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Facial Emotion Detection Using Neural Network

Md. Forhad Ali, Mehenag Khatun, Nakib Aman Turzo

Abstract— Human emotions are mental states of feelings that come off spontaneously rather than through conscious effort and are accompanied by physiological changes in facial muscles which imply expressions on the face. Non-verbal communication methods such as facial expressions, eye movement, and gestures are used in many applications of human-computer interaction, which among them facial emotion is widely used because it conveys the emotional states and feelings of persons. Emotion recognition is not an easy task because there is no blueprint distinction between the emotions on the face and also there is a lot of complexity and variability. In the machine learning algorithm some important extracted features used for modeling the face, so, it will not achieve a high accuracy rate for recognition of emotion because the features are hand-engineered and depend on prior knowledge. Convolutional neural networks (CNN) have developed in this work for recognition facial emotion expression. Facial expressions play a vital role in nonverbal communication which appears due to internal feelings of a person that reflects on the faces. To computer modeling of human emotion, plenty of research has been accomplished by different kinds of researchers. Yet still far behind from the human visual system. This paper has been used the Viola-Jones algorithm to detect the eye and lips region from a face and then with the help of the neural network. Also, Machine Learning techniques, Deep Learning models, and Neural Network algorithms are used for emotion recognition. This paper detected emotion from those features from the positioning of the mouth and eyes. This paper will be proposed as an effective way to detect anger, contempt, disgust, fear, happiness, sadness, and surprise. These are the seven emotions from the frontal facial image of human Beings.

Keywords: Emotions, Feature Extraction, Viola-Jones, Neural Network, Emotion Recognition, Emotion Detection, Facial Recognition.

1 INTRODUCTION

FACIAL expressions play a key role in understanding and detecting emotion. Even the term "interface" suggests how important face plays in communication between two entities. Studies have shown that reading of facial expressions can significantly alter the interpretation of what is spoken as well as control the flow of a conversation. The ability for humans to interpret emotions is very important to effective communication; accounting for up to 93% of communication used in a normal conversation depends on the emotion of an entity. For ideal human-computer interfaces (HCI) would desire that machines can read human emotion. For that this research is all about how computers can detect emotion properly from its various sensors. This experiment has been used as a facial image as a medium to read human emotion. The research on human emotion can be traced back to Darwin's pioneer working and since then has attracted a lot of researchers to this area. Seven basic emotions are universal to human beings. Namely neutral, angry, disgust, fear, happy, sad, and surprise, and these basic emotions can be recognized from a human's facial expression. This research proposes an effective way to detect neutral, happy, sad, and surprise these four emotions from frontal facial emotion.

Md. Forhad Ali is currently pursuing Bachelor degree in Computer Science & Engineering in Varendra University, Bangladesh, PH: +8801718981909, E-mail: cseforhad1997@gmail.com

During the past decades, various methods have been proposed for emotion recognition. Many algorithms were suggested to develop systems applications that can detect emotions very well. Computer applications could better communicate by changing responses according to the emotional state of human users in various interactions. The emotion of a person can be determined by speech or his face or even one's gesture. The work presented in this paper explores the recognition of expressions from the face.

For facial emotion recognition, the traditional approaches usually consider a face image that is distinguished from an information picture, and facial segments or milestones are recognized from the face districts. After that different spatial and worldly highlights are separated from these facial segments. At last dependent on the separated highlights a classifier, for example, Keras library, random forest, is trained to produce recognitions results.

This work is an applied, deep learning model. Deep learning is a well-set model in the pattern recognition domain. It uses a Convolutional Neural Network (CNN) algorithm using Keras library. CNN is a specific sort of artificial neural network that uses a machine-learning unit. CNN applies to objects detections, face recognition, image processing, etc. Deep convolutional neural network (DCNN) composition of many neural network layers. Which is also can be able to extract significant features from the data.

2 REVIEW OF LITERATURE

In a research field of emotion detection, there is a contribution of several domains like machine learning, natural language, neuroscience, etc. In previous works, they individually rummaged facial expressions, voice features, and textual data as universal indicators of emotions. Emotion can be classified into several static classifications like happiness, sadness, disgust, anger, fear, and surprise. In later works are improved by combining the image, voice, and textual data. The fusion of this data gives the maximum accurate result. This type of fusion can be done in three ways early, late, or hybrid. Other ethos features the elements of emotion and the collaborations between emotional processes and other intellectual procedures.

A. Emotion Detections Through Facial Feature Recognition

This work deals with the emotion recognition with the Machine learning using support vector machine (SVM). Some principles are work to detection, extraction, and evaluation of facial expressions of image. These are:

i) Viola-Jones cascade object detectors and Harris corner key-points to extract faces and facial features from images.
ii) Histogram of oriented gradients (HOG) feature extraction.
iii) Support vector machines (SVM) to train a multi-class predictor for classifying the seven fundamental human facial expressions such as: (Anger, Contempt, Disgust, Fear, Happiness, Sadness, Surprise).

Computers can easily recognize facial expressions and can find out the motive of a person including in entertainment, social media, content analysis, criminal justice, and healthcare. Here is discussed mainly two-approach such as: (Zhang's approach and Gabor wavelet coefficients). Zhang has shown that lower resolution (64x64) is adequate, we will resize the extracted faces to 100x100 pixels.

When using the HOG and SVM classifier only, the accuracy for detection is 81%, much better than a Fisher's face. Only approach. When using the dual-classifier method, the accuracy is the same as HOG only at 81%, but the testing process is 20% faster.

B. SVM Point-based Real-time Emotion Detection

This work deals with the emotion recognition with Machine learning using a cascade of a multi-class support vector machine (SVM) and a binary SVM. This algorithm is developed to extract emotions based on the movement of 19 feature points. These feature points are located in different regions of the countenance such as the mouth, eyes, eyebrows, and nose. It mainly works non-changeable rigid points on the nose. Its divide into facial recognition and action unit (AU). Computers can easily recognize facial expressions and can find out the motive of a person including in entertainment, social media, content analysis, criminal justice, and healthcare.

A final suggestion for improvement is the fact that in the real-time application the user needs to stay on the same distance concerning the camera from which the neutral frame was taken. Otherwise, the theory behind the displacement ratios is no longer valid. Rescaling the neutral distances based on the movement of the user can be a solution to this problem.

3 METHODOLOGY

This work consider the leading challenge faced by machine learning and the entire system is the training part. Where the system has to train by using real data of human face reactions. For example, if the system has to detect an angry face then the first system has to be acquainted with the angry face. Also if the system has to detect a happy face then the first system has to be acquainted with the happy face. To antecedents the system with this emotion types, the re-training process has been used. The re-training data were collected from the real world. The hardest part of this system was the re-training part. There are also many other parts of the system. Machine learning is a strong tool that enables data analysis of large databases more proficiently and fleetly. This enables the capability of detection emotion more accurate. It gives feedback in real-time. The system did not wait for the result for the future, not the image has to be stored. With help of modern-day computers, neoteric data mining techniques can analyze thousands of data within a very short amount of time saving lots of hours. Besides, using and installing such programs costs significantly less. If properly optimized these data mining techniques can give perfect outcomes than a human. This work resented a general and feasible framework for emotion data mining to identify emotion patterns using machine learning. This paper proposed the program based on the Deep learning model and computer vision emotion recognition. This proposed method uses the CNN algorithm for this paper. This proposed a more advanced method than the one that recognized only seven emotions with CNN. Their emotion recognition method using deep learning followed four steps, as follows.

(1) Training the public face database with CNN.
(2) Extraction of seven probabilities for each frame of the face.
(3) Aggregation of single-frame probabilities into fixed-length image descriptors for each image in the dataset.
(4) Classification of all images using a support vector machine (SVM) trained on image descriptors of the competition training set.

A. Emotion Database

In the data collection steps, this is used both in real-world media and online media to collect as much data as that could. Real-world includes different types of emotional pictures of friends and family members, relatives, some known unknown people's different kinds of facial expressions. They culled data was initially stored for future analysis. From online media, the data is collected data set from kaggle.com. This site uploaded this data set 6years ago. This site most trusted data set of emotions. This converted the data into 48×48 pixel grayscale images of faces. It contains two sections pixels and feelings. The feeling section contains a numeric code which runs from 0 to 6. What's more, the pixel section contains a string incorporated in statements for each picture. Furthermore, the picture should be only the picture of a face. So the collected pictures are resized and cropped picture of a face. And a clear picture.

B. Training phase using deep learning

A great way to use deep learning to classify images is to build a convolution neural network (CNN). The keras library in python makes it pretty simple to build a CNN. Computer see images using pixels. Pixels in images are usually related. For example, a certain group of pixels may signify an edge in an image or some other pattern. Convolutions use this to help identify images. A convolution multiplies a matrix of pixels with a filter matrix or 'kernel' and sums up the multiplication values. Then the convolution slides over to the next pixel and repeats the same process until all the image pixels have been covered. This process is visualized below.

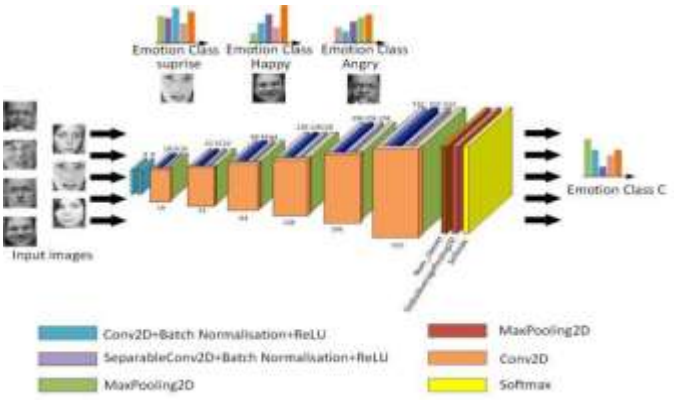

Figure: Emotion detection using Convolutional Neural Network

The model type that we will be using is Sequential. Sequential is the easiest way to build a model in Keras. It allows you to build a model layer by layer. We use the 'add ()' function to add layers to our model. Our first 2 layers are Conv2D layers. These are convolution layers that will deal with our input images, which are seen as 2-dimensional matrices. 64 in the first layer and 32 in the second layer are the number of nodes in each layer. This number can be adjusted to be higher or lower, depending on the size of the dataset. In our case, 64 and 32 work well, so we will stick with this for now. Kernel size is the size of the filter matrix for our convolution. So a kernel size of 3 means we will have a 3x3 filter matrix. Refer back to the introduction and the first image for a refresher on this. Activation is the activation function for the layer. The activation function we will be using for our first 2 layers is the ReLU or Rectified Linear Activation. This activation function has been proven to work well in neural networks. Our first layer also takes in an input shape. This is the shape of each input image, 28,28,1 as seen earlier on, with the 1 signifying that the images are greyscaling. In between the Conv2D layers and the dense layer, there is a 'Flatten' layer. Flatten serves as a connection between the convolution and dense layers. The model will then make its prediction based on which option has the highest probability. Next, need to compile that model. Compiling the model takes three parameters: optimizer, loss, and metrics. The optimizer controls the learning rate. It will be using 'adam' as their optimizer. Adam is generally a good optimizer to use for many cases. The adam optimizer adjusts the learning rate throughout the training. The learning rate determines how fast the optimal weights for the model are calculated. A smaller learning rate may lead to more accurate weights (up to a certain point), but the time it takes to compute the weights will be longer. We will use 'categorical cross-entropy' for our loss function. This is the most common choice for classification. A lower score indicates that the model is performing better. To make things even easier to interpret, that will use the 'accuracy' metric to see the accuracy score on the validation set when that train the model. To train, it will use the 'fit ()' function on their model with the following parameters: training data (train_X), target data (train_y), validation data, and the number of epochs. For its validation data, it will use the test set provided its dataset, which has split into X_test and y_test. The number of epochs is the number of times the model will cycle through the data. The more epochs we run, the more the model will improve, up to a certain point. After that point, the model will stop improving during each epoch. For our model, we will set the number of epochs to 3. After 3 epochs, it has gotten to 93% accuracy on that validation set.

C. Detection

K-means clustering was used with the number of clusters taken as two. Here, the maximum value in all rows is found out and its average is determined. Similarly, the minimum value in all rows is found out and its average is determined. Considering these two points as the base, the pixel values nearer to the maximum average value are grouped into a cluster and the pixel values nearer to the minimum average value are grouped into another cluster. Based on the clustering result, the total number of components in the image is calculated. Based on the number of components,

the person's eyes are segmented first by using bounding box function. Since the eye or eyebrow forms the first element while traversing the pixel values column-wise, the eyes are segmented first. Using the eye matrix, other facial parts are segmented using a distance-based algorithm. The resulting image after performing k-means clustering for different expressions are shown.

Figure: K-means clustering segmentation outputs

The Viola-Jones algorithm is a widely used mechanism for object detection. The main property of this algorithm is that training is slow, but detection is fast. This algorithm uses the Haar basis feature. Haar features are the relevant features for face detection. There are various types of features such as:

i) Edge features

Figure: Edge features

ii) Line Features.

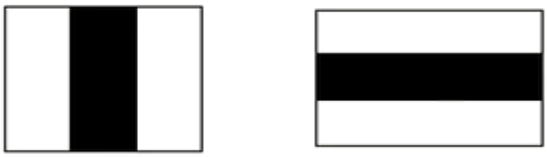

Figure: Line features

iii) Four Rectangle Features

Figure: Four rectangle features

For example, we need face detection of a person then we need at first image conversion in grayscale then second step image segmentation.

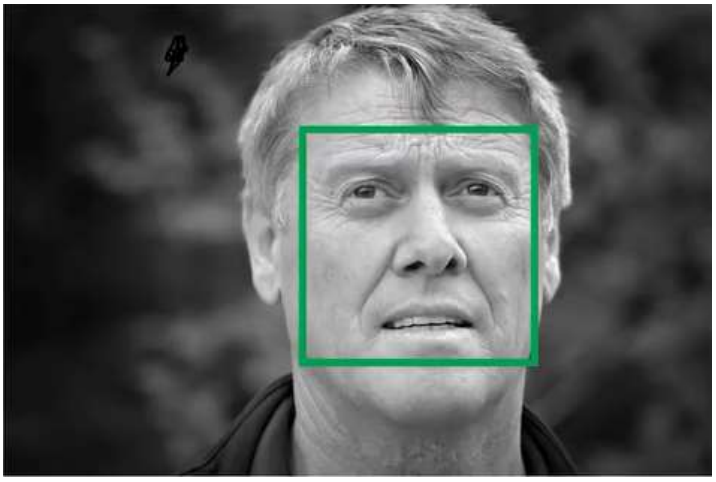

Figure: Landmark image

Suppose we need to detect the eyebrow. Then we need edge features. If we want to detect nose then we need line features black-white-black. If we want to detect teeth then we need edge features. After using these Haar features the image goes on the next feature. The ratio between these detected features is used in emotion detection.

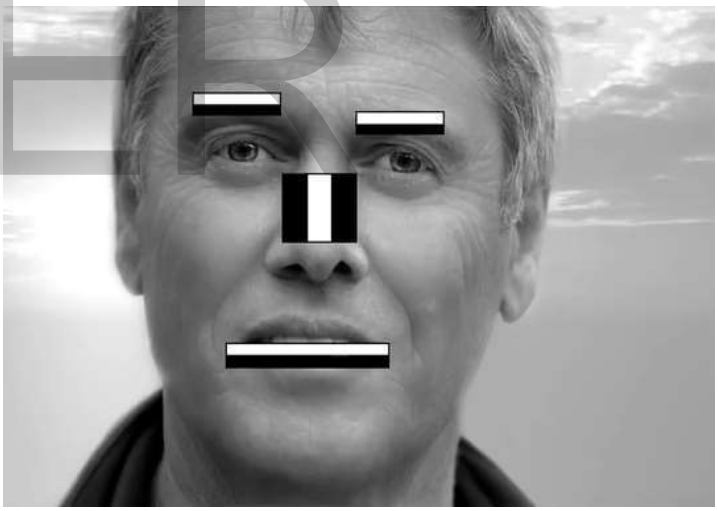

Figure: Haar features image.

We can calculate value by using Fourier equation,

$$\Delta = dark - white = \frac{1}{n}\sum_{black}^{n}[(x) - \frac{1}{n}\sum_{white}^{n}](x)$$

For ideal Haar features,
The black region value is 1 and the white region value is 0.
So the difference between dark and white 1-0=1.
Δ for ideal Haar features is 1

For real image,

If we calculate the black region and we average it's when we get 0.74 and the same way white region value is 0.18. So the difference between dark and white: 0.74-0.18=0.56

Δ for real image: 0.56.

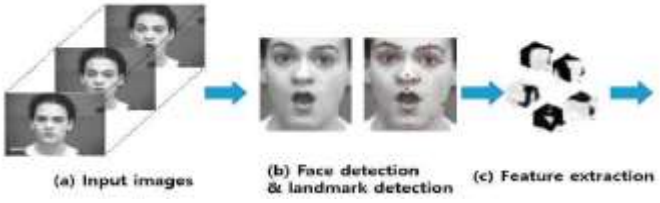

Figure: Feature extraction

Neural networks are typically organized in layers. Layers are made up of several interconnected nodes that contain an activation function. Patterns are presented to the network via the input layer, which communicates to one or more hidden layers where the actual processing is done via a system of weighted connections. This process of the facial expression recognition system is divided into three stages- Image Pre Processing which involves Face and facial parts detection using the viola-Jones algorithm, facial Feature extraction, and feature classification using CNN. Keras is an open-source neural network in python, which is used for the preprocessing, modeling, evaluating, and optimization. It is used for high-level API as it handled by backend. It is designed for making a model with loss and optimizer function, and training process with fit function. For backend, it designed for convolution and low-level computation under tensors or TensorFlow. Importing the below python libraries is used for preprocessing, modeling, optimization, testing, and display emotion which having a maximum percentage. It uses a sequential model and some layers such as image pre-processing, convolution layer, pooling layer, flatten layers, and dense layers, activation, ReLU. Image preprocessing is the first phase of the proposed system and it involves the Face Detection and FPs detection and extraction. The Viola-Jones face detection framework, which is a robust algorithm capable of processing images extremely rapidly for real-time situations, is used. This algorithm detects face region irrespective of variance in size, background, brightness, and spatial transformation of the raw input image. The face FP detection is achieved by combining classifiers in a cascade structure that is capable of increasing the detection performance while reducing computational complexity. The final classifier is computed by the linear combination of all weak classifiers, which separates the positive and negative in terms of the weighted error (weight of each learner is directly proportional to its accuracy). The face is first detected, cropped, extracted and normalized to a size of 64 x 64 pixels, and then facial parts (both eyes and mouth) are detected, cropped and extracted from the normalized face image. The extracted facial parts are resized to equal size of 32 x 64 pixels. The reduced image scale helps to reduce the information that has to be learned by the network and also makes training faster and with less memory cost. Convolution layers will be added for better accuracy for large datasets. The dataset is collected from CSV file (in pixels format) and it's converted into images and then classify emotions with respective expressions. Here emotions are classified as happy, sad, angry, surprise, neutral, disgust, and fear with 34,488 images for the training dataset and 1,250 for testing. Each emotion is expressed with different facial features like eyebrows, opening the mouth, raised cheeks, wrinkles around the nose, wide-open eyelids, and many others. Trained the large dataset for better accuracy and result that is the object class for an input image. Pooling is a concept in deep learning visual object recognition that goes hand-in-hand with convolution. The idea is that a convolution (or a local neural network feature detector) maps a region of an image to a feature map. For example, a 5x5 array of pixels could be mapped to oriented edge features. Flattening occurs when you reduce all Photoshop layers to one background layer. Layers can increase file size, thereby also tying up valuable processing resources. To keep down file size, you may choose to merge some layers or even flatten the entire image to one background layer. The dense layer is the regular deeply connected neural network layer. It is the most common and frequently used layer. The dense layer does the below operation on the input and returns the output. Based on the connection strengths (weights), inhibition or excitation, and transfer functions, the activation value is passed from node to node. Each of the nodes sums the activation values it receives; it then modifies the value based on its transfer function. In Keras, it can implement dropout by added Dropout layers into our network architecture. Each Dropout layer will drop a user-defined hyperparameter of units in the previous layer every batch. Remember in Keras the input layer is assumed to be the first layer and not added using the add. ReLU is one of the most popular types of nonlinearity to use in neural networks that are applied after the convolutional layer and before max pooling. It replaces all negative pixel values in the feature map by zero. It normally used after the convolutional layer.

Example: ReLU is the max function(x, 0) with input x, matrix from a convolved image. ReLU then sets all negative values in the matrix x to zero and all other values are kept constant. ReLU is computed after the convolution and therefore a nonlinear activation function like than or sigmoid. Adam is an optimization algorithm that can be used instead of the classical stochastic gradient descent procedure to update network weights iterative based on training data. It has been found that there are many endeavors have been taken using several automated techniques to analyze emotions. However, most of them are found without any establishing framework and describing how to properly use them. More specifically, understanding and maintaining the emotion analysis capability can help law-enforcement authorities effectively use machine learning techniques to track and identify emotion patterns.

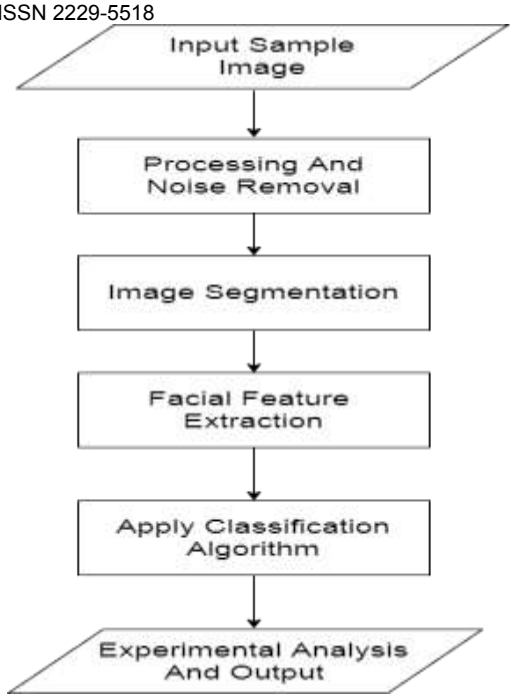

Figure: Emotion Detection Data Flow Diagram

At first, take the image from the user then remove the noise. Then identify only the face of a person and applying the Haar features. Then match the image with the previous training dataset. Here use the Keras library of python. It works with the convolution neural network (CNN). CNN works with a sequential model. It also uses some layers such as Conv2D, MaxPooling2D, AveragePooling2D, Dense, Activation, Dropout, and Flatten. After the approach, these layers select the emotion from the classification set. This is the final output. After performing some pre-processing (if necessary), the normalized face image is presented to the feature extraction part to find the key features that are going to be used for classification. In another word, this module is responsible for composing a feature vector that is well enough to represent the face image. After doing this comparison, the face image is classified into one of the seven expressions (anger, contempt, disgust, fear, happiness, sadness, surprise).

4 RESULT & ANALYSIS

The first major challenge was the confined measure of information for preparing a broad framework. Which needs to defeat for framework in nature. Move learning is the most prevalent response to this. In this methodology that was begun from pre-prepared strategy and calibrated this model with the put-away information which is gathered from a genuine world. A progression of starter investigations affirmed the presumption that face acknowledgment would serve better in highlight extraction. There are models where such systems are effectively utilized.

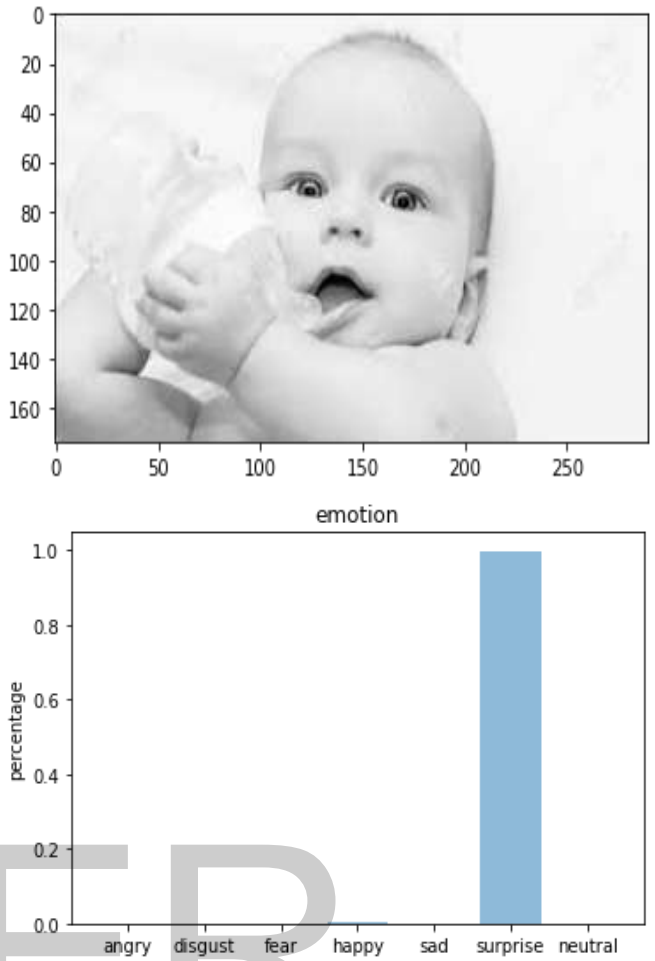

Figure: Expression with surprise emotion

Machine learning algorithms work well on the datasets that have a couple of hundred highlights or segment. The algorithm successfully classifies an image and classify the sentiment of the image and choose the match emotion for the image. The reason behind choosing the deep learning classifier is that the classifier runs data through several layers. And a deep learning algorithm can be useful for less unpredictable issues since they gain admittance to an immense measure of information to be compelling. For pictures, the regular benchmark for preparing profound learning models for broad picture acknowledgment approaches more than 14 million pictures. For perfect visualization of emotion detection pattern analysis, it used a decision tree. In the decision tree, the character is represented by the nodes and layers, and also the outcome of the experiment is represented by the branch. The advantage of the decision tree is that it is very helpful and easy to visualize the emotion and interpret the result. The working process of a decision tree is easy to understand. If it has been classified the data according to their movement, reactions, and order which ideally different types of emotions. This also has been classified into trees and sub trees which reflects that whether the person is sad, angry or happy, etc. if this could find something that can categorize their using these methods more simply. To do this it has been used retrain method that memorized the pattern and satisfies the condition. When any of the condition is

satisfied it carry on to the end of the tree. However, if none of the conditions satisfy the intermediate condition, it will stop checking and say "The emotion cannot be identified. The emotion is unknown". Emotions are complicated to understand. There are different kinds of expression for the same emotion. Different people give different kinds of expression for the same kind of emotion. Modern-day machine learning technology can help law-enforcement authority to detect emotion so the machine can understand the emotion of humans and more behave and act like humans. This data for emotion came from different online and offline media. Such as Google, kaggel.com site. Friends and family, random people, etc. This is used Keras library to initially classify and analyze the emotion and got that data. Then with the help of Haar features and Numpy, It identifies the emotion. And with the help of platform anaconda. It generates the output from the raw data where the result is going to show in real-time. The hierarchical data mining procedure like decision tree helps to generate probability decision by calculating various probability decisions by calculating various characteristic which is initially used to identify the emotion pattern. Along with offline and online data collection, it also conducted an effective field study to gather more people and various kinds of people and various emotional deferent expressions lots of different faces. In online data collection, the data set is taken from kaggel.com. They provide quality data sets. They converted the images into pixel grayscale and use the numerical number of the images. So, it gives the quality data and the batter result. Both of the experts believed that this analysis of sentiment could help identify emotion more accurately and help to take accurate actions on behalf of accurate emotion identification. It would provide more knowledge about different types of expression of their sentiment as well as the percentage of each existed various kinds of emotions. While completing this work, we found that a large quantity of test data and keywords are needed if it wants to get greater accuracy. A lack of a good quantity of raw data is also required to extend the research work. A high configuration graphics processing unit (GPU) qualified computer is also required if this wants to process a large quantity of test data in the shortest time. So, if this gets adequate data along with a high-performance computer, it will be easier for that to rise the accuracy to more than 97%. It will also be able to use that system for a different platform for a different outcome and help to determine the emotion expression pattern.

5 CONCLUSION

An experienced human can often identify another human's emotions by analyzing and looking at him or her. However, in this modern age machines are becoming more intelligent. For the time been machines are trying to act more like humans. If the machine has been trained on how to react on behalf of the human sentiment at that time. Then the machine can behave and act like a human. On the other hand, if the machine can identify the emotion it can prevent lots of occurrences too. With increased proficiency and errorless computation emotion, data mining can facilitate accurate expression patterns enabling machines to find and act more like humans effectively. To determine the emotion expression patterns this thesis is created or framework with comprehensive research and field works. This followed the framework step by step to get the expected outcome. To follow the framework and to identify the emotion expression patterns more effectively and used deep learning CNN algorithm along with Keras, Tensorflow, and retraining concepts. With these techniques, it was possible to identify emotions, type of emotion in the real image. To delineate the result and procedures more visually and this has also introduced decision tree techniques which helps to decide which emotions percentage is high and which emotions percentage is low. Now the high percentage of emotions get the most possible accurate emotions. And the low percentage of emotions get the low chance of existence. With this discovery, it is now possible to determine accurate emotions. And machines can identify emotion more accurately and on behalf of that, they can give a proper reaction and also can help to prevent the same unwonted occurrence. This machine can also become the replacement of a human.

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