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Facial Expression Recognition using Compressed Images

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Abstract*: *Facial expression plays an integral part in expressing ones emotions. These expressions can be conveyed in various forms such as happiness, sadness, anger, surprise, fear, disgust, and neutral. So we propose a system which recognizes and classifies these expressions. We have used an image compression method (FMM) to compress the images collected. Then we detect human face in the compressed image using Viola Jones Haar-like object detector. Using the detected face, we extract the facial features that changes with the changing expressions using LBP. Finally we classify the expression using the extraction using k-NN. Presently, FER is applied in a wide variety of environments including robotics, mobile application, digital signs, as a psychiatric tool for verifying the observations made by the psychologist, etc. The existing system use grayscale/ RGB images which consumes a lot of space and requires a lot of computational time. We present a new approach of using compressed images to reduce the space and time required.

Index Terms:* *FMM, Image Processing, Image Compression, LBP, k-NN

I. INTRODUCTION

A human face is a crucial part of an individual. It consists of numerous muscles which help in the formation of various expressions that convey emotions such as anger, happiness, disgust, etc. These expressions are understood by all. A human can understand these emotions or expressions easily, but it is difficult for a system to understand these emotions. Over past few decades, many techniques have been developed for analyzing these expressions and the emotion behind these expressions. These include feature based expression analysis, geometry based expression analysis, etc. Many researchers have researched in this field to make the process of FER automatic and also many effort have been made to associate this technology with the devices that are used by people on a daily basis, for example smart phones. This technology has also been applied in the field of psychiatry where it is used by psychiatrists to verify their observations of a patient during a session. FER can also be used in the field of medicine, learning and as a part of a smart home, etc. Our paper presents a method for Facial Expression Recognition (FER) which uses the concept of Image Processing. Image processing is the manipulation and analysis of a digitized image, which is used to improve its quality or to conduct experiments for certain results. It involves methods that help in performing operations on an image, so as to enhance the image or to extract some information. It is a signal processing method where an image is taken as an input and the output may be an image or some feature associated with the input image. Image compression is a way of compressing data that is used on the digital images where the data is represented with as few bits as possible. There are 2 types of image compression methods – lossy compression and lossless compression. These days, image compression techniques are very common in various fields of research. So through this paper, we propose a method of FER which recognizes the expressions using the feature based method, i.e. by extracting the features that change with change in expressions. To reduce the amount of space, we use compressed images as input.

This paper is in the following manner. A brief literature survey on the existing models and methods is presented in section 2. The proposed method is explained in detail in section 3. Details of the results obtained, datasets used is presented in section 4. The work is concluded in section 5.

I. LITERATURE SURVEY

FER can be done using numerous methods or a combination of methods. And these methods can be categorized into different stages in the process of FER. Most commonly performed steps include:

1. Preprocessing
2. Face detection
3. Facial feature extraction
4. Expression classification

These steps are performed on the input images to obtain the desired result. Preprocessing is a stage in image processing/image classification where the quality of the image is enhanced and the unwanted details or features are removed. Commonly implemented preprocessing steps are - removal of noise, conversion of input image to binary/grayscale/compressed form, operations on image pixels, geometric transformations. Face detection is a technique which is used to identify human faces in digitized images, where face is detected in the preprocessed image.

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Facial feature extraction is the next step and a very important step in expression recognition and it can be defined as the process of extracting facial features like eyes, eyebrows, nose, etc. Expression classification is the final step in FER, where expressions are classified into 6 categories of expressions, i.e. happy, sad, anger, disgust, surprise and neutral.

All classifications depends upon labeled datasets, i.e. data must be pre-defined by humans so that classification may take place by correlating labels and data. [11] This paper presents an detailed summary on the above mentioned steps and the different techniques related to these steps. [10] The idea behind compressing an image is to reduce the size of the original data and in turn reducing the storage space required. FMM uses the same concept of image compression where the image is divided into blocks of 8x8 pixels and since each pixel lie in between the range 0-255, each pixel value is transformed into a number divisible by 5, and the minimum value from the newly obtained pixel values is subtracted from the original image to obtain a compressed image. [9] Vector Quantization is a quantization technique for processing signal. It is a method of lossy data compression. It is a technique used for the purpose of speaker modelling using MFCC features. It consists of extracting small number of features from the given data so as to reduce the dimension of vectors and the time taken to classify the data. From this paper, we notice that the shape of the graph representing the original data and the compressed data are more or less same. Hence, it can be said that the vital information present in the original data will remain unaltered in the compressed data. [1][7] Viola Jones Object Detection Framework is a popular algorithm for face detection as it reduces redundant operations and it also computes data and produces results within seconds. It is used as a method for human face detection and tracking in real time. [12] PCA is one of the most commonly used methods for signal processing. This paper uses the Viola Jones algorithm on images with static and non-static conditions. And it implements different existing techniques and methods for face detection and their performance, limitations are also presented. They use PCA and Viola Jones algorithm for face detection. [2][3][4] LBP is a simple texture operator that gives a label to all the pixels in an image by thresholding the neighbouring pixels and takes the result between 0 and 1, i.e. binary values. It is used as a feature extraction method on images which contain faces and it is also used as a face recognition method. [1][4][5] Neural network is a network of neuron or artificial nodes. They are useful in clustering and classifying data. DNN is one of the types of neural network. It consists of input, hidden and output layers. And multiple layers exist between the input and the output layers. DNN can be used for both ID signal processing (like voice) and face recognition. It has a number of hidden layers. Activation of each layer is done using ReLU (Rectified Linear Unit). ReLU is a popular activation function for DNN. CNN is a part of DNN. It is a variation of multiple layer perceptron. CNN's hidden layer consists of the following layers – activation function (ReLU), pooling layer, normalization layer and fully connected layers. CNN is used when the input size is very huge, and DNN is used when the input size is not too large. [6] LDA is a method that classifies linear combination of features or separates object classes. It is mostly used for dimensionality reduction. This paper uses PCA and LDA for face detection. The main objective of this paper is to get the best facial recognition algorithm (Eigenface and Fisherface). In this paper, faces are captured in real time as input for the proposed system, i.e. attendance system.

[18]k-NN (k-Nearest Neighbours) is a method that comes under pattern recognition. It is a method used for regression and classification. It is a non-parametric technique, i.e. it does not make assumptions based on data distribution. This paper uses 3 stages of classifiers after pre-processing. Stage 1 uses k-NN classifier. This allows the system to vary in different ways.

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II. PROPOSED METHOD

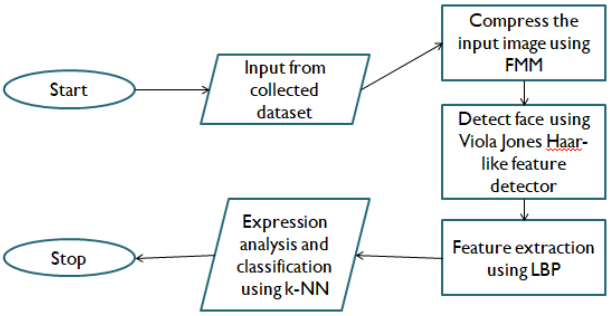

Figure 1 Proposed method

A. ALGORITHM

Step 1 : Compress the collected images and the images in the datasets.
Step 2 : Detect the face in each of the compressed image and store the result.
Step 3 : Extract facial features in the face necessary for FER using LBP extraction method.
Step 4 : Classify the expression in the selected input image using K-NN classifier and display it.

B. PREPROCESSING

Five Modulus Method (FMM) is a lossy data compression method where the image is converted into a blocks of 8x8 pixels. And since all the pixel values range from 0-255 for each of the Red, Green, and Blue arrays. The Human Visual System is a part of the nervous system that allows humans to see. Sometimes, HVS does not notice some parts of the signal/image, i.e. excluding these parts will go unnoticed by the receiver. This is called as Irrelevancy. Hence, by keeping this point in mind, the RGB arrays can be converted into multiples of 5, i.e. dividing each pixel value in the image by 5. This converts the pixels into values ranging from 0-51. And then obtain the minimum value from the new image matrix and subtract it from all the pixels in the image. This gives the compressed image. The compressed images help in the reduction of storage space required. This method can be used on bi-level images (black and white images).

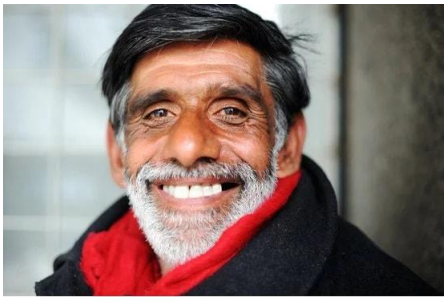

Figure 2(a) Original Image

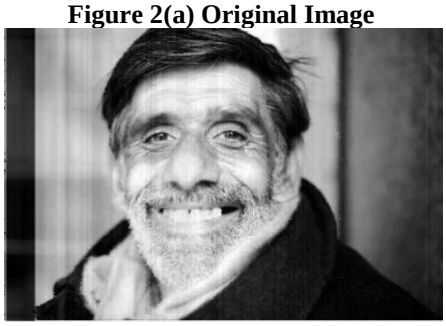

Figure 2(a) Compressed Image

A. FACE DETECTION

Face detection is an important step in any FER system. It makes the task of feature extraction easy. A facial recognition system makes use of bio-metrics to recognize faces in an image. It is a widely used technology in various applications. Cascade Object Detector uses the Viola Jones Detection Algorithm for face and feature detection. In this step, we use the Cascade Object Detector to detect facial features such as eyes, mouth, nose, etc. We use this detector to detect the face in the input image. It consists of a large pre-trained dataset of face and feature templates which is used as a sample to detect the selected features in the face. For the accurate working of the method, we have used full frontal images as input.

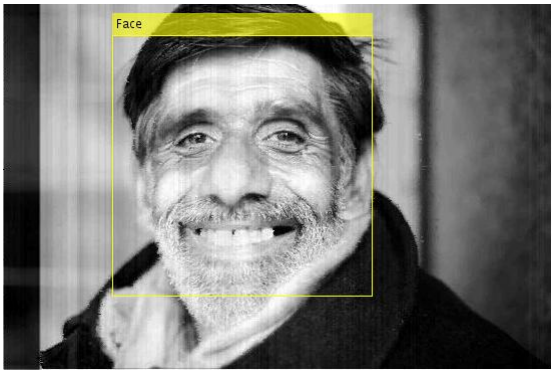

Figure 3(a) Face detection

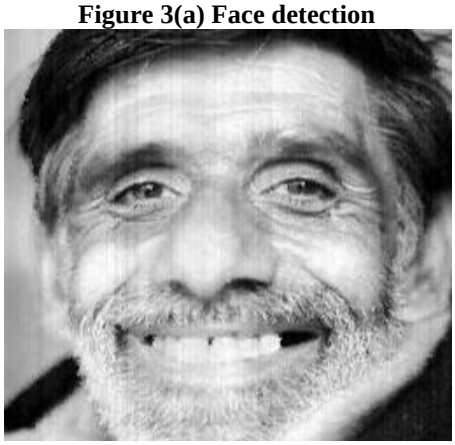

Figure 3(a) Cropped face after detection

B. FEATURE EXTRACTION

A feature is a part of the information, to which more importance is given than to the rest of the information present along with it. This information is extracted or separated from the rest of the information for further manipulation or use. Feature extraction is the process for extracting this information. In our case the information to be obtained are the facial features such as eyes (with eyebrows) and mouth. To do so, we have used the segmentation methods available in MATLAB for detecting along with LBP (Local Binary Pattern) method for extracting the required features. These extracted features are used in the next stage - expression classification.

Figure 4(a) Eyes extraction

Figure 4(a) Mouth extraction

C. EXPRESSION CLASSIFICATION

Classification is a process of categorizing the image into different classes. It refers to the classification of expressions based on the universal emotions - angry, sad, happy, disgust, surprise, neutral. For the classification of expressions, we have used the k-NN classification method where the dataset is categorized into different expressions and each of these are loaded separately.

The facial features necessary for expression recognition are provided in bulk to the classifier from the dataset. Confusion matrix is used to calculate the number of correctly classified expressions and the incorrectly classified expression, based on which the accuracy is calculated for all the expressions.

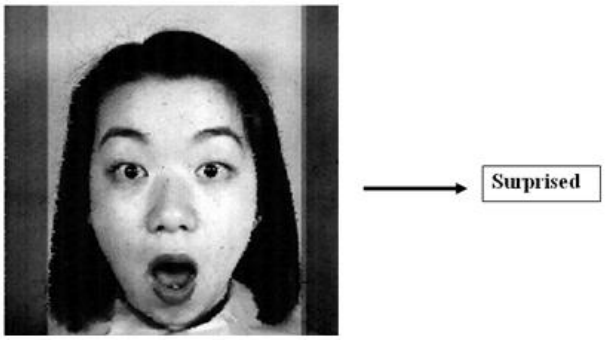

Figure 5 Expression Classification

III. EXPERIMENTAL SETTINGS

During the implementation, we conducted 2 sets of experiments; where each set lead to a different result. For the first set of experiment, we used compressed images to train the system. For the second set of experiment, we used normalized grayscale images. In each of the sets of experimentation, we used 60\% of the images as training data and the rest 40\% as test data. We have used the pre-built dataset JAFFE and images collected from various sources on internet as a data source for building our own compressed dataset which consists of 400 images. To evaluate the system we have made use of the Confusion Matrix as a means to calculate the accuracy of the adopted method. To check the accuracy and to study the behavior of the implemented method on compressed images and grayscale images,
we have conducted experiments on datasets consisting of 7 classes. FMeasure for the self built dataset and MUG dataset is shown in Table 1.

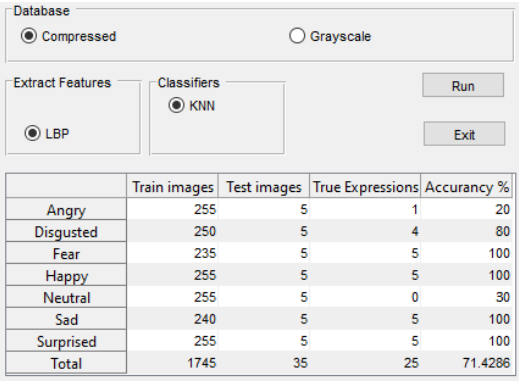

Figure 6 Working example of the GUI

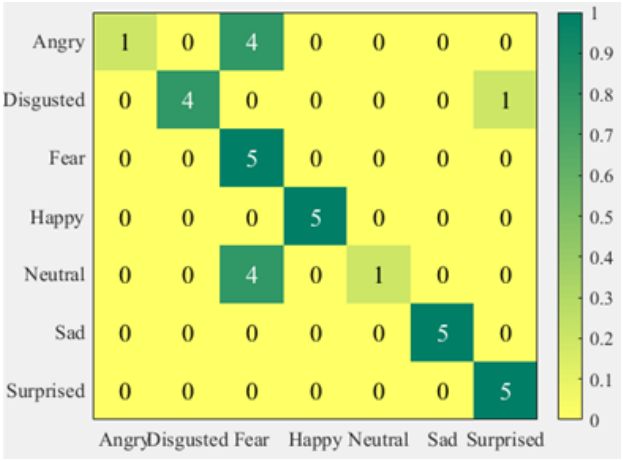

Figure 7(a) Confusion matrix for compressed image dataset

Figure 7(b) Confusion matrix for grayscale image dataset

IV. CONCLUSION

The method works well on the compressed image dataset (Table 1). But the method falls behind in the classification of 2 of the expressions - angry and neutral. The experiments conducted on the two datasets show the efficiency of the method on compressed images.

TABLE 1
Aggregate Accuracy comparison between datasets for each expression

DATASETS / EMOTIONS	COMPRESSED IMAGES (%)	GRAYSCALE IMAGES (%)
ANGRY	42.21	45.3
DISGUSTED	80	66.67
FEAR	94.35	93.90
HAPPY	90.11	85.33

NEUTRAL	61.84	72.45
SAD	97.2	67
SURPRISED	81.21	50.33

TABLE 2
FMeasure comparision between datasets

DATASET	FMEASURE (%)
COMPRESSED IMAGES	80.5
GRAYSCALE IMAGES	70

A brief introduction on the various steps involved in FER, an extensive study on different feature extraction methods, feature detection methods and different methods for facial expression classification is presented in this paper. Also the concept of data compression is used to reduce the computation time and memory requirement. A method for Facial Expression Recognition is explored in this paper. To check the accuracy of the proposed method, an extensive experiment is carried out on facial expressions database and the details are presented corresponding section. For evaluating the results, we have made use of Confusion Matrix as metrics. The proposed method is efficient due to usage of compressed images and thus indicates that the proposed expression recognition method is effective in reducing the amount of storage space required and computation time.

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