Study on Face Recognition

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Abstract— Face recognition deals with identifying the person from digitally captured image from previous knowledge. Face recognition has applications in security, image database investigations, access control and surveillance. Various features or patterns can be extracted from the images stored in database and can be used for training the machine learning model in order to classify the captured probe image. There are various techniques for extracting features and classifying the probe image. This survey provides various feature extraction and classification techniques that can be implemented.

Keywords: ANN, LBP, PCA, SURF, SVM

I. INTRODUCTION

This Face recognition has become most common way for recognizing individuals. Instead of giving system access to customers through cards, passwords and keys, Face recognition technique can be used providing user convenience. In order to make the face recognition system applicable, there are several factors to be considered. The speed of face detection and recognition should be good and results has to be accurate. The system should be capable of updating new subjects for recognition. Researchers with different backgrounds deal with face recognition including computer vision, neural networks, pattern recognition and computer graphics. Face recognition can be divided into 3 categories [9].

Holistic Matching Methods: In this, entire face region is taken as input data. Examples include PCA, LDA and Eigen faces.

Feature-based Methods: Entire face region is not given as input. Only certain features of eyes, nose, mouth and their locations are extracted and fed to a structural classifier.

Hybrid Methods: It is the combination of Holistic Matching Methods and Feature-based Methods.

II. LITERATURE SURVEY

Support Vector Machine(SVM) was designed as a binary classifier. Given the training set, each example belonging to one of the two classes, SVM builds a model that classifies new examples to one of the two categories

The two classes, say Yes and No are linearly separable then there exists a hyperplane which can divide the Yes and No data as shown in Figure 1. These two classes can be represented by the two bounded planes [1]:

$$w^Tx+b=+1 \quad (1)$$

$$w^Tx+b=-1 \quad (2)$$

In (1) and (2), b determines the points location relative to origin and w is a normal vector to the planes. The data points that fall on $w^Tx+b=\pm1$ are called support vectors. The hyperplane that separates these two classes linearly is:

$$w^Tx+b=0 \quad (3)$$

SVM finds the separating hyperplane while maximizing the margin between these two bounded planes. If the two classes cannot be linearly separated, then data cannot be separated by a linearly separating hyperplane.

Kernel method is used for such cases which calculates the dot product in order to a higher dimension linearly separable function from non-linearly separable function. It is shown in Figure 2.

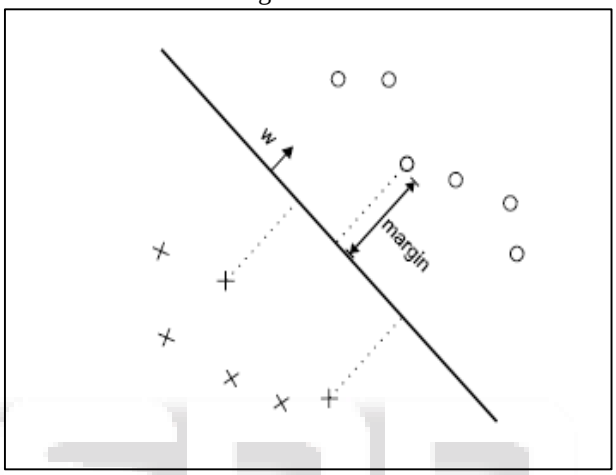

Fig. 1: linear classification of support vector machine [10]

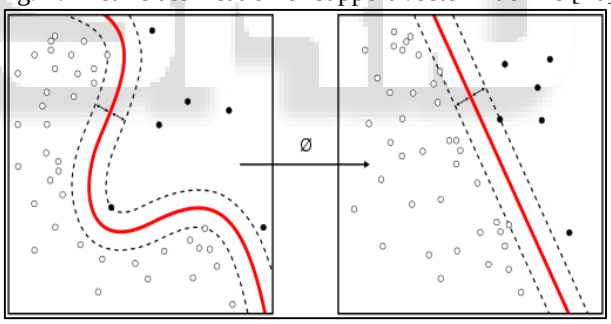

Fig. 2: support vector machine nonlinear classification

There are two approaches for classifying the new examples if they belong to more than two classes, say n [2]: one-vs-all approach and pairwise approach. In one-vs-all approach there will be n SVM classifiers, one per each class. SVM1 classifies all class1 labels as positive and rest as negative. Similarly, for all n classifiers, SVM_i classifies class i label as positive and rest as negative. Thus an example belongs to class 1 if SVM_1 classifies it as positive and all other SVMs classifies classify it as negative. In pairwise approach, a SVM classifier has to be trained for each pair of labels. Therefore, there will be n(n-1)/2 SVM classifiers.

Hausdorff distance [3] tells how long the two subsets from each other are. It is the largest distance from a point in one set to its closest point in other set.

Speeded Up Robust Features (SURF) is a feature detector which can be used for object recognition, image registration and classification [1][4]. SURF can be used to recognize objects, faces or people. Interest points in the image are detected by detector and their features are described by

descriptor. It constructs the feature vectors of interest points of the image. SURF descriptor do not vary for change in brightness, pivot, scale and perspective of the image.

Local Binary Patterns is a descriptor used for classification [5]. A LBP feature vector is created by dividing window into cells.

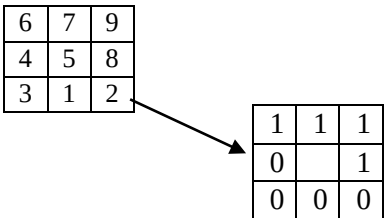

Fig. 3: local binary pattern

Each pixel in cell is compared with its eight adjacent neighbors. Comparison is done along a circle in clockwise or anti clockwise direction. If the pixel's value is greater than the center pixel's value, then it is represented as "0". Otherwise it is represented as "1" as shown in the Figure 3. The new cells give an 8-bit binary number which is converted to decimal. Histogram is computed for frequency of each number in the cells and is seen as a 256- dimensional feature vector. The histogram is normalized and concatenation of this is the feature vector for entire window.

Machine learning algorithms like SVM can be used for processing of the feature vector and classify images.

III. METHODOLOGY

Face recognition is method of identifying someone by using previously obtained data. This is done by extracting face features of the image and comparing these face features with the database to find which image matches closest to it.

A. Using Hausdorff Distance, SURF and SVM

The steps for carrying out this method is displayed in Figure 4. First step is to select an image from database. The code has to be written to load image to the workspace of the tool being used. In the second step code has to be developed for pre-processing of the loaded image. The RGB image is converted to greyscale image and face is detected and extracted in the tool. In the third step, code is developed to calculate Hausdorff Distance. Face features from the image are extracted. Fourth step is to develop code for recognition and matching. SVM is used for classification of the image and SURF technique is used for matching the image. In the last step performance measures like accuracy, precision and recall are calculated and compared with other existing methods.

The image classification is done by SVM as follows:

- From the dataset violating point is identified.
- If a Violator point is identified in the dataset, then add it to the candidate set.
- It may take place if adjoining of the contaminate point as a Support Vector might be impeded by other candidate Support Vectors that are already present in the set.
- Steps are repeated

For matching the images, geometric constraints are introduced to point-matching technique of SURF feature. In face recognition, the faces in two images should have matching points at similar locations.

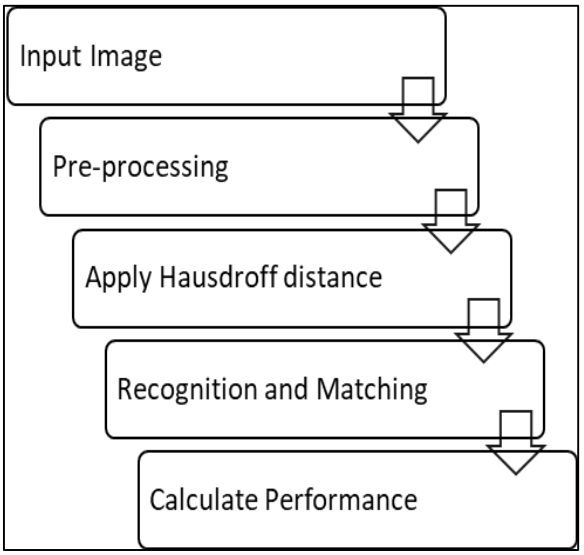

Fig. 4: Flowchart of methodology [3]

Figure 5 shows the interest points in two images of same person with different facial expressions. An interest point (x,y) is in the test image then its search area in its mate stored as trained image is limited to a rectangular area around the point (x,y). Candidate matching pairs are selected as the point pairs having minimum distance.

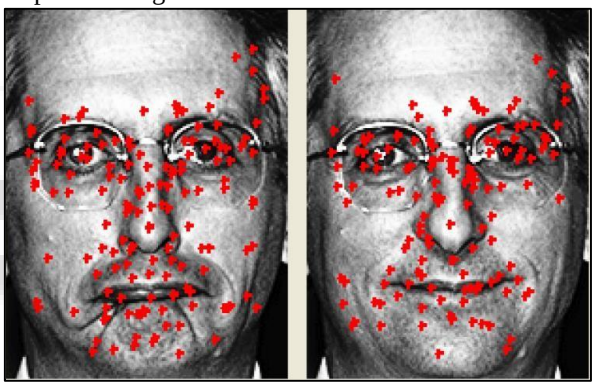

Fig. 6: Interesting points in two images [4]

To verify the candidate point pairs, the next minimal distance of point pair is calculated among the probe image and trained image. If the ratio of these two distances is lesser than predefined threshold, then the point having minimum distance is confirmed as matched. Figure 6 shows matched interest points which are represented in red lines.

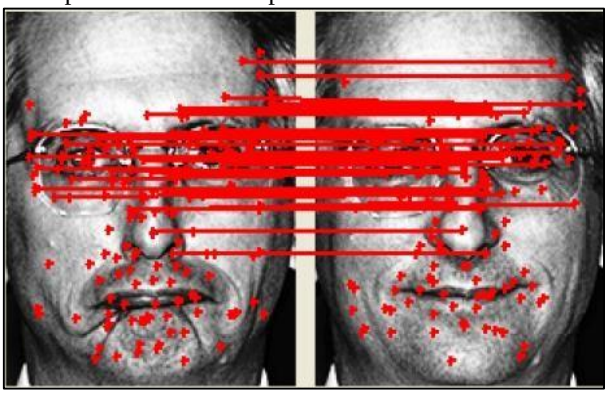

Fig. 5: Lines showing matching interesting points [4]

B. Principal Component Analysis and Artificial Neural Networks

The three main stages of face recognition are preprocessing stage, dimensionality reduction stage and classification stage. The methods followed are as follows:

- Prepare the training set having faces of each person.
- The faces from training set are transformed to Eigen faces.
- Eigen faces calculated for each image is stored in a set
- covariance matrix, eigenvectors and Eigen values are calculated.
- Principal components are selected
- Classification of the image is done using Artificial Neural Networks.

PCA is a dimensionality reduction method can be used in the field of image compression and recognition. By means of data compression dimension of data is reduced by PCA and presents low dimensional structure of facial patterns [7]. PCA removes unwanted information and decomposes the face into Eigen faces. The weighted sum of these Eigen faces gives the actual face. These Eigen faces are stored in 1D array. A probe image is compared with gallery image by calculating the distance between their feature vectors which are derived using Eigen faces. For PCA full frontal face has to be presented each time so that performance does not become poor. PCA method represents face image in the form of Eigen values and Eigen vectors.

The ANN takes the feature vectors for training the network. For making the training easier, one neural network is made to represent the features each person [8]. Each neuron identifies whether the probe image face is present in the network's host or not. The network having maximum output is selected by the recognition algorithm and if this output passes a predefined threshold then it will be reported as the host of the input probe image. If the output is less than the predefined threshold the input face is rejected.

C. Decision Tree-Based Local Binary Patterns

Figure the steps are presented in [5] for face recognition are as follows:

- Face region of the image is cropped and by using similarity transformation and face alignment is done by mapping the eyes.
- perform illumination normalization using Difference of Gaussian (DoG) Filtering [6].
- partition the image into equally sized cells.
- apply LBP for each grid cell to obtain spatial histogram.
- classify probe image to nearest neighbor in the gallery.

LBP assigns a 0 if the center pixel value is greater than the neighbor n_i. Otherwise LBP assigns 1 to the neighbor. The resulted is interpreted by a number in base 2. If there are n neighbors, then there are 2^n possible LBP values. The obtained binary value is converted to decimal and a histogram is computed where each bin represents the frequency of the obtained decimal number. Histograms computed for different grids are concatenated to construct spatial histogram. This histogram is compared against database using nearest neighbor match. Application of fixed binary decision tree is equivalent to the operation of LBP over a given neighborhood. The tree has S levels and each level i center pixel is compared with the neighbor n_i. If neighbor value is greater than center pixel value, the vector is assigned to left node at level i-1. If center pixel value is greater, the vector is assigned to right node at level i-1. Tree gets completed at level 0 having 2^S leaf nodes. Path taken by (c,n) through the tree is encoded by LBP. Consider, a tree having 8 neighbors, 11111100 indicates a (c,n) pair that has taken left path at i=0 and 1, and right path taken at all other levels. This indicates that LBP like descriptors from training data can be learnt by tree induction algorithms. Once the tree is obtained, a histogram can be constructed where each bin represents a leaf node. Thus standard LBP operator, trained decision trees can be used in the process of face recognition.

D. Haar Cascade Classifiers

Haar like features are basis for a Haar classifier. For a pixel at location (x,y), the sum of intensity values of pixel located above and intensity values of pixel located to the left is stored in an array. The array is called integral image. Using Integral image, the rectangular features of image are calculated. For an image A[x,y], integral image AI[x,y] is calculated as

$$AI[x,y] = \sum_{x' \le x, y' \le y} A(x',y') \quad (4)$$

The features are rotated by forty-five degrees which requires computation of rotated integral image. For a pixel at location (x,y), the sum of intensity values of pixels located at forty five degree angle to left and above the point x, and intensity values of pixels located below point y is stored. It is the rotated integral image. For an image A[x,y], rotated integral image
AI[x,y] is calculated as

$$AR[x,y] = \sum_{x' \le x, x' \le x - |y - y'|} A(x',y') \quad (5)$$

In two passes, the two integral image arrays are computed. Features of any scale can be computed by taking difference between elements of integral image and forming connected rectangles. Haar classifier cascades should be trained for detecting facial features like eyes, nose and mouth. For training, two set of images are needed. One set contains face images that can be detected and does not contain required facial feature. Another set of images contains face images having required facial features. The first set is referred as positive example and the second set is referred as negative example. Positive examples contain multiple face images of a single person. Haar classifier cascades accepts only sub image that contain facial features. The original set of images should be representative of variance among different people. It should consider the factors like age and gender. It should include different poses, angles and lighting conditions. Three separate classifiers are used for eyes, nose and mouth. For recognition, face region is detected from the image. The area under face contains the required facial features, such as eyes, nose and mouth. The top area of face region contains eyes, the center area contains nose and the bottom area contains mouth. The top area is analyzed for eyes, which can show variance in tilt angle and other features can be eliminated. The center area of face region is analyzed for nose and this eliminates all features except the upper lip of mouth to the lower eyelid. From the bottom area, mouth region is extracted. If all 3 classifiers classify a given probe image to same subject, then face is said to be recognized.

IV. CONCLUSION

This paper presents various techniques to extract face features from digitally captured image and classify using machine learning techniques. Using SURF technique there is improvement in matching speed. Face recognition using PCA and ANN can give better recognition than using only PCA. The decision tree based face recognition can work better than classical LBP methods. Using Haar cascade classifiers, only some portion of face region are extracted for face recognition and recognition requires less time. Therefore, we consider these methods are suitable for recognition.

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