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Facial Emotional Expression Recognition using Gabor Filter

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Abstract: *Facial expressions and gestures provide instinct for interpersonal communication.. Facial expressions and emotions are governed by identification of facial muscle movement by visual cortex and training a machine to identify these highly in-situ movements is our primary interest. Imparting intelligence to computer for identifying facial expressions is a determinig task. This theory presents robust facial expression analysis algorithms for static images as well as an efficient extension to sequence of images. Robust Local Binary Patterns and Gabor filters are implemented for extractimg feature which are known to provide efficient face representation and analysis. LBP facial features are represented in form of weighted histograms which are classified using Kullback Leibler divergence measure .Artificial Neural Network classifier is also tested for classification of fused Gabor and LBP features. Further expressions are rarely defined by static images as their complete essence lies in a order of images. So further exploration is concerted on analyzing expressions from a sequence of images. To eliminate head pose variations in consecutive frames and register images to keep the dimentional information intact which is necessary for LBP feature representation we adopted SIFT flow alignment procedure and more distant tested the resultant image classification with implemented algorithms. The classification accuracy resulted in 95.24% for static expression images and 86.31 % for sequence of images which is indeed appreciable when compared to other standard methods.*

Keywords: Feature Extraction, Gabor Filter, Classifier, Facial Expression

I. INTRODUCTION

Facial expressions and gestures provide instinct cues for interpersonal communication. Verbal communication consists of only raw voice data input and nonverbal communication accounts for the tone and intensity of voice merged with facial expressions and gestures. While having a Face to Face interaction facial expression conveys the non-verbal communication. The facial expression of the Speaker gives about 55 percent of the effect , 38 percent of his/her voice tone and 7 percent of his/her spoken words. Facial expression can be defined as a temporal deformation of facial features like eyes, nose, lips, cheeks, etc which is a result of muscular activity aroused by internal feelings or events occurring in the surroundings. Extent of Opening of eyes, frowning of eyebrows, rise of eye brows, widening and shortening of mouth especially at the corners form an important aspect of expression classification as identified by the human visual cortex. Hence our facial expression recognition system should be designed such that even the normal change in the movement of facial organs can be efficiently identified and adhere to exact classification.

1.1 Various types of Emotions

According to Russel[1] based on the extent of activation and pleasure there are about 200 different emotions as listed below:

1. High activation: aroused, astonished, stimulated, surprised, active.
2. Pleasant: happy, delighted, glad, cheerful, pleased, warmhearted .
3. Low activation: idle, tranquil, still, passive, quiet.
4. Unpleasant: unhappy, sad, miserable, grouchy, blue .
5. High activation + Pleasant : enthusiastic, elated, excited, euphoric, lively.
6. Low activation + Pleasant : relaxed, contented, atrest, calm, serene .

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7. High activation + Unpleasant : distressed, annoyed, fearful, nervous, jittery, anxious.
8. Low activation +Unpleasant : dull, tired, drowsy, sluggish, bored, droopy.

All the above listed expressions vary with slightest change in the facial features , hence these are named as micro facial expressions. . Detecting these changes is a crucial and difficult task and resultant emotion displayed by human is often a combined outcome of numerous microfacial expressions. So, classifying these micro expressions exactly is indeed not possible rather difficult. Paul Ekman a renowned psychologist classified expressions and emotions into seven universal classes namely[2].

- Anger
- Disgust
- Fear
- Happy
- Neutral
- Sad
- Surprise.

II. APPLICATIONS OF FACIAL EXPRESSION RECOGNITION SYSTEM

Application of Facial emotion recognition can be visible in different HCI areas such as:

1. Treatment of Asperger's syndrome: Asperger's syndrome or autism is a disorder where children are not able to recognise the words and emotions of the speaker which is a barrier to interact with others. A Facial expression recognition system would help them by recognising the speaker's emotion and help them with day-day communication.
2. Driver state surveillance: Driver state surveillance is an ultimate necessity for preventing unforeseen circumstances. When the driver is scared to an accident the foremost thing that happens is the redden of fear and anxiety in his face whichif instantly identified can prevent all forthcoming happenings using automated preventive measures.
3. Commercial survey: As online shopping is acquairing importance it is necessary to survey the customer satisfaction the product replenishes on the customer. By recognizing the emotion on the customer's face the extent of satisfaction can be measured and hence product success can be roughly calculated.
4. Human computer interconnection: Human computer interconnection is an emerging field where computers can interact with people by Recognising the audio, videoor combination signal input delivered and act accordingly. Recognising emotions in HCI platforms like gaming consoles for example Xbox Kinect, etc pact with cognitive and affective aspect of interaction where the machines changes to the state of user.
5. Affective computing: Affective computing is the learning and improvement of frameworks and gadgets that can perceive, decipher, handle, and recreate human influences. It is an interdisciplinary field crossing software engineering, brain science, and subjective science. The machine ought to translate the enthusiastic condition of people and adjust its conduct to them, giving a fitting reaction for those feelings.

III. PROBLEM DESCRIPTION

The main objective of this thesis is to design a facial expression recognition system which can categorize expression into predetermined set of classes accurately and efficiently from both static as well as a sequence of images. It later aims at recognising slightest change detection in facial features which results in different emotion classes.

3.1 Overview of Facial Expression Recognition

The major procedural steps involved in facial expression recognition namely, face detection, feature extraction and classification. Dimensionality reduction can also be included based on the computational complexity and feature vector length. Different systems for perceiving human facial expressions from face pictures have been proposed and their execution has been assessed with databases of face pictures with varieties in expressions. The generalized procedure followed for facial expression recognition is shown as a block diagram. The images which are to be classified form the test image set and in order to train the system some predefined cues are to be given as input. This is implemented in the

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form of features extracted from the set of training images. The training set is a combination of images from different classes and distinguishable features are extracted for common classes to provide information cues to the classifier. The training set is a combination of images from different classes and distinguishable features are extracted for common classes to provide information cues to the classifier.

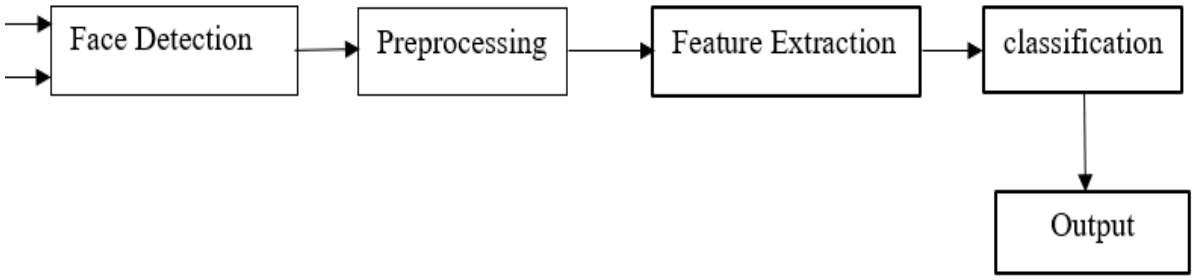

Fig 1: System Overview

3.2 Face Detection

Face detection has two main approaches:

- Skin color-based segmentation :[6] in which area and color of the skin are major parameters for classifying face from non-face. The images are represented in YCbCr , RGB and HCI color models and a new model is proposed by combining them. As skin color becomes an important cue for the presence of face in an image Sanjay Kr. Singh et al. have proposed detection of face using skin color. This procedure becomes inefficient with movement and varying illumination and also when background is of the similar color of skin many false detections are present. Another hindrance of skin color is it is non uniform for all races and varies with ageing.
- Boosted cascade of simple features :[7] mostly known as 'Viola Jones algorithm' in which Haar like features are cascaded in each stage and face class is filtered out from non-face classes using Adaboost algorithm.

3.3 Feature Extraction

Feature extraction is categorized by two types:

Geometric feature :based [8] which extracts features based on the movement , shape and location of facial muscles and of main organs like eyes, cheeks, nose lining of lips . The movement of these regions termed as action units(AUs) generalized based on their involvement in an expression and judgement for classification is done accordingly. Et al. have used fiducial points to track facial features in order to classify the expressions. This method is computationally heavy and real time implementation is difficult.

Appearance based features :

Linear Discriminant Analysis (LDA)[3]

Facial expression classes have some highly distinguished features separating classes from one another. Such describing features if identified can be mathematically utilized to solve a multiclass problem. Here images are projected over a subspace namely 'Fisher space 'which usually deals with reducing feature dimensionality and classification of information.

Gabor Filters[4]

Facial expression is highly dependent on the direction of movement of facial organs and muscles. An excellent feature which is inspired by Human Visual Cortex and can detect the orientation of facial movement is Gabor filters. They extract facial features with varying orientations and dimensions when applied on image which can be further analyzed. Thus, Gabor filtered features are thus efficient in representing facial expressions.

Local Binary Pattern (LBP)[5]

Local binary patterns are predominantly used for texture identification and representation can be extended to face representation. Most importantly they can identify features which aim at representing varying texture of face with facial movements or expressions. The local binary pattern operator can be termed as an image operator transforming an image into an array of integer labels representing the image in small-scale. The statistics of these patterns use histogram

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which is further analyzed. The LBP operator has many versions designed for analysis of monochrome and color still images and also volumetric data and videos.

3.4 Classification

Efficient approaches for classification are mentioned below:

- Support Vector Machine (SVM) :[10] is allocated administered learning models with related learning calculations that dissect information and perceive examples, utilized for classification. It is a binary classifier but can be extended to multiclass classification. SVM is a non-probabilistic binary classification method where classes are separated by boundary and patterns are shown as points in space. SVM being supervised learning method it is reliable tool for classification.
- Distance classifiers :like nearest neighbor classifier and KNN classifier which give the minimum distance class as detected class of test image. Efficiency of distance classifiers is less but their hardware implementation easy.
- Artificial neural networks :[11]are another efficient method to classify samples with large number of attributes. They take help of a back propagation algorithm such that every layer is trained efficiently with numerous iterations minimizing classification error in adhering to the correct class.

IV. IMAGE PRE-PROCESSING

Image Pre-processing normally used for noise removal and for image processing. Here median filter of size 5*5 is removal of noise. Median filter is suitable for the noises such as Black and white spots on image .It is low pass filter usually used for smoothening the image. Median filters are favoured because They provide excellent noise reduction ability . especially effective in the presence of impulse noise (Salt and Pepper). After applying the Median filter, crop the Image of the size 160*128.

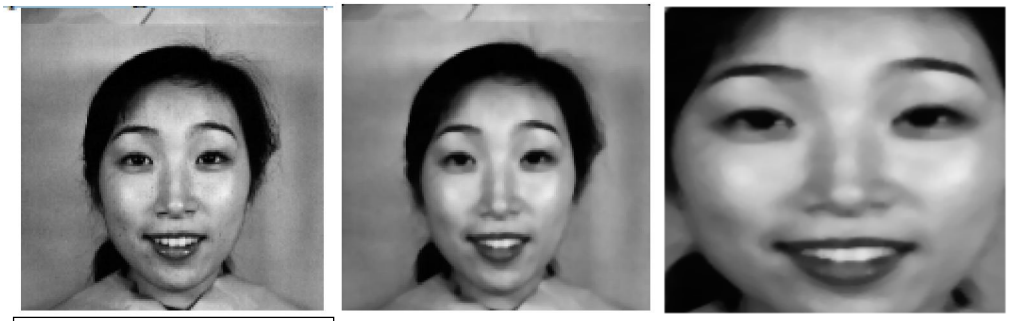

Fig2: Image Pre-processing

4.1 Algorithm

Algorithm I :Feature extraction using LBP and classification using Kullback Leibler (KL) Divergence.

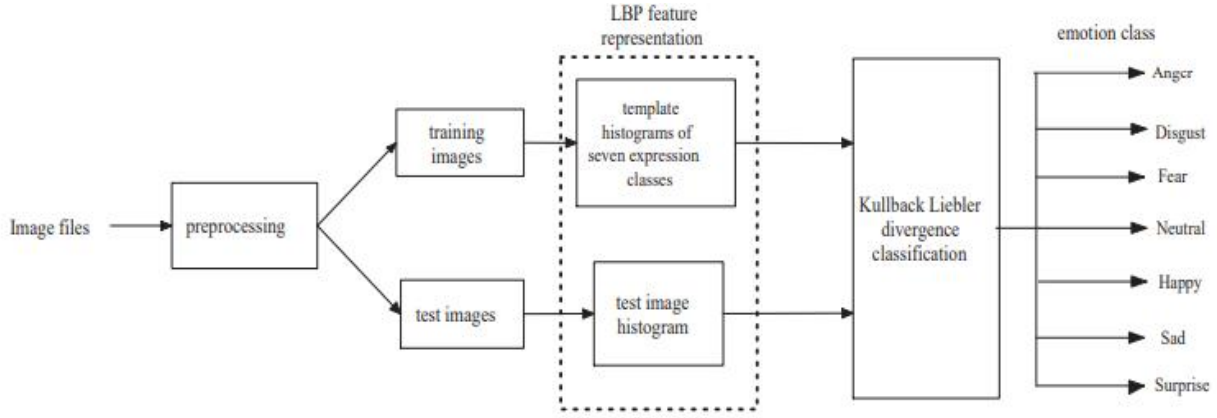

Fig 3: Block diagram for Algorithm 1

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Implementation Details:

1. Uniform LBP (8,1) operator is considered .
2. Training and testing images are divided into 7×6 subregions
3. Resulting bins in spatially enhanced histogram is 7×6×59=2478 bins as shown in figure.

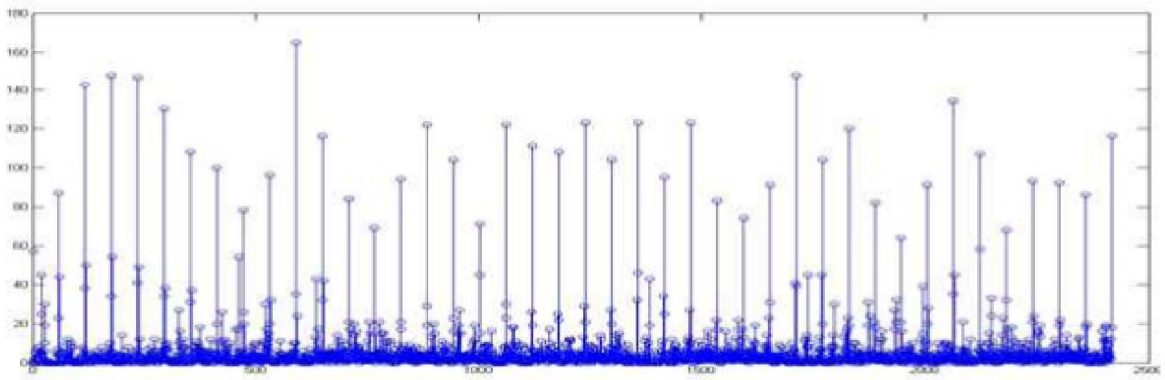

Fig 4: Generated LBP spatially enhanced histogram

1. For expression classification the database is segregated into training and testing image sets ,test image set not inclusive in training 5. The seven expression images of training are grouped manually and training algorithm is applied(refer the above fig).
2. Spatially enhanced LBP histograms of each expression are averaged to form a template histogram for one expression.
3. Test image LBP histogram is also obtained which is compared with the seven template histograms of anger, annoy, fear, happy, neutral, sad and surprise using weighted KL divergence measure given by eq

$$KL(templ(r), test(r)) = \sum templ(r) \log \frac{templ(r)}{test(r)}$$

where templ(r) is the template histogram and test (r) is the test image histogram., r is the number of bins.

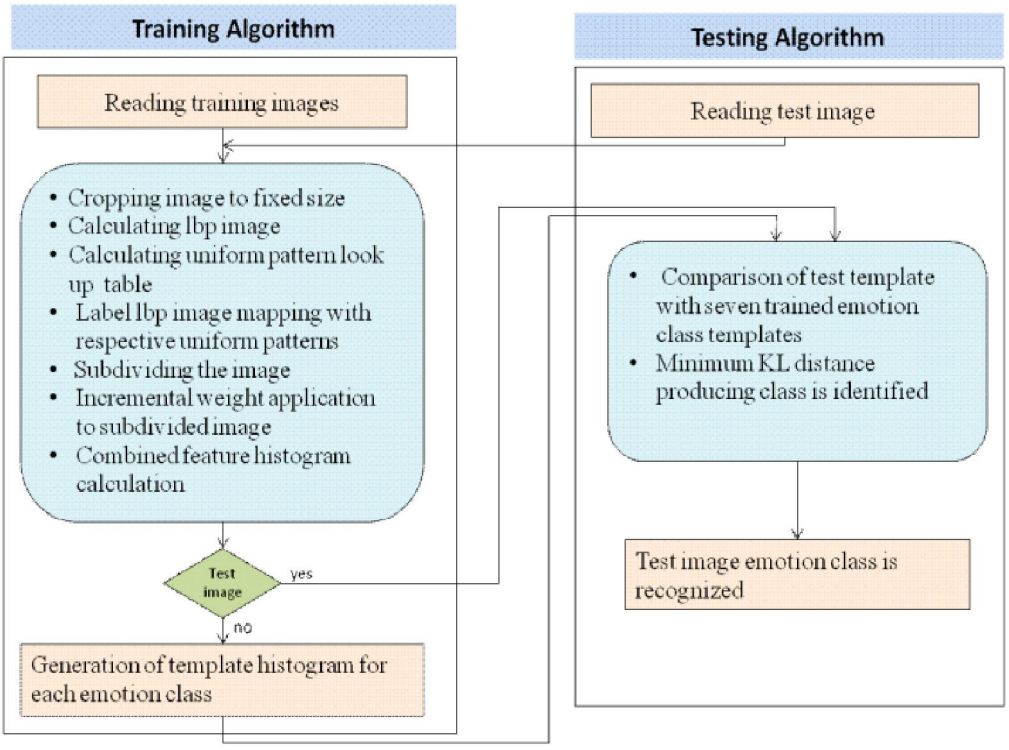

Fig 5: Flow Diagram of Algorithm

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Algorithm II: Feature extraction using Gabor followed by LBP and classification using ANN classifier

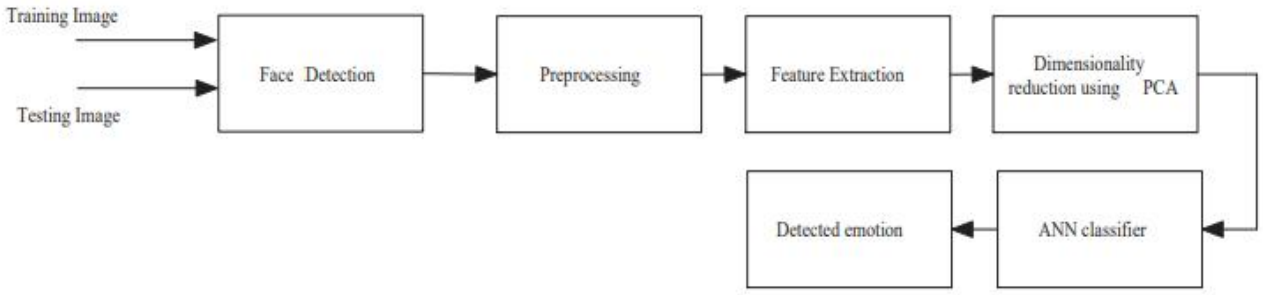

Fig 6: Block diagram of algorithm 2

Gabor filtered images are obtained in 5 scales and 8 orientations resulting in 40images. To decrease the feature vector size which is currently (122 × 112× 40) we averaged the gabor filtered images in different orientations into one image. The Gabor filtered images are obtained by convolution of training image and 8×5 gabor filters using equ () of section

- Average of orientations for 5 scales is given by the eq ()

$$GF_v = \sum_{u=0}^{7} GF_{v,u} \quad where\ v = 0, 1, 2, 3, 4$$

- LBP operator is applied to the gabor filtered orientation averaged images resulsin fused LGBP(Local Gabor Binary Pattern) features extracted.
- Both Gabor and LBP are well regulated in extracting local features adopting differentorientations and scales. Therefore using them together is considered to give robust feature extraction to determine multiclassclassification. The feature vector lengthobtained here 68320 (122×112×5)which increases the computational time .So weapply Principle component Analysis for obtaining the most definite features forcomparison.
- Unlike the former algorithm which classify using KL divergence, here the extractedfeatures are classified using both Artificial Neural Network classifier and KL divergence and their results are compared.

V. CONCLUSION

System operates in two modes. :

- Training mode: In this mode, approximately 100 images from database are to be taken. Out of these 100 images, Euclidean distances for 60 images are calculated. Further analysis needs to be done and accordingly threshold value will be decided for recognition.
- Recognition Mode: In this mode remaining images from database approximately 100 images are to be taken for recognition .In this, calculated Euclidean distances from images

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