LITERATURE SURVEY REPORT ON

REAL-TIME EMOTION DETECTION FROM FACE

Submitted in partial fulfillment of the requirements for the award of the degree of

Bachelor of Technology

In

Computer Science And Engineering

By

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CERTIFICATE

This is to certify that Literature Survey for the project titled **Real-Time Emotion Detection From Face** is a bonafide work carried out by **Muhammed Abilaj K E (Reg no-14004081)** in partial fulfilment for the award of Bachelor of Technology in Computer Science and Engineering from Mahatma Gandhi University, Kottayam, Kerala during the academic year 2017-2018.

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ABSTRACT

Facial emotion recognition systems would contribute in several areas of identification, psychological researches and many real world problems.For human-computer interaction facial expression makes a platform for non-verbal communication.The key elements of Face are considered for prediction of face emotions and the user. The variations in each facial feature are used to determine the different emotions of face.The emotions are effectively changeable happenings that are evoked as a result of impelling force. So in real life application, detection of emotion is very challenging task. Facial expression recognition system requires to overcome the human face having multiple variability such as color, orientation, expression, posture and texture so on.A literature survey is done to investigate the various frameworks available for emotion detection from face.

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Chapter 1

Introduction

1.1 Overview

In today's society, automated face recognition has become increasingly relevant in many commercial and law enforcement applications. The recent interest in face recognition can be attributed to the increase of commercial interest and the development of feasible technologies to support the development of face recognition [1], [2], [3]. Mugshot matching, user verification and user access control, crowd surveillance, enhanced human computer interaction; all become possible when an effective face recognition system is implemented. Automatic face detection and recognition are two challenging problems in the domain of image processing and computer graphics that have yet to be perfected. Manual recognition is a very complicated task where it is vital to pay attention to primary components like: face configuration, orientation, location where the face is set (relative to the body), and movement (i.e. traces out a trajectory in space). It is more complicated to perform detection in real time. Dealing with real time capturing from a camera device, fast image processing would be needed. Haar features by Viola and Jones [4] is the first real time frontal-view face detector.

Facial recognition can be attempted once the face is detected in the image. There are a number of different approaches to performing face recognition, which have varying levels of success. Some of the better-known algorithms utilize eigenfaces [5] or active appearance models [6] to identify an image. However, eigenface approaches suffer from requiring extremely constrained frontal face images and potentially large amounts of training data to deal with high variability. Active appearance models are more promising for a noisy environment but require computationally expensive models. Detection of face in an image or video is the fundamental step in any recognition system. It is difficult for computer to find the face in light of the fact that the number of features in an image is extremely high. P.Viola and Jones [14] introduces different classifiers which groups the number of features into different classifiers. Using these classifiers, the different facial features are detected which can be used for further processing. But this method is limited to only frontal view of the face. Therefore in order to detect the facial features of the persons face under different poses, face landmark annotation is required. For annotation of facial landmarks, the popular method active shape model (ASM) or open source software dlib can be used. Emotion detection is based on different expressions of face and these expressions are generated by variations in facial features.

In geometric feature-based methods [10], [11] facial features such as eyes, nose, mouth, and chin are detected. Properties and relations such as areas, distances, and angles, between the features are used as the descriptors of faces. The proposed system attempt at facial recognition follows the popular use of machine learning to determine the differences between features. Face emotion recognition [7] uses support vector machine [8] for finding the different emotions of face and also for classifying them. PCA is used to extract the facial features and to reduce the image dimensions. Face is a two dimensional image, for face analysis it is preferred to use two dimensional vector space. Therefore for dimensionality reduction also 2DPCA [9] is best for faces under different poses. 2DPCA is used to remove the unnecessary parts of the image. Multiobjective algorithm based optimization and classifiers are used. SVMs are used to classify the image data under consideration. It finds the minimum possible separation between two or more classes of data and creates a hyper-plane with a margin. Since in general greater the margin and lesser is the generalization error. SVMs are memory efficient and effective in higher dimension spaces

The Proposed System evaluated three classifiers: Support Vector Machines, Modified Naive Bayes and Multilayer Perceptron. The goal was to train the classifiers to distinguish between eye and non-eye regions on a face expressing an emotion. As classifier input vectors, used integral projections encoded using the TESPAR method. The measurements revealed that each classification method has its own outstanding advantages, especially when it is tuned to our particular case. Moreover, in order to further enhance the results, applied a post-processing step on the output of the classifiers. With this approach, reached detection ratios of over 95% while keeping the rate of incorrect decisions below 5%. We conclude that the problem of detecting eyes in images with human emotions can be resolved by employing neural network classifiers. While the SVM provides the best accuracy, its computational demands make it less appealing for real-time systems for embedded use the Bayes or the MLP algorithms are more appropriate, especially when accompanied by carefully tuned post-processing steps.

Chapter 2

Related Works

2.1 An Efficient Method to Face and Emotion Detection

[24] Face detection and emotion selection is the one of the current topic in the security field which provides solution to various challenges. Beside traditional challenges in captured facial images under uncontrolled settings such as varying poses, different lighting and expressions for face recognition and different sound frequencies for emotion recognition. For any face and emotion detection system database is the most important part for the comparison of the face features and sound Mel frequency components. For database creation features of the face are calculated and these features are store in the database. This database is then use for the evaluation of the face and emotion by using different algorithms. The system proposes an efficient method to create face and emotion feature database and then this will be used for face and emotion recognition of the person. For detecting face from the input image we are using Viola-Jones face detection algorithm and to evaluate the face and emotion detection KNN classifier [13] is used.

Most of the face recognition (FR) approaches have focused on the use of two dimensional images. Since FR is still an unsolved problem under the different conditions, such as pose, illumination or database size. The expression of emotions and the recognition of a person's affective state are abilities indispensable for natural human interaction and social integration. The study of emotions has attracted interest of researchers from very diverse areas, ranging from psychology to the applied sciences. Face and emotion features detection is the currently very active area of research in the computer vision field as different kinds of face detection application are currently used such as image database management system, monitoring and surveillance analysis, biomedical image, smart rooms intelligent robots, human computer interfaces and drivers alertness system.

2.2 Facial Emotion Recognition in Real Time

[25]Emotions often mediate and facilitate interactions among human beings. Thus, understanding emotion often brings context to seemingly bizarre and/or complex social communication. Emotion can be recognized through a variety of means such as voice intonation, body language, and more complex methods such electroencephalography (EEG) [19]. However, the easier, more practical method is to examine facial expressions. There are seven types of human emotions shown to be universally recognizable across different cultures : anger, disgust, fear, happiness, sadness, surprise, contempt. Interestingly, even for complex expressions where a mixture of emotions could be used as descriptors, cross-cultural agreement is still observed . Therefore a utility that detects emotion from facial expressions would be widely applicable. Such an advancement could bring applications in medicine, marketing and entertainment.

The task of emotion recognition is particularly difficult for two reasons: There does not exist a large database of training images and classifying emotion can be difficult depending on whether the input image is static or a transition frame into a facial expression. The latter issue is particularly difficult for real-time detection where facial expressions vary dynamically.

Most applications of emotion recognition examine static images of facial expressions. We investigate the application of convolutional neural networks (CNNs) to emotion recognition in real time with a video input stream. Given the computational requirements and complexity of a CNN, optimizing a network for efficient computation for frame by frame classification is necessary. In addition, accounting for variations in lighting and subject position in a nonlaboratory environment is challenging. We have developed a system for detecting human emotions in different scenes, angles, and lighting conditions in real-time.

To develop a working model, we use two different freelyavailable datasets: the extended Cohn-Kanade dataset (CK+)) the Japanese Female Facial Expression (JAFFE) database. The CK+ dataset, although small, provides well-defined facial expressions in a controlled laboratory environment. The JAFFE database provides additional images with more subtle facial expressions with laboratory conditions. They also uniquely developed their own new (home-brewed) database that consists of images from five individuals. Many images were recorded for each of the seven primary emotions (anger, disgust, fear, happy, neutral, sad, surprise) from each subject. We subsequently applied jitter to these images to account for variations in lighting and subject position in the final implementation.

A particularly difficult aspect of real-time recognition is deciding how to classify transition frames from neutral to fully formed expressions of emotion. One viable solution is to use a running average of the top classes reported by each frame which would ameliorate the problem of noise/errors caused by dynamic expressions. Unfortunately, the relatively slow frame-rate of their demonstration made this solution untenable.

2.3 Discriminative Deep Feature Learning for Facial Emotion Recognition

[26] In recent years, the increase of generally available computational power has allowed us to train very deep neural network models. From that, researchers have proposed various different models to solve practical problems in our life. Many previous hard tasks, especially, computer vision tasks and natural language processing, are able to be solved simply by using deep neural networks and it makes human life easier and more convenient.

Emotion recognition is an important task in facial expression analysis with various potential applications. The goal of this task is to classify facial images into seven classes: disgust, neutral, sad, happy, fear, surprise and angry. In this paper, we propose a discriminative deep feature learning approach with dense convolutional networks (DenseNet) for facial emotion recognition. Particularly, we employ an auxiliary loss, namely center loss, to regulate the training process of neural networks in order to reduce the intra-class variation of the deep features and, hence, to enhance the discriminative power of the learned networks. The experimental results show that their proposed approach achieves superior performance in comparison with other recent state-of-the-art methods on the well-known FERC- 2013 dataset.

2.4 Facial Expression Recognition Using Deep Convolutional Neural Networks

[27]Ever since computers were invented, people have wanted to build artificially intelligent (AI) systems that are mentally and/or physically equivalent to humans. In the past decades, the increase of generally available computational power provided a helping hand for developing fast learning machines, whereas the Internet supplied an enormous amount of data for training. Among a lot of advanced machine learning techniques that have been developed so far, deep learning is widely considered as one of the most promising techniques to make AI machines approaching human-level intelligence.

Facial expression recognition is the process of identifying human emotion based on facial expressions. Humans are naturally capable of recognizing emotions. In fact, children, which are only 36 hours old, can interpret some very basic emotions from faces. In older humans, this ability is considered one of the most important social skills. There is a universality in facial expressions of humans in expressing certain emotions. Human develop similar muscular movements belonging to a certain mental state, despite their place of birth, race, education, etcetera. Therefore, if properly being modelled, this universality can be a convenient feature in human-machine interaction: a well trained system can understand emotions, independent of who the subject is.

Automated facial expression recognition has numerous practical applications such as psychological analysis, medical diagnosis, forensics (lie-detection), studying effectiveness of advertisement and so on. The ability to read facial expressions and then recognize human emotions provides a new dimension to human-machine interactions, for instance, smile detector in commercial digital cameras or interactive advertisements. Robots can also benefit from automated facial expression recognition. If robots can predict human emotions, they can react upon this and have appropriate behaviors.

The system adopt deep learning technique and propose effective architectures of Convolutional Neural Networks to solve the problem of facial expression recognition. We also apply different loss functions associated with supervised learning and several training tricks in order to learn CNNs with a strong discriminative power. We show that Multiclass SVM loss works better than cross-entropy loss (combining with softmax function) in facial expression recognition. Besides, the evaluation of the test sets using multiple crops with different scales and rotations can yield an accuracy boost compared to single crop evaluation.

The proposed networks are composed of a stack of convolutional blocks. Each block has a few 3 x 3 convolutional layers followed a max pooling layers. Despite having much smaller number of parameters, their proposed networks outperform the winning model of the Kaggle competition. The results prove the power of small filter and very deep network in classification tasks. We also show that L2 multi-class SVM loss is preferable than cross entropy loss in facial expression recognition. Additionally, data augmentation is shown to be an important trick in training deep neural networks.

2.5 A comparison of several Classifiers for Eye Detection on Emotion Expressing Faces

[28]Eye detection is an essential component in many image processing applications - face recognition algorithms or human-computer interfaces rely on the accurate determination of the position of the eyes. For example, a computer security system will need to identify faces and this can be done by comparing them to references from a database. For a proper comparison, the faces must be aligned. As the position of the eyes and the interocular distance only slightly vary from one person to another, it means that the position of the eyes can be used to normalize and align a set of faces.There are other possible applications in the field of human computer interaction - the eyes are the key elements for the recognition and the classification of human emotions.

If we can make a computer understand the user's emotions, then a software program can adapt the communication to match the user's state of mind. A potential application would be a teaching environment which knows when to ask easier questions or when to provide the user with some form of gratification.

Alternatively, it can warn the user when an answer was given under a strong emotional state.

Psychological studies identified six types of facial expressions which are generally recognized. These are: fear, disgust, anger, happiness, sadness and surprise. When a person enters into one of these states, the face will change appearance significantly. In some cases, the eyes may become partially or fully closed, making the iris less visible. In other cases, such as when the person is surprised, the eyes might become much wider, producing a larger shining glint. All these changes of the eye appearance and of the other facial features (lowering eyebrows for example) will make precise eye localization more difficult, compared to the case of neutral state of the face.This work gives a comparative study of three solutions to this non-trivial problem of finding the eyes on faces expressing emotions. This approach is based on machine learning techniques i.e. training a set of classifiers so that they can distinguish between eye and noneye regions on the face.

Firstly, the classifiers will be trained with a set of positive and negative samples, followed by an evaluation of their performance. Several iterations will be made in order to find the best combination of classifier parameters and training environment. The algorithm is robust and works under various illumination conditions. The sole problems that might occur are in cases when very strong shadows appear on the eye region. In these extreme situations, the shape features of the eyes can be significantly modified, thus leading to errors.

The purpose of the system is to compare the performance of three classifiers and their ability to separate correctly the pixel regions which are close to the eye centers from those which are further away. The classifiers will be trained with features computed as previously described. The following methods are studied: Support Vector Machines, Naive Bayes and the Multilayer Perceptron.

The SVMs (introduced by Vapnik) are considered to be among the top methods of supervised learning. They are generally used for binary classification, with the goal of finding a hyperplanar surface which separates two data sets, by maximizing the margins between the two classes. While they are considered very powerful classifiers, the SVMs are sensible to outliers in the training set and to noise. The computational demands are also quite high for SVMs, both for processing power and memory usage.

2.6 A Robust Method for Face Recognition and Face Emotion Detection System using Support Vector Machines

[29]The study of face and its features is an active research area from past few decades. Pose variation, illumination conditions, bad lighting etc., are still challenging factors faced by all algorithms. Face recognition and emotion detection system are the major applications of recognition system, in which many algorithms have tried to solve these problems. The face recognition is the basic part in modern

authentication/identification applications; the accuracy of this system should be high for better results. Fisherface algorithm presents high accurate approach for face recognition; it performs two classes of analyses to achieve recognition i.e. Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA) respectively.

Face emotion recognition uses support vector machine for finding the different emotions of face and also for classifying them. PCA is used to extract the facial features and to reduce the image dimensions. Face is a two dimensional image, for face analysis it is preferred to use two dimensional vector space. Therefore for dimensionality reduction also 2DPCA is best for faces under different poses. 2DPCA is used to remove the unnecessary parts of the image. Multiobjective algorithm based optimization and classifiers are used. SVMs are used to classify the image data under consideration. It finds the minimum possible separation between two or more classes of data and creates a hyper-plane with a margin. Since in general greater the margin and lesser is the generalization error. SVMs are memory efficient and effective in higher dimension spaces.

Recognition is based on the stored image data of the different group of persons. Input images are of any type can be used for recognition,

1. Still images.
2. Video frames or video stills.
3. Video.

Input image is subjected for face detection to detect the face. Detected face is then extracted from the image and these images are saved as a database. Saved images are used to compare with the input image. The matching of input image is performed to identify the user's identity. The recognition result gives identification of the person (particularly his/her name).

The algorithm is designed in such a way that, if the person is recognizing for the first time then the system considers him as a new user and performs each step of operation. But if the person/user data is already stored then it is considered as "Registered user" and it performs only matching operation to recognize the user identity. OpenCV contains cascade classifiers in which Viola and Jones face detection algorithm [12] is implemented.By using these classifiers the face region is detected from the image. It classifies the images into positive and negative images respectively.

Facial features such as eyes, nose, lips and face contour are considered as the action units of face and are responsible for creation of expressions on face, are extracted using open source software called dlib. SVM classifier compares the features of training data and testing data to predict any emotion of the face. Here facial features are considered as the key points which are used for training and testing. Support vector machine is the supervised learning method of machine learning.

2.7 A Technique For The Measurement of Facial Movement

[21] A procedure has been developed for measuring visibly different facial movements. The Facial Action Code was derived from an analysis of the anatomical basis of facial movement. The method can be used to describe any facial movement (observed in photographs, motion picture film or videotape) in terms of anatomically based action units. The development of the method is explained, contrasting it to other methods of measuring facial behavior. An example of how facial behavior is measured is provided, and ideas about research applications are discussed. Although different in almost all other respects, most facial measurement techniques have shared a focus upon what is visible, what a rater can differentiate when he sees a facial movement. An exception, Schwartz (in press) used electromyographic (EMG) measurement to study changes in muscle tone which are not visible. EMG could also be used to measure visible changes in muscle tone which do not involve a noticeable movement, but such work has not been done. EMG also could be employed to study visible movement, but we think it is unlikely that surface electrodes could distinguish the variety of visible movements which most other methods delineate. Vascular changes in the face are another aspect of facial behavior which can occur without visible movement and which, like muscle tonus, could be measured directly with sensors. No such work has been published on coloration or skin temperature although Schwartz

Research focused on the face has been impeded by the problems of devising an adequate technique for measuring the face. Over the years various procedures for facial measurement have been invented. Early work has rarely been cited by current investigators, e.g., FroisWittmann (1930), Fulcher (1942), Landis (1924), or Thompson (1941). More current approaches to facial measurement have varied in methodology, ranging from analogic notations of specific changes within a part of the face (Birdwhistell, 1970), to photographic depictions of movements within each of three facial areas (Ekman, Friesen, Tomkins, 1971), to verbal descriptions of facial gestalts (Young Decarie, Note 1). No consensus has emerged about how to measure facial behavior. No tool has been developed which has become the standard, used by all investigators. Each investigator has almost been in the position of inventing his own tool from scratch. The only exception has been that the category lists of facial behavior described by some human ethologists (Blurton-J ones, 1971; Grant, 1969; McGrew, 1972) have influenced other human ethologists studying children.

2.8 Face Detection using Color Segmentation Thresholding

[22]Color segmentation is an effective process to separate skin from its background. The color segmentation process will be followed by energy thresholding. Face detection has been a fascinating problem for image processing researchers during the last decade because of many important applications such as video face recognition at airports and security check-points, digital image archiving, etc. we attempt to detect faces in a digital image using various techniques such as skin color segmentation, morphological processing, template matching, We determined that the more complex classifiers did not work as well as expected due to the lack of large databases for training. Reasonable results were ob- tained with color segmentation, template matching at multiple scales, and clustering of correlation peaks we try to replicate on a computer that which human beings are able to do effortlessly every moment of their lives, detect the presence or absence of faces in their field of vision. The model will take three different color spaces into consideration namely HSV,RGB and YCbCr. Assuming that a person framed in any random photograph is not an attendee at the gathering or get-together, it can be assumed that the face is not white, green, red, or any unnatural color of that nature. While different ethnic groups have different levels of melanin and pigmentation, the range of colors that human facial skin takes on is clearly a subspace of the total color space. With the assumption of a typical photographic scenario, it would be clearly wise to take advantage of face-color correlations to limit their face search to areas of an input image that have at least the correct color components. The color segmentation process will be followed by energy thresholding

Thresholding is the operation of converting a grayscale image into a binary image. Thresholding is a widely applied preprocessing step for image segmentation. Often the burden of segmentation is on the threshold operation, so that a properly thresholded image leads to better segmentation. There are mainly two types of thresholding techniques available: global and local. In the global thresholding technique a grayscale image is converted into a binary image based on an image intensity value called global threshold. All pixels having values greater than the global threshold values are marked as 1 and the remaining pixels are marked as 0. In local thresholding technique, typically a threshold surface is constructed that is a function on the image domain. propose to develop a model for face detection based on color segmentation. The color segmentation process will be followed by energy thresholding. The model tries to take advantage of face color correlation. The model will take three different color spaces into consideration namely HSV,RGB and YCB.

2.9 Facial Emotion Recognition Based on Visual Information

[23]Facial Emotion Recognition (FER) is an important topic in the fields of computer vision and artificial intelligence owing to its significant academic and commercial potential. Although FER can be conducted

using multiple sensors, this review focuses on studies that exclusively use facial images, because visual expressions are one of the main information channels in interpersonal communication. It provides a brief review of researches in the field of FER conducted over the past decades.

First, conventional FER approaches are described along with a summary of the representative categories of FER systems and their main algorithms. Deep-learning-based FER approaches using deep networks enabling learning are then presented. This review also focuses on an up- to-date hybrid deep-learning approach combining a Convolutional Neural Network (CNN) for the spatial features of an individual frame and Long Short-Term Memory (LSTM) for temporal features of consecutive frames.

A brief review of publicly available evaluation metrics is given, and a comparison with benchmark results, which are a standard for a quantitative comparison of FER researches, is described. This review can serve as a brief guidebook to newcomers in the field of FER, providing basic knowledge and a general understanding of the latest state-of-the-art studies, as well as to experienced researchers looking for productive directions for future work.

2.10 Support Vector Machine for Face Emotion Detection on Real Time Basis

2.10.1 Introduction

[15] Automatic face detection and recognition are two challenging problems in the domain of image processing and computer graphics that have yet to be perfected. Manual recognition is a very complicated task where it is vital to pay attention to primary components like: face configuration, orientation, location where the face is set (relative to the body), and movement (i.e. traces out a trajectory in space). It is more complicated to perform detection in real time. Dealing with real time capturing from a camera device, fast image processing would be needed. Haar features by Viola and Jones [4] is the first real time frontal-view face detector. Support Vector Machines (SVMs) have been recently proposed very effective method for general purpose pattern recognition.

2.10.2 Proposed System

Although a vast array of algorithms are available for each module of Facial Expression Recognition (FER) system, combining them is still a challenging problem, especially for an expression recognition task. Fig. 2.1 depicts the overall system architecture developed in this work. When building an FER system, these main issues we must consider are: face detection, image normalization, feature extraction, and classification. Implementing these steps sequentially and independently are the methods that most of the current works in FER are based on.Face detection finds the face areas in the input image. Face

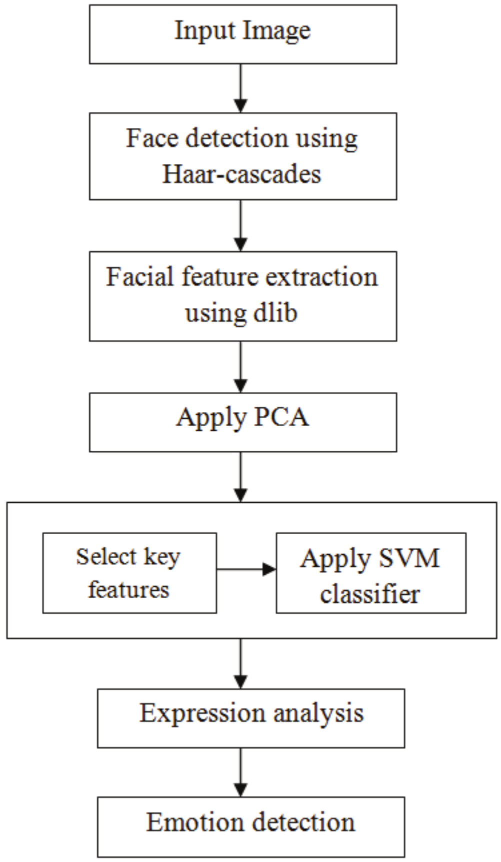

Figure 2.1. Overall system architecture

detection is only performed on key frames and a tracking algorithm is applied on interval frames, if the input is a video. The reasons are to be more efficient and also to achieve better robustness. The system use of Haar-Like Feature and AdaBoost Classier to detect the face.

All the effective information that are useful for recognizing and classifying labels in which there is interest, such as identity, gender, or expression, are provided when feature extraction is performed on the normalized face. Those extracted feature vectors are then sent to a classifier and compared with the training data to produce a recognition output. Support Vector Machine (SVM) is the classifier used in their system.

2.10.3 Face Detection

A face will not be considered as detected or found until the user sits steady for a few frames and the face is detected in the image within those frames in this system. A good detection of the features is very important for an effective performance of the whole system and the user must start the process with the so called 'neutral' expression. Face detection has a major influence on the performance of the entire face recognition system [16] as it is the first step in face recognition. Several examples of cues that are used in face detection are skin colour, motion (for videos), facial/head shape, and facial appearance.Block

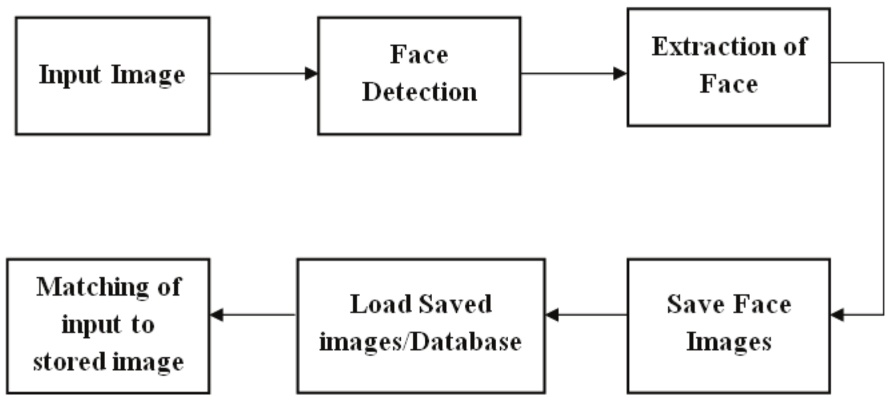

Figure 2.2. Block diagram of Face recognition system.

diagram of Face recognition system is shown in the Fig 2.2. Almost all the state of the art face detection systems are developed based upon Viola's Frame work [17], using Haar-Like features and AdaBoost.

2.10.3.1 Haar-Like features

The core basis for Haar classifier object detection is the Haar-like features. Haar-like feature refers to a feature set that is determined as coefficients in Haar wavelet transform [18]. Haar wavelet is one of the simplest wavelet, and a step function also is a type of Haar wavelet [18]. These features, rather than using the intensity values of a pixel, use the change in contrast values between adjacent rectangular groups of pixels. The contrast variances between the pixel groups are used to determine relative light and dark areas. The value of a Haarlike feature is the difference between the sums of the pixel gray level values within the black and white rectangular regions.

Two or three adjacent groups with a relative contrast are the variance forms of Haar-like feature. Haar-like features, as shown in Fig.2.3 are used to detect an image. These three kinds of features that are usually used are defined as; "The value of a two rectangle feature (edge features) is the difference between the sums of the pixels within two rectangular regions. A three rectangle feature (line features) computes the sum within two outside rectangles subtracted from the sum in a centre rectangle. Finally, a four-rectangle feature (center-surround features) computes the difference between diagonal pairs of rectangles" [18]. Haar features can easily be scaled by increasing or decreasing the size of the pixel group being examined which allows the features to be used to detect objects of various sizes.

A detection process can be much more efficient if it is based on the detection of features that encode some information about the class to be detected. This is the case of Haar-like features that encode the existence of oriented contrasts between regions in the image. A set of these features can be used to encode the contrasts exhibited by a human face and their special relationships. These specifically

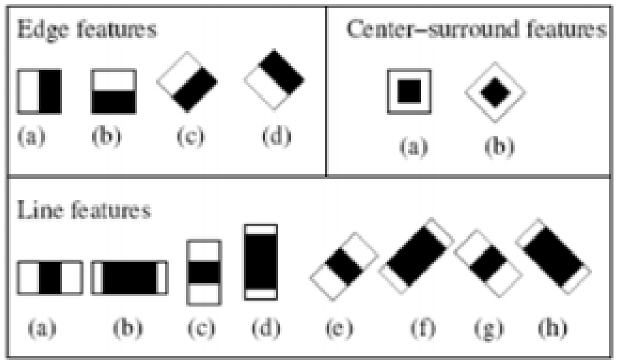

Figure 2.3. Examples of the used feature prototypes.

structured regions are called Haar-like features are superimposed on a man's face, as shown by Fig.2.4

Figure 2.4. Two examples of Haar-like features superimposed on a man's face.

2.10.3.2 AdaBoost

AdaBoost, from Adaptive Boosting, was rapidly made popular in the machine learning community. AdaBoost algorithm sequentially constructs a classifier as a linear combination of "weak" classifiers.

The core idea behind the use of AdaBoost in the system is the application of a weight distribution to the sample set and the modification of the distribution during each iteration of the algorithm. At the beginning, the weight distribution is flat, but after each iteration of the algorithm each of the weak hypotheses returns a classification on each of the sampleimages. If the classification is correct, the weight on that image is reduced (seen as an easier sample), otherwise there is no change to its weight. Therefore, weak classifiers that manage to classify difficult sample-images (i.e. with high weights) are given higher weighting in the final strong classifier. Some of the initial rectangular features selected by AdaBoost in an experimental run are shown in Fig.2.5 In the figure, the second feature selected measures the difference in intensity between the region of the eyes and the bridge of the nose. While the third and fourth feature selected focuses on the observation that the eye region is often darker than the cheeks.

2.10.4 Face Detection

Face Detection is done using Haar Cascade Classifier. This classifier is already implemented in EmguCV as a part of its library. This method provides fast and efficient face detection because we are dealing with

Figure 2.5. Example of some features selected by AdaBoost.

real-time capturing from camera devices where fast image processing is required. Haar Cascade method is also capable in achieving high detection rates.

In EmguCV, there is an already built-in function for face detection using Haar Cascade Classifier. One of the parameter in this function is a classifier file. This classifier file (which is an already-trained Haar Cascade for face detection) is an xml file which we can find easily in Open Computer Vision library (OpenCV). For creating this xml file contain haar classifier for face detection, we have to collect many faces and non-faces image for training, and then train the classifier using some functions in OpenCV.

After a classifier is trained, it can be applied to a region of interest (of the same size as used during the training) in an input image. The classifier outputs a "1" if the region is likely to show the object (i.e., face), and "0" otherwise. To search for the object in the whole image one can move the search window across the image and check every location using the classifier. The classifier is designed so that it can be easily "resized" in order to be able to find the objects of interest at different sizes, which is more efficient than resizing the image itself. So, to find an object of an unknown size in the image the scan procedure should be done several times at different scales.

Currently Discrete Adaboost is used in their system. The word "boosted" means that the classifiers at every stage of the cascade are complex themselves and they are built out of basic classifiers using one of four different boosting techniques (weighted voting). The basic classifiers are decision-tree classifiers with at least 2 leaves. Haar-like features are the input to the basic classifiers. The feature used in a particular classifier is specified by its shape, position within the region of interest and the scale (this scale is not the same as the scale used at the detection stage, though these two scales are multiplied). Though each weak classifier is a simple detector based on Haar set applied on the image block. After training the system using positives and negative images resized by 20x20, AdaBoost is used to linearly combine many weak classifiers to detect the face. The system accuracy for indoor environment is shown in Table 2.1.

Face	Classification			Average Time(ms)	Accuracy
	Samples	Hits	Missed		
Indoor Environment	50	49	1	84.25	98%

Table 2.1. System accuracy for indoor environment.

2.10.5 Emotion Recognition

The system proposes a method for automatically inferring emotions by recognizing facial expressions in live video. The method is based on the machine learning system of Support Vector Machines (SVM).

2.10.5.1 Support Vector machine

In machine learning, support vector machines (SVMs, also support vector networks) are supervised learning models with associated learning algorithms that analyze data used for classification and regression analysis. Given a set of training examples, each marked as belonging to one or the other of two categories, an SVM training algorithm builds a model that assigns new examples to one category or the other, making it a non-probabilistic binary linear classifier (although methods such as Platt scaling exist to use SVM in a probabilistic classification setting). An SVM model is a representation of the examples as points in space, mapped so that the examples of the separate categories are divided by a clear gap that is as wide as possible. New examples are then mapped into that same space and predicted to belong to a category based on which side of the gap they fall.

In addition to performing linear classification, SVMs can efficiently perform a non-linear classification using what is called the kernel trick, implicitly mapping their inputs into high-dimensional feature spaces.

When data are not labeled, supervised learning is not possible, and an unsupervised learning approach is required, which attempts to find natural clustering of the data to groups, and then map new data to these formed groups. The support vector clustering algorithm created by Hava Siegelmann and Vladimir Vapnik, applies the statistics of support vectors, developed in the support vector machines algorithm, to categorize unlabeled data, and is one of the most widely used clustering algorithms in industrial applications.

2.10.5.2 Implementation of Support Vector Machine

The system uses libsvm as the underlying SVM classifier. It encapsulates its stateless functionality in an object-oriented manner to work in an incrementally trained interactive environment. This avoids having to supply the set of training examples in its entirety before any classification can proceed and allows the user to augment the training data on the fly. It also enables the export of the entire state of

Table 2.2. Percentage of correctly classified examples per basic emotion

Emotion	%Correct
Joy	93.0
Sad	84.5
Surprise	97.0

a trained SVM classifier for later use. Hence, data gathered across several training sessions is preserved and can be re-used for classification. In addition, it allows for convenient combination of training data from multiple individuals to accomplish person-independent classification. The user requests for training examples to be gathered at discrete time intervals and provides a label for each. This is combined with the displacements output by the feature extraction phase and added as a new example to the training set. The SVM is then retrained. Unseen expressions to be classified pass the same feature extraction process and are subsequently assigned the label of the target expression that most closely matches their displacement pattern by the SVM classifier. Because evaluation of an SVM decision function on unseen input essentially amounts to checking which of the two subspaces defined by a separating hyperplane a point lays in, classification overhead is negligible. This allows this approach to perform classification both directly upon user request and continuously in real time for every frame in the video stream, with the current result being constantly reported back to the user.

2.10.6 Experimental Results

The developed system was tested on datasets which represents a wide variety of real time situations. This includes faces under a very wide range of conditions including: illumination, scale, pose, and other variation. The system was also tested for its ability to recognize expressions of an expert user who is familiar with the system approach and wholly inexperienced users whom were not given any instructions on how to express each basic emotion. Features were manually defined for each image and displacements were subsequently extracted from pairs of images consisting of a neutral and a representative frame for each expression. A set of ten examples for each basic emotion was used for training, followed by classification of 15 unseen examples per emotion. The standard SVM classification algorithm was used together with a linear kernel. The results are shown in Table 2.2. It can be seen from these results that each emotion, expressed in terms of feature motion, varies widely across subjects. Kernel choice is among the most important customizations that can be made when adjusting an SVM classifier to a particular application domain. By experimenting with a range of polynomial, gaussian radial basis function (RBF) and sigmoid kernels and found RBF kernels to significantly outperform the others, boosting overall recognition accuracy on the still image data to 87.9%. The human 'ceiling' in correctly classifying facial expressions into the three emotions has been established at 91.7% by Ekman Friesen (1976).

Table 2.3. Percentage of correctly classified examples per basic emotion on Inexperienced users

Emotion	%Correct
Joy	91.5
Sad	67.0
Surprise	90.5

The proposed system is able to customize the tracker to a particular person by calibrating the face template used to initially locate facial features. This further increases recognition performance slightly and allows a trade off between generality and precision to be made.Then, this approach was evaluated for the most challenging but ultimately desirable scenario of "ad-hoc" interaction, whereby wholly inexperienced users are asked to express emotions naturally in an unconstrained setup in terms of lighting conditions, distance from the camera, pose and so forth. Six individuals were asked to provide one training example per basic emotion and subsequently supply a number of unseen examples for classification. The resulting confusion matrix is shown in Table 2.3.

The significantly lower accuracy achieved in these trials can mainly be attributed to the often significant amount of head motion by the subjects during feature extraction, resulting in inaccurate displacement measurements. In addition, since subjects were not given any instructions on how to express each basic emotion, cross-subject agreement on what constituted, for instance, an expression of surprise was considerably lower, resulting in much more variable and difficult to separate data. Finally, it was founded that it is crucial that training and classification to be performed under similar conditions, particularly with regards to the distance from the camera.

2.11 Face Emotion Recognition System through Machine Learning Approach

2.11.1 Introduction

[20]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.Example for expressions for the six basic emotions is shown in the Fig 2.6.

Figure 2.6. Example for expression for the six basic emotion

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, 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.

2.11.2 Database

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 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.

2.11.3 Proposed System

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 as shown in the Fig 2.7. 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.

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 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

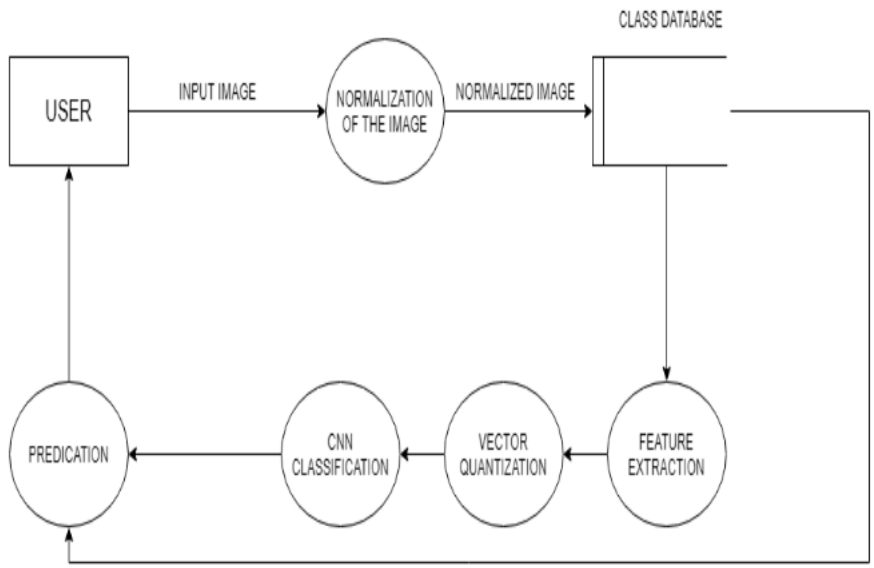

Figure 2.7. System Architecture

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.

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

Table 2.4. Emotion and their impact on Facial feature

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.
Surprise	eyebrow up, open eyes, jaw dropped.
Anger	eyebrow pulled down, open eyes, lip tightened
Fear	outer eyebrow down, inner eyebrow up, mouth open.
Disgust	lip corner depressor, lower lip depressor, eyebrows down, nose wrinkled

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. Emotion and their impact on Facial features are shown in the Table 2.4.

Chapter 3

Scope of the Work

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.[1] 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.The proposed system hopes to be very promising and developed for individuals going through stress during their working hours giving them music therapy.

Robots that communicate with human have attracted much attention in the research field of robotics. In communication between human, almost all human recognize the subtleties of emotion in each other's facial expressions, voices, and motions. Robots can communicate more smoothly with human as they detect human emotions and respond with appropriate behaviors. Usually, almost all human express their own emotions with their facial expressions.The system propose an emotion detection system with facial features using a Bayesian network. In actual communication, it is possible that some parts of the face will be occluded by adornments such as glasses or a hat. In previous studies on facial recognition, these studies have been had the process to fill in the gaps of occluded features after capturing facial features from each image. However, not all occluded features can always be filled in the gaps accurately. Therefore, it is difficult for robots to detect emotions accurately in real-time communication. For this reason, an emotion detection system taking into consideration partial occlusion of the face using causal relations between facial features.

Video games belong to the wide area of entertainment applications. Thus, assuming the existence of human emotions and in fact basing on them, they attempt to make the player to become emotionally attached with them. As the primary goal of a video game is to entertain the player, each video game try to allow the player to fulfill his or her dream. Standard video games try to do it in different ways depending on their genre and involving such elements as good gameplay, immersing storytelling, novelty, graphics and so on. Although video games belong to applications in which emotions naturally play an important role, only few of them try to incorporate their players affective state into the gameplay. Such games can be referred as affective or more properly affect-aware games. The importance of affect in delivering engaging experiences in entertainment and educational games is well recognized. Potential profits for affect-aware video games are not to be underestimated. Unfortunately, this affect-awareness is usually statically built-in the game at its development stage basing on the assumed model of so called representative player. There are two problems with such attitude. Firstly, each player differs in some way from that averaged model. Secondly, and more important, player's affect state can change even radically from session to session making almost impossible to predict the current user emotions at the development stage.

Eye Detection is an essential component in many image processing applications face recognition algorithms or human computer interfaces rely on the accurate determination of the position of the eyes. For example, a computer security system will need to identify faces and this can be done by comparing them to references from a database. For a proper comparison, the faces must be aligned. As the position of the eyes and the interocular distance only slightly vary from one person to another, it means that the position of the eyes can be used to normalize and align a set of faces. There are other possible applications in the field of human computer interaction the eyes are the key elements for the recognition and the classification of human emotions. If we can make a computer understand the users emotions, then a software program can adapt the communication to match the users state of mind. A potential application would be a teaching environment which knows when to ask easier questions or when to provide the user with some form of gratification. Alternatively, it can warn the user when an answer was given under a strong emotional state. Such systems are also useful to deal with medical conditions, such as autism in children

Psychological studies identified six types of facial expressions which are generally recognized. These are: fear, disgust, anger, happiness, sadness and surprise. When a person enters into one of these states, the face will change appearance significantly. In some cases, the eyes may become partially or fully closed, making the iris less visible. In other cases, such as when the person is surprised, the eyes might become much wider, producing a larger shining glint. All these changes of the eye appearance and of the other facial features (lowering eyebrows for example) will make precise eye localization more difficult, compared to the case of neutral state of the face.

Chapter 4

Conclusion

Face recognition which is implemented in real-time helps to recognize the human faces can be used for person identification and authentication purposes.Various Methods for implementing the same is studied.Most reported facial emotion recognition systems, however, are not fully considered subject independent dynamic features, so they are not robust enough for real life recognition tasks with subject (human face) variation, head movement and illumination change.The accuracy of both face recognition and emotion detection can be increased by increasing the number of images during training.

From this survey it has been understood that extracting the feature of the training images is the most challenging task.So Proposed system should have a effective mechanism for feature extraction.By creating a model using conventional neural network it would be much more easier to implement the project.

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