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# A Modified Technique for Recognizing Facial Expression

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**ABSTRACT**

This paper consists of analysis of an algorithm dealing with facial expressions recognition. The algorithm has three major steps, initially image is processed, then the facial features are extracted and finally facial expression is recognized. In the initial processing stage the facial region is identified using a Haar cascade classifier. This facial region is passed on to the model trained by a CNN where facial features are matched with the features specified in the model. In the final step on the basis of comparison in the previous step the image is labelled and results are displayed. By the experiment results it is clear that the method specified in the paper can detect facial expressions very well.

## 1. Introduction

The enhancement of science and technology leads to make the life more comfortable than older days. The emerging technologies like neutrosophic shortest path [1-5], transportation problem [6-8], uncertainty problem [9-14], fuzzy shortest path [15-18], powershell [19], wireless sensor network [20-27], computer language [28-29], neural network [30], routing [31], image processing [32] making the products more intelligent and self-healing based. The smart city applications like smart water [33, 34], smart grid, smart parking, smart resource management, etc. are based on IoT and IoE [35-38] technologies. In this manuscript, the facial expression system is proposed. Facial expressions are a universal way of communication and the promptest response to any situation. Ekman and Friesen defined a few basic emotions which humans perceive in the same way regardless of race, culture, etc. [39]. Hence facial expression recognition is a crucial field of research in various industries like entertainment, marketing research, retail, psychology, and various other fields. The way we interact with computers has changed a lot but it is still very difficult to build complex systems that can not only understand verbal communication but also understand non-verbal communication such as facial expressions [40]. If a system can be built that can detect such emotion it would help improve consumer experiences in various industries. Various AI-powered systems like Google Assistant, Alexa, Cortana,

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etc. can leverage the output of these systems to have the best possible interaction with users, as one of the shortcomings of these voice assistants is an inability to understand the emotions [41].

With the increase of smart devices and the rapid growth of IoT (internet of things) devices, efficiency and optimization have become more important along with the existing standard accuracy measurement. A lot of researchers have recognized facial expressions from images or videos but there are still a lot of challenges that need to be addressed as the problem is complex, and a lot of variation in human appearance as there are many cultures, races, etc. At the technical level, as all the images would vary in lighting conditions, face pose, background, etc.

Traditionally, Facial Expression Recognition (FER) systems use three basic steps to recognize any facial expression: face detection, facial features extraction, and finally classification [40] but advancements in the field of deep learning algorithms have made it possible for both facial features extraction and classification to be optimized jointly and performed with lower latency.

This research focuses on developing a FER system that can classify an image into different classes of emotions. To develop this system, we used Open CV and CNN along with leveraging transfer learning to develop a more accurate model that can be used for classification.

An earlier convolutional neural network has been used in a few kinds of research but the consistency rate was low and most researches had an issue of low recognition rate in case of emotion like disgust or fear [42]. Here to overcome that problem we used multiple datasets and collected first-hand data 2, FER method

## 2. Facial Expression Recognition Methods

Facial expression recognition has been the topic of research for quite some time. Here are a few techniques that have been studied to create this model.

### *2.1. Graph-Based Feature Extraction*

In this method graph-based feature extraction is done where the Voila-Jones algorithm is utilized to detect the face, this algorithm first converts an image to grayscale and then uses HAAR like feature to detect the face, and then features are extracted from the image with the help of edge-based feature transform then they use weighted visibility graph to optimize them. Finally, a self-organizing neural network is used to classify the expression [43].

### *2.2. Geometric Feature Extraction and Classification*

In this methodology, the features are extracted using the geometric feature extractors. Here the projection ratios and displacement information is used to automatically extract and give us the four most important facial points, which are the height of the face, the location of eyes, the eyebrow region, and the lip-nose region. Along with this, geometric feature extractor LBP classifier works to get similar information for increased accuracy, and then finally the data from both of them is passed to SOM based classifier where the facial expression is classified [44].

### *2.3. Using Local Binary Feature and Shallow Networks*

In this technique, appearance-based features are extracted around the facial landmarks using local binary features which comprise decision tree-based models that are trained to find out expressions around a landmark. Then with the help of this data expressions are classified by simple network architecture comprising of shallow network with one hidden layer [40].

### *2.4. AU Classification Based Approach*

In this methodology after extracting the facial features, the AUs (action units) are detected by recognition engines, then the expression is classified with either spatial classification approaches or by spatial-temporal classification approaches. In both of them, the output from multiple AUs is taken and then by using them, the expression is finally classified [45].

## 3. Literature Review

There are many papers and techniques available regarding facial expression detection. Most of them work efficiently under static conditions like similar lighting conditions and either they classify emotions like fear or disgust inaccurately or they do not classify these complex emotions at all.

Tong et al. [45] suggested the use of a dynamic Bayesian network where they would model different action units and finally use the probabilistic approach to determine facial expression. Authors [40] proposed an algorithm that combines the result of the decision tree and neural network to give more accurate results. Mollahosseini et al. [46] proposed the use of deep neural network architecture to solve the problem of facial expression recognition by working on multiple datasets. The work [47] proposed the use of the subnets in the network for a more efficient and accurate system. Xie et al. [48] proposed two modules, Salient Expression Region Descriptor (SERD) and Multi-Path Variation Suppressing Network (MPVS-Net) to incorporate in their CNN to recognize the facial expression with increased precision. An and Liu [49] proposed a function that could initialize CNN and LSTM networks to deploy in their facial expression recognition model.

### *3.1. Different Researcher's Contribution*

Some of the major contributions in the field of facial expression recognition have been discussed in the below *Table 1*.

***Table 1.*** *Different researcher's contribution.*

| Authors | Years | Description |
|---|---|---|
| *Tong et al. [45]* | *2007* | *The authors use a dynamic Bayesian network to model different action units and use a probabilistic approach to analyze facial expressions.* |
| *Kulkarni & Baga [50]* | *2015* | *The authors compared various facial recognition techniques based on the time required and the accuracy of methods.* |
| *Yu & Zhang [51]* | *2015* | *The authors proposed a new method for facial recognition created by using various face detectors and deep CNN.* |
| *Happy & Routray [52]* | *2015* | *The authors proposed a new method for facial expression recognition which extracts features from selected patches and used them to label an expression.* |
| *Shin et al. [53]* | *2016* | *The authors worked on different kinds of network structures to propose a detailed procedure for better accuracy.* |
| *Mollahosseiniet al. [46]* | *2016* | *The authors proposed deep neural network architecture to recognize facial expressions that can work on multiple datasets.* |
| *Lopes et al. [54]* | *2016* | *The authors proposed a method that uses CNN and fixed pre-processing steps to recognize facial expressions which has accuracy in multiple available datasets.* |
| *Liu et al. [47]* | *2016* | *The authors proposed the concept of using multiple subnets in the network for better accuracy of the model.* |
| *Majumder et al. [44]* | *2016* | *The authors proposed a new method that uses LBP features extractor and Kohonen self-organizing map-based classifier to recognize facial expressions.* |
| *Gogić et al. [40].* | *2016* | *The authors proposed an algorithm that combines gentle boost decision tree and neural networks to optimize the recognition of various complex expressions.* |
| *Carranza et al. [41]* | *2019* | *The authors developed a chatbot that took two inputs from the user, the response, and the facial expression to determine the emotional state of the user.* |
| *Li et al. [55]* | *2019* | *The authors, proposed a face cropping and rotation strategy for better extraction of facial features to accurately identify a facial expression.* |
| *Shao & Qian [56]* | *2019* | *The authors proposed multiple CNN models with different architecture to classify a facial expression.* |
| *Xie et al. [48]* | *2019* | *The authors proposed two new modules, Salient Expression Region Descriptor (SERD) and Multi-Path Variation-Suppressing Network (MPVS-Net) to use in their Dam-CNN model to recognize a facial expression.* |
| *An & Liu [49]* | *2019* | *The authors use deep learning to recognize facial expressions, they proposed a new function to initialize CNN and LSTM networks.* |
| *Kimet al. [57]* | *2019* | *The authors proposed the new scheme based on hierarchical deep learning where they've fused feature-based networks with geometric features in the hierarchical structure.* |
| *Li et al. [42]* | *2019* | *The authors propose the concept of adaptive pooling map to facilitate facial expression recognition and they've created an algorithm to learn adaptive pooling maps efficiently.* |
| *Li & Deng [39]* | *2020* | *The authors review the various available facial expression recognition datasets, training strategies, and models used for facial expression recognition.* |
| *Krithika & Priya [43]* | *2020* | *The authors proposed the graph-based features extraction and hybrid classification approach to overcome the problems of inaccuracy in the existing methodology.* |

From the above discussion, we found that image processing and face detection are gaining prominence and popularity amongst the researchers of various fields because of their use in a variety of applications in various branches of engineering and sciences. A significant amount of work has been done on face detection and recognition, but when it comes to facial expression recognition from the literature study, we found there are a lot of gaps. As such, the subsequent gaps are studied:

- There are very few systems in which we can identify facial expressions.
- Sometimes the complex expressions such as fear and disgust are not identified accurately.

- The introduction of multiple subjects in the image sometimes affects the result given by the available techniques.

Therefore, this motivates us to propose a model for facial expression recognition issues.

Haar-cascade classifier is a very effective object detection classifier by Open CV and CNN is used to label or predict the class by performing classification on the given input data. The role of this paper is as follows:

- The proposed methodology helps to eliminate the gaps found in the literature survey.
- Proposed a model to identify the facial expression by using Haar cascade classifiers and CNN.
- The discussed methodology has high recognition rates.
- The main attraction of this paper is to recognize complex expressions such as fear, disgust, and surprise with high accuracy as well as to recognize the expression of multiple facial objects in an image with high precision.

## 4. Description of Research Work

### *4.1. Research Problem*

In recent few years, a lot of problems in computer vision have been solved in various ways. With the help of deep learning and use of neural network not only these problems have been solved but also the efficiency and accuracy have increased gradually but still there are some areas which require an extensive amount of work. One such key area is the recognition of facial expressions.

There are many conventional facial expression detections available but still, they are not flexible enough due to the lack of available datasets. Most of the facial expression recognition techniques either fail to recognize emotions like fear or disgust or classify them inaccurately which is a challenging task to do as not all people similarly perceive these emotions this is a reason why we need an exceptionally large dataset.

### *4.2. Solution Methodology*

Here solution methodology is divided into two parts that are creating a model and using the model. The following *Table 2* and *Table 3* discuss them, respectively.

*Table 2* discusses the algorithm to create the model which has to be used in later phases of the project to recognize the facial expression.

***Table 2.*** *Sub algorithm to create the model.*

| Steps | Overview |
|---|---|
| **Step 1** | *Remix the collected data with the existing datasets.* |
| **Step 2** | *Label the collected data.* |
| **Step 3** | *Create a model using transfer learning methodology by providing the above-labelled data.* |
| **Step 4** | *Export the above model to consume it to predict the data.* |

*Table 3* briefly discusses the algorithm which is going to consume the model which has been created in *Table 2*, this table shows steps to derive the result using the model, which is the predicted facial expression.

***Table 3.*** *Sub algorithm for consuming model for facial expression recognition.*

| Steps | Overview |
|---|---|
| **Step 1** | *Import the required libraries including Open CV and Tensor Flow.* |
| **Step 2** | *Load the model created in Table 2 in the classifier.* |
| **Step 3** | *Using Open CV start reading the stream from the webcam.* |
| **Step 4** | *Detect the face using Haar cascade frontal alt classifier.* |
| **Step 5** | *Detect facial landmarks.* |
| **Step 6** | *Pass the above data to the classifier.* |
| **Step 7** | *Draw the result of the classifier on the image.* |

*4.2.1. Pseudo code of proposed system*

Here, we discuss the pseudo-code of the system in the below-given *Table 4*.

*Table 4* consists of pseudo-code which has been used to consume the model created in *Table 2* and implement the consumer model discussed in *Table 3*.

***Table 4.*** *Pseudo code of the proposed methodology.*

| Steps | Elaboration |
|---|---|
| **Step 1** | *Import OpenCV, TensorFlow.* |
| **Step 2** | *Load the cascade classifiers.* |
| **Step 3** | *Load the model layers in the neural network created in Table 2.* |
| **Step 4** | *Start video stream from webcam using OpenCV.* |
| **Step 5** | *Convert the data grayscale using brgToGray.* |
| **Step 6** | *Detect the face and other facial features using Haar cascade classifiers.* |
| **Step 7** | *Create ImageData of the facial region.* |
| **Step 8** | *Pass the data to the TensorFlow predictor.* |
| **Step 9** | *Obtain the result and draw it on the image.* |

The flow chart of the proposed system is as follows:

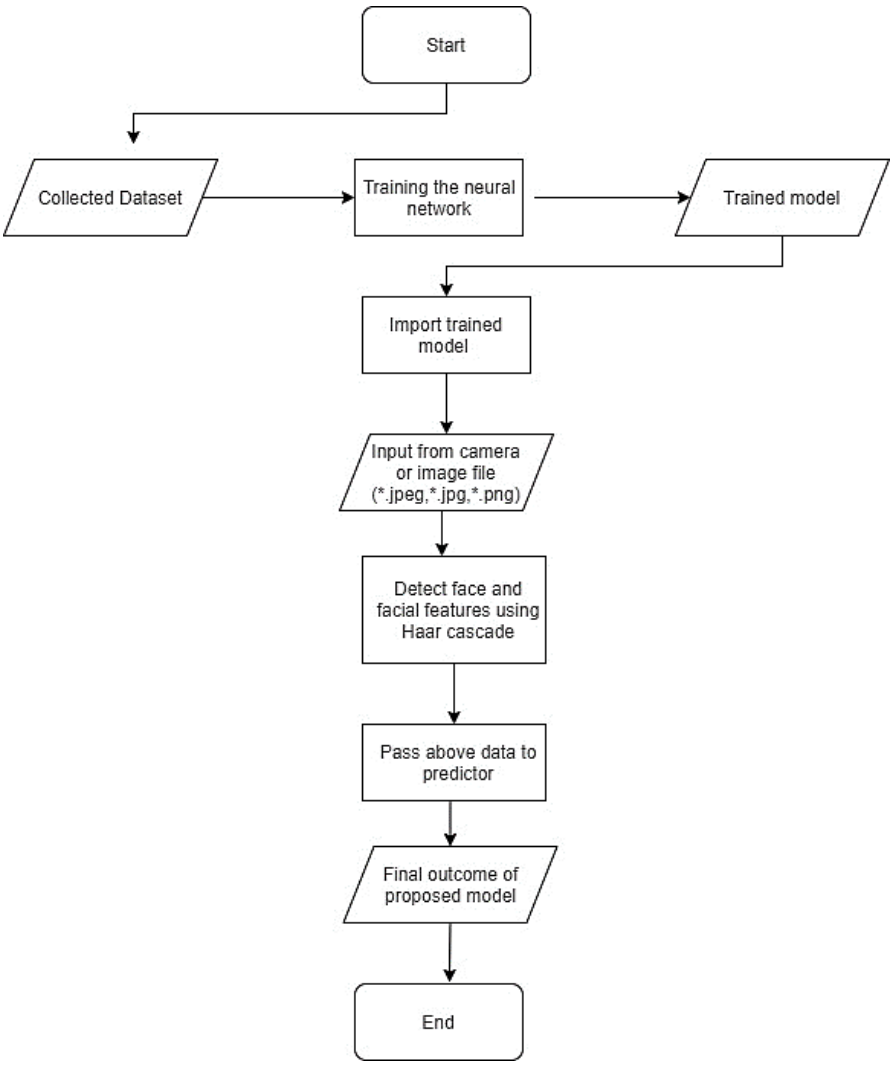


***Fig. 1.*** *Flow chart of the proposed system.*

## 5. Results and Discussions

In this section, we discuss the results achieved for different expressions as well as discuss the results obtained after intermediate steps on the given datasets [57-58].

***Fig. 2.*** *Input image [58].*

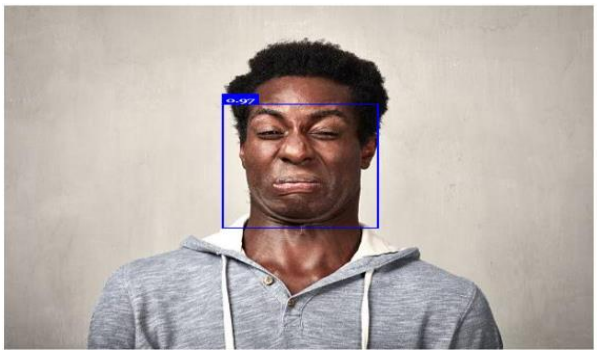

***Fig. 3.*** *Detection of face.*

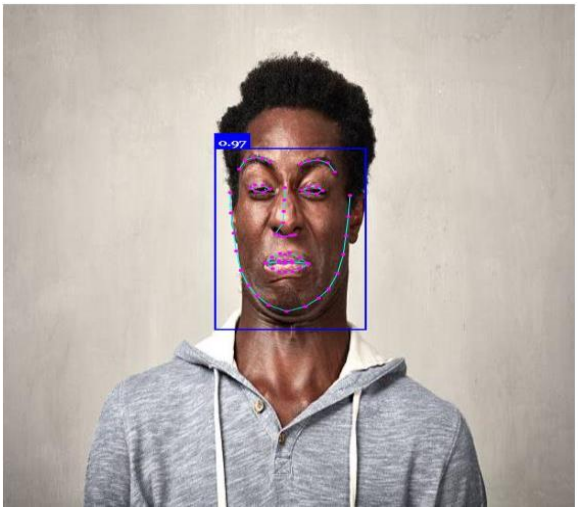


***Fig. 4.*** *Detection of facial landmarks.*

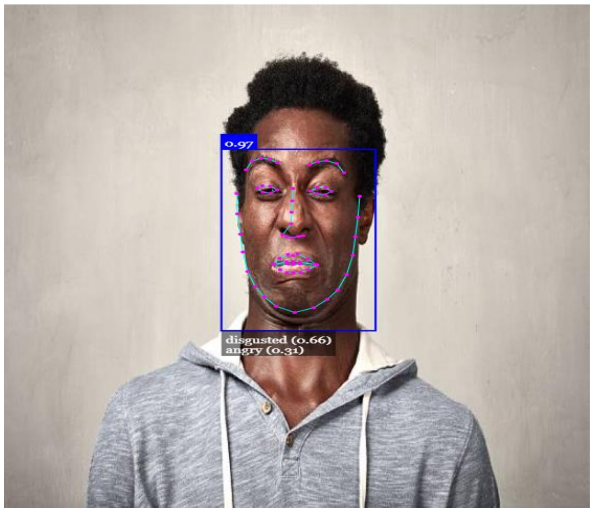


***Fig. 5.*** *Predicting of expression.*

Now we consider one picture from the above-cited dataset, execute the proposed algorithm, and get results which are shown in the following *Figs. 2-5*.

Now we consider one group image from each dataset and we execute our proposed algorithm on it to test the model on the image with multiple faces. We got the accurate results which are shown in the following *Figs. 6-9*.

***Fig. 6.*** *Input image for multiple faces [57].*

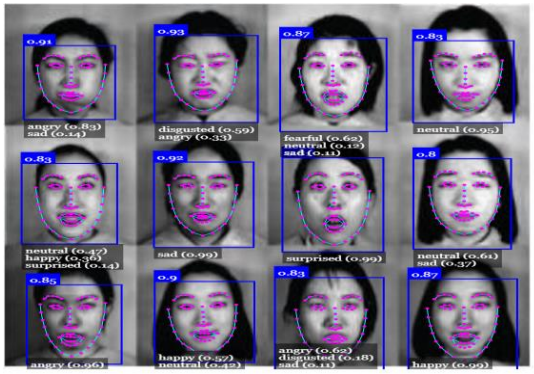


***Fig. 7.*** *Output on image taken from dataset 1.*

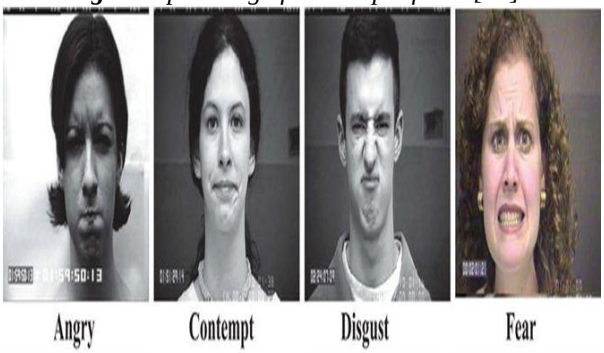


***Fig. 8.*** *Input image for multiple faces [58].*

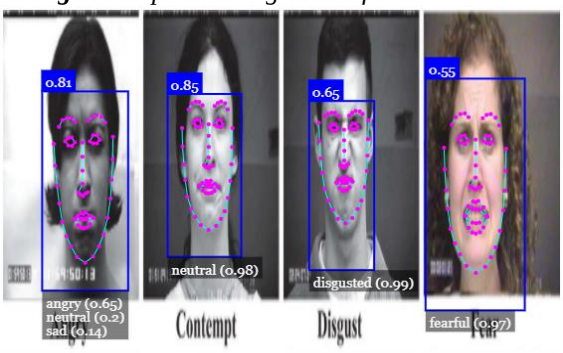


***Fig. 9.*** *Output on image taken from dataset 2.*

## 6. Conclusion

In this article, we have solved the facial expression detection using the Haar cascade classifier and CNN by using multiple datasets. Here we found a gradual increase in accuracy and efficiency as we kept on increasing the images from different datasets. We found that model was able to predict complex expressions like fear and disgust with high accuracy.

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