested the model using test data samples.
9) The Confusion Matrix shows the system performance and overall accuracy.

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V. PROPOSED SYSTEM

1) *Image Acquisition:* A well structured input image dataset is very important thing before starting any experiment. The images can be captured from cameras or can be acquired from other sources.
2) *Image Pre-processing:* Images acquired from different sources are raw and may have some redundancies and noise. This hampers the rate of accuracy in recognition. So, it is necessary to pre-process the raw images by removing unnecessary information from them before they are passed to the input layers of the model.
3) *Feature Extraction:* Any person/ object identification takes place using some features either in real life or in Computer vision field. So, feature extraction is one of the most challenging parts of image recognition which involves finding out important information/ features from the given image.
4) *Classification:* In simple terms, classification is a grouping of outputs having similarities in patterns. On the basis of extracted features, classification is performed by categorizing things among different classes having pre-defined labels.

VI. IMPLEMENTATION

I conducted my research work using MATLAB R2018a. It provides a rich framework for Artificial Intelligence based applications. I used face image samples from Faces 95 database. The image dataset used in my work belong to Faces 95 database. This database has a collection of face images in the resolution of 180 by 200 pixels obtained from 72 individuals [10].

VII. RESULT DISCUSSION

I conducted my research on facial recognition using facial images obtained from faces 95 database. I used 100 images of 10 people; it means each person has 10 pictures taken from different angles, and having different zoom levels. A few of the image samples, which I have used in my project, are as-



Figure 2: face image samples

I grouped the images and saved all the images belonging to a person in a folder with that person's name. So, I have a data from 10 people where each people have 10 image samples. The purpose of prior labelling is done to achieve better recognition result and this is one of the integral features of Deep learning. As I have worked on AlexNet model, all the images used in experiment were made to fit in the size of 227*227*3 because input layer of AlexNet accepts images in the mentioned size only. All the images were loaded to fit in memory using ImageDatastore object. It stores the location of the image files on computer along with the file name in a variable named myFaceData. I used splitEachLabel command to randomly split the entire dataset among two classes of training and testing dataset in certain ratio.

```
[imgTrn,imgVldt] = splitEachLabel (MyFaceData ,0.6,'randomized');
```

In the above lines, 60% of the total data are randomly split and stored into a datastore for training which has been defined for training data and rest 40% were stored in a testing datastore.
My work is based on transfer learning approach of Deep learning, so, I copied the Alexnet architecture and stored it in a variable. The Alexnet model is made up of 25 layers in which there are five convolutional layers pursued by some ReLU. The model has normalization layers, Pooling layers, Dropout layer and Fully connected layers also. The last Fully connected layer '**fc7'** is responsible for extracting 4096 feature.

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We can see the layers as-

```
layer =
  25x1 Layer array with layers:

     1   'data'                Image Input                 227x227x3 images with 'zerocenter' normalization
     2   'conv1'               Convolution                 96 11x11x3 convolutions with stride [4  4] and padding [0  0  0  0]
     3   'relu1'               ReLU                        ReLU
     4   'norm1'               Cross Channel Normalization cross channel normalization with 5 channels per element
     5   'pool1'               Max Pooling                 3x3 max pooling with stride [2  2] and padding [0  0  0  0]
     6   'conv2'               Convolution                 256 5x5x48 convolutions with stride [1  1] and padding [2  2  2  2]
     7   'relu2'               ReLU                        ReLU
     8   'norm2'               Cross Channel Normalization cross channel normalization with 5 channels per element
     9   'pool2'               Max Pooling                 3x3 max pooling with stride [2  2] and padding [0  0  0  0]
    10   'conv3'               Convolution                 384 3x3x256 convolutions with stride [1  1] and padding [1  1  1  1]
    11   'relu3'               ReLU                        ReLU
    12   'conv4'               Convolution                 384 3x3x192 convolutions with stride [1  1] and padding [1  1  1  1]
    13   'relu4'               ReLU                        ReLU
    14   'conv5'               Convolution                 256 3x3x192 convolutions with stride [1  1] and padding [1  1  1  1]
    15   'relu5'               ReLU                        ReLU
    16   'pool5'               Max Pooling                 3x3 max pooling with stride [2  2] and padding [0  0  0  0]
    17   'fc6'                 Fully Connected             4096 fully connected layer
    18   'relu6'               ReLU                        ReLU
    19   'drop6'               Dropout                     50% dropout
    20   'fc7'                 Fully Connected             4096 fully connected layer
    21   'relu7'               ReLU                        ReLU
    22   'drop7'               Dropout                     50% dropout
    23   'LastFullyConnected'  Fully Connected             10 fully connected layer
    24   ''                    Softmax                     softmax
    25   ''                    Classification Output       crossentropyex
```

Figure 3: layers of Alexnet

The model was trained on the given faces image by passing some parameters to it. Here, I have set the value of Execution Environment as 'auto' which means that the model automatically starts its training by sensing the processing unit. If the system has Graphics Processing unit (GPU), then the training starts on it otherwise it automatically shifts on CPU. MaxEpochs is set to 20 which is maximum no. of passes used for training the entire dataset. I have set the InitialLearnRate to 0.001 which specifies the rate at which the model starts learning. Learning rate can be increased or diminished to minimize or maximize the time taken in training process. The value set as Shuffle at every-epoch, means that all the samples are continuously shuffled at every epoch to ensure equal participation of each sample during training.

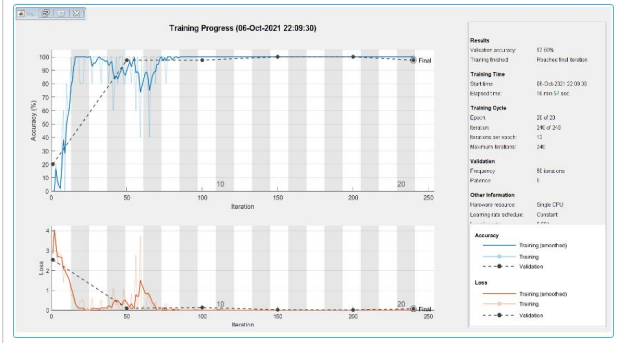


Figure 4: Training progress in AlexNet model.

Finally, the classification took place and in this way, my experiment showed 97.5% of accuracy. The confusion matrix obtained for the result is as-

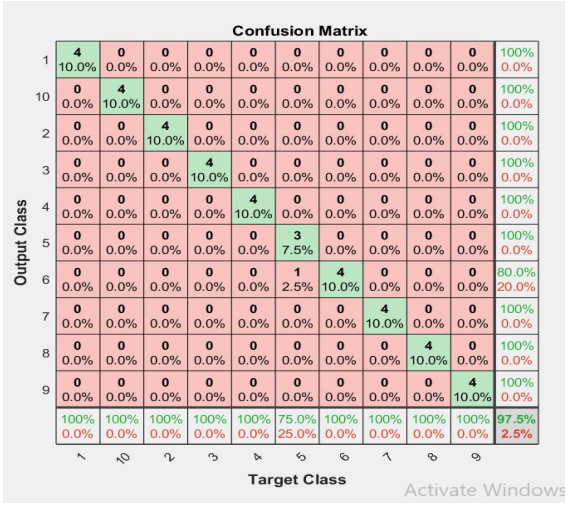


Figure 5: Confusion matrix for the face recognition.

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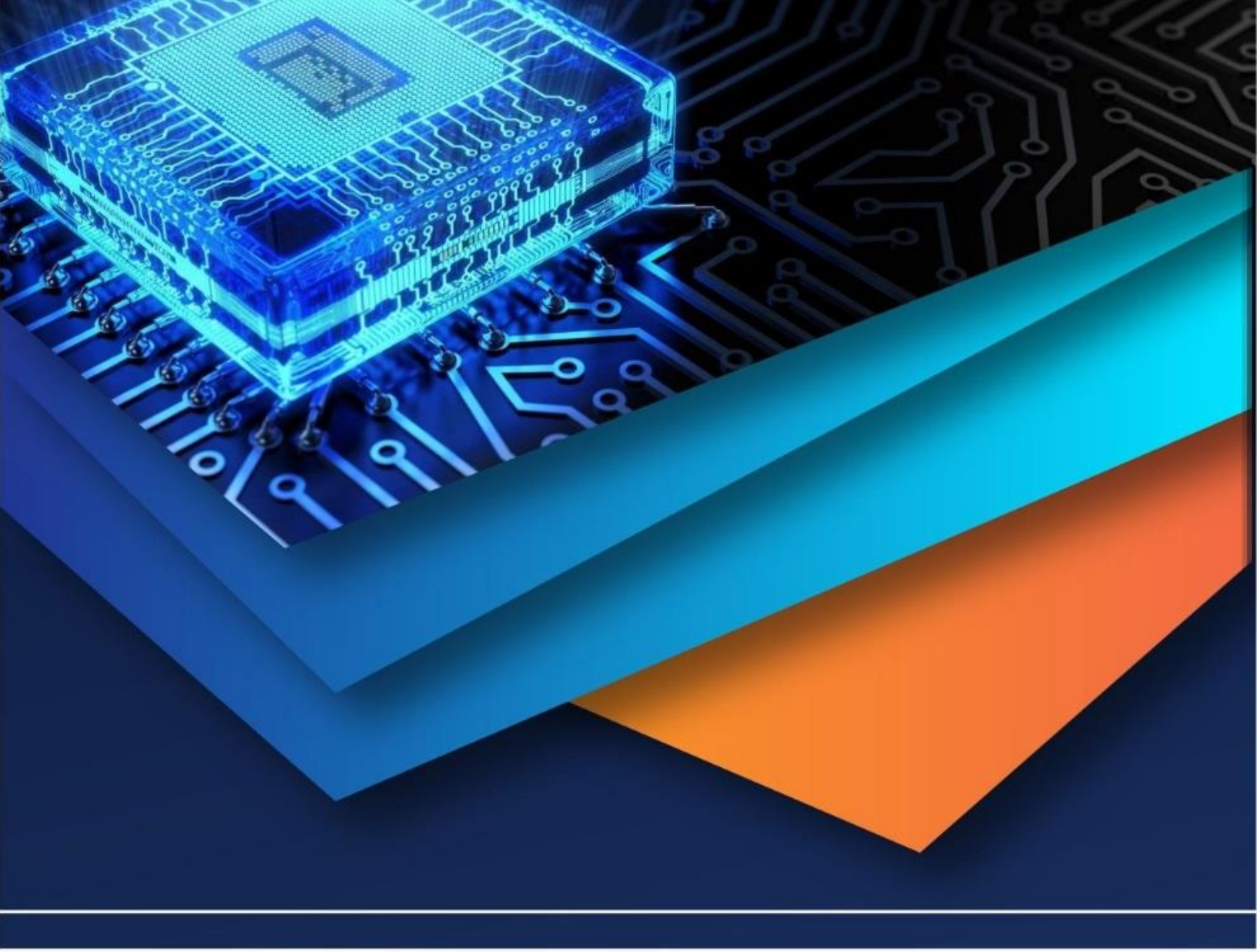
VIII. CONCLUSION

Facial recognition is a very popular method of recognition and it has been widely explored using different algorithms. Here, I have proposed a recognition method using pre-ptrained model of CNN because I have less dataset. Rather than opting traditional methods for extraction, I focussed on AlexNet, where the entire image related operations like pre-processing; normalizing and detection of the important features are done automatically. I achieved a good accuracy of 97.5% when the model was tested on Faces 95 database. In future, I will extend my work on recognition using other CNN models with different classification algorithms.

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