ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 5, Issue 10, October 2016

Recognition of Emotions from Facial Expressions and its Application in Car Driving System

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ABSTRACT: The objective of this paper is to Recognize Emotions using Texture based approach and geometrical based approach and apply the detected Emotion in car driving system. Texture based approach alone or geometrical based approach alone not recognize emotions very efficiently but when we train the system using combination of both feature we get optimal result. This recognized state is apply to the Fuzzy rule based system (FBS)[14] to control the road accidents take place due to drowsiness or bad mood of the driver in Indian Transportation system. The idea behind this paper is to detect Facial Expressions by detecting the motion of eyes & lips along with classification of different facial expressions into one of the six basic human emotions,[1] viz. happy, anger, sad, surprise, Fear and Normal state with fuzzy rule based system for better system performance.

Keywords: Fuzzy Rule based system, LBP, Texture Feature, Membership Function.

I. INTRODUCTION

Sometimes it is found that in case of emergency or in case of long drive it may happen that the car driver may undergo in bad mental state due to personal busy schedule. Sometimes they may be too tired and realize its own drowsiness . In that case we require a system that perfectly recognise the facial expression of driver and that system should be so much perfect that it will analyze the situation automatically and should take the necessary action. So recognition of emotion and mood of the driver is a key technology through which driver assistance system judges the safety States itself and accordingly the vehicle will be switch into automatic mode.

Automatic driver's Assistance System was thus came into Picture to improve operation reliability of any vehicle by substituting humans operating system with automatic operating system . When the vehicle is installed with Automatic driver's Assistance System the driver will feel Safety without being worried in any mental condition. This Paper introduces an approach to Human Centered Transportation System based on Fuzzy rule based system by assisting drivers by tracking Simultaneous texture feature and Emotion Recognition. With the advancement of technology the human Transportation System has made good progress in roads and vehicles. In this case drivers are not only responsible for driving activity but they act as a sensor to evaluate whether the driving is satisfactory or not , in case whether it found not satisfactory, the vehicle inbuilt safety system can be activated at proper time and vehicle can be put into automatic mode. This will assist the drivers and will avoid accidents to the greater extent.

So an emotion is a mental and physiological state which involves many type of behavior actions thoughts and feelings. The human face communicate a lot of information about the identity and expressional state of the person[2]. A face is the most noticeable and distinctive feature of the person which provide an identity in the society. A person can also be identified by his voice, clothing, body shape but the level of information retrieval is very high in case of the face. However, automatic facial expression recognition is a challenging problem due to head pose, illumination, aging, glasses, and cultures. Human can not recognize hundred percent by facial expressions due to several reasons. Different people interpret expressions differently. Fear expression images which considered as fear in America and most of the other countries are mostly considered as surprise in Japan. People from different cultures and society think about facial expressions in different ways for example in some society people focus on mouth but in others society focus on eyes etc. Third in different cultures and society expressions are expressed in different ways i.e. not all the facial expressions are innate and universal. The identification of human emotions from facial expressions by a machine is a complex problem due to reasons that humans, machines usually do not have visual perception to map facial expressions into emotions[3].

Initial research carried out in emotions can be traced to the book 'The Expression of the Emotions in Man and Animals' by Charles Darwin. He believed emotions to be species-specific rather than culture-specific but in 1969 after recognizing a universality within emotions despite the cultural differences, Ekman and Friesen classified six emotional expressions to be universal: happiness, sadness, anger, disgust, surprise and Fear.

HAPPY SAD NEUTRAL ANGRY FEAR SURPRISE

Fig.1 The six universal emotional expressions

II Texture Features Analysis

Texture feature is a property which is the surface and structure of an image which is defined as a regular repetition of an element on a surface . Texture representation is divided into two categories structural and statistical approach . In statistical approach the texture features are computed from the statistical calculation of observed combination of intensities at specified positions relative to each other position in image. There are many texture features that I used in this study some of them are gray level co-occurrence matrix, edge direction, gabor wavelet, local binary pattern and histogram. The following sub-sections describe the five texture features in detail.

Gray Level Co-occurrence Matrix (GLCM)

Gray Level Co-occurrence Matrix is the two dimensional matrix of joint probabilities between pair of pixels. It is statistical distribution of examining texture that considers the spatial relationship of pixels also known as the gray-level spatial dependence matrix. The gray level co-occurrence matrix functions characterize the texture of an image by calculating how often pairs of pixel with specific values and in a specified spatial relationship occur in an image, creating a gray-level co-occurrence matrix and then extracting statistical measures from this matrix. Based on the co-occurrence matrix[4], the next step is computing the GLCM descriptors as following:

Angular Second Moment / Energy : Angular Second Moment provides the sum of squared elements in the Gray Level Co-occurrence Matrix. It is also known as uniformity or the angular second moment shows the texture uniformity or texture homogeneity. Energy value will be greater for a homogeneous texture.

Entropy: Entropy Shows the degree of randomness. The maximum value of entropy will be reached when all elements have the same value. Entropy is one of the important texture features. Inhomogeneous scenes have low entropy, while a homogeneous scene have a high entropy.

Contrast / Second Order Element Difference Moment: Second Order Element Difference Moment shows the contrast texture value. The calculation results in a larger figure when there is great contrast. It measures the local variations in the gray-level co-occurrence matrix.

Cluster Shade: Cluster Shade shows the lack of symmetry in an image.

Correlation: Correlation measures the joint probability occurrence of the specified pixel pairs. It is a measure of gray level linear dependence between the pixels at the specified positions relative to each other.

Homogeneity: Measures the closeness of the distribution of elements in the GLCM . It shows the first order inverse element difference moment.

Local Binary Patterns: There are many methods for extracting the most powerful features from facial images to perform face recognition. Local Binary Pattern is one of these feature extraction methods which is very simple and efficient. This approach was first introduced in 1996 by Ojala et al[12]. With the help of Local Binary Pattern it is possible to measure the texture and shape of a image. First of all by dividing an image into many small regions from which the features are to be extracted. These features have a binary pattern that describe the neighbors of pixels in the regions. The obtained features from the regions are combined in series into a single feature histogram, which is the representation of the image. Local binary pattern is a local Image descriptor that efficiently summarizes the local structures of images. In recent years, increasing application in many areas of computer vision and image processing and has shown its effectiveness in a number of applications, in particular for facial image analysis, including as face detection, face recognition, facial expression analysis, and demographic classification. Local binary pattern has been successfully used for many different image analysis tasks, such as facial image analysis, aerial image analysis, biomedical image analysis, motion analysis, and image and video retrieval. Some of authors presents a comprehensive survey of LBP methodology, including several more recent activities. (1). Improved LBP (Mean LBP): Consider the effects of central pixels; present complete structure patterns.(2) Hamming LBP : Incorporate non-uniform patterns into uniform patterns.(3) Extended LBP : Discriminate the same local binary patterns; cause high dimensionality. (4) Completed LBP : Include both the sign and the magnitude information of the given local region (5)Local Ternary Patterns : Bring in new threshold; no longer strictly invariant to gray-level transformation. (6) Soft LBP : Not invariant to monotonic grayscale changes; cause high computational complexity.(7) Elongated LBP: Extract the anisotropic information and lose anisotropic information; not invariant to rotation. (8) Multi-Block LBP : Capture micro- and macro-structure information Three/Four Patch LBP Encode patch type of texture information (9) 3D LBP: Extend LBP to 3D volume data (10) Volume LBP (LBP-TOP): Describe dynamic texture; cause high dimensionality. (11) LBP and Gabor Wavelet : Combine advantages of Gabor and LBP; increase time cost and cause high dimensionality. (12) LBP and SIFT : Bring in the advantages of SIFT; reduce feature vector length (13) LBP Histogram Fourier: Obtain rotation invariance globally for the whole region. After that Images are compared by measuring the similarity between their histograms. According to several researchers , emotion recognition using the Local Binary Pattern method provides very good results, both in terms of speed and performance. The way by which the texture and other features are described , the method seems to be much robust against face images with different lightening conditions, facial expressions, image rotation and aging of persons.

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III Geometrical Features Analysis

Facial expressions are communicated by changes in one or more features such as tightening the lips and raising the eyebrows closing and opening of the eyes or certain combination of them, which can be identified by observing the changes in facial point movement located near regions of mouth, eyes and eyebrows. Here the use of predefined areas of the face in conjunction with angles and distances for constructing feature sets. Following facial model use some feature points that represent to identify the principle facial point actions and provide measurements of discrete features responsible for each of the six basic human emotions such as universal: happiness, sadness, anger, disgust, surprise and fear. A combination of various approach of facial feature points accumulation can be utilized for finding these points of interest from the facial components such as eyes , forehead, eyebrows and mouth. Feature vectors composed of some features are then obtained by calculating the degree of displacement of these feature points from a non changeable rigid point[8]. Most of the important feature points are located just about the area of eyes ,mouth, nose, and eyebrows. Distance between the two eye centers serves as the principal parameter of measurement for locating the centers of other feature regions. The task of automatic facial expression analysis can be divided into three main steps. First is face detection second is facial feature extraction and third is classification. Face detection is a processing stage to automatically detect the face region for the input images . It is a detector to detect face for each frame or just detect face in the first frame and then track the face in the remainder of the video sequence. Most of the existing systems for expression analysis requires the face to be nearly in frontal view under predefined conditions. For these systems, information about the presence of a face and its coarse location in the scene usually has to be given. Still, the exact location, scale and orientation has to be determined by hand or by an automatic tracking system. Occlusion, Head motion, changing illumination, presence of hair, glasses or jewelery are possible complications for the system.

IV SYSTEM DESIGN

The first step in face detection is preprocessing. The reason is to obtain pure facial images with normalized intensity, uniform size and shape. The steps involved in converting a image to a normalized pure facial image for feature extraction is detecting feature points, rotating to line up, locating and cropping the face region using a rectangle, according to the face model. Detecting faces in a single image involves four methods Knowledge based, Facial invariant, Template matching and Appearance based.

Feature extraction is a method in facial recognition. It involves several steps like dimensionality reduction, feature extraction and feature selection. Dimensionality reduction is an important task in pattern recognition system.

Face detection: Face detection is a specific case of object-class detection, which main task is to find the position and size of objects in an image belonging to a given class. Face detection algorithms were firstly focused in the detection of frontal human faces, but nowadays they attempt to be more general trying to solve face multi-view detection: in-plane rotation and out-of-plane rotation. However, face detection is still a very difficult challenge due to the high variability in size, shape, color and texture of human faces. Generally, face detection algorithms implement face detection as a binary pattern classification task. That means, that given an input image, it is divided in blocks and each block is transformed into a feature. Features from class face and non face are used to train a certain classifier. Then given a new input image, the classifier will be able to decide if the sample is a face or not.

Face detection methods can be classified in the following categories:

(a)Feature invariant techniques: (e.g. facial features : they consist of finding structural features that remain invariant regardless of pose variations and lighting condition.

(b) Template matching methods : these approaches are based in the use of a standard face pattern that can be either manually predefined or parameterized by means of a function. Then, face detection consists of computing the correlations between the input image and the pattern.

(c) Appearance-based methods : contrary to models searching techniques, appearance based models or templates are generated training a collection of images containing the representative variations of face class.

(d)Color-based methods: these techniques are based on the detection of pixels which have similar color to human skin. For this propose, different color spaces can be Used.

(e) AdaBoost face detector: the Adaptive Boosting (Viola & Jones) method consists of creating a strong face detector by forming an ensemble of weak classifiers for local contrast features found in specific positions of the face.

(f) Video-based approaches (e.g. color-based, edge-based, feature-based, optical
flow-based, template-based and Kalman filtering-based face tracking): this kind of face detectors exploits the temporal relationship between frames by integrating detection and tracking in a unified framework. Then, human faces are detected in the video sequence, instead of using a frame-by-frame detection.

Facial Features Extraction: Feature value extraction subsystem is to extract 18 feature points from facial image, and calculate 16 feature values from those points. At first, from a color image image taken by CCD camera, the background is excluded and the facial image is extracted. Then the facial organs such as brows, eyes and mouth are extracted. After processing facial organs' image into binary image, feature points are extracted and feature values are calculated.

V. Fuzzy Emotion Model

There are five primary GUI tools for building, editing, and observing fuzzy inference systems.

(a) Fuzzy Inference System (FIS) Editor
(b) Membership Function Editor
(c) Rule Editor
(d) Rule Viewer
(e) Surface Viewer

These GUIs are dynamically linked, in that changes we make to the FIS using one of them, can affect what we see on any of the other open GUIs. we have any or all of them open for any given system. The FIS Editor handles the high-level issues for the system: How many input and output variables? What are their names? Fuzzy Logic Toolbox software does not limit the number of inputs. However, the number of inputs may be limited by the available memory of your machine. The Membership Function[14] Editor is used to define the shapes of all the membership functions associated with each variable.The Rule Editor is for editing the list of rules that defines the behavior of the system. The Rule Viewer and the Surface Viewer are used for looking at, as opposed to editing, the FIS. They are strictly read-only tools.

The FIS Editor displays general information about a fuzzy inference system. There is a simple diagram at the top that shows the names of each input variable on the left, and those of each output variable on the right. The sample membership functions shown in the boxes are just icons and do not depict the actual shapes of the membership functions.The Membership Function Editor is the tool that lets we display and edit all of the membership functions associated with all of the input and output variables for the entire fuzzy inference system.

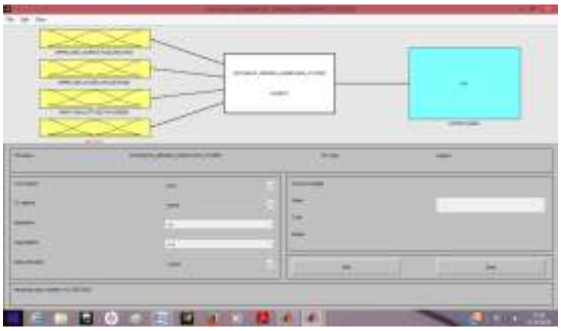

Fig. 2 The FIS Editor

Total 256 rules are formed on the basis of the inputs and output of the fuzzy system. After running the program several times for different samples, it has been found that only 32 rules shown are optimum while the remaining are redundant to compute the final output.

Input	Type of membership	No of linguistic variables	Action Taken
Upper and lower eyelids distance	Gauss	Happy, Surprise, Normal, Sad, Fear, Anger	1. Stop the Car 2. Normal Driving 3. Slow down the Car
Upper and lower lips distance	Triangular	Happy, Surprise, Normal, Sad, Fear, Anger	
Right and Left mouth corner	Pi	Happy, Surprise, Normal, Sad, Fear, Anger	
Emotions	Trap	Happy, Surprise, Normal, Sad, Fear, Anger	

TABLE I. DIFFERENT STATE OF FBS

Fig. 3 Membership function for Upper and lower eyelids distance

This is a Membership function for Upper and lower eyelids distance. Gaussian Membership function is used for Upper and lower eyelids distance. The Membership Function Editor is the tool that lets to display and edit all of the membership functions associated with all of the input and output variables for the entire fuzzy inference system.

Fig. 4 Membership function for Upper and lower lips distance

This is a Membership function for Upper and lower lips distance. Triangular Membership function is used for Upper and lower lips distance. On the upper-left side of the graph area in the Membership Function Editor is a "Variable Palette" that lets we set the membership functions for a given variable.

Fig. 5 Membership function for Right and Left mouth corner

This is a Membership function for Right and Left mouth corner. Pi Membership function is used for for Right and Left mouth corner. When we open the Membership Function Editor to work on a fuzzy inference system that does not already exist in the workspace, there are no membership functions associated with the variables that you defined with the FIS Editor.

Fig. 6 Membership function for Emotions

This is a Membership function for Emotions. Trapezoidal Membership function is used for for Emotions.

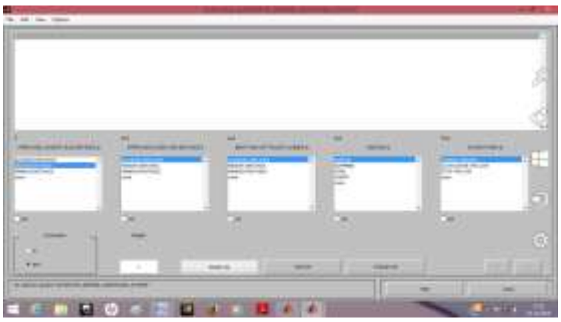

Fig. 7 Rule Editor

Constructing rules using the graphical Rule Editor interface is fairly self evident. Based on the descriptions of the input and output variables defined with the FIS Editor, the Rule Editor allows us to construct the rule statements automatically.

Fig. 8 Rule Editor

Create rules by selecting an item in each input and output variable box, and one Connection item and clicking Add Rule. We can choose none as one of the variable qualities to exclude that variable from a given rule and choose not under any variable name to negate the associated quality. Delete a rule by selecting the rule and clicking Delete Rule. Edit a rule by changing the selection in the variable box and clicking Change Rule.

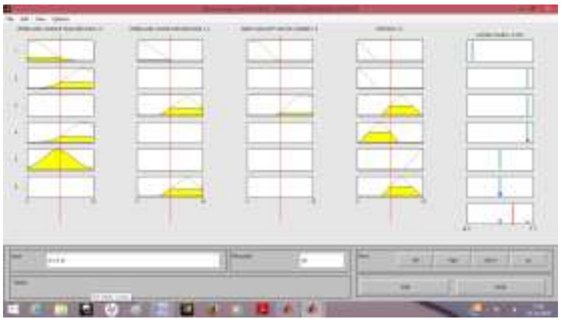

Fig. 9 Rule Viewer

The Rule Viewer displays a roadmap of the whole fuzzy inference process. It is based on the fuzzy inference diagram described in the previous section. We see a single figure window with 10 plots nested in it. The five plots across the top of the figure represent the antecedent and consequent of the first rule. Each rule is a row of plots, and each column is a variable. The rule numbers are displayed on the left of each row.

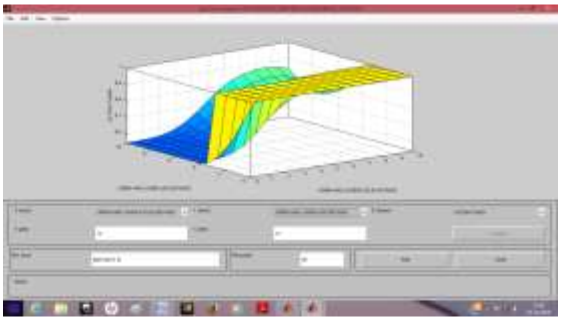

Fig. 10 Surface Viewer

Accordingly, the Surface Viewer is equipped with drop-down menus X (input):, Y (input): and Z (output): that let us to select any two inputs and any one output for plotting. Below these menus are two input fields X grids: and Y grids: that let we specify how many x-axis and y-axis grid lines you want to include.

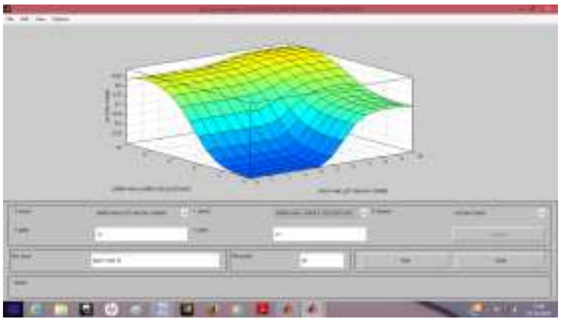

Fig. 11 Surface Viewer

The Surface Viewer has a special capability that is very helpful in cases with two (or more) inputs and one output: you can grab the axes, using the mouse and reposition them to get a different three-dimensional view on the data.

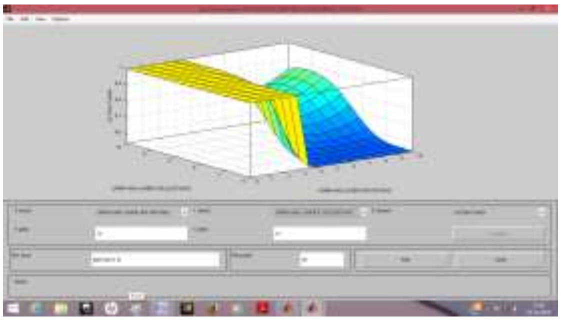

Fig. 1. Surface Viewer

VI. CONCLUSION

This research work presents a comprehensive and simultaneous detection of Emotion and its application in car driving system. The Fuzzy logic systems, Very good at explaining their decisions since they can process imprecise information and they cannot automatically acquire the rules they use to make those decisions. The proposed system is found a novel approach to assist the driver and safeguard the vehicle by switching into auto mode driving need. It also shows the increasing percentage of Accuracy when Both Texture Feature and geometrical feature for Emotion recognition is done simultaneously. It is very well helpful for detection of an emergency to switching vehicle control from manual to automatic mode.

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