INTERNATIONAL RESEARCH JOURNAL OF ENGINEERING AND TECHNOLOGY (IRJET) E-ISSN: 2395-0056
VOLUME: 06 ISSUE: 07 | JULY 2019 WWW.IRJET.NET P-ISSN: 2395-0072

Real Time Facial Expression Detection using SVD and Eigen Vector

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Abstract — Humans can use vision to identify objects quickly and accurately. Computer Vision seeks to emulate human vision by analyzing digital image inputs. For humans to detect an emotion will not be a difficult job to perform as humans are linked with emotions themselves but for a computer detecting an emotion will be difficult job to perform. Detecting emotion through voice, for example: detecting 'stress' in a voice by setting parameters in areas like tone, pitch, pace, volume etc can be achieved but in case of digital images detecting emotion just by analyzing images is a novel way.

The algorithm we proposed first detects facial regions in the image using a skin color model using RGB and HSV color space. Then lip region is extracted from the face region using the lip color model YCrCb color space. All the above color space uses a definite threshold value to differentiate between the regions of interest. Finally after the extraction of lip region from the image, it is compared with the series of templates and on the basis of best correlated template emotion is recognized. The proposed method is simple and fast compared to neural analysis of facial region as a whole. A simple pre defined database will be needed to help detecting various emotions that can be recognized using lip region. Size of database will affect the effectiveness of the proposed algorithm

Keywords *- Facial Expression Recognition, SVD, Eigen Vector, Emotion*

I Introduction

THIS Human vision can experience emotion as associated with mood, temperament, personality and disposition. Computer Vision seeks to emulate the human vision by analyzing digital image as input. The fact that world is three- dimensional while computer vision is two-dimensional is basically one of the main problems that complicate Computer Vision. Trying to interpret a person's emotional state in a nonverbal form, usually requires decoding his/hers facial expression. Many times, body languages and especially facial expressions, tell us more than words about one's state of mind.

1. Finding out, once and for all, who "reads" facial expressions better- Men or Women, and if so, suggesting an answer for the question- why do those differences exist?
2. Revealing special features for recognizing classically defined facial expressions and answering the question- which facial cues help us the most decipher facial expressions?

Moreover, I will try to justify those features from an evolutionary point of view.

1.1 Overview

The image will be systematically broken down and analyzed by the series of algorithms to determine the pixels that represent facial region. After this a second algorithm is applied to first crop the facial region and then next algorithm will detect lips from facial region. The automatic algorithm must correctly identify all pixels correctly included in lips while not incorrectly classifying the other regions as lips or lip colored coat. Use of emotion recognition from digital images has a large opportunity and upcoming market. This is the primary reason to adopt a general and easy to apply approach towards the entire process. The approach is based on the assumption that there are not multiple faces in the image.

II Emotions used in this project

In this project we are considering five major emotions which are mainly centering toward lips in facial region. These emotions are: A common assumption is that facial expressions initially served a functional role and not a communicative one. I will try to justify each one of the seven classical expressions with its functional initially role:

1. **Anger:** involves three main features- teeth revealing, eyebrows down and inner side

tightening, squinting eyes. The function is clear- preparing for attack.

1. **Disgust:** involves wrinkled nose and mouth. Sometimes even involves tongue coming out. This expression mimics a person that tasted bad food and wants to spit it out.

2. **Fear:** involves widened eyes and sometimes open mouth.

The function- opening the eyes so wide is suppose to help increasing the visual field and the fast eye movement, which can assist finding threats. Opening the mouth enables to breath quietly and by that not being revealed by the enemy.

3. **Surprise:** very similar to the expression of fear. Maybe because a surprising situation can frighten for a brief moment, and then it depends whether the surprise is a good or a bad one. Therefore the function is similar.

4. **Sadness:** involves a slight pulling down of lip corners, inner side of eyebrows is rising. Darwin explained this expression by suppressing the will to cry. The control over the upper lip is greater than the control over the lower lip, and so the lower lip drops. When a person screams during a cry, the eyes are closed in order to protect them from blood pressure that accumulates in the face. So, when we have the urge to cry and we want to stop it, the eyebrows are rising to prevent the eyes from closing.

5. **Contempt:** involves lip corner to rise only on one side of the face. Sometimes only one eyebrow rises.

6. This expression might look like half surprise, half happiness. This can imply the person who receives this look that we are surprised by what he said or did (not in a good way) and that we are amused by it. This is obviously an offensive expression that leaves the impression that a person is superior to another person.

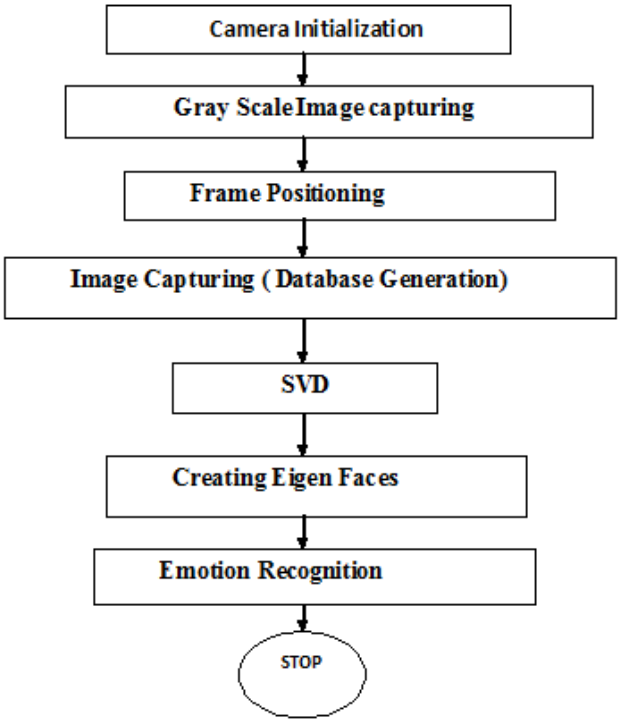
7. **Happiness:** usually involves a smile- both corner of the mouth rising, the eyes are squinting and wrinkles appear at eyes corners. The initial functional role of the smile, which represents happiness, remains a mystery. Some biologists believe that smile was initially a sign of fear. Monkeys and apes clenched teeth in order to show predators that they are harmless. A smile encourages the brain to release endorphins that assist lessening pain and resemble a feeling of well being.

Those good feeling that one smile can produce can help dealing with the fear. A smile can also produce positive feelings for someone who is witness to the smile, and might even get him to smile too.

Newborn babies have been observed to smile involuntarily, or without any external stimuli while they are sleeping. A baby's smile helps his parents to connect with him and get attached to him. It makes sense that for evolutionary reasons, an involuntary smile of a baby helps creating positive feelings for the parents, so they wouldn't abandon their offspring.

Figure 2: List of emotions used in this project

III Methodology



Steps for Face Detection-

- Camera Initialization
- Gray Scale Image capturing
- Frame Positioning
- Image Capturing (Database Generation)
- SVD
- Creating Eigen Faces
- Emotion Recognition

Camera Initialization

Color image Recording

A general description of an automated face detection machine is as follows: getting some fixed or moving images from a given landscape (three-dimensional image regardless of location, direction and light status) as input, then categorizing input images into two distinct sets: images that have face in them and images without face. And finally, facial area detection among first set of categorized images [1]. Because of less amount of computation among first category, system performance will be higher. Progress in the field of hardware and software, computing power enhancement and hardware prices decreasing are some of major reasons for more attentions to the image processing systems (such as face detection and recognition). By analyzing of face processing system, we can find out that first steps in such systems are determining facial area position, face direction(right, upward - rotary) and face mode (frontal - profile). Some of biometric systems' applications are: commercial and legal usages (especially in identifying criminals and guiltier), to improve safe driving, security systems, visual phones, face recognition, signature detection and also medical applications such as MRI and CT-SCAN. Face detection, usually is one of the first stages of these applications. It is important to note that different light conditions, face direction against the camera, occultation (such as covering face by scarf) and quality of camera can make face detection process more complicated. Also, some algorithms, that are using face images, imagine face detection phase as a default and solved phase [2, 3]. During past years, most researches have been conducting on gray images. But recently, thanks to high quality digital cameras, researchers can take precise color images and do study on them by fewer amounts of costs. Early color images had low quality, and that is why work on them was started later than work on gray images.

RGB-

The RGB color model is the most widely recognized color model. It comprises of three components namely the red, green and blue color channels. The RGB model is used to a great extent in solving computer vision problems, but is better known for color representation in the displays of television sets and monitors. The value of a color by this model is best described as being a vector in three-space where red, green and blue represent the axis as shown in figure 3. Color is thus a result of the combination of the red, green and blue components. The origin of the cube (0, 0 and 0) represents pure black while its polar opposite (255, 255 and 255) represents pure white.

From studying and experimenting with various thresholds in RGB space, we found that the following rule worked well in removing some unnecessary pixels:

0.836G – 14 < B < 0.836G + 44 => Skin [1]

0.79G -67 < B < 0.78G + 42 => Skin [2]

Fig- Colour Image Recording

Gray Scale Image

The cascade structure of the FD classifier allows achieving high image processing speed due to the fast background rejection and paying more attention to the face-like regions. But in comparison with the monolithic classifiers the cascade classifier (for example, Haar -like features' cascade of weak classifiers [10]) increases the detection error and FP rate. The extension of Haar-like features' set [12] as well as improvement of the training algorithm [11] for the cascade of weak classifiers allows increasing the detection rate only by 7-8% for the low FP rate. Therefore, to achieve higher detection and lower FP rates it is necessary to join the quick cascade classifier and accurate monolithic one within the two-level combined cascade of classifiers instead of using them independently. The two-level cascade of classifiers is called "combined" because it combines the different-nature classifiers, which are chosen and justified by authors: the first level is represented by the Haar-like features' cascade of weak classifiers, which is responsible for the face candidates' detection, and the second level is a convolutional neural network for the candidates' verification (Fig.

1). We should also mention that there is no input image preprocessing stage as well as in [5].

Fig- Gray Scale Image

Frame Positioning-

Red colour square window it automatically find out the position of person face on the screen.

Face detection can consider a substantial part of face recognition operations. According to its strength to focus computational resources on the section of an image holding a face. The method of face detection in pictures is complicated because of variability present across human faces such as pose, expression, position and orientation, skin colour, the presence of glasses or facial hair, differences in camera gain, lighting conditions, and image resolution.

Object detection is one of the computer technologies, which connected to the image processing and computer vision and it interacts with detecting instances of an object such as human faces, building, tree, car, etc. The primary aim of face detection algorithms is to determine whether there is any face in an image or not.

In recent times, a lot of study work proposed in the field of Face Recognition and Face Detection to make it more advanced and accurate, but it makes a revolution in this field when Viola-Jones comes with its Real-Time Face Detector, which is capable of detecting the faces in real-time with high accuracy.

Face Detection is the first and essential step for face recognition, and it is used to detect faces in the images. It is a part of object detection and can use in many areas such as security, bio-metrics, law enforcement, entertainment, personal safety, etc.

It is used to detect faces in real time for surveillance and tracking of person or objects. It is widely used in cameras to identify multiple appearances in the frame Ex- Mobile cameras and DSLR's. Facebook is also using face detection algorithm to detect faces in the images and recognise them.

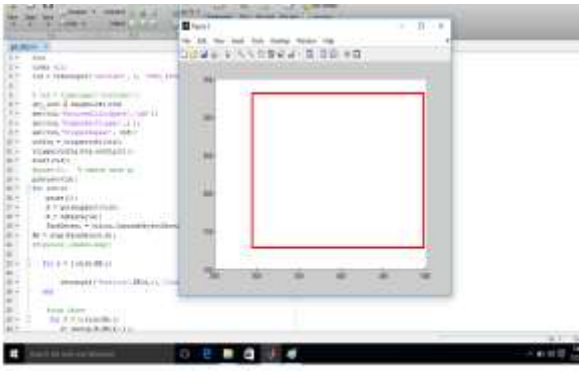


Fig- Frame Positioning

Database Generation

Once the process of frame positioning completed image capturing process start automatically

Database Sample-Because of its non rigidity and complex three-dimensional (3D) structure, the appearance of a face is affected by a large number of factors including identity, face pose, illumination, facial expression, age, occlusion, and facial hair. The development of algorithms robust to these variations requires databases of sufficient size that include carefully controlled variations of these factors. Furthermore, common databases are necessary to comparatively evaluate algorithms. Collecting a high quality database is a resource-intensive task: but the availability of public face databases is important for the advancement of the field. In this chapter we review 27 publicly available databases for face recognition, face detection, and facial expression analysis.

When benchmarking an algorithm it is recommendable to use a standard test data set for researchers to be able to directly compare the results. While there are many databases in use currently, the choice of an appropriate database to be used should be made based on the task given (aging, expressions, lighting etc). Another way is to choose the data set specific to the property to be tested (e.g. how algorithm behaves when given images with lighting changes or images with different facial expressions). If, on the other hand, an algorithm needs to be trained with more images per class (like LDA), Yale face database is probably more appropriate than FERET.

Fig- Database Sample

SVD (Singular Value Decomposition)

The purpose of this project to demonstrate the usage of Singular Value Decomposition (SVD) in Image Compression applications. This report consists of several sections that discuss different aspects of the SVD-based image compression scheme. First, a straight-forward compression and decompression scheme will be used to show the basic idea of reducing storage requirement with SVD. Second, various block-size will be tested on the same image to compare their effects on the quality of the compression. Third, a rank selection scheme that is adaptive to the complexity of the image is introduced and discussed. Possible enhancements and drawbacks of SVD-based image compression scheme are presented in the conclusion.

Instead of compressing the whole image at once, all popular image compression techniques work on the sub-block of original image. The purpose of this practice is to exploit the uneven complexity of the original image. If a portion of the image is simple, then only a smaller of singular values needs to be used to achieve satisfactory approximation. On the other hand, if the image is complex, then more singular values would have to be used in order to maintain the image quality. A simple way to adaptively select the appropriate ranks to be used in each sub-block is to specify the percentage of the sum of the singular values instead of a fixed number.

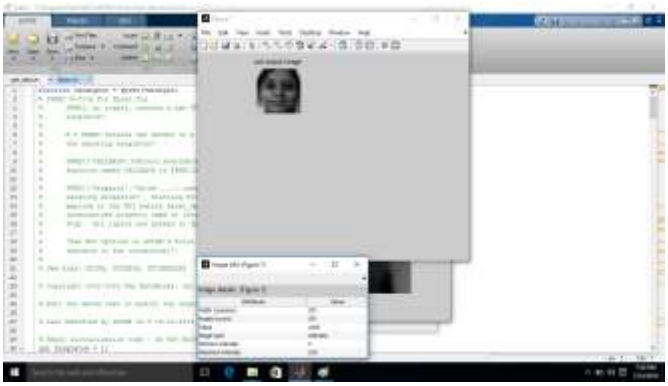


Fig- SVD Output Image

Create Eigen faces

Eigen values are a special set of scalars associated with a linear system of equations (i.e., a matrix equation) that are sometimes also known as characteristic roots, characteristic values (Hoffman and Kunze 1971), proper values, or latent roots (Marcus and Minc 1988, p. 144).

The determination of the eigen values and eigenvectors of a system is extremely important in physics and engineering, where it is equivalent to matrix diagonalization and arises in such common applications as stability analysis, the physics of rotating bodies, and small oscillations of vibrating systems, to name only a few. Each eigen value is paired with a corresponding so-called eigenvector (or, in general, a corresponding right eigenvector and a corresponding left eigenvector; there is no analogous distinction between left and right for eigen values).

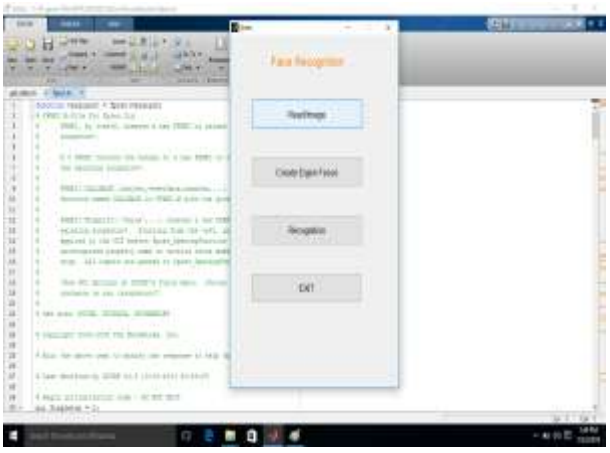


Fig- Face Recognition

The decomposition of a square matrix into eigen values and eigenvectors is known in this work as eigen decomposition, and the fact that thisdecomposition is always possible as long as the matrix consisting of the eigenvectors of is square is known as the eigen decomposition theorem.

The Lanczos algorithm is an algorithm for computing the eigen values and eigenvectors for large symmetric sparse matrices. Let be a linear transformation represented by a matrix. If there is a vector such that for some scalar, then is called the eigen value of with corresponding (right) eigenvector. Letting be a square matrix with eigen value, then the corresponding eigenvectors satisfy

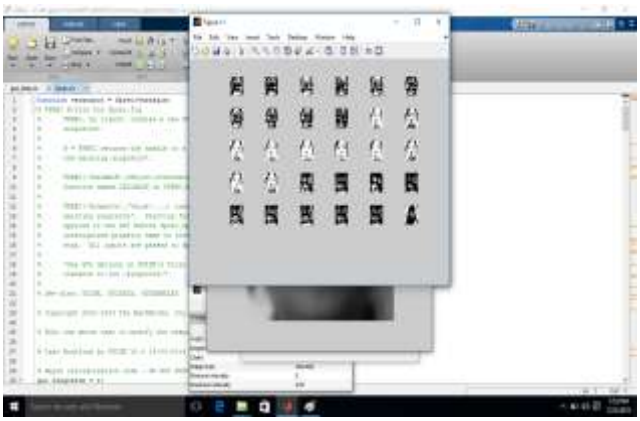


Fig- Eigen Faces Image

Expression Recognition

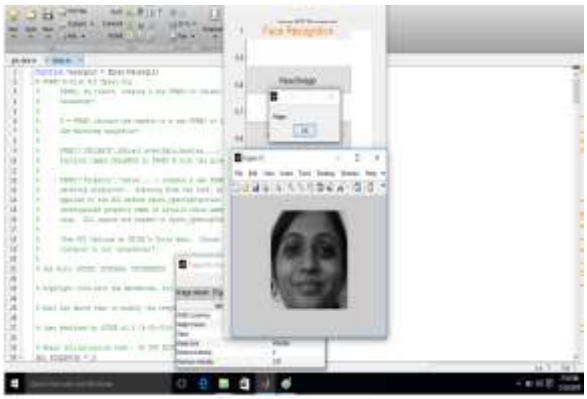


Fig- A) Output For Happy

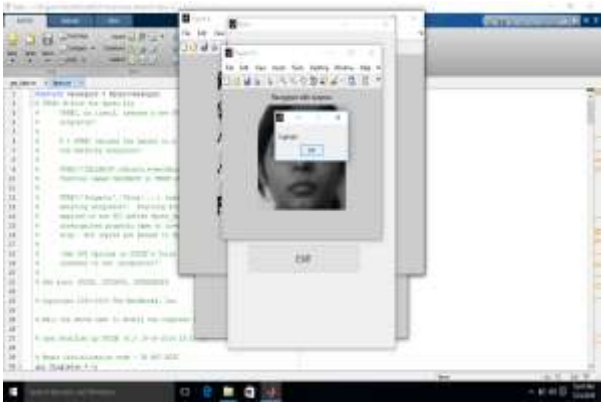


Fig B) Output For Surprised

IV Results

The three emotions that we have been working on i.e. happiness, anger, surprise and neutral were successfully identified on the majority of images used. The degree to how well facial region as well as lips detected varied from

picture to picture depending on multiple factors. Generally no false emotion were found or wrongly interpreted. The only problem was that database generation was done only on limited faces. Most of the artifacts that were present in the image were rectified separately before applying algorithm.

V Future Work

There are several aspects of this project that have high market potential, so, the concept needs to upgraded for better results. Firstly, this concept needs to be extended from a single face to multiple faces and this concept should be able to adapt itself to non-uniform backgrounds. Secondly, different poses, structural components as well as different imaging conditions should be no hurdle in the process. There should be option of automatic generations of similar dimension templates. More sensitive and adaptive thresholds can be developed for facial and lip detection. Inclusion of more templates in the database so as to make emotion recognition more precise and accurate. Many more emotions can also be introduced. Overall, the aim should be to make this algorithm more flexible and adaptive in real time applications.

Conclusion:

The system correctly identified the correct facial expression in 640 of the 480, from 12 subjects not used in training or in initial testing. The three emotions that we have been working on i.e. happiness, anger, surprise and neutral were successfully identified on the majority of images used.

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