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Facial Expression Recognition using Artificial Neural Network

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Abstract

Facial expression recognition is a key element in human communication. In order to promote man and machine interaction a framework is proposed for facial expression recognition from images and videos. The database used is gathered by capturing images and videos of around 50 people bearing different emotion. An intelligent system is deployed using artificial neural network and image processing for facial expression recognition. Images bearing different emotions are trained using radial basis neural network. Simulation is done for the trained network to test the new data for the classification in different facial expressions.

Keywords

Emotion recognition, Facial expression recognition, Face detection, Artificial Neural Network, Emotion classification.

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Introduction

Facial expressions are temporary which are caused due to deformation of facial muscles or facial features such as nose, lips, eyes, skin texture eye lids and eye brows generated by facial muscles contractions. Source of emotion through facial expression can be verbal or non-verbal communication. Many factors contribute in conveying emotion of an individual. Pose, speech, facial expression, behaviour and actions are some of them. Facial expressions can or cannot be equated with emotions. The definition of expression recognition often refers back to the classification of facial features within the six basic emotions such as Disgust, Surprise, Happy, Sad, Fear and Anger. The truth is, human emotion comprises a huge selection of expressions and thousands of emotional words, although most of them differ in subtle changes of a few facial features.

Most powerful way of representing human behaviour is facial Expression. According to Mehrabian (1968), 7% of the effect of the message is contributed to verbal part, 38% of the effect is vocal part and facial expression has an effect of 55% [5]. Automatic expression analysis is surely an interesting and challenging problem in real time domain for applications in candid photography, video surveillance, psychology, emotion and behavioural study.

In order to classify facial expression into different categories it is essential to extract facial features first, which highly contributes in identifying an expression. In this work, we proposed an interface for expression recognition by extracting features like nose, eyes and mouth. In this work, facial expression recognition has been proposed by extracting facial features like nose, mouth and eyes. We propose an approach for the facial expression recognition from images and videos.

The method of facial Expression Recognition System consists of four components: input image, image processing, feature extraction and Expression Recognition. Image processing is made up of scaling and image rendering to arrange the facial skin for expression recognition. The operation of expression recognition involves processing images by extracting the facial features, and employing an algorithm to recognize the expressions. The required database for this task has been collected from male and female images and videos of different age groups. The database used in this work is gathered by capturing frontal face images and videos of around 50 people bearing different emotion. With this database features for example nose, mouth and eyes are extracted which are trained using artificial neural network for the classification of expression.

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The rest of the paper is organized as follows: Next section briefs about the databases used. Section III provides the details of feature extraction. An overview of classifiers (Feed Forward neural network) is provided in section IV. Development of facial expression recognition system and results is described in Section V. The paper concludes with summary (section VI) followed by important citations.

Review of Literature

Value of aspect product is more popular in social interaction and social intelligence. It analysis have been an energetic research topic since 19th century. The facial expression recognition system was introduced in 1978 by Suwa et. al. The principle issue to build a expression recognition system is face detection and alignment, image normalization, feature extraction, and classification. There are number of techniques used in each of the process. Ekman and Freisen have been pioneers in this field, helping identify six basic emotions (anger, fear, disgust, joy, surprise, sadness) that seem to be universal across humanity [2]. Normally architecture of expression recognition system consists of four stages. We took the input data from our dataset for extraction techniques. Image preprocessing stage normalizes the input face by adjusting the contrast, brightness etc. and enhancing the input face image. After that we extract the set of features which is used to describe the emotion expression and with suitable algorithm we can classify these expressions. In 2001 Viola and Jones detection described a machine learning approach which is capable of processing images extremely at high rate to achieve high detection rates. This worked on three major contributors. Firstly, is the introduction of image representation newly named as the "Integral Image" which allows detector to be compare features quickly. Secondly algorithm based on AdaBoost which yields extremely efficient classifiers by selecting a small number of critical visual features from a larger set. Thirdly, a method for combining complex classifiers in a "cascade" which discards background and concentrate more on object [7]. They proposed a methodology detect faces within an image accurately and rapidly.

Viola and Jones technique enables you to detect facial features accurately. There are a number of algorithms exist to execute face detection and they all have certain weaknesses and strengths. Viola and Jones devised an algorithm named Haar Classifiers which rapidly detect any object, including human faces, using AdaBoost classifier cascades which have been depending on Haar-like

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features [8]. KLT Algorithm is one of the technique which is used to detect and track face. In our system we use KTL algorithm in order to track face in a video. KLT algorithm automatically does it by using feature points. KLT algorithm is introduced by Lucas and Kanade and later extended in the works of Tomasi and Kanade. When a person moves towards or away, or tilts his or head this approach tracks the person's face [2].

It works by using spatial intensity information to direct scouting around for the career that yields the top match. Despite being a lot more than 2 decades old, the KLT algorithm is widely used, as it are operating in a completely automatic way and its particular performance when it comes to feature point quality and runtime is competitive compared to other methods. After image processing, face detection, feature extraction expression classification is the major part of recognizing emotion. Classification of features are made under two broad categories [9] first is statistical non-machine learning approach such as Euclidean and linear discrimination analysis and second approach is machine learning approach such as Feed forward Neural Network [4], Hidden Markov Model, Multilayer Perceptron, Radial Basis Function Network [6], etc.

Proposed Methodology

Figure 1 illustrates the working model of expression recognition. The figure 1 shows the proposed model.

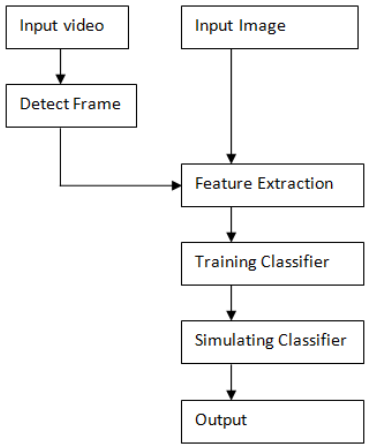

Figure 1: *Flow diagram/model of expression recognition*

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The Input image, Image Preprocessing, Feature Extraction (Using the Haar classifier), Classification (Using the Feed Forward Neural Network) and output. The process includes major areas such as face detection, feature extraction and classification in images and video.

Algorithm for Emotion Recognition

```
Load source data for training
Initialize required variables
    I: image name
    s: source data
    t: target data
    o: output

While images in files
    I <- Read image files
    Extract Facial Features using Haar Classifier
End While

s <- create source
Extract features of target image

t <- create target data
net <- newrbe(s,t)          // create radial basis network
o <- sim(net,s)             // simulate network

If o matches our source data display facial expression recognized from image
    Else displays try again
End if
```

Load Image or Video

In the first module, the image of the face will be taken as input. Then the image processing will be performed which will convert the image into the desired resolution and color and thereafter in the next module the feature extraction will be performed. While uploading image frame is detected from the video playing and further processing is done on the frame captured.

Feature Extraction

Feature extraction is done using Haar classifier. Haar-like feature is the core basis for Haar Classifier. Rather than using the intensity values of pixel Haar like features use contrast values between rectangular adjacent groups of pixels. Relative light and dark areas are determined from group of pixels. In order to detect features from an image Haar like features are used as shown in figure 2. With the increase and decrease in size of pixel groups Haar features are scaled. Thus, this helps in detection of objects of various sizes. The easy rectangular

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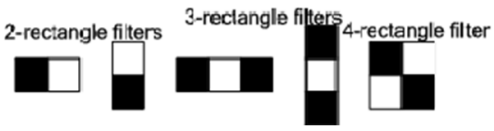

Figure 2: *Haar like feature used for facial feature extraction [8]*

popular features of a graphic are calculated utilizing an intermediate representation of image, called the integral image [9]. The integral image is definitely an array containing the sums with the pixel's intensity values located on to the left of an pixel and directly above the pixel at location (x, y) inclusive. So if A[x,y] could be the original image and AI[x,y] will be the integral image then this integral image is computed as shown in equation 1 and illustrated in figure 2.

$$AI[x, y] = \sum_{x' \leq x, y' \leq y} A(x', y') \tag{1}$$

Training Classifier

In order to train input against target data radial basis neural network is used as training classifier. To make an expert system, system is enabled to learn different emotions. A classifier is trained for different images and videos bearing different emotions like Happy, Sad, Fear, Anger, Surprise and Neutral.

Simulation

Simulation of trained classifier is performed to test target data to identify facial expressions. Classification of facial expression is done which is a major step of proposed automated system.

Experimental Results

An automated system is implemented in MATLAB. Figure 3 shows facial expression classification from an image where as 4 shows classification from a video. Nose, mouth and eyes are the extracted features from the input image. Figure 4 shows the net diagram also called as neural network model of the facial expression recognition system. The neural net model contains 2 layers one is hidden layer and another one is output layer. There are 14 input neurons, hidden layer contains 7 neurons whereas output layer contains 2 neurons. Input layer and output layer use transfer function to normalize the output for each of the layer which varies between -1 and $+1$.

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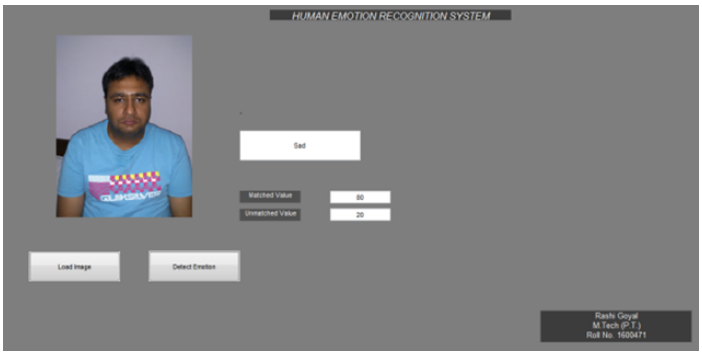

Figure 3: *Facial feature classification from an image*

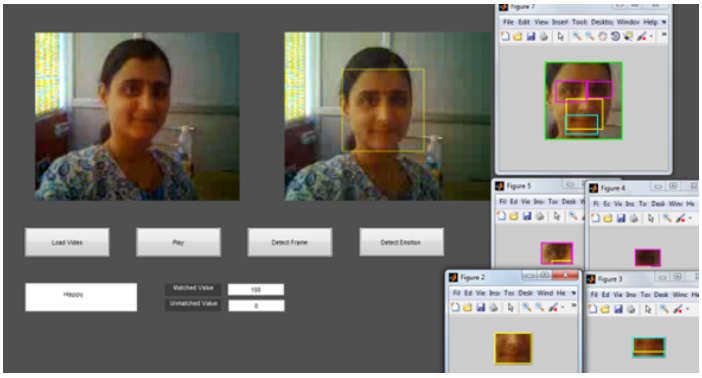

Figure 4: *Facial feature classification from a video*

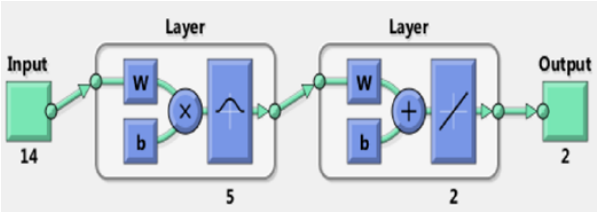

Figure 5: *Neural Network*

To verify performance of the system confusion matrix is calculated. It has a layout in a specific tabular form that shows performance, typically a supervised learning. Matrix column represents the predicted class instance, while each row represents actual class instance. As the name represents it is easy to calculate if the automated system is confusing between two classes. In the figure 5 the output class is matched with the target class. NaN shows not a number. The

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matched value and matched value is displayed on the interface. Percentage of right and wrong classification is calculated. Right classification of the system is 80%.

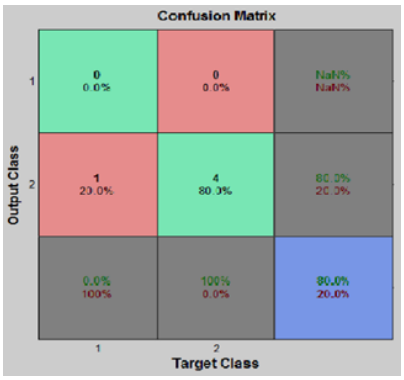

Figure 6: *Confusion Matrix*

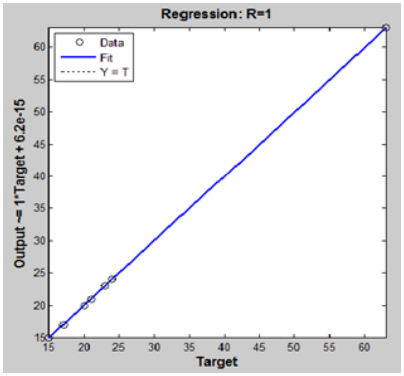

Figure 7: *Regression Plot*

Other criteria used to check the network performance is Regression Plot as shown in figure 7. Plot shows a value of $R = 1$. Value $R = 1$ is considered as best fit of data by network and worst fit as $R = 0$. Since system value in plot is shown as 1 therefore after training network has fit the data well.

Conclusion

As the proposed system is the automated human emotion recognition system which successfully displays emotion from an image uploaded by a user by

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matching it with our trained data set. In case when our trained datasets is matched with the uploaded image our system will show the output otherwise not. The input to the system is an image of a human emotion or a video from our database. The output is the emotion of the uploaded image or the frame taken from the video. Although facial expressions often occur during conversations, none of the cited approaches did consider this possibility. In the proposed approach emotion is depicted from an image as well as from video and target data is matched with source data in order to check or results over the trained data set. To check over the performance regression plot is another criterion. Confusion matrix is another measure to verify performance measure which shows percentage of right classification with respect to percentage of wrong classification.

Future Scope

In hindsight there is always the realization of different ideas or approaches that could have been pursed during the course of a research project. It is difficult to speculate on the relative usefulness of untested ideas, but it is worthwhile discussing potentially new directions that this research could take none the less. Despite the success of the research in the thesis, there is still much room for improvement for the adaptation and consistency modelling techniques presented in this dissertation. Three areas where future research could be directed are:

1. There are a number of applications where human emotion can be explored driving and monitoring.
2. Studying human psychology.
3. We have detected emotion from video on a frame work can be carried out to get emotion on each frame.
4. Emotion can also be detected from side images of human face.

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