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A Combined Approach for Emotion Recognition using Bezier Curve and Facial Expression Analysis

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Extracting and comprehension of emotion is of high significance for the collaboration among human and machine communication frameworks. The most expressive approach to show the human's emotion is through facial expression analysis. Facial Expression is an acknowledged, non-nosy additionally skillful technique for communication that has been well thoroughly considered as a plausible cooperation of such interface. This paper introduces and actualizes an extraction and acknowledgment technique for facial expression and emotion from still picture. The mean of this examination is making a Facial Expression Recognition (FER) conspire by utilizing Bezier curve and afterward checking the precision by utilizing diverse classifiers (Naïve Bayes, SVM and ANN). After taking a picture from dataset and sequentially applying skin color segmentation, largest connected component and binary image conversion, eyes and lips are isolated from the face. Subsequently Bezier curve for eyes and lips are recognized and are contrasted with those pictures that are stored in the database. Next it finds the nearest Bezier curve from the database. In this way by utilizing these technique emotions (Smile, Normal, Sad & Surprise) communicated by the human face can be distinguished effortlessly. Hence, a Bezier curve based solution together with image processing is used in classifying the emotions by using WEKA. Finally, ANN, Naïve Bayes and SVM classifiers are used to determine the accuracy of the system by training and testing the dataset.

Keyword: Facial Expression, Emotion Detection, Bezier Curve, ANN, SVM, Naïve Bayes.

Research Field: Digital Image Processing

1. Introduction

A computer will be comfortable with the perspective of an individual when the range of human-computer interaction (HCI) will come in actuality. Facial expressions can be perceived, by the instrument of human's feelings and state of mind. Facial expression examination that has been very prevalent on account of the significant consideration (Fasel and Luettin, 2003).Tange et al (1995) said that a man's interior perspective, expectations or social interchanges are the reasons that trigger Facial Expression change. Chibelushi and Claude (2003) explained that facial expression is a fundamental part in our contacts between individuals since they can uncover the

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consideration, identity, aim and mental condition of a man. A few plans have been anticipated to recognize a human face in pictures that can be sorted into following gatherings: information based plans, include based plans, and layout based plans additionally appearance-based plans. Jain and Li (2005) emphasized in the event that they are connected separately, these plans can't manage every one of the issues of face acknowledgment for instance posture, articulation, and introduction. Facial Expression acknowledgment techniques basically concentrate on the accompanying essential expressions: happy, normal, sad, anger, surprise and disgust. So the importance of the research finding becomes so essential as to distinguish facial expression becomes difficult.

The framework offers a chance to recognize human facial expressions. To do this, eyes and lip are removed from the face and approximated utilizing Bezier bends. For confront location shading division has been connected that impact vulnerability in hues (Bassili, 1979).Exploratory outcomes uncover that this technique can firmly order skin district and non-skin locale. To pick whether the skin locale is a face or not, biggest network strategy has been utilized. This method can recognize the facial expression category, as well as the degree of facial expression change.To proof whether the system is functioning properly, a total number of 70 datasets (smile, normal, sad and surprise) has been trained and tested in WEKA. These 70 dataset has been checked at first individually and then by pairing up using classifiers such as ANN, SVM and Naïve Bayes which gives us a very higher rate of success and proves that produced software works effectively. Thus it fills up the gap from the previous researches in an optimal way where some numbers of classifiers were used.

This paper is organized as follows: Section 1 deals with Introduction. Section 2 portrays the Literature Review. Section 3 contains Methodology. Data about various classifiers are given in Section 4. Results are provided in Section 5 and Section 6 is the conclusion.

2. Literature Review

The starts of facial expression investigation started from the nineteenth century when Darwin essentially foreseen the possibility of basic outward attributes in living animals. Since the mid-1970s, (Ekman and Friesen, 1975) have made various inquires about of human outward qualities, giving confirmation to support this comprehensiveness theory. Various late papers subsist on programmed influence break down and acknowledgment of facial expressions. Gunes and Piccardi (2009) examined on the full of feeling face and body show recommends a technique to naturally identify their transient fragments or stages. The test comes about acquired emotional face and body shows which are immediate yet not entirely synchronous. Classifiers were not used in this process to check accuracy. Recently Gupta and Sharma (2017) used HOG & GSS method for smile detection. At first interest points are collected and then threshold values are calculated. From threshold values curves are detected. Performance are measured by Accuracy, PSNR and Elapsed Time But this process did not give a good enough result. As of late Shan (2012) utilized the power contrasts between pixels in the grayscale confront pictures as highlights. The paper gives an effective way to deal with smile recognition, in which the force contrasts between pixels in the grayscale confront pictures are utilized as highlights.

This approach gives 85% precision by looking at 20 sets of pixels. Due to small set of pixels, training could not be done properly. At first Lee (2007) detected skin color segmentation using YCbCr which is very complex. Eyes and mouth were detected using feature map. After that Bezier curve was drawn on eyes and mouth. Lastly training and recognizing facial emotion was performed with Hausdorff Distance. The success ration of this process was 78.8% which is way lesser than our process. Rai and Dixit (2013) recognized smile utilizing Bezier curve taking mouth intrigue focuses as a component. The Face is identified by the well known Viola-Jones algorithm and mouth corner focuses are removed by the strategy for Shi and Tomasi through least Eigen value of the lattice and furthermore checked accuracy with corner recognition algorithms. The accuracy is average around 75%.Sebe et al (2006) tried to create a facial expression database based on spontaneous emotions. Face and features were tracked using PBVD tracker. Then the data's were tested and compared with a wide range of classifiers from the machine learning community including Bayesian networks, decision trees, SVM, KNN, etc. Voting classification was considered to improve the classification results of the classifiers. The classifiers were integrated and a face tracking system was built for a real time facial expression recognition system. But their accuracy results were not that good. At first Agarwal et al (2009) performed image pre-processing. Then feature extractions were done by normalized pixel intensities and Gabor filter representation. After that Eigen face mask was used to eliminate pixels that vary little across training samples. Only SVM classifier was used in this process.

From above discussion it can be said that existing approaches for facial expression recognition can be divided into three categories, based on how features are extracted from an image. Categories are geometric based, appearance based and hybrid based. A face image is represented geometrically via fiducial points or the shape of facial regions. Classification is done by analyzing the distances between the fiducial points. Appearance-based methods process the entire image by applying a set of filters to extract facial features. The Features describe the change in face texture.

However facial expression recognition can be improved by combining appearance and geometric features. The system described in this paper is a combination of appearance and geometric feature.

3. Facial expression Recognition Methodology

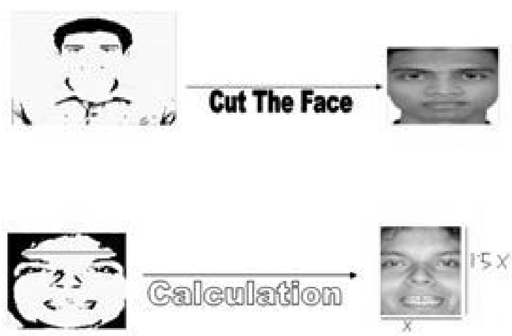
3.1. Skin Color Segmentation

In the beginning, the image is contrasted and skin color segmentation is executed (Bouzerdoum et al, 2003). Then the largest connected region is found and verified whether it has the possibility to become a face or not (Jain et al, 2002) .If it is true then it will create a new form with the largest connected region. If the largest connected regions height & width is larger or equal to 50 and the ratio of height/width is between 1 and 2, then it will be a face.

3.2. Face Detection

In case of face detection at first RGB image is converted into a binary image (Pentland and Bichsel ,1994). By calculating the average RGB value for each pixel, the image is converted into the binary image. If the calculated value is smaller than 110, it is replaced by black pixel, if not then replaced by a white pixel. After that, scan begins from the center of the image to get the temple, and then consecutive white pixels are found following a consecutive black pixel. The highest width of the white pixel is searched left along with the right side perpendicularly. Next, if the new width is smaller half of the previous highest width, then the search is stopped. This situation will arise only if eyebrow is detected. Then the face is cut from the initial point of the temple and height will be 1.5 times of its width. X will be equal to the highest width of the temple in Fig 2.

Figure 1 : Detection of Face(Cutting the Face and Calculating the Face Height According to the Width)



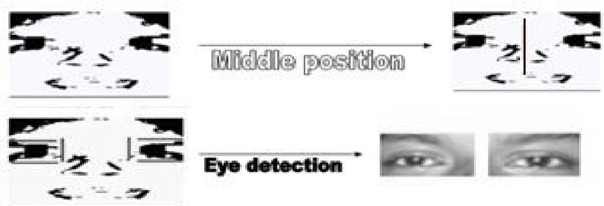
Then the image will contain eyes, nose along with lip. Finally, the RGB image is cut in accordance with the binary image.

3.3. Eye Detection

In case of eye detection, the RGB face is converted into a binary face (Rahayfeh and Faezipour, 2013). The scan starts from the wid/4 to (wid-wid/4) to determine the center point of the two eyes. Then the higher point of the two eyebrows is searched perpendicularly. For the left eye, the scan starts from wid/8 to center and for the right eye, the scan starts from center to wid–wid/8. Here wid is the width of the face. Some white pixels amid the eyebrow and the eye can be found. (Ghosh et al, 2015). For making the eyebrow and eye connected, a number of consecutive black pixels are placed perpendicularly from eyebrow to the eye. For the left eye, the perpendicular black pixel-lines are located amid center/2 to center/4 and for the right eye, the lines are amid center+ (wid-center)/ 4 to center+3*(wid-center)/ 4.

Then the lower point of the two eyes is found by detecting black pixel perpendicularly. For the left eye, the scan starts from the center/4 to center- center/4 wid. And for the right eye, the scan starts from center+(wid-center)/4 to center+3*(wid-center)/ 4 width from image lower end to the initial point of the eyebrow. Then the right region of the left eye is found via scanning black pixel parallel from the center point to initial point of black pixels amid the higher point and lower point of the left eye. And left region for the right eye is searched from center to the initial point of black pixels amid the higher point and lower point of the right eye. The left region of the left eye is the initial width of the image and the right region of the right eye is the finishing width of the image. Now the higher point, lower point, left region and the right region of the two eyes of the RGB image are cut.

Figure 2: Eye Detection (Finding the Center Position and Separating the Eyes)



3.4. Lip Detection

In case of lip detection, at first the lip square is determined and it is considered that lip lies within the lip square. Distance is calculated amid the temple and eyes. Next, this calculated distance is added with the lower height of the eye. By doing this we can find the higher height of the square that has the lip. The initial point of the square will be the ¼ position of the left eye square and finishing point will be the ¾ position of the right eye square. So, this square will contain only lip and some part of the nose. Finally, the RGB image is cut in accordance to the square.

Figure 3: Detection of Lip (Adding the Distance after Calculating It and Obtain the Lip Box)

3.5. Apply Bezier Curve on Lip

The lip square contains lip and some part of the nose. The region of the square contains skin color or the skin. So, the skin pixel is converted into white pixel and other pixels into black pixel. Again those pixels which are alike to skin pixels are converted to the white pixel. If the difference between two RGB pixels is less than or equal 10, they are named similar pixel. If the distance is below than 70, then value 7 is used to detect similar pixel and if the distance is greater than or equal to 70 then value 10 is used to detect similar pixel. So, the value to detect similar pixel depends on the class of the image. Then big connected region is applied for detecting the black region which contains lip in the binary image. Lip is the big connected region as in the lip square; lip is the biggest thing which is not similar to skin. Then the Bezier curve is applied on the binary lips. To apply Bezier curve, the initial and ending pixel of the lip in parallel is detected (Dixit and Silkari, 2015). Next two tangents on the upper lip from the initial and ending pixel are drawn

Figure 4: Applying Skin Color, Big Connected and Then Bezier Curve on Lips.

Then two points on the tangent are detected which is not the portion of the lip. For the lower lip, same approach is applied as the upper lip. Cubic Bezier curve is used for drawing the Bezier curve of the lip (Udai and Sinha, 2008). Two Bezier curves for the lip are drawn.

3.6. Apply Bezier Curve on Eye

Now applying Bezier curve on eyes, eyebrow is removed from the eye. At first, 1st consecutive black pixel is searched, after that consecutive white pixel and then consecutive black pixel from the binary image of the eye square. Next, the 1st consecutive black pixel is removed from the square and here the eye square has only eye, it has some skin or skin color in the region of the square. Similar skin color like the lip is applied for finding the region of the eye. After that, big connect is applied for locating the largest connected region. Here this is the eye as in the eye square, eye is the major part which is different to the skin color. Afterward Bezier curve is applied on the eye square like the process used for the lip. Finally, the outline of the eye is detected.

Figure 5: Remove Eye Brow and Apply Skin Color

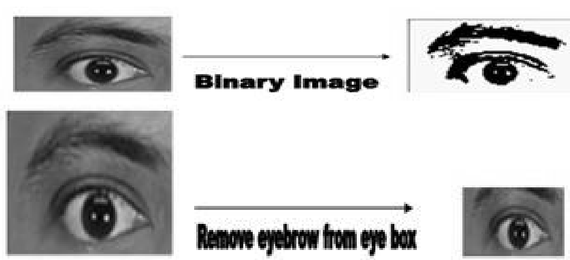
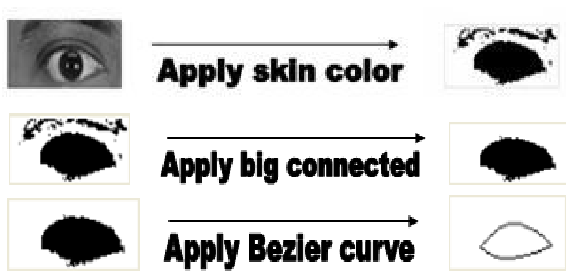


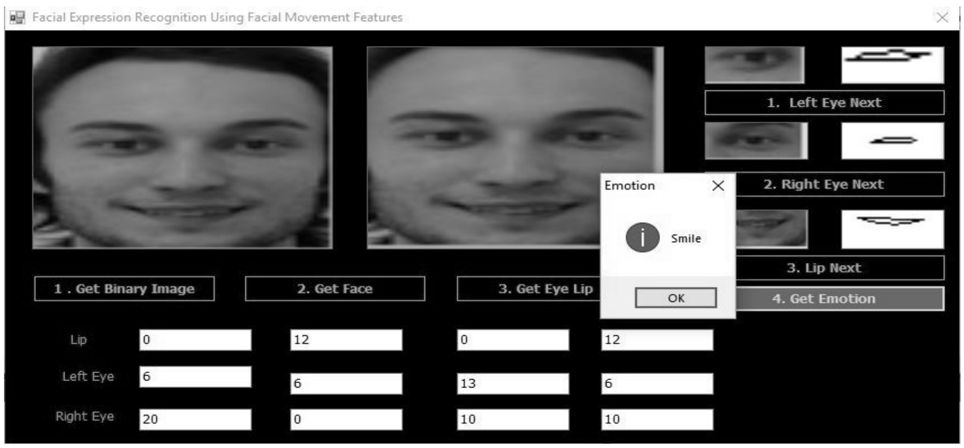
Figure 6: Apply Big Connected and Bezier Curve on Eye



3.7. Emotion detection

To figure out the emotional state of a face, Bezier curve of the lip, left eye and right eye is found (Khatri et al, 2014). Then each width of the Bezier curve is converted into 100. Height is calculated in respect of its width. After matching current height with the emotion's height which is available in the database; the output will be the closest emotional state. If the database does not contain the information about that emotion, then the system calculates the average height of each emotion in the database for all people and then gets a result with respect to the average height.

Figure 7: Detection of Emotion



Materials used in this system are-firstly software is developed to make sure the process is more accurate. Then RGB model was used for less computational complexity. Here this system uses only two facial features (eyes and lip) but still the system can recognize almost all the expressions correctly. To get the accurate facial expression, twelve control points were identified using Bezier curve. These control points can be viewed by anyone to see how the system works and also can recognize the different values in control points among all the expressions.

4. Classification

Classification (Wikipedia, Statistical Classification) is the plan of arranging to which of an arrangement of classes, a most recent investigation has a place, on the establishment of a preparation set of information having comments whose classification affiliation is recognized.

4.1. WEKA

Essentially, WEKA is an arrangement of machine learning calculations for information mining errands. WEKA gives apparatuses which help in – information pre-handling, order, relapse, bunching and perception.

4.2.Artificial Neural Network

According to (Krogh et al, 1991; Lin. et al, January 1997) by and large, an ANN comprises of an arrangement of information esteems & related weights. It is a function that sums the weights and plots the result to an output(y).We have executed ANN in WEKA utilizing Multilayer Perceptron.

Multilayer Perceptron

A multilayer perceptron (MLP) is fundamentally a bolster forward simulated neural system display which utilizes an administered learning strategy got back to proliferation for preparing the system (Boser et al, 1989).

4.3. Naïve Bayes Classifier

It is a characterization procedure organized on Bayes' Theorem with a speculation of freedom among indicators.

4.4. SVM:

Support Vector Machine assembles a hyper plane or number of hyper-planes in a high-or interminable dimensional space, which can be utilized for grouping.

5. Applying the Classifiers and Result Comparison

5.1. Preparing Dataset:

A dataset is prepared by taking 70 images of four types of facial expressions and then analyzing each single image through the developed software application to find out the major varying facial attributes which will build our dataset. So our total features for our final dataset is (4 control points for Lip, 4 control points for right eye, 4 control points for left eye and expression) total 13 attributes and stored into a database directly from the application. Then final dataset is taken into ". arff" format to be used in WEKA. Firstly, we use this total data to build up our training and test set for the classifiers.

5.2. Building Training and Test Dataset for ANN:

5.2.1. For Building Training Dataset:

Amongst total of 70 entries of final dataset and after loading it into WEKA and using the filter "Remove Percentage 40%", 42 data are chosen and used as the Training Dataset for WEKA.

5.2.2. For Building Test Dataset:

For test dataset total original of 70 entries are used.

5.3.Building Training and Test Dataset for Naïve Bayes:

5.3.1. For Building Training Dataset

Amongst total of 70 entries of final dataset and after loading it into WEKA and using the filter "Remove Percentage-35.0", 45 data are chosen and used as the Training Dataset for WEKA.

5.3.2. For Building Test Dataset

For test dataset total original dataset of 70 entries is used.

Table 1: Comparison of Accuracy Factors between Classifiers (Naïve Bayes & ANN)

Comparison Factors	ANN (MLP)	Naïve Bayes
1.Correctly Classified Instances(Out of 70)	61	60
2.Incorrectly Classified Instances (Out of 70)	9	10
3.Training Set Accuracy	97.619%	91.1111%
4.Test Set Accuracy	87.1429%	85.7143%

5.4. Building Training and Test Dataset for Accuracy of Recognizing a Particular Expression

For this amongst 70 data two expression pair "Smile-Normal" consisting of total 19 data for smile and normal are formed for a training dataset and another pair "Sad-Surprise "consisting of total 9 values of sad and surprise as a training dataset for these two expressions. For testing dataset only, the data for a particular expression is taken excluding the ones in training dataset and is tested against the training data.

5.4.1. For Building Training Dataset

Two pairs were considered for building training dataset.

5.4.1.1. Normal-Smile Pair

For this dataset first 10 values for expression "Smile" and 9 values for "Normal" were taken respectively from original dataset of 70 data and was converted into ". arff" format.

5.4.1.2. Sad-Surprise Pair

For this dataset first 2 values for expression "Surprise" and 7 values for "Sad"were taken respectively from our original dataset of 70 data and was converted into ". arff" format.

5.4.2. For Building Test Dataset

5.4.2.1. Testing Dataset for Smile

The rest of the 14 data excluding the data used for training dataset, representing "Smile" expression was taken from the original dataset.

Table 2: Comparison of Accuracy for Correct Recognition for the Expression "Smile"

Expression	ANN (MLP)	Naïve Bayes	SVM (SMO)	Comparison Factor
Smile (Training Set: Smile-Normal pair) (Test Set: Only data representing Smile)	14(out of 14 test data)	14(out of 14 test data)	13(out of 14 test data)	1.Correctly Classified
	0(out of 14 test data)	0(out of 14 test data)	1(out of 14 test data)	2.Incorrectly Classified
	100 %	100 %	92.86%	3.Accuracy

5.4.2.2. Testing Dataset for Normal

Apart from the data used in training dataset rest of 9 data representing "Normal" expression in the original dataset were chosen.

Table 3: Comparison of Accuracy for Correct Recognition for the Expression "Normal"

Expression	ANN (MLP)	Naïve Bayes	SVM (SMO)	Comparison Factor
Normal (Training Set: Smile-Normal pair) (Test Set: Only data representing Normal)	6(out of 9 test data)	8(out of 9 test data)	7(out of 9 test data)	1.Correctly Classified
	3(out of 9 test data)	1(out of 9 test data)	2(out of 9 test data)	2.Incorrectly Classified
	66.67 %	88.89 %	77.78 %	3.Accuracy

5.4.2.3. Testing Dataset for Surprise

For this 4 data representing "Surprise" expression was taken from the original dataset.

Table 4: Comparison of Accuracy for Correct Recognition for the Expression "Surprise"

Expression	ANN (MLP)	Naïve Bayes	SVM (SMO)	Comparison Factor
Surprise (Training Set: Sad-Surprise pair) (Test Set: Only data representing Surprise)	4(out of 4 test data)	2(out of 4 test data)	4(out of 4 test data)	1.Correctly Classified
	0(out of 4 test data)	2(out of 4 test data)	0(out of 4 test data)	2.Incorrectly Classified
	100 %	50 %	100 %	3.Accuracy

5.4.2.4. Testing Dataset for Sad

Apart from the data used in training dataset rest of 6 data representing “Sad” expression in the original dataset were chosen.

Table 5: Comparison of Accuracy for Correct Recognition for the Expression “Sad”

Expression	ANN (MLP)	Naïve Bayes	SVM (SMO)	Comparison Factor
Sad (Training Set: Sad-Surprise pair) (Test Set: data representing Sad)	5(out of 6 test data)	6(out of 6 test data)	5(out of 6 test data)	1.Correctly Classified
	1(out of 6 test data)	0(out of 6 test data)	1(out of 6 test data)	2.Incorrectly Classified
	83.33%	100%	83.33%	3.Accuracy

To sum up, it can be said that this system is better and different than other previous researches because in this system 70 datasets has been trained and tested at first individually and then by pairing up in WEKA. These training and testing datasets give a higher rate of accuracy which helps in correctly classifying. Three different classifiers were also used in this process to make it more. All these reasons make this system more unique and compact.

6. Conclusion

To add to the area of research, in this study, a new way for acknowledging the group of facial expression is projected by using Bezier curve, various classifiers are applied and also required resources planning have been done to achieve the goal.

The importance of this project lies on the recognition of facial expression in an optimum way in terms of run time onto the embedded system. This system also gives the knowledge to detect facial expression by having less computational complexity with higher success rate and timing issues were also considered. This project can be implied in our daily lives also for the betterment of human life with help of technology.

Some limitations should be considered while doing further studies based on this research: 1) A more sophisticated face detection algorithm is necessary. Because our system has only worked on well-defined databases, we choose a comparatively simple detection algorithm. To apply for real image or video, this component must be strengthened.2)Though this way has been applied on only some persons, however trial results reveal that this way is dependable providing the images symbolize a diverse outlook of the faces and are low resolution images.

For further research, we will try to make the system fully automatic having the capability to work with video feeds as well as images. We will try out the project for images taken at different angles and higher resolutions. More classifiers can be combined to achieve better results.

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