International Journal of Sciences, Engineering & Environmental Technology (IJOSEET), 6(4): 31 – 38, 2021
ISSN 0794-9650
www.repcomseet.com

FACIAL EXPRESSION RECOGNITION SYSTEM USING KNN

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Abstract: Facial expression is one of the most powerful, natural, and universal signals for human beings to communicate their emotional states and intentions irrespective of national borders, race, and gender within themselves. It is used in several applications such as patient monitoring, driver fatigue detection, human-computer interaction, situation analysis in social interaction, affective computing, and feedback during e-learning, psychology, contests, and entertainment industries. The paper employed KNN (K – Nearest Neighbour) for the recognition of faces while PCA (Principal Component Analysis) was used for extracting the important features in the faces which show fewer features. The Japanese Female Facial Expression (JAFFE) dataset was used in this paper which consists of 10 Japanese female expressers with 7 Posed Facial Expressions i.e. 6 basic facial expressions such as happy, sad, surprise, anger, disgust, and fear plus 1 neutral expression. A total of 210 images were used i.e. 140 images for training and 70 images for testing. The pre-processing stage converts the image to a grayscale image, normalize and resizes the images. The features of the images were extracted using principal component analysis (PCA). The extracted features of the pre-processed images then serve as input to the KNN classifier which classifies the facial expressions as happy, sad, surprise, anger, disgust, fear, and neutral. The algorithm was implemented with MATLAB script codes and the performance was evaluated based on correct classification, incorrect classification, and accuracy. The results showed a correct classification, incorrect classification, and accuracy of 60 images, 10 images and, 85.71% respectively. The feature extraction technique used in this paper was Principal Component Analysis (PCA) using Eigenvectors which shows fewer features while Saheed and Prabir (2007) employed Facial Feature Point Detection as their feature extraction technique. The facial recognition system could be adopted in psychology or in virtual learning environments to make informed decisions on the mood of individuals.

Keywords: classification, expression, extraction, images, intensity, pixel, recognition,

1. Introduction

An Emotion is a mental and physiological state which is subjective and private. It involves a lot of behavior, actions, thoughts, and feelings. Human emotions can be used to convey messages and are mainly classified into various categories like Neutral, Happy, Sad, Anger, Disgust, Fear, and surprise. However, different sizes, angles and, poses of the human cause various errors while determining emotions. Emotions of any person can be detected without error by a human being but not always true when detected by a machine.

Facial expression is a powerful and natural means of communicating emotions and intentions within human beings. Automatic facial expression analysis is an interesting and challenging problem that impacts important applications in many areas such as human-computer interaction and data-driven animation. Due to its wide range of applications, automatic facial expression recognition has attracted much attention in recent years [1].

A facial expression is a combination of an expressive component and a neutral component of a person. All emotion is derived from the presence of stimulus in the body which evokes the physiological response such as emotion recognition, face recognition, edge detection, Feature extraction, and database. In our day-to-day activities, emotions or facial expressions are the prime factors that are required for communication purposes. Recognition of emotions from facial expressions consists of two steps, viz: feature extraction and classification. Extraction of relevant features from the input image is known as feature extraction and classification refers to the process of classifying the emotions using the extracted features into any one of the six basic expression classes.

Research in facial emotion recognition has been carried to improve non-verbal communication especially while determining emotion recognition. Facial expressions are non-verbal signs that play an important role in interpersonal communications. The presence of spectacles, beard, hair, and makeup has a considerable effect on the facial appearance and increases the chances of error in the system. Emotion recognition from facial expression systems finds its application in robotics, automobile, online gaming, and text chat applications.

This research aim is to develop a system that will recognize the emotions from facial images to gather and analyze the feeling of humans. Facial recognition is important in human communication that helps to understand the intention of people. It assists to infer the emotional states of other people, such as joy, sadness, and anger using facial expression and vocal tone. The facial expressions are utilized for distinguishing the essential human feelings like indignation Monitoring and interpreting facial expressions provides important information to lawyers, police, security, and intelligent agents regarding a person's identity. This face recognition system will not detect profile as well as non-frontal face images and cannot extract faces covered with sunglasses.

2. Related works

Intelligent Human-Computer Interaction (HCI) focuses on the interrelation between human beings and machines using body gestures, eye gaze, speech, facial expressions, cognitive modeling and, so on. Perceptual recognition, machine learning, cognitive modeling and, affective computing are the emerging trends of interest in recent years. Facial expressions can be used as an efficient way of emotion detection, thus facilitating HCI [2]. To participate in natural human-machine interaction, machines must be able to derive information from human communication channels, such as spoken language, gestures, or facial expressions [3].

Detection and classification of facial expressions can be used as a natural way of interaction between man and machine. However facial expressions and their intensity vary from person to person and also vary along with age, gender, size, and shape of the face, and further, even the expressions of the same person do not remain constant with time [2]. Face detection and alignment are fundamental to numerous face applications; for example, face recognition and facial expression analysis [4].

Existing methods for human-machine interaction are often considered unintuitive. As a consequence, a lot of time is required for humans to adapt to the operation of a specific machine [3]. [3] employed deformable 3D wireframe Candide-3 face model in additi on with a learned objective function for face model fitting and the resulting sequence of the model parameters were passed to the recurrent neural network for classification. The system was employed in Coffee Tea System (CoTeSys) to recognize guests to be served by robot waiters.

Facial expression has a significant contribution in the fields like human-computer interaction, neurology, psychiatry, image processing, computer vision, affective computing, and information security [5]. The field of computer science that moves human-computer interaction to the next level by imparting emotional interaction between humans and machines is regarded as affective computing. The reason for affective computing is to simulate empathy so that the human-computer interaction becomes more efficient i.e., the machine should adapt to the human emotions and react accordingly. An "affect" model is built by capturing information using various sensors, for instance, knowing the heartbeat rates and blood pressure of a person, to develop a personalized computing system that can perceive and interpret human feelings and also can give intelligent, friendly, and sensitive responses [5]. The developed system classified emotions into happiness, sadness, disgust, fear, surprise, and anger but the system found it difficult to distinguish between angry and sad. [5] classified facial expression into two types: (i) Pose based expressions: are the expressions caught by making people implicate an expression, could be considered as artificial facial expressions, and (ii) Spontaneous expressions which are the expressions which are produced by the humans resonating in life, like daily conversations, etc.

In a research done by [6], twenty-one (21) different forms of facial expressions were identified from 230 human subjects. A facial Action Coding system analysis showed the production of these 21 categories. In their research, happily surprised expression combines muscle movements observed in happiness and, surprise and these differences were used to differentiate between the 21 defined categories. Then, computational models of face perception were employed to demonstrate that most of these categories are visually discriminable from one another [6].

An algorithm developed by [7] was used to identify a person's emotional state through facial expressions. A Radial Basis Function Network (RBFN) was used for classification and Fisher's Linear Discriminant (FLD), and Singular Value Decomposition was for feature selection.

[8] focused their research on a sample of 50 university students where each student was shown 100 random images and the student's reaction to every image was captured. The results of their work showed several

imperfections of the face analysis system when the recorded reactions were compared to the reactions of the image that were expected.
Human emotional facial expressions play important roles in interpersonal relationships because humans demonstrate and convey information visually rather than verbally.

3. Materials and Methods

The work is divided into several steps for simplicity and the complete framework is presented in Figure 1. The first step is the image acquisition followed by pre-processing of the images where each image is converted to a grayscale image, normalized, and resized. The feature extraction stage extracts the salient and useful features of the pre-processed images and the output was used as input to the classifier. KNN classifier was used to classify the facial expressions as either happy, sad, surprise, anger, disgust, fear, and neutral.

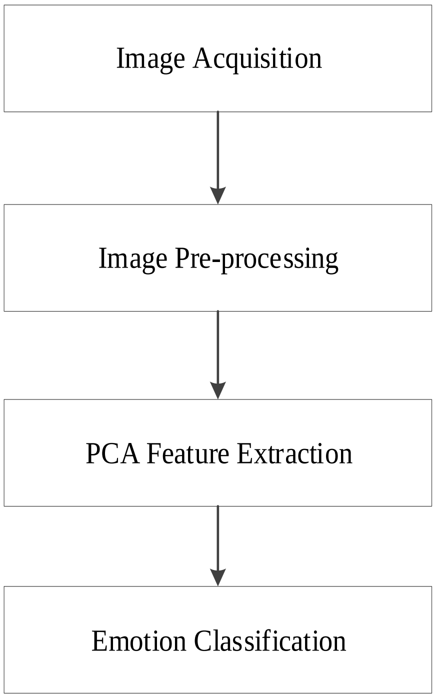

Figure 1: Framework of the facial expression recognition system

3.1. Image acquisition

The Japanese Female Facial Expression (JAFFE) dataset was used in this research. The database consists of 10 Japanese female expressers with 7 Posed Facial Expressions i.e. 6 basic facial expressions plus 1 neutral expression. Several images of each expression for each expresser make up a total of 213. Each image has been labeled by 60 Japanese subjects such as KA.AN1.39. The acronyms HA, SA, SU, AN, DI, FE, and NE represent happy, sad, surprise, anger, disgust, fear, and neutral respectively. A total of 210 images were used i.e. 140 images for training and 70 images for testing.

3.2. Image pre-processing

One essence of pre-processing is to reduce the effects of illumination and lighting. Pre-processing enhances the quality of the input image and locates data of interest by removing noise and smoothing the image. It removes redundancy from images without the image detail. Pre-Processing also includes grayscale conversion, normalization, and resizing of the image which produces a uniform size.

3.2.1 Grayscale conversion

The RGB images were converted to grayscale images to eliminate the hue and saturation information, to retain the needed luminance, and to reduce the processing time, being a two-dimensional matrix. With grayscale images, it is possible to access the low-level features (pixels) of the image in lower dimensions and easy to perform pixel-level transforms and mathematical operations on the image.

3.2.2 Image normalization

Normalization changes the range of the pixel intensity values in an image. The purpose of normalization is to transform the intensity of a grayscale image. Normalization helps to make computation efficient by reducing the pixel values of an image between 0 and 1. Normalization brings the image range to a normal range.

3.2.3 Image resize

Having obtained the required portion of a given facial image, the image was scaled to the appropriate size to avoid distortion. The image was scaled to preserve the image quality and the chosen scale was uniform for easy processing. The images were resized to 100 by 100 pixels using resize MATLAB function.

3.3 Feature extraction stage

Principal Component Analysis (PCA) was employed to extract the relevant facial features. In this research, PCA extracts useful information from the input facial image. Feature Extraction serves two purposes, to extract properties that can identify the facial expression and extract properties that can differentiate between similar expressions. This stage is very essential to improve the recognition rate and to reduce misclassification.
PCA finds the eigenvectors of a covariance matrix with the highest eigenvalues and then uses it to project the data into a new subspace of equal or fewer dimensions. PCA reduces the number of features by constructing a new smaller number variable that captures a significant portion of the information found in the original features. The extracted training features and labels were stored and used for testing. PCA was used to reduce the dimension of a large number of features keeping most of their information.

3.4 Emotion classification

K-Nearest Neighbour (KNN) classifier was used for classification. The KNN algorithm is a non-parametric method used for classification and regression. The input comprises ‘K’ closest training examples in the feature space. The value of K used in this project is 1 as it produces the optimal result. This stage tends to recognize facial expressions based on the extracted features. A classification model is responsible for predicting a certain label given an input image or features.

3.5 Training and Testing

Training involves giving the various features that will identify each character to the system so that when a facial image is an input into the system, the system compares the extracted features from the image with the trained features in the database of the system and identify the corresponding label and recognize the emotion. 140 images with 7 different expressions were used for training and 70 images with 7 different expressions were used for testing. Figure 2(a) and 2(b) shows the flowchart for the training and testing stages.

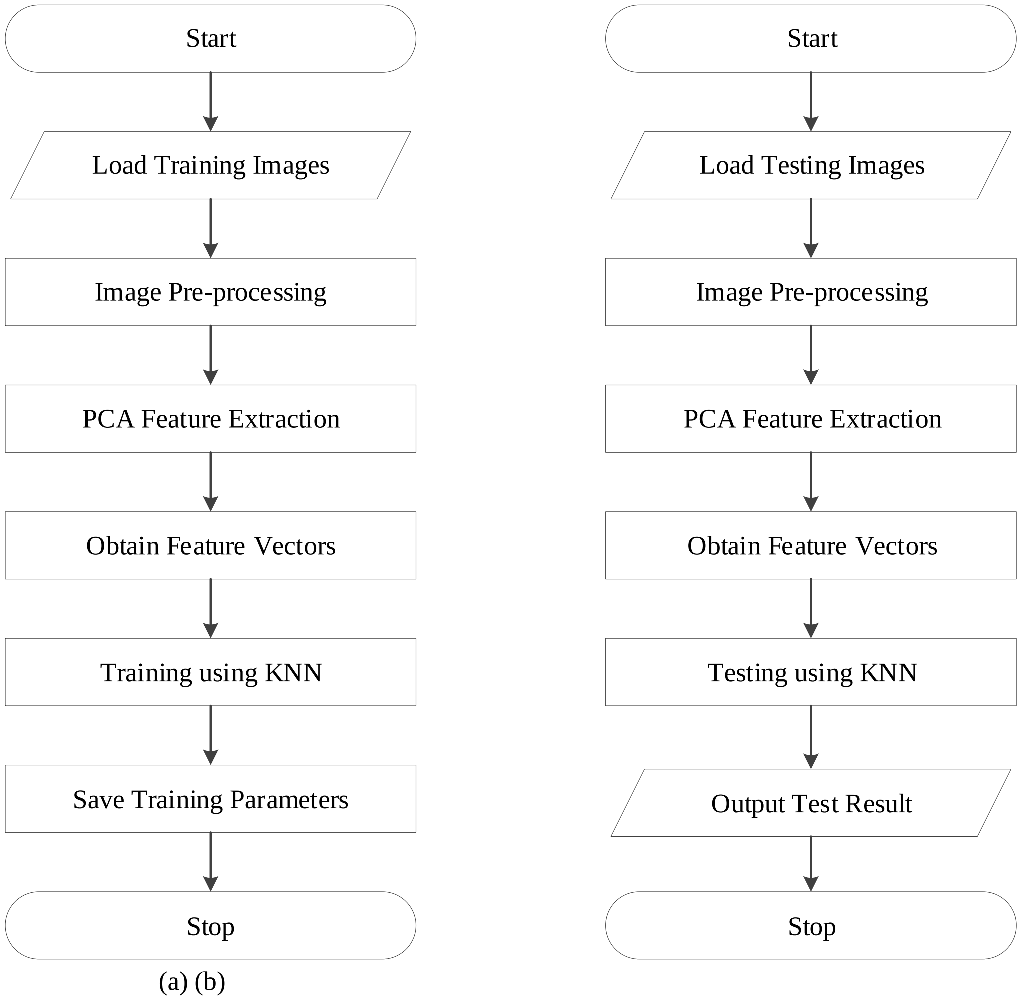

Figure 2: Flowchart of the facial recognition (a) training Stage (b) testing Stage

4. Results and discussion

After the development of the system, the system was put to test to observe how effectively it has met the aim of the project. The recognition system was implemented using MATLAB 2015a. The expression from the JAFFE dataset was used to train and test the system. 140 images were used to train while 70 images were used to test the system. The images consist of 7 different expressions which are happy, sad, surprise, anger, disgust, fear, and neutral. Figure 3 shows the GUI of the developed system.

The results obtained from the developed system show a training time of 11.4614 seconds with a training sample of 140 facial images consisting of 7 different facial expressions and a testing time of 7.1833 seconds when tested with 70 facial images. A total of 60 images were classified correctly while 10 images were wrongly classified, which gives an accuracy of 85.71%. The performance summary is shown in table 1.

From table 1, using confusion matrix as the performance metrics, the facial expression happy has 6 correct classifications which show an accuracy of 60%, sad has 8 correct classifications producing an accuracy of 80%, 10 correct classifications for a surprise showing an accuracy of 100%, 9 correct classifications for anger showing an accuracy of 90%, 10 correct classifications for disgust showing an accuracy of 100%, 8 correct classifications for fear showing an accuracy of 80% and 9 correct classifications for neutral showing an accuracy of 90%. The facial expressions surprise and disgust have the highest accuracy of 100% while happy has the lowest accuracy of 60%.

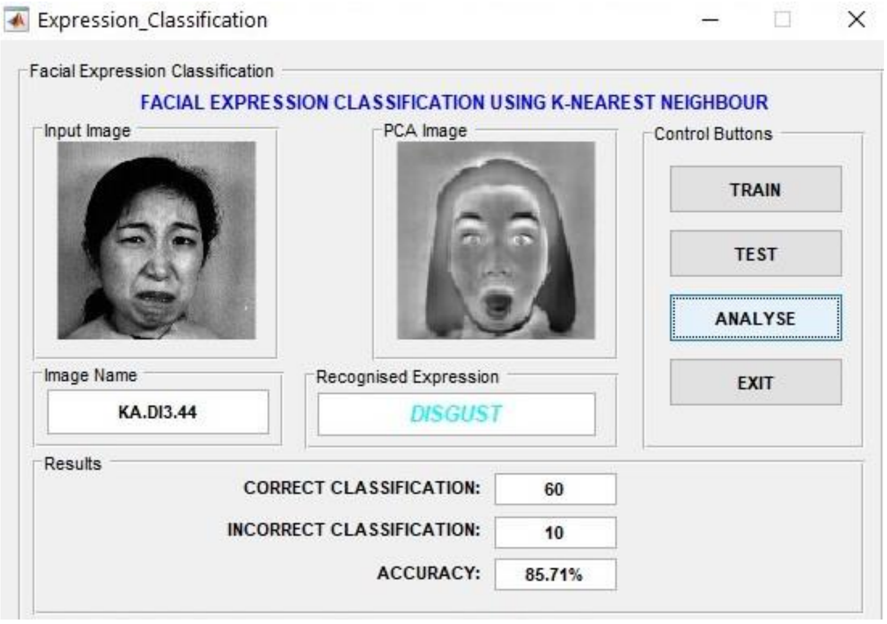

Figure 3: GUI of the developed system

Table 1: Performance summary of the developed system

Facial Expression	**Correct**	**Incorrect**	**Accuracy (%)**
Happy	6	4	60
Sad	8	2	80
Surprise	10	0	100
Anger	9	1	90
Disgust	10	0	100
Fear	8	2	80
Neutral	9	1	90
Total Accuracy (%)			85.71

4.1. Summary of results using a confusion matrix

The Confusion matrix summarizes the classification performance of the KNN classifier concerning the test labels i.e. happy, sad, surprise, anger, disgust, fear, and neutral. It displays a table that is used to describe the performance of a classifier on test data for which true values are known. The confusion matrix is shown in table 2.

From table 2, it was observed that four (4) happy facial expressions were misclassified in which two of them were misclassified as neutral and one(1) each was misclassified as sad and surprise. From the same table 2, two (2) sad facial expressions were misclassified in which one (1) each was misclassified as happy and neutral. Moreover, table 2 showed one anger facial expression that was misclassified as disgust. Furthermore, two (2) fear facial expressions were misclassified for which one (1) each was classified as disgust and neutral, and we have only one (1) neutral facial expression that was misclassified as sad. The facial expressions for surprise and disgust were rightly classified.

Table 2: Confusion matrix of the developed system

	HAPPY	SAD	SURPRISE	ANGER	DISGUST	FEAR	NEUTRAL
HAPPY	6	1	1	0	0	0	2
SAD	1	8	0	0	0	0	1
SURPRISE	0	0	10	0	0	0	0
ANGER	0	0	0	9	1	0	0
DISGUST	0	0	0	0	10	0	0
FEAR	0	0	0	0	1	8	1
NEUTRAL	0	1	0	0	0	0	9

Conclusion

It has been shown in this study that the recognition of expression in faces uses K-nearest neighbor has been developed and has performed effectively in the recognition of faces subjected to it. Two hundred and ten sample images (210) from the JAFE data set were used to test the performance of the system. Out of these images, 140 images were used for training while 70 images were used for testing. The system has a training time of 7.18433 seconds for training the 140 images and 7.1833 seconds for the tested images. The performance of the system was achieved using accuracy and confusion matrix table to show the level of efficiency of the classifier. Only the frontal images can be analyzed correctly by the system.

Recommendation

This system could be employed in recognizing the expression in faces in any organization to determine the actual period of interaction among people in any organization and create a better relationship between the staff and the superior ones. Further work should use another optimization technique to see if a better result will be achieved. Also, a better result would have been obtained if the number of images is increased.

References

[1] Caifeng S., Shaogang G. and Peter W. M. (2009). Facial expression recognition based on local binary patterns: a comprehensive study. *Image and Vision Computing* 27, 803–816

[2] Happy S L, Anjith G, and Aurobinda R. (2002). A Real-Time Facial Expression Classification System Using Local Binary Patterns. . *Department of Electrical Engineering,* IIT Kharagpur, India

[3] Alex G. and Jurgen S. (2004). Facial Expression Recognition with Recurrent Neural Networks. *Robotics and Embedded Systems Lab, Department of Computer Science, Technische Universitat Munchen, Germany, 01.*

[4] Sailaja G., V. and Hima D. (2017).Facial Expression Recognition Complications with the Stages of Face Detection and Recognition. *Blue Eyes Intelligence Engineering & Sciences Publication*. *DOI: 10.35940/ijrte.B1864.078219*

[5] Obulesu A., and Keerthi R. (2021).Facial expression classification using Cross Diagonal Neighborhood Pattern. *International conference on computer vision and machine learning, IOP Conf. Series: Journal of Physics*: Conf. Series 1228, doi:10.1088/1742-6596/1228/1/012055.

[6] Shichuan D., Yong T., and Aleix M. M. (2014). Compound facial expressions of emotion. *Department of Electrical and Computer Engineering, and Center for Cognitive and Brain Sciences, the Ohio State University, Columbus, OH 43210*. www.pnas.org/cgi/doi/10.1073/pnas.13223551111

[7] Devi A. (2011). Emotion Classification Using Facial Expression. *International Journal of Advanced Computer Science and Application (IJACSA), Vol. 2, No. 7*.

[8] Martin M,,L'ubomír B. and Štefan K. (2019). A Case study of Facial Emotion Classification Using Affdex. *Department of Informatics, Constantine the Philosopher University in Nitra, Tr.A.Hlinku 1, 94974 Nitra, Slovakia*; Ibenko@ukf.sk (L.B); skoporda@ukf.sk (S.K)