Facial Emotion Recognition System through Machine Learning approach

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***Abstract*— Data mining also sometimes called data or knowledge discovery is the process of analyzing data from different perspectives and summarizing it into useful information. Image processing is related to Computer vision, which is a high-level image processing out of which a machine/computer/software intends to decipher the physical contents of an image or a sequence of images. One of the ways to do this is by comparing selected facial features from the image and a facial database. Recognizing emotion from images has become one of the active research themes in image processing and in applications based on human-computer interaction. This research conducts an experimental study on recognizing facial emotions. The flow of our emotion recognition system include the basic process in FER system. These include image acquisition, preprocessing of an image, face detection, feature extraction, classification and then when the emotions are classified the system assigns the user particular music according to his emotion. Our system focuses on live images taken from the webcam. The aim of this research is to develop automatic facial emotion recognition system for stressed individuals thus assigning them music therapy so as to relief stress. The emotions considered for the experiments include happiness, Sadness, Surprise, Fear, Disgust, and Anger that are universally accepted.**

Keywords— Emotion recognition, emotion classification, images.

I. INTRODUCTION

While language is crucial to human communication, in most interactions it is supplemented by various forms of expressive information, such as facial expressions, vocal nuances, gesture and posture. The features depend on the context of the interaction and are usually accompanied by physiological reactions, such as changes in heart rate. Human computer interaction and human-mediated communication have become a major part of our lives, and although still lack the basic means of recognizing and responding to non- verbal cues of attitudes, emotions and mental states, that we take for granted in human communication and reasoning. Reeves and Nass observed that people interact with computers in the same way that they interact with each other. There is a requirement for human computer inter face (HCI) applications that support human emotional needs.

Fig. 1: Example of expression for the six basic emotions

Facial expressions are studied since ancient times, one of the reason is that it is one of the most important channel of non-verbal communication. Initially facial expressions were studied by great philosophers and thinkers like Aristotle and Stewart. With Darwin, the study of facial expressions became an empirical study. Darwin's studies created large interest among psychologists and cognitive scientists. The 20th century saw many studies relating facial expression to emotion and inter-human communication. Most notably, Paul Ekman reinvestigated Darwin's work and claimed that there are six universal emotions, which are produced and recognized independently of cultural background.

The general approach to automatic facial expression analysis consists of three steps: face detection and tracking, feature extraction and expression classification / recognition. Facial expression presents key mechanism to describe human emotion. From starting to end of the day human tend to changes plenty of emotions; it may be because of their mental or physical circumstances. Face detection stage processes stimuli to automatically find the face region from the input images or sequences. After face is located, the next step is to extract meaningful or discriminative information caused by facial expressions. Facial expression recognition is the last stage of the systems. The facial changes can be identified either as prototypic emotions or facial action units. Although humans are filled with various emotions,

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modern psychology defines six basic facial expressions that are Happiness, Sadness, Surprise, Fear, Disgust, and Anger as universal emotions. Facial muscles movements help to identify human emotions. Basic facial features are eyebrow, mouth, nose and eyes, cheeks.

II. REVIEW OF LITERATURE

Lokesh Singh et. al., objective is to introduce the needs and applications of facial expression recognition. Between Verbal and Non-Verbal form of communication facial expression is the form of non-verbal communication but it plays vital role. It express human perspective or filling and also his or her mental situation. A big research is been made to enhance Human Computer Interaction (HCI) over two decades. This paper includes introduction of facial emotion recognition system, Application, comparative study of popular face expression recognition techniques and phases of automatic facial expression recognition system. The author reviewed the paper related to this topic and gave its pros and cons. The Facial expression recognition system is also described [1]

Mustafa Sert, Nukhet Aksoy (2016); the author present a novel method for recognizing the facial expressions of emotion based on the developed facial action unit (AU) detector and using rule-based reasoning. The author choose the Support Vector Machine (SVM) algorithm as the binary method and utilize Active Appearance Model (AAM) features. Using ADT-AU detector they detect 17 AUs occurring alone or in the combination. It recognize six facial expressions of emotion (e.g., surprise, fear, happiness, etc.) using the prototypic and major variants of AUs by our rule-based emotion classifier [2].

The author Pravin Nagar [3], proposes a system which automatically recognizes the emotion represented on a face. The Bezier curve based solution together with image processing is used in classifying the emotions. Colored face images are given as input to the system. Then, Image processing based feature point extraction method is applied to extract a set of selected feature points. Finally, extracted features like eyes and mouth, obtained after processing is given as input to the curve algorithm to recognize the emotion contained. The Canny Edge Location calculation was utilized through OpenCv API as a part of which haar cascades record, for eyes and mouth was predefined. The experiment shows the recognition results under different facial expressions such as smile, sad, surprise and normal. The method gives successful emotion recognition of ratio 60.

Almudena Gil, et.al, presents a simple and fast expression recognition algorithm that aimed at running in a secondary plane to provide emotion awareness for primary applications as e.g. exergames, in real time. The algorithm is based on the extraction of 19 facial landmarks, which are used to detect some of the Action Units (AUs) that are defined in the Facial Action Coding System (FACS) and a newly created one. In addition, the new concept of Combined Action Units (CAUs) is presented and well described. Those are grouped AUs which are detected as a unit. On the one hand, results are weak for individual emotion recognition due to two problems: one is the difficulty to analyze the action units robustly with few facial landmarks. The other is the sparse matrix used to train the decision tree. On the other hand, very good results are obtained for a fast estimation of the mood of a person. This knowledge can be used as the valuable knowledge by a primary application. The applied emotion classification is based on logical rules, no learning is involved in it. The implementations have been made on a mobile platform [4]. Ashim Sahaa, et. al., The author implemented the HSV (Hue-Saturation-Value) color model for the detection the face in an image. PCA that is principal component analysis has been used for reducing the high dimensionality of the eigenspace and then projecting the test image upon the eigenspace and calculate the Euclidean distance between the test image and mean of the eigenfaces of the training dataset the expressions are classified. A generic dataset is used for the purpose training. The gray scale images of the face is used by the system in order to classify five basic emotions such as surprise, sorrow, fear, anger and happiness. The training dataset consists of images of different people and when tested it gives satisfactory results but there exists a resemblance between Sorrow and Fear to some extent and can be improved by more extensive training [5].

The authors Gupta, G., Rathee, N [6], states that though SVMs have a good generalization performance, but their results are in general less sparse. This sometimes results in almost all of the training data to be used as Support Vectors. Comparing with RVM, the results obtained are more sparse than SVM which results in lesser number of Relevance Vectors that ultimately leads to lesser computation overhead. The models are compared for facial expression recognition on Cohn Kanade database. Local Binary Pattern features are extracted from the facial images. These are preprocessed for illumination and size, and also for the purpose of dimensionality reduction before being used for training the RVM and SVM models. The author specifically compares SVM and RVM for regression and evaluates them on the basis of sparsity of the learned model and also their accuracy. On the basis of results RVM produces a sparse model than SVM (nearly half of the Relevance Vectors as compared to Support Vectors). However the accuracy of both SVM and RVM is nearly the same.

Weihong Deng, Jiani Hu, et.al, the author of this paper explores the necessary characteristics of the training dataset, feature representations and machine learning algorithms for a system which operates reliably in more realistic conditions. A new database, Real world Affective Face Database (RAF-DB), is presented which contains about 30,000 greatly diverse facial images from social networks. Crowdsourcing results suggest that real-world expression recognition problem is a typical problem in imbalanced multi-label classification. The balanced, single-label datasets currently used in the literature could potentially lead the research into misleading algorithmic solutions. A deep learning architecture, DeepEmo, is proposed to address the real-world challenge of emotion recognition by learning the high level feature representations that are highly effective

for discriminating the realistic facial expressions. Extensive experimental results show that the deep learning method is superior to handcrafted features, and with the near frontal pose constraint, human-level recognition accuracy is achievable [7].

The authors Vinola, C., Vimaladevi, K., presents the various emotion classification and recognition systems which implement methods aiming at improving the Human Machine Interaction. The modalities and approaches used for affect detection vary and contribute to accuracy and efficacy in detecting the emotions of human beings. This paper discovers them in a comparison and descriptive manner. Various applications that use the methodologies in different contexts to address the challenges in real time are also discussed. The author also describes the databases that can be used as standard data sets in the process of emotion identification. Thus an integrated discussion of methods, databases used and applications pertaining to the emerging field of Affective Computing (AC) is done and surveyed [8].

Filko, D., Martinovic, G.,[9] This paper proposes a system for human emotion recognition by analyzing key facial regions using principal component analysis and neural networks. Emotion recognition in this paper is based on observation of contours, namely of facial features displayed in still pictures. Facial features used are obtained by edge detection and focusing on specific facial regions of eyes and the mouth. Therefore, classification and emotion recognition is performed through those two facial regions. The selection of these two regions, as the basis for emotion recognition is intuitive since the most visual indication of emotions is visible in those regions. The neural network was chosen for a classifier that will learn to recognize specific emotions, because it enables a higher flexibility in training and adapting to a particular problem of classification. According to the data, the average successful emotion recognition is approximately 70 percent, which means that 73 out of 105 test pictures were successfully classified.

III. SYSTEM ARCHITECTURE

Facial expression presents key mechanism to describe human emotion. From starting to end of the day human changes plenty of emotions, it may be because of their mental or physical circumstances. This is both something that humans do automatically but computational methodologies have also been developed. The general approach that is proposed to automatic facial emotion recognition consists: input (image), preprocessing, face detection and tracking, feature extraction and expression classification / recognition. Face detection stage processes stimuli to automatically find the face region from the input images or sequences. After face is located, the next step is to extract meaningful or discriminative information caused by facial expressions. Facial emotion recognition is the last stage of the systems.

The system architecture describes the various phases that is included in an emotion recognition system. The emotion detection block include naormalization where the preprocessing on takes place on the image, the capturing and feature selection module are further developed followed by the training. The dataset will be further used for the purpose of training and testing of the system. The emotions considered for the experiments include happiness, Sadness, Surprise, Fear, Disgust, and Anger that are universally described.

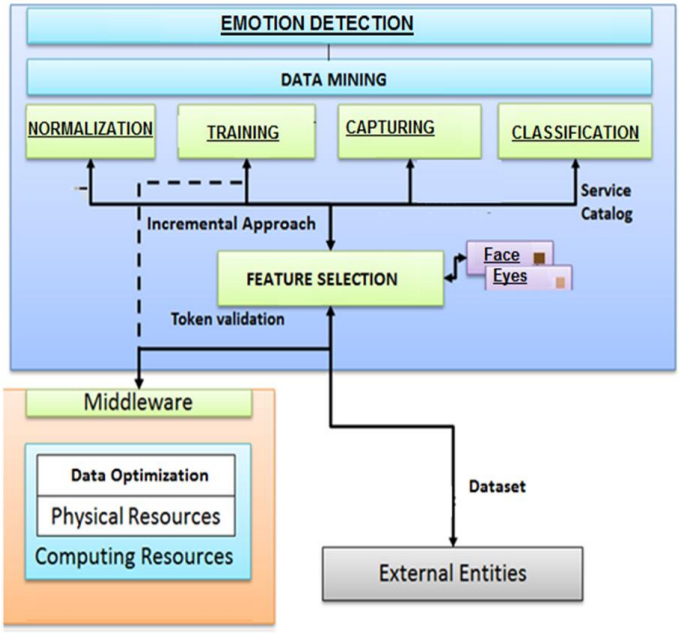

Fig. 2. System Architecture

IV. SYSTEM ANALYSIS

There are many factors contribute in conveying emotions of an individual. Pose, speech, facial expressions, behavior and actions are some of them. From these above mentioned factors, facial expressions have a higher importance since they are easily perceptible.

The table depicts the emotions and their impact on

TABLE I. TABLE STYLES

Emotion	Motion of Facial parts
Happy	open eyes, open mouth,lip corner pulled, cheeks raised
Sad	Outer eyebrow down,inner eyebrows raised, eyes closed, lip corner down
Suprise	Eyebrow up, open eyes, jaw dropped
Anger	Eyebrow pulled down, open eyes, lip tightened
Fear	Outer eyebrow down, inner eyebrow up, mouth open

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Disgust	Lip corner depressor, lower lip depressor, eyebrows down, nose wrinkled

facial feature that can be considered for classification of emotions. In this research, the system will recognize the six universal emotions from face images. The system can be broadly categorized in to three stages: Preprocessing stage, face detection stage, feature extraction stage and emotion classification stage. The input to the system is live image taken from the webcam. The preprocessing stage include conversion of the facial image to binary image. The Viola Jones algorithm is implemented for the face feature detection as it does not consumes much time, thus giving greater accuracy. The further steps is of feature extraction, will consider basic facial features eyes (left eye and right eye), nose, mouth for further classification of emotions. The system will further classify the emotion of an individual and then accordingly for respective emotion, the song will be played automatically.

The machine learning algorithm will be used for the purpose of classification of the emotions. The emotion API will be further developed that will give us an output in the form of emotion that are classified based on the given input to the system. The paper includes only the partial results of implementation; the further implementation is carried on. The performance measures will be used depending on the further implementation that is in process.

A. Result of implementation:

These are the results of our partial implementation of our system.

Fig. 3: Login page

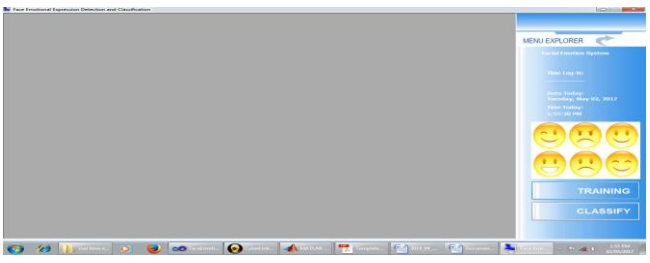

Fig. 4: System GUI

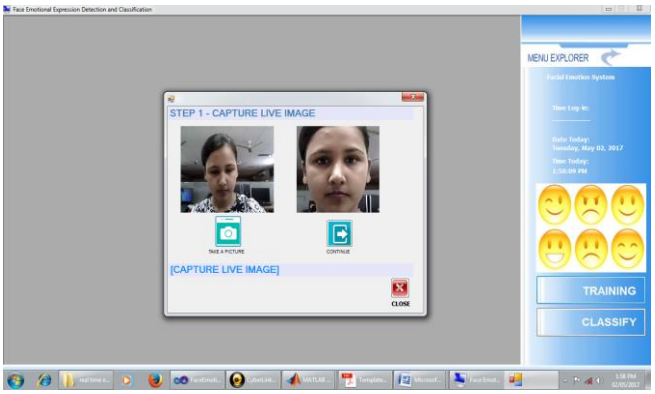

Fig. 5: Real time face capture through webcam

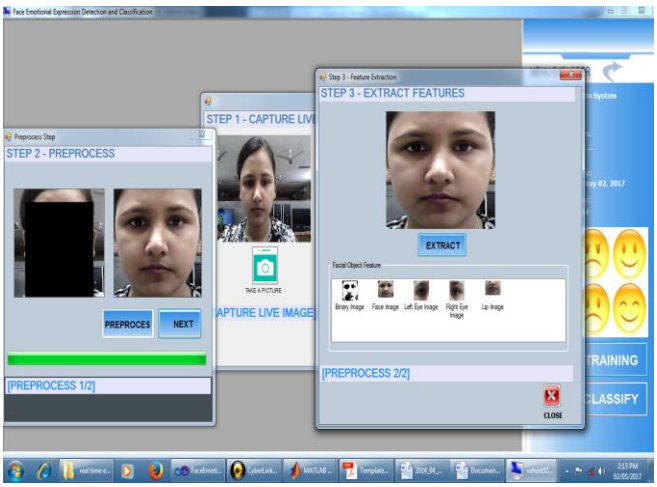

Fig.6: Face detection and feature extraction stage

V. DATABASES

There are a number of emotion databases that have been developed to advance the automatic recognition of affective states. The databases facial expression includes posed and spontaneous in major. In posed expression databases, the subjects are asked to display different basic emotional expressions, while in spontaneous expression database, the expressions are natural. Spontaneous expressions differ from posed ones remarkably in terms of intensity, configuration, and duration. When creating the spontaneous facial expression databases, it is necessary to validate that the facial expression of a person is corresponding to the emotional state of the person. Sebe et al. have indicated some guidelines to create an authentic validated database. The subjects should not be aware of being tested for elicitation of their emotional states; else it influences their emotional states. Secondly, the subject's self-report should be documented after the test in order to validate the emotional states of the subjects. Thirdly, the presence of the experimenter may effect the elicitation of facial expression. Spontaneous emotion elicitation is possible through human-to-human interaction, human to computer interaction, by means of emotion eliciting tasks or by induction through

picture, music, or videos. The ISED created database contains subtle to full blown elicitation of different emotions. It contains facial expression videos and still images of 50 participants with the emotion ground truth and its intensity. The six basic emotional expressions include happiness, sadness, surprise, fear, anger and disgust, and the corresponding intensity on a scale of six-point. Higher value in the scale corresponds to high intensity of elicited emotion, where the scale varies from 0-5. An End User License Agreement (EULA) needs to be produced for accessing the database [10].

The need for real time detection of emotion in real world contexts has encouraged researchers to create spontaneous emotion databases. The Extended Cohn-Kanade Dataset (CK+) is an extension of which includes posed expressions of 123 multi-ethnicity subjects along with the spontaneous smile expressions. Ekman's study correlated the facial muscle movements with the emotional state. Facial Action Coding System (FACS) measures all visually observable facial movements in terms of Action Units (AUs). Using this concept of facial muscle movements, posed expression databases include the reproduction of different emotion which are unnatural and hardly found in actual situations. In Belfast induced emotions database, the emotions are induced using laboratory based tasks and uninterrupted trace ratings of the coloured responses, generated in terms of valence and intensity scale. It uses both active and passive tasks while watching emotional videos to engage the subjects and thereby elicit emotion [10].

The BHU facial expression database was collected from April to May in 2005, at Beihang University, China. 32 college students (14 males, 18 females) from the age group of 21 to 25 participated as subjects in the data collection experiment. Every subject was asked to act 25 facial expressions (pure, mixed and complex facial expressions) in a staff room. Totally, 1600 color videos were obtained for the frontal and 30-degree profile of each facial expression of every subject. Each video of facial expression is stored in AVI file, lasting about 6 seconds. The facial expression includes smile, laugh, sneer, worry, anger, fury, surprise, fear, disgust, doubt, impatient, contempt, plea, despair, sadness, curiousness, shyness, gape [11].

TABLE II. FACIAL DATASETS

Database	Class	Type	Number of samples	Image resolution
CMU Facial Expression Database (Cohn-Kanade) [16]	Joy, Surprise, Anger, Fear, Disgust, And Sadness	Posed	200 subjects	-
Extended Cohn-Kanade Dataset (CK+) [17]	Neutral, Sadness, Surprise, Happiness, Fear, Anger, And Disgust	Posed; spontaneous smiles	593 image sequences (327 sequences having discrete emotion labels)	640* 490
Japanese Female Facial Expressions (JAFFE) [18]	Neutral, Sadness, Surprise, Happiness, Fear, Anger, And Disgust	Posed	213 static images	256* 256
FERG (Facial Expression Research Group Database)-DB [19]	Angry, Disgust, Fear, Joy, Neutral, Sad, Surprise	Frontal pose	55767	768x768
Radboud Faces Database (RaFD) [20]	Neutral, Sadness, Contempt, Surprise, Happiness, Fear, Anger, And Disgust	Posed	Three different gaze directions and five camera angles (8*67*3*5=8040 images)	681*1024
Beihang University facial expression database [21]	Despair, Grief, Worry, Surprise, Flurry, Horror, Disgust, Fury, Fear, Doubt, Impatience, Hate, Contempt, Disparagement, Sneer, Smile, Plea, Laugh	-	-	-
NVIE (Natural Visible and Infrared facial Expression)[22]	Basic Expressions	Posed & Spontaneous expressions	-	-
The Yale Face Database [23]	Sad, Sleepy, Surprised	Posed	15 subjects	
The Psychological Image Collection at Stirling [24]	Smile, Surprise, Disgust	Posed	Aberdeen: 116 subjects Nottingham scans: 100 Nott-faces-original: 100 Stirling faces:36	-

VI. CONCLUSION

The increasing integration of computers and computer interfaces in our lives, the arise in the need of computers in order to be able to recognize and respond to human communication and behavioral cues of emotions and mental states. Furthermore, the expressions in facial image are meaningful. In particular, the expressions that relate to the affective and cognitive states of the mind that are not part of the basic emotions set. This is a challenging endeavor because of the uncertainty inherent in the inference of hidden mental states from behavioral cues, because the automated analysis of expressions in images is challenging. This research, facial expressions is considered for the recognition of emotions in humans facial images from live image from webcam. The proposed system is independent of factors like gender, age, ethnic group, beard, backgrounds and birthmarks. The proposed system hopes to be very promising and developed for individuals going through stress during their working hours giving them music therapy.

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