Smile Detection from Still Images Using KNN Algorithm

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Abstract- **Reliable detection and recognition of facial expression from still images in the unconstrained real world situations has many potential applications. Smile detection can be used in many applications include modeling systems for psychological studies on human emotional responses, expression recognition technologies, extending image search capabilities etc. This paper proposes an experimental study of smile detection in embedded environment using Raspberry Pi board, by extracting mouth and eye pair from images using Haar-cascade classifier and train these images using KNN matching algorithm. The relatively simple K- Nearest Neighbor is used because of its lazy learning efficiency. OpenCV- 2.3.1(Open Source Computer Vision) library is used as the imaging library. The experiments explored that the proposed approach has an accuracy of 66.6%**

Keywords: KNN matching, smile detection, Haar Classifier, Machine Learning

I. INTRODUCTION

The visual information plays a very important role in our daily life, specifically in regard to communication between human beings, we can come to understand deeply and smoothly each other to pay attention to behaviors and facial expressions as well as languages. During the past several decades, Facial image analysis is an important and popular research topic in the image processing area which includes face recognition, facial expression analysis and several other applications. This is due to the interests of cognitive and psychological scientists, applications in biometric identification, surveillance and image/video retrieval and brain science etc.

The project's aim is to identify smiles in a picture correctly. This information is useful for various studies and researches. The human smile is a distinct facial configuration and it is a significantly useful facial expression. The identity, age, gender as well as the emotional state can be seen from someone's face. The rapidly expanding research in face processing is based on the premise that information about a user's identity, state, and intent can be extracted from images, and systems can then react accordingly, i.e., by observing a person's facial expression. The idea of Facial representation is to derive a set of features from original face images for describing faces. If the features are inadequate, even the best classifier will fail to achieve accurate recognition. Therefore, it is of great importance to extract discriminative facial features for facial representation. Facial expressions are a form of nonverbal communication. The facial expression analysis can be divided into three main Steps: face detection, feature extraction and classification into emotions. The approach mentioned in this paper describes the machine learning methodology to detect smile.

This paper is organized as follows. Section II describes the related work that have done during the project. Section III describes the experiments done followed by conclusion in IV

II. RELATED WORK

This section deals with the survey of the recent work carried out by researchers in the area of Facial Expression Analysis. Survey of papers is carried out to know the existing techniques being used for detecting smile in static as well as in real time images.

Caifeng Shan [1] presents an efficient approach to smile detection. In this, he used the intensity differences between pixels in the grayscale images as features. He adopted Adaboost to choose and combine weak classifiers based on intensity differences to form a strong classifier. In [2] D. Freire, M. Castrill´on makes an extensive experimental study of smile detection, testing the Local Binary Patterns (LBP) as main descriptors of the image, along with the powerful Support Vector Machine classifier. In [3] Naïve Bayes, and Artificial Neural Network Machine Learning Techniques is used in identifying smiles within a picture.

A. Face Feature Extraction Techniques

In [5] Bhumika G. Bhatt and Zankhana H. Shah describes the various feature extraction techniques. They are Geometry based techniques, Color segmentation based techniques, Appearance based techniques and Template based techniques. Geometry based features are extracted by using relative positions and sizes of the components of face. One of the method used is the Gabor wavelets transform feature extraction which are described in [6] and [7]. In color segmentation based technique we use the skin color to isolate

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the face which is described in [8]. In Template based eye and mouth detection first an eye template is used to detect the eye from the image of face and then mouth is detected which is described in [9].

B. Feature Detection Algorithm used

Before detecting eye pair and mouth in an image, we have to detect the face. Face detection is done in real time by using Haar like feature classifiers. Haar like features are rectangular features. They can indicate special features in an image. [4] describes the approach for object detection which minimizes computation time and achieving high accuracy. This approach is used to construct the face detection, eye pair detection and mouth detection They recognize objects or features based on the value of simple features, instead of pixel values directly. The Haar-like features are very fast to compute, because it depends only on the sum of pixels within a rectangle instead of every pixel value. The method of face detection is based on the Viola and John algorithm. They have made an invention in the research of face detection using an Integral image, simple Haar like feature and used Adaboost algorithm for converting week classifier into strong classifier.

1. Integral Image- It is the intermediate representation of the original image and by using this integral image rectangle feature is calculating very fast. The integral image at location p, q contains the sum of the pixels above and to the left of p, q inclusive:

$$ii\;p,q \;=\; _{p' \leq p,\, q' \leq q}\; i\;p',q' \qquad (1)$$

where ii(p, q) is the integral image and i(p, q) is original image. Integral image computed in one pass over the original image is given by (2) and (3) respectively

$$x(p, q) = x(p, q-1) + i(p, q) \qquad (2)$$

$$ii(p, q) = ii(p-1, q) + x(p, q) \qquad (3)$$

x(p, q) = cumulative row sum, x(p, -1)= 0 and ii(-1,q)= 0

Using an integral image for calculating the sum, one rectangle can be computed with only four references, independent of the size of the feature.

2. Haar Like Feature- The most simple Haar like feature is the two- rectangle feature. The value of this feature is calculated as the difference between the sum of the pixels within the two rectangles. This indicates edge features or borders between light and dark regions. The three rectangle feature presents dark line or dark thin area lying between light regions, based on the size of the middle rectangle. Four rectangle feature gives the difference between diagonal pairs of rectangles. Usage of integral image will calculate the sum most efficiently. It allows a two rectangle feature to be calculated with six references to the integral image, a three rectangle feature with eight references, a four rectangle feature with nine references. Figure 1 shows some of the Haar like features used.

3. Adaboost- Adaboost in Haar cascade method is used for training by supervised learning to classifying positive and negative sample. AdaBoost learning algorithm is used to boost the classification performance of a simple learning algorithm. There are over 180,000 rectangle features associated with each image sub-window. This is larger than the number of pixels in image sub window. But computing these features are computationally expensive. Figure 2 shows the schematic of cascade of classifiers used in Viola Jones algorithm.

C. KNN matching algorithm

K Nearest Neighbor algorithms are very simple to understand but works well in practice. Its applications range from vision to proteins to computational geometry to graphs. KNN is one of the top 10 data mining algorithms. This algorithm is a non parametric method used for classification and regression. Both of these cases consist of k closest training examples in the feature space as input. The output is based on whether it is a KNN classification or regression.

In this method, an object is grouped by the majority vote of its neighbors.

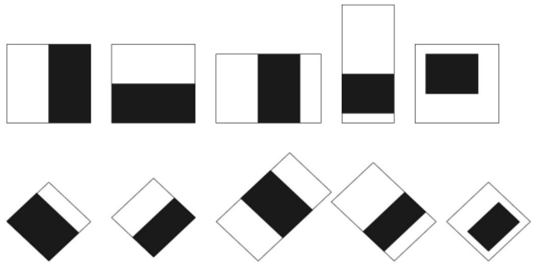

Fig. 1. Examples of Haar like features

- The object is assigned to the class which is most common among its k nearest neighbors.

- In KNN regression, the output is the property value of the object KNN is a non parametric or lazy learning algorithm, which means that it does not make any assumptions on the underlying data distribution. This algorithm does not use the training data points to do any generalizations ie, there is no explicit training phase or it is very minimal.

- In the testing phase, KNN makes decision based on the entire training data set. The training examples are multidimensional vectors or scalars. The training phase of the algorithm consists of only storing the feature vectors and corresponding class labels to it. In the classification phase, we are giving a single number k, which decides how many neighbors influence the classification. If k=1, then the algorithm is called the nearest neighbor algorithm. Larger values of k reduce the effect of noise on classification, but the boundary between them becomes less distinct. The accuracy of KNN algorithm is severely degraded by the presence of noisy or irrelevant features.

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A commonly used distance metric for is the classification is Euclidean distance. Another metric can be used, such as the Hamming distance. The classification accuracy of KNN can be improved significantly if the distance metric is learned with specialized algorithms such as Large Margin Nearest Neighbor or Neighborhood components analysis.

III. EXPERIMENTS

To implement KNN algorithm we need a set of images containing smiling and non-smiling faces. The faces are extracted from the images using haarcascade_ frontalface_alt.xml. The eyes and mouth are extracted from the images by using haarcascade_mcs_eyepair_big.xml and haarcascade_mcs_mouth.xml respectively. The smiling and non-smiling faces are stored in file.

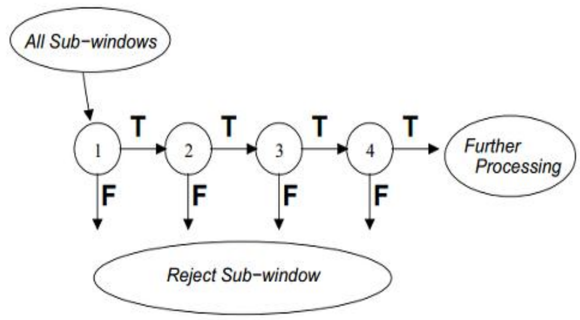

Fig.2 Cascade of classifiers used in Viola Jones algorithm

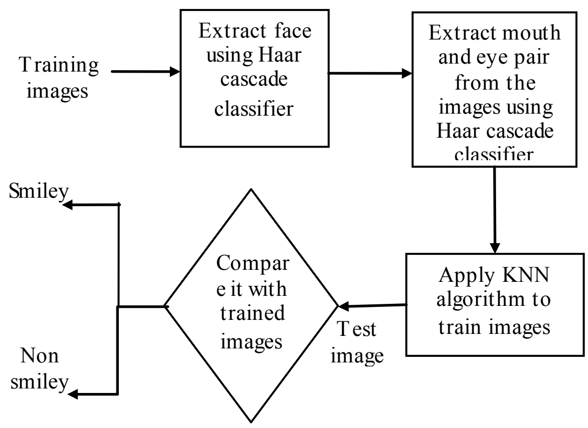

Fig 3. Basic steps in this experiment

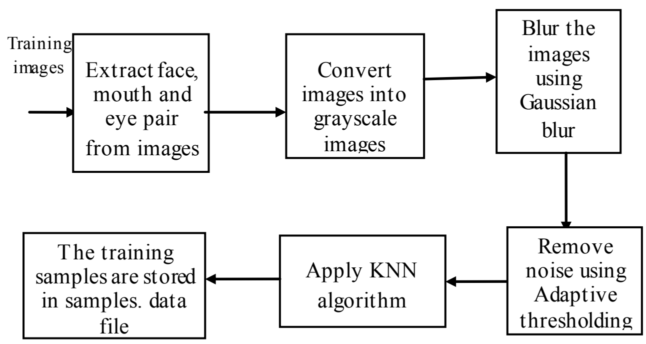

Fig.4. Processing of training images

These are trained using KNN algorithm. The following steps have to be done during training. Figure 4 shows the basic steps used in this experiment. Figure 5 shows some samples in the testing phase.

1. The training images should be converted to grayscale images

2. Blurring the images using Gaussian Blur: The Gaussian blur is a type of image-blurring filter. It uses a Gaussian function for calculating the transformation to apply to each pixel in the image. The equation of Gaussian function in one dimension is given by (4)

$$G\ x = \frac{1}{2\pi\sigma^2} e^{-\frac{x^2}{2\sigma^2}} \quad (4)$$

In 2 dimensions, it is the product of two such Gaussians, one in each dimension:

$$G(x,y) = \frac{1}{2\pi\sigma^2} e^{\frac{x^2+y^2}{2\sigma^2}} \quad (5)$$

where x- distance from the origin in the horizontal axis
y- distance from the origin in the vertical axis
σ- standard deviation of the Gaussian function
Gaussian blur is typically used to reduce image noise and reduce details in an image.

3. Adaptive thresholding : Thresholding is the way to segment objects from a background. We can use global thresholding if the background is relatively uniform. If there is large variation in the background intensity, we can use adaptive thresholding. In this by using the threshold_adaptive function binarizes the images, which calculates thresholds in regions of block_ size surrounding each pixel.
4. The trained samples are stored in samples. data file
5. The responses are stored in responses. data file
6. Then initialize K-Nearest Neighbor algorithm and pass the samples. data and responses. data to train KNN

In the test phase we should bring a new comer and classify it with the help of KNN. Before that we should do some image transformations as we have done in training images. I used K=1, the number of neighbors. The algorithm takes all the training samples and predicts the response for a new sample using voting, calculating weighted sum etc. Figure 4 shows the image processing steps that have to be done during training.
Figure 6 and Figure 7 shows the mouth and eye pair extracted from the set of images. Using eye pair only the experiment using KNN algorithm has accuracy of only 60%. Extracting mouth and eye pair we have obtained a better result. The number of training images used in this experiment contains 300 smiling and 300 non smiling faces. The results obtained using these samples with 55 test cases are shown in Table I.
The features were extracted by using relative positions and sizes of the important components of face. This method concentrated in two directions. First, detecting edges, directions of important components or region images contain important components, then building feature vectors from

these edges and directions. So far in case of KNN we always set $k = 1$. The experiments shows that as K go on increasing, the accuracy goes down.

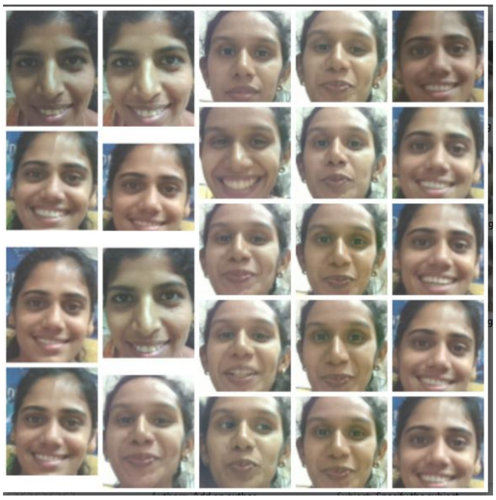

Fig 5. Samples in training phase

IV. CONCLUSION

In this paper we have proposed a method of smile detection which is based on KNN classifier by extracting mouth and eye pair from images. We presented a theoretically and computationally simple but efficient approach for smile detection from still images. This machine learning approach produces the best performance for smile detection analysis. Hence it is possible to produce accurate facial expression analysis by machine learning approaches. In future, will try to detect mouth corner points more precisely and will use Naïve Bayes classifier approach.

TABLE I. RESULTS WITH NUMBER OF TEST CASE= 55

Test case	Result	Percentage accuracy
Smile	Smile	66.66
	No smile	33.33
No smile	Smile	26.31
	No smile	73.68

Fig 6. Eye pair extracted from images

Fig 7. Mouth extracted from images

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