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Facial Expression Emotion Recognition Model Integrating Philosophy and Machine Learning

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Abstract:

The human face has peculiar and specific characteristics, therefore it becomes difficult in understanding and identifying the facial expressions. It is easy to identify the facial expression of particular person in any image sequence. If we look to automated recognition system, however, the systems available are quite inadequate and incapable of accurately identify emotions. The area of facial expression identification has many important applications. It is an interactive tool between humans and computers. The user, without using the hand can go-ahead with the facial expressions. Presently, the research on facial expression are on the factors i.e. sad, happy, disgust, surprise, fear and angry. This paper aims to detect faces from any given image, extract facial features (eyes and lips) and classify them into 6 emotions (happy, fear, anger, disgust, neutral, sadness). The trainingdata is passed through a series of filters and processes and is eventually characterized through a Support Vector Machine (SVM), refined using Grid Search. The testing data then tests the data and their labels and gives the accuracy of classification of the testing data in a classification report. Various approaches, including passing the training images through Gabor filter, or transforming images using Histogram of Oriented Gradients (HOG) and Discrete Wavelet Transform (DWT) for better classification of data are implemented. The best result achieved so far is by passing the training images through Histogram of Oriented Gradients (HOG), followed by characterization by SVM, which gives an average precision of 88%.

Keywords*: *Characterization, Facial Expression, Emotions, Cascade, Classification, SVM, Kernel, Grid Search, Wavelet, HOG, Precision

INTRODUCTION:

The key is to understand the human behavior and how it reacts or interact with the environment. Computer interface provides

Technology which analyses human and computer interaction. Facial emotions convey the intention of a person. The emotion communicates the state of the person such as joy, sadness, anger. The human communication has one-third part of verbal communication and two third part of nonverbalcommunication [1]. Moreover, the facial expressions are an important means of interpersonal communication. Therefore,the facial expression is a key means for the detection of emotions. The non-verbal interaction among humans is through facial expression. The reason behind this interactionis that humans can identify the emotion in an efficient and prompt manner. Thus, there exists a demand to develop a machine, which can recognize the human emotion. The objective of the work is to evaluate the performance using different models and their combinations. The models include Support Vector Machine, Linear Discriminant Analysis, Principal Component Analysis, Fisher face classifier, Gabor filters, Discrete Wavelet Transform, Histogram of Gradients. The methodologies were defined for the respective models and the Cohn-Kanade dataset is used as a stimulus for evaluation of the models [2]. This is followed by a comparative study of the said models and results. The usual way for doing the evaluation is for complete facial expression but the main focus was to reduce the features to eyes and lips only.

FACE DETECTION, EXTRACTION AND CLASSIFICATION

In this section, a step-by-step approach towards the various processes taking place for fulfilling this work has been described. The final prediction of emotion is preceded by multiple processes.

The first step will be to determine the face of the person in the given input image, which is then succeeded byidentifying the features (eyes and mouth). These features are then passed through their respective filters and transformation, if that is a part of the decided method. The outputs are then sent to the classifiers to get classified according to the trained data. This gives us the output emotion predicted by the system. These

processes will be explained in much more detail in the next sub-sections and will give a holistic view of how the system as a whole works with various comparative methods.

A. Face Detection and Feature Extraction:

Face detection is regarded as one of the most complex problems in computer vision, due to the large variations caused due to changes in lighting, facial appearance and expressions. Let's solve all the stages step by step. For face detection Viola Jones Algorithm is used. Though it was proposed in 2001 it is one of the simple and easiest method for face detection giving high accuracy[3]. This algorithm uses Haar based feature filters. The objective of this filter is to find the face in an image given asinput. In each sub window Haar features are calculated and this difference is compared with the learned threshold that separates objects and non-objects.Haar features are weak classifiers so a large number of Haar classifiers are organizedin such a way that they form a strong classifier which is called as "Classifier Cascade". Each classifier looks at the sub window and determines ifthe sub window looks like a face and if it does then the next

classifier is applied. If all the classifiers give a positiveanswer then face is there in the sub window otherwise size ofsub window is changed and whole process is repeated till theface is detect [4].

Feature Classification: Different Approaches Towards Classification of Data:

Once faces have been detected and the required featureshave been extracted, it is now time to put them through various methods designed to simplify and classify them into 6 emotions (happy, sadness, fear, neutral, anger, disgust).

It is important to note that each and every methoddescribed below is independent of each other in terms of application. The section heading defines the combination of filter(s)/transform(s)/classifier(s) used in the respective method. This section gives a brief account of all the methodsused, along with description and methodology. Methodology highlights the application of that method in the dataset being used in this work.

Fisher face Classifier:

Linear Discriminant Analysis is a supervised algorithmthat aims for classification of the input dataset. They analyze the sub space that matches the given vectors of the same class in a single blot of the feature presentation and thedifferent classes. Thus it improves the ratio between theclass scatter to the within class scatter. The sub space presentation of a group of face images, the outcome of the basis vector resulting that spaces are defined as Fisherfaces. They are helpful when facial images have wide differences in facial expressions and illumination. Principal component Analysis is predominantly used for dimensionality reductionin facial classification, image compression, etc.

Initially, the training data is to be reduced to at least N-c dimension using Principal Component Analysis where N represents the number of images in the images in the training set and c represent the number of classes. Thereafter Linear Discriminant Analysis is applied to further reduce the projected data. The equation for finding optimum weight is as follows:

$$(W_{OPT})^T = (W_{LDA})(W_{PCA})^T$$

Where,

$(W_{LDA})^T$= Projection representing the reduction in PCA-Space

$(W_{PCA})^T$

Both of the given projection, (W_{OPT}) has combination of PCA and LDA. The precision of classification for Fisher face classifier turns out to be 0.74.

- ***Support Vector Machine:***

A Support Vector Machine (SVM) is a machine-learning algorithm, utilizing supervised mechanism of classification. It classifies by utilizing a separating hyperplane discriminatively. The algorithm creates an optimal hyperplane which categorizes the testing data. The classifier in two-dimensional form represents a line which consists of classes on either side. This classifier utilizes the "kernel trick". This trick uses specific mathematical formulae to project the data into feature space of higher dimensions, where a hyperplane creates the possible boundaries among possible outputs. SVM is usually used to solve classificationor regression problems. A kernel takes data as input and transforms it to the required form. The product between two points is returned by kernels. Thus, high dimensional projection becomes possible with very low computational cost. The kernels used in SVM are as follows:

Linear kernel : $k(x, x') = x \cdot x'$ (2)

Polynomial kernel : $k(x, x') = (\gamma(x \cdot x') + r)^d$ (3)

Radial biased function kernel: $k(x, x') = exp(-\gamma\|x - x'\|^2)$(4)

Sigmoid kernel : $k(x, x') = tanh(\gamma(x \cdot x') + r)$ (5)

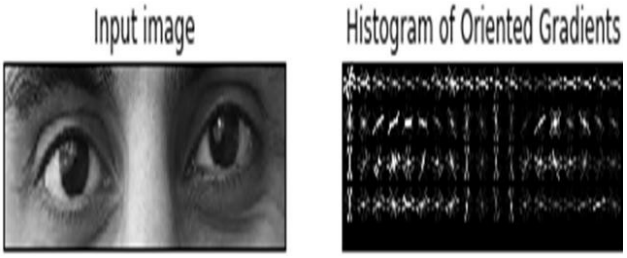
where,

x, x' = two samples shown as feature vectors in input space

$\gamma = \frac{1}{2\sigma^2}$, where σ is free parameter

recognition and object detection algorithms get an efficient boost using this filter. It is not very useful for viewing the image, though. The feature vector produced by these algorithms produce good results, when fed into an image classification algorithm like Support Vector Machine (SVM).

The images are processed through the HOG filter to create output feature vectors of every image according to its magnitude and gradient (See Fig. 3 and Fig. 4) and are then compiled into a single dataset. This dataset describes the magnitude and vector of every pixel and is passed through SVM for classification.



DWT + HOG + SVM:

The images saved after going through the Discreet WaveletTrans formation (DWT) are processed through the HOG filterto create output feature vectors of every image (See Fig. 5 and Fig. 6) and are then compiled into a single dataset. This dataset describes the magnitude and vector of every pixel andis passed through SVM for classification.

DATASET:

The Extended Cohn Kanade Dataset (CK+) has 593numbers of image sequences (327 image sequence contains the emotion labels) from 8 facial expressions namely neutral, sadness, fear, happiness, surprise, anger, disgust, contempt. The emotions considered in this dataset are 6 out of the 8, namely neutral, sadness, fear, happiness, anger and disgust. The image sequences begin with a neutral expression and end towards a peak face expression. Each frame size has a resolution of 640 x 490 and are usually grey. To begin with, data is classified into two folders, one has collection of images and the other containing the text file [7].

EXPERIMENTAL SETUP:

The experiment utilizes the Cohn-Kanade dataset by extracting the extreme image showing the required expression, amongst a series of images of any individualfrom neutral to the labelled expression. These images are then fed to their respective filters, which finally convert the image to a CSV file consisting of data representing that image, which is fed to the classifier to predict results. Real time images are taken on mobile phones, and then processedthrough the system accordingly.

I. RESULTS AND COMPARATIVE STUDY

The classification of emotions carried out in previous sections involves multiple approaches towards characterizing the given dataset, that too with a combination of multiple methods (See Table 1). The Fischer face classifier uses Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA), both of which contribute to its accuracy. PCA aims to reducedimensionality, such that variables in the dataset are reducedto a minimum. The new set of variables, called principal components make the classification much simpler in terms ofspace complexity. It gives a precision output of 0.74, which is fairly good, but still not enough.

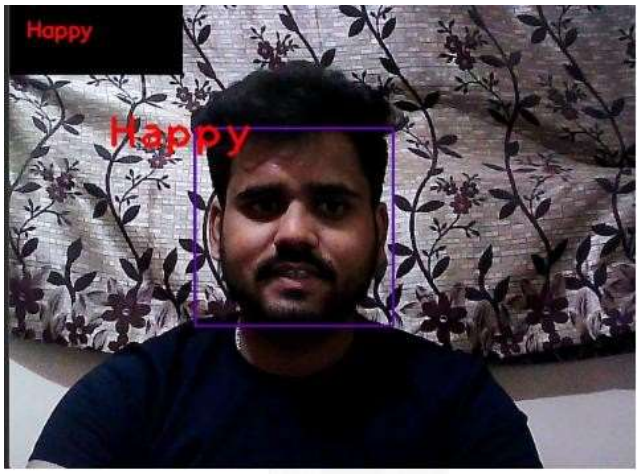
Gabor filter recognizes texture in any given image and creates frequency and orientation components. This gives Gabor filter an edge over other filters, as difference in texture could be a very efficient way to differentiate mouth and eyes from the rest of the skin. These filters also decompose in multiple dimensions in space. This might also be the reason why SVM works best with this filter, as projecting in higher spatial dimensions is a property common to both the filter and the classifier in this case, thus giving a precision of 85%.

The most precise classification of 85% occurs by using a combination of Histogram of Gradients (HOG) filter followed by classification by SVM. This combination has been used frequently in the past due to its high precision rate,and due to valid reason. The method by which HOG partitions the image into boxes, so as to provide features of every box available, makes the data much more precise, and reduces noise from the image. The classifier thus gets an image which not only has less noise, but also has a strong sense of direction. Gabor filters are not as powerful in cases where the texture is more complex, such as in the face of disgust, but in such cases, HOG filters have the upper hand, due to simplicity of data. Simply applying SVM also gives a

Precision of 85%, which is due to the ability of a simple SVM algorithm to project the pixel densities of trained Image in to higher dimension.

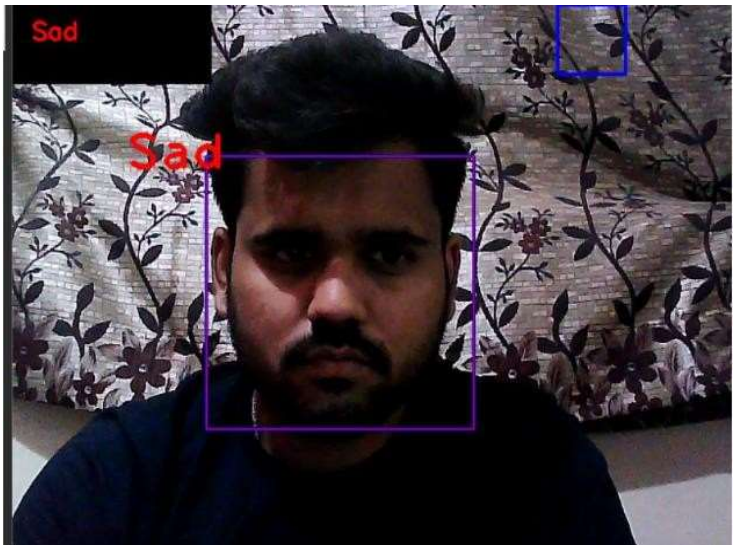
A gradient proportional to the magnitude and direction at that given pixel is decided by the cell. Image recognitionand object detection algorithms get an efficient boost using this filter. It is not very useful for viewing the image, though. The feature vector produced by these algorithms produce good results, when fed into an image classification algorithm like Support Vector Machine (SVM).

The images are processed through the HOG filter to create output feature vectors of every image according to its compiled into a single dataset. This dataset describes the magnitude and vector of every pixel and is passed through SVM for classification.



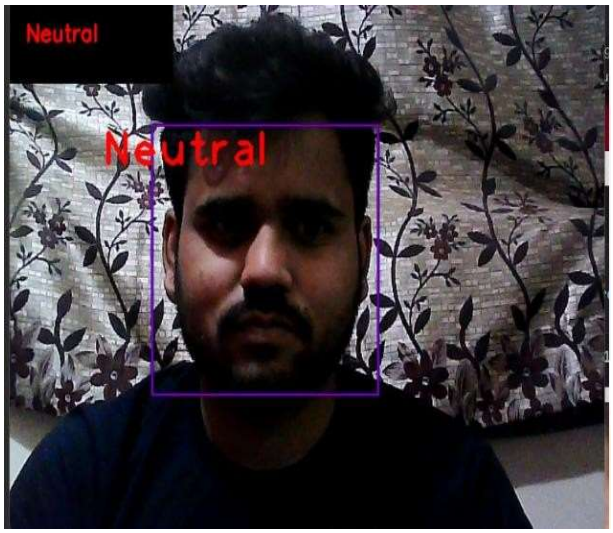
Input face image and predicted result "happy"

(Classification method = HOG + SVM) [9]



Input real time photo and predicted result "sadness"(Classification method = HOG + SVM)

Input real time photo and predicted result "angry"(Classification method = HOG + SVM)



Input face image and predicted result "neutral" (Classification method = HOG + SVM) [8]

Discrete Wavelet Transform (DWT) creates sub-signals in the horizontal, vertical and diagonal direction, which are then analyzed to gain a general form of the image taken. This transformation is very useful in detecting patterns, or abnormalities among regular trends. In face detection however, DWT falls back as compared to Gabor filter and HOG. This happens due to the variation in every image that has to be trained. Change of skin tone, differing features in the greyscale image of a face can tend to confuse the Wavelet specifications, thus giving a precision of 88%

Finally, passing the images through a DWT filter followed by an HOG filter and then classifying by SVM gives us a precision of 85%. This is bound to occur, as transforming the image to DWT form, as seen before, has reduced the precision to 85%. The Wavelet features obtainedby the output of DWT do not provide any sense of direction or magnitude, which is exactly what the HOG filter is supposed to receive and analyze. This leads to unnecessary information being passed to the HOG filter, which the classifier classifies with a precision of 85%. Also, horizontaldetails of mouth might appear very similar, thus resulting in decrease of precision.

When we overview all the used filters above, it is eminent that the main contributors of classification are the directionality and magnitude of a facial image, followed by the texture differences in that particular image. Wavelet transformation seems to provide satisfactory results, whereasthe combination of HOG followed by SVM classifier does not disappoint.

CONCLUSION:

Emotions are an integral method of expressing our judgement and decisions in daily life, and this work aims to recognize and detect exactly these emotions. This work is capable of recognizing 6 integral emotions – Happy, Sad, Anger, Fear, Neutral and Disgust; with the help of the Support Vector Machine algorithm. This image primarily uses only 2 crucial features of the face, namely eyes and mouth, to detect an emotion within a face. The Viola Jones algorithm is utilized in order to detect face and features of the individual in the input photo. These features include eyes and mouth.

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