

# Design and Evaluation of a Deep Learning Algorithm for Emotion Recognition Using Convolutional Neural Networks (CNN)

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## ABSTRACT

Facial emotion recognition is one of the most interesting research areas where many researchers are actively participating over the past few decades. This paper attempts to discuss about the application of emotion recognition where seven different emotions such as happy, sad, neutral, angry, surprise, fear and disgust are obtained. Humans can produce thousands of emotions in different situations which have different meanings, intensities and complexities. By using convolutional neural network (CNN) algorithm, an accuracy of about 89% has been achieved. It is the simplest way of all. For better results deep learning and neural networks have been used. Our proposed deep learning model helps us in focusing important features in humans face to detect emotion using multiple datasets such as FER-2013 and image dataset.

**Keywords:** Emotion Recognition, Neural Networks, Dataset, Types of Emotions.

## INTRODUCTION

Emotions are an important part of any interpersonal communication. In every human's life emotions plays an important role. Humans are efficient in producing lot of emotions during their daily life at different situations that hold disparate meanings and intensities. At several situations humans plays a different emotion based on their mood. They can be shown in disparate forms which may or may not be noticed visually. Therefore, with the help of accurate tools, the emotions are detected and recognized. For detecting emotions in face, facial emotion recognition process is used. Humans vary widely in their accuracy at finding others emotion. So, here are using technology to recognize the emotion. Emotion can be expressed through face, speech, electroencephalogram (EEG) and via text. Out of these, facial expressions are in favour as they are visible to human eye.

Emotion Recognition supports us in sensing emotions in humans at diverse situations. It is classified into 3 stages they are Face Detection, Feature Extraction and Emotion Classification. Face detection is a pre-processing stage which helps in detection emotions, During Feature extraction various features of the face is extracted, in the final stage it produces labels and model will be trained. However, with growing connections of humans with machines, researchers now aim at constructing deep learning models that can perfectly analyze affective content in conversations. This can help in creating empathetic facial emotion recognition systems, thus improving the overall human-machine interaction experience. This paper presents a deep learning-based algorithm i.e., Convolutional Neural Networks (CNN) to detect emotions in face

**II.PROBLEM STATEMENT**

In the set of thousands of emotions, 7 basic human emotions are happy, sad, anger, disgust, neutral, fear, and surprise. As shown in Fig 1. These emotions contain lot of information about their state of mind. When humans are communicating each other, they produce various emotions based on their situations [2].This application can be applied in health cares before the treatment of the patient. By this, the additional information of the patient can be obtained to provide better service during the treatment. Criminals and terrorists are always found tensed and angry. So, the criminals and terrorists can be easily found in heavy crowds based on their facial expressions. Facial emotion recognition is important for the interpretation of facial expressions. The facial expressions are useful for efficient interaction. It is found that it is insufficient to describe all facial expressions and these expressions are categorized based on facial actions. Detecting face and recognizing the facial expression is one of the complex tasks when it is an essential to show attention to primary elements like: face configuration, orientation, location where the face is set.



Fig 1. Different Types of Facial Expressions

**III.DATABASE**

In this paper, we provide the work of experimental analysis of the proposed model on various popular facial expression datasets, such as FER2013 DATASET and IMAGE DATASET. Before moving into the results, we are going to give a brief overview of our datasets.

FER2013: The Facial Expression Recognition 2013 (FER2013) database was first introduced in the ICML 2013 Challenges in Representation Learning. Our dataset consists of different 48x48 pixels of images which shows various emotions [8]. This dataset contains 3 columns such as emotion, pixels and usage. In emotion column there are some numbers which indicates different emotions i.e., 0 refers to Angry, 1 refers to Disgust, 2 refers to Fear, 3 refers to Happy, 4 refers to Sad, 5 refers to Surprise, 6 refers to Neutral.

	emotion		pixels	Usage
0	0	70 80 82 72 58 58 60 63 54 58 60 48 89 115 121...		Training
1	0	151 150 147 155 148 133 111 140 170 174 182 15...		Training
2	2	231 212 156 164 174 138 161 173 182 200 106 38...		Training
3	4	24 32 36 30 32 23 19 20 30 41 21 22 32 34 21 1...		Training
4	6	4 0 0 0 0 0 0 0 0 0 0 3 15 23 28 48 50 58 84...		Training

Table 1.Sample Dataset

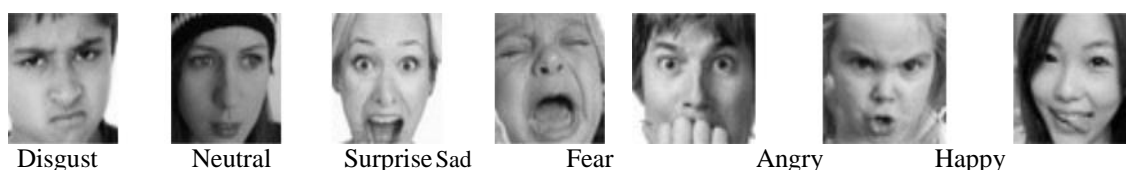


Fig 2. Some Sample pictures of the Image Dataset

**IV. PROPOSED METHODOLOGY**

In our model we use CNN and activation layer Softmax as output layer because with the help of Softmax layer we get more accuracy. CNNs are neural networks which are sensitive to spatial information. It is capable of recognition complex shapes and patterns in a given image. They are used for a wide variety of image classification algorithms. The CNNs for detecting facial emotions was built using Keras. The final layer of the CNN is actually changed and replaced with Softmax layer as seven output layers in our dataset i.e., FER2013 dataset. The Seven is actually a variable parameter changes with respect to dataset [3].

**1. Implementation**

Import the required libraries for building the model. Import NumPy for numerical calculations, Pandas for reading csv file and Keras for developing and evolution of deep learning models and the dataset will be imported. Here, this research work also import some layers, some Keras library like dense, dropout, Conv2D, Maxpooling2D. Fig 3 shows the steps to follow for building CNN model [10].

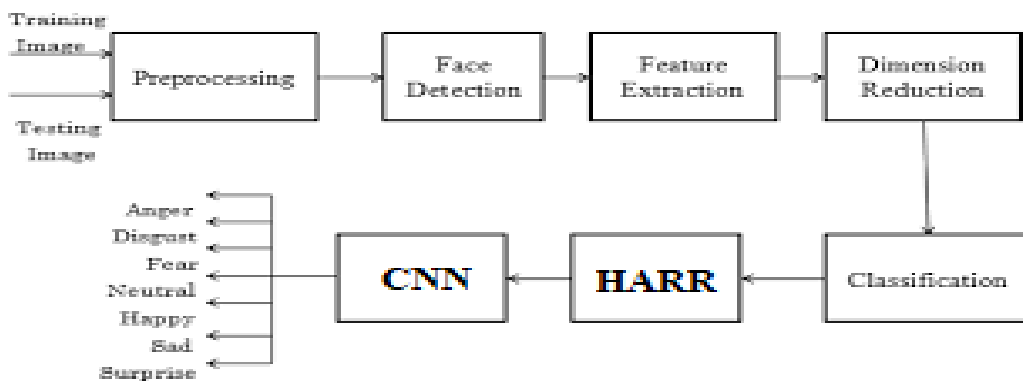
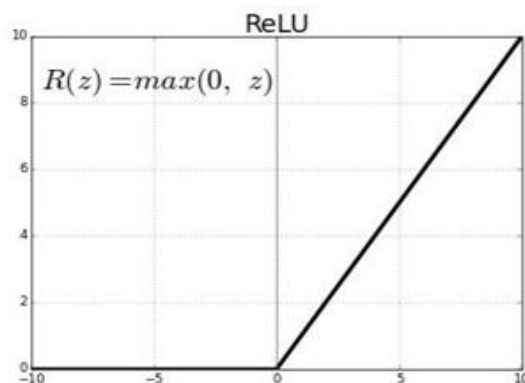


Fig 3. Steps to follow for Building CNN to data

**1.1. Convolutional Layer:** This layer is used to get features from images. Here features mean edges, intersect points which provides rich information. The number of convolution layers matter. By using different activation functions with different number of features, we can change the architecture.

This network will have the following components:

**1.1.1 Activation functions:** Here in our model, we use two Activation functions i.e., Relu and Softmax which are applied to all the layers of output.



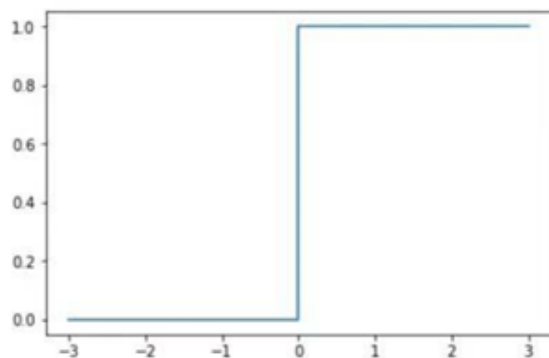


Fig 4. ReLu Activation Function Fig 5. Derivative of ReLu Activation Function

**1.1.2. Pooling Layers:** It is added after the convolution layer which performs continuous dimensionality reduction i.e., reduced number of parameters and computations thereby shortening training time and controls overfitting.

**1.1.3. Dense layers:** It is the bottom most layer of CNN. In this layer all feature data produced by convolution layers will take and do the decision making.

**1.1.4. Dropout Layers:** We have a deep neural network we will have many weight parameters and bias parameters due to this model may tend to overfit the dataset. For preventing overfitting of irregular turns of neurons in the network. In dropout layer we select subset of features from input layer and subset of neurons from hidden layer, based on the given p value some neurons and features get deactivated and some are activated.

$$\text{Dropout ratio: } 0 \leq p \leq 1$$

**1.1.5. Batch Normalization:** It is the method for training neural network models as the batch normalization increases the no of epochs required to train the deep neural network model decreases. It allows every layer of model to learn independently. This helps to speed up the training process. After this, we compile the model using Adam as an optimizer, loss as categorical cross -entropy, and metrics as accuracy. After building and compiling the model, we split the data into training data and validation data. In our model we are taking the batch size as 64 with 100 epochs.

Once the training has been done, we can evaluate the model and compute loss and accuracy. We now save the model to fer.json and save the model weights in a fer.h5 file. For making predictions instead of training the model again we can make use of this file. Now by using OpenCV and webcam we test the model in Real-time manner. For building our model we use jupyter notebook. You can use many python platforms and IDEs to build the model and detect the emotion in real-time with the help of system webcam. We need to import the required libraries, then model weights which we saved earlier after training are loaded. Once the model weights are loaded then we need to import haarcascade file which was build using OpenCv to detect facial emotion. Once we import the haarcascade file we had written a code to detect the faces and classify into certain emotions. The certain emotions are labelled as angry, happy, sad, surprise, neutral, disgust and fear. If we run the code it will connect to webcam and through webcam, we will detect the emotion in the face with a blue colour square box around the face [4]. To stop the code, you need to press 'q'. Anything we want that can place here to stop the execution.

**V.EXPERIMENT RESULTS**

The accuracy of the trained model for respective epochs is given in the table ACCURACY RESULTS. The best modern deep learning model outperforms the best simplistic model by almost 2% under undistinguishable conditions All measured architectures outperform the best simplistic model, including Inauguration, which has only half as many parameters [5]. These accuracy results tell us that modern deep learning architectures model has the potential to significantly improve FER performance. Our distinct CNNs already perform competitively to previous works that exploit collaborative voting. By forming a group of 8 such CNNs, we achieve a FER2013 test accuracy of 89%. Our group of deep learning models attains the art performance of the state without operating further training data or structures, wide-ranging data expansion or demanding face registration. Deprived of any face registration, our Facial emotion recognition process is theoretically modest than earlier techniques and not caused by registration blunders. By exploiting secondary training data and wide ranging, FER definite data expansion would progress the performance additional.

In this paper we use FER2013 dataset which is the most communal and widely obtainable image dataset for CNN based Facial Emotion Recognition field. Due to various dataset the FER performance is indicative of real-world.

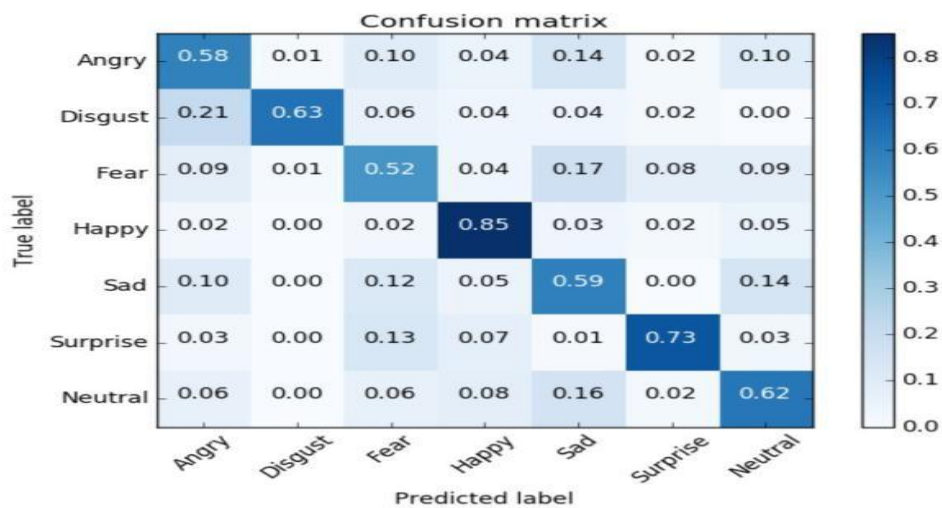


Fig 6. The confusion matrix for test set of FER Dataset model

**Parameters:** 3 convolutional layers, ReLu and softmax Activation functions, dense layer as output layer,7 outputs

**VI.ACCURACY RESULTS**

S.no	Epochs	Accuracy
1	30	66.92%
2	70	79.62%
3	100	84.29%

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Table 2. Results

For image dataset we got an accuracy of 53 percent for 150 epochs. For increase in more no of epochs we get more accuracy.

## VII.CONCLUSION

The primary theme of our research paper is to build an CNN model to detect different facial emotions in real-time manner. The work done by us made the model to work in a better way such that it can recognize various emotions in different illumination and pose. In our model we use Keras which is a python library helps in deep learning model, tensor flow and OpenCV to detect emotions in face at different situations. We initially build a model and trained it such that it is capable of detecting and classifying facial emotion in real-time. The model gave good accuracy but takes much time to train the data. Here by, I conclude this paper by hoping that you got a fair knowledge, idea and understood the whole concept of designing the facial emotion recognition using CNN in real-time. You can make use of pre-trained models like VGG16, ResNet, MobileNet and EfficientNet for better performance of models.

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