Face Expression Extraction Using Eigenfaces, Fisherfaces and Local Binary Pattern Histogram Towards Predictive Analysis of Students Emotion in Programming

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Abstract. Emotion plays an important role to assess individual reaction and responses depends on the degree of encounter, scenario and experience. In this paper, the study examines the emotions of the five (5) randomly selected students according to the Basic Emotions and Non-Basic Emotions while performing their Java Programming activity task. The study utilized RaspberryPi and Smartphone to capture an image, OpenCV application to analyze the image and application of algorithms: the Fisherfaces, Local Binary Pattern Histogram and Eigenfaces to determine the most like emotion. In this study, the Fisherfaces algorithm showed the highest average accuracy rate of 47.93% among the algorithms. Specifically marked an emotion of "happy and surprise" with accuracy rate of 100% which means that the students perform the activity with knowledge and skills. This result can be used by the experts to consider the emotion as part of assessment hence it may also serve as a tool for effective decision making.

Keywords: Facial expression · Emotion · Predictive analysis

1 Introduction

Emotions plays a crucial role in our lives it should be managed and interpreted accurately. In fact, this has been the concern of scientific inquiry in psychology since emotion is consider as the driver in decision making [1] and the source of moral judgement [2]. This may be interpersonal, intrapersonal, socio and cultural functions [3] thus, constitute to individual level, dyadic level, group level and cultural level [4]. Moreover, emotions made a great influence on how people manage emotion, understand emotion, using emotion and perceiving emotion which is evidently noticed in the academe and in workplace environment [5]. These factors lead the affective computing focused area.

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Affective Computing, on the other hand has been a great interest in intelligent interactive and pattern recognition, emotion expression learning and understanding of emotion [6]. Due to the contributory impact of technologies there are innovative solutions which are being developed in the form of audio, visual and text that are capable to recognize expressions, interpret gestures and simulate appearance to determine emotion. Many companies integrate analysis of emotions and sentiments to enhance customer relationship management and recommendation system [7] however, there are some issues and concerns since emotions [8] is broad because it is more than thoughts, it also depends on the response of the body and it is difficult to achieve its accuracy and progress towards cognitive modelling because of various modalities to be considered. But, this would not hinder the discovery and contribution of affective computing in producing good results that may affects areas of concern.

1.1 Related Works

In the advancement of technology, the emotion can be detected and analyzed based on the facial expression, in fact facial expression is used to determine the current emotion pertaining to stress [9], used to capture individual identity for security purposes to recognize malicious intention through gestures and surveillance, access control to a building [10], used in virtual meetings to assess person reactions, [11] used by deaf people to convey a message, assess a customer feedback on a certain product, evaluation of student emotions and behavior in computer programming using Python Language which resulted to confusion, frustration and boredom [12], used to assess the emotion of participants interact with different computer interfaces activities resulted to consider the non-basic basic emotion such as engaged, bored, frustrated and confusion be part of Affective Computing research [13].

Several Studies applied various approaches to detect emotions through Facial Expression to achieve accuracy and performance through different various models, algorithms and applications. Notably, Neural Network Model using JAFEE [14], Curvlet Transform which is fast, less complex and less redundant and Online Sequential Extreme Learning Machine (OSELM) with radial basis function (RBF) which increase classification performance to 95.17% recognition rate [15], Automated Learning Free Facial Landmark Detection Technique which performs in different resolutions and accurate for classification of the Six universal expression [16] and SMQT features, split up SNoW classifier to detect face using standard pattern and Principal Component Analysis in terms of luminance, chrominance to locate the eyes based on valley points [17], Kanada-Lucas Tomasi Tracker which is accurately used for face detection based on distance from the camera, brightness and contrast and the Skin color pixel value that ranges from 120 to 180 pixel in value and Tree Naive Bayes Classifier [18], the face detection that employed Active Appearance Model to locate landmarks [19] used the Support Vector Machine classification using nearest neighbor rule and Extended Cohn-Kanade (CK+) datasets thus resulted to 87.7% performance based on the local and global features of the face. In Eigenfaces and Fisherfaces face recognition shows better recognition accuracy of 97.50% and 95.45% based Euclidean Distance using Bray Curtis [20]. For complexity issues eigenfaces is applied with Gaussian Curvature to detect 3D image [21] and it is the best algorithm to extract

feature of a face with the application of Fisher Linear Discriminant and its classify using Dynamic Fuzzy Neural Networks to reduce errors [22]. Fisherfaces on the other hand is used to treat image with eyeglasses based on genetic algorithm [23] and this also used for gender recognition with fuzzy iterative self-organizing technique with accuracy rate 95.55% [24] the FGGA System on Chip applied the Local Binary Pattern Histogram recorded an accuracy rate of 79.33% [25].

2 Method

In this part, the study applied a systematic approach to examine the emotions portrayed by the respondents.

Figure 1 showed the methodology on how the study is being conducted and facilitated. In this framework there are two types of approaches applied by the researchers, capture a video then convert into frames and capture an image. These images are stored in the database assigned in the study annotated by the experts and with incorporation of the CK/C+ database which will be used to match the real-time video and analyzed the data based on the employed algorithm in the study which is expected to produce certain emotions.

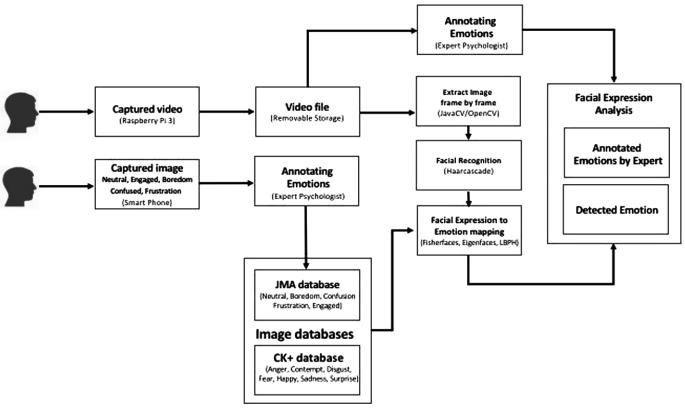

Fig. 1. Methodology framework

2.1 Data Gathering

The study applied the Random Sampling in selecting the sample population to be used in the training set and in the testing part which aim to capture certain emotion. The participants are represented from Colleges and Universities who offered Information Technology Program.

In the training set part, the sample population is twenty (20) student participants composed of 10 males and 10 females from First Asia Institute of Technology while in the testing part, the sample population is five (5) students composed of 2 males and 3 females from Technological Institute of the Philippines (TIP).

2.2 Tools

Raspberry PI

In this experiment that researchers used Raspberry Pi 3 model V to provide high resolution and can capable to capture the image in 300 × 300 pixel in size from the video sequence and used smart phone LG G3 13-megapixel F/2.4 29 mms to capture an image portrayed by the students with the presence of the experts in the field. OpenCV also used for face detector that process 90–95% of clear images [14].

Figure 2 showed the images of the student who portrayed the Non-basic emotions annotated the expert in the field.

Fig. 2. Facial expression data sets

Databases: JMA Database & Cohn-Kanade Database (CK+)

The JMA database is referred to a database where all the captured images gathered by researchers will served as the training data sets and this will be incorporated and as additional pattern of emotion such as neutral, engaged, frustration, confusion, boredom and Cohn-Kanade Database (CK+) L.

Table 1 showed the number of images used in the study. These images portrayed different types of emotion with its corresponding numbers of images.

Table 1. CK/CK+ Database

Coding	Emotion	No. of images
1	Anger	45
2	Contempt	18
3	Disgust	60
4	Fear	25
5	Happy	69
6	Sadness	28
7	Surprise	83

To execute and populate the database, the captured images are manually classified according to the five (5) emotions (neutral, boredom, confusion, frustration and engaged) then normalizing the training set using OpenCV for face detection and face images are cropped into 300 × 300 pixel in size and integrate to the CK/CK+ database that have the seven (7) basic emotions (anger, contempt, disgust, fear, happy, sadness and surprise). These datasets are trained through the application of algorithms Fisherfaces, Local Binary Pattern Histogram and Eigenfaces to further improved the datasets being developed.

2.3 Data Gathering Procedure

To facilitate the conduct of the data gathering, the researchers formalized the study through a formal letter of request indicating the requirements needed in the study. In this study, the researchers selected twenty (20) students from First Asia Institute of

Technology for the sample of the training data sets. Each student are requested to portray five (5) pose per emotion with a total of 25 emotions per student with the guidance of an expert in the field to appropriately portray such emotion using Smartphone, then these images are cropped and displayed for re-evaluation purposes of an expert before its final classification of emotion. These images are stored in the JMA database together with the CK/CK+ database that will served as the training sets used in the study.

For the testing part, the researchers prepared the Computer Laboratory for the data gathering, the RaspberryPi is installed and it is placed at the back of the monitor and the camera is attached at the center top head area of the monitor to capture the image proportionately. The identified students are requested to position themselves in front of the monitor and advised to answer the provided machine problem in 15 min in a continuous video recording. The raw video file are stored and converted into frames with an interval of 5 min to determine the emotions portrayed by the students. This frame of images are subject for processing.

2.4 Analysis

Presented the system architecture of the Facial Expression Extraction Prediction of Student Emotion in Programming (FEEPSEP).

Figure 3 showed the real-time video is used to extract the images into frames and then be analyzed and classified using the Haar-based Cascade Classifier to serve as the input images. These images are then compared to the JMA and CK/CK+ databases which is already been trained to detect the most like emotions according to the respective results of the three algorithms.

Eigenfaces is implemented since it efficiently processes the time and storage with accuracy rate of 90% with the Principal Component Analysis [16], the application of Local Binary Pattern Histogram which performed very well in terms of texture classification and segmentation, image retrieval, surface inspection and [32] showed enough discriminated faces and non-faces faster. And, the Fisherfaces algorithm which is good distortion analysis of the faces such as illumination, facial expression and pose

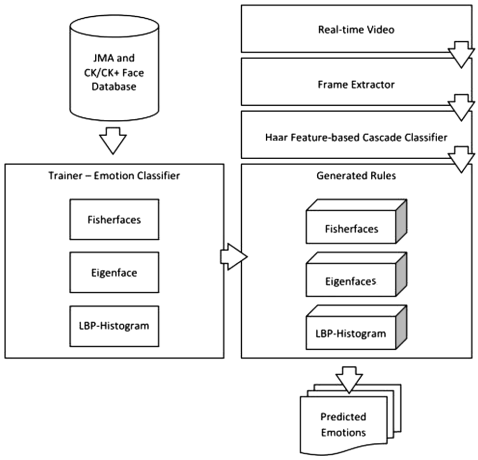

Fig. 3. FEEPSEP system architecture

variations of the face. This three (3) features of algorithm applied in this study will surely made a significant effect on its performance to detect certain emotion.

The images has been analyzed using percentage formula:

$$\frac{\text{Total image detected per algorithm}}{\text{The total number of detected emotion of the (3) algorithms}} \text{ multiplied by } 100$$

3 Results and Discussion

In this study, the researchers developed a prototype to detect certain emotion. In result, the solution showed that the Fisherfaces algorithm have the highest accuracy of 47.93% among the algorithms used in the study. Specifically, the Fisherfaces algorithm achieved 100% accuracy presented in Table 2. "Happy and Surprise" means that the majority of the students in the study perform the programming task provided during the testing part.

Table 2 Showed the comparative results of the algorithm based on combine JMA and CK/CK+ database, the Fisherfaces marked an accuracy rate of 47.93%, LBPH is 26.09% accuracy rate and the Eigenfaces marked the lowest accuracy of 25.16%. However, looking at the results of the JMA and CK/CK+ database, the CK/CK+ database significantly produce a remarkable highest accuracy results of 100% observed in Fisherfaces Algorithm, 98.53% in LBPH Algorithm and 82.76% percent in Eigenfaces Algorithm than the JMA Database annotated by the experts only produced the highest accuracy rate of 69.66% in Fisherfaces Algorithm, 38.82% in LBPH Algorithm and 82.76% in Eigenfaces Algorithm.

Table 2. Comparative results of detected emotion based on the three (3) algorithms

No.	Emotion	Database	%Fisherfaces	% LBPH	% Eigenfaces
11	Engage	JMA	23.19%	38.82%	37.98%
10	Frustration	JMA	24.31%	20.30%	55.39%
9	Confusion	JMA	69.66%	10.59%	19.75%
8	Boredom	JMA	50.03%	17.99%	31.99%
7	Surprise	CK/CK+	100.00%	0.00%	0.00%
6	Sadness	CK/CK+	17.24%	0.00%	82.76%
5	Happy	CK/CK+	100.00%	0.00%	0.00%
4	Fear	CK/CK+	0.00%	0.00%	0.00%
3	Disgust	CK/CK+	0.74%	98.53%	0.74%
2	Contempt	CK/CK+	18.19%	65.27%	16.54%
1	Anger	CK/CK+	96.72%	0.00%	3.28%
0	Neutral	CK/CK+	27.18%	44.43%	28.39%
		Total	47.93%	26.90%	25.16%

4 Conclusion and Recommendation

Based on results, the Fisherfaces algorithm is more flexible and efficient considering some issues on the integration of the JMA database because the annotation of the expert alone may possibly have encountered inaccuracy in identifying real emotions.

In addition, by looking at the results of 47.93% accuracy rate, there are some factors also be considered, the lack of training dataset presented in Table 1 and in the testing part showed in Table 2, showed 0% detection rate that may significantly create a negative effect on the accuracy result, therefore the study highly recommend the number of training data sets is consistent, the integration of the new training data set should have further analysis, used solutions that will assist the expert to re-validate the results and may apply all approaches of the three algorithms if the new training data set is embedded to the existing database like the CK\CK+ database which is highly tested and validated to ensure higher accuracy rate in detecting emotions.

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