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Face Recognition to Handle Facial Expression, Occlusions, and Posture Variation

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Abstract: ***In this paper, we present a framework for analysing faces, with the specific goals of matching, comparing, and averaging their shapes. Here we handle variations of facial expression, pose variations, and occlusions between the gallery and probe scans. The radial curves are drawn from the nose tips and filled to the occluded part to form the shape of full facial surfaces. This representation seems natural for measuring facial deformations and is robust to challenges such as large facial expressions, large pose variations, missing parts, and partial occlusions due to glasses, hair, and so on. In this, we consider ORL data set for handling different types of challenges, like SVD is used to the estimation of missing facial parts. Here we using MATLAB for implementing our project.***

Keywords: Face Recognition, Occlusion Detection, Biometrics, Quality Control, SVD, ORL Dataset, PCA.

INTRODUCTION

In this paper, we represent facial shapes, which are dealing with large expressions, occlusions, and missing parts. The system should recognize people despite large facial expressions, occlusions, and large pose variations. During initial work on the 3D face, the 3D acquisition was a major problem because 3D capturing process was quite time-consuming, costlier and not much accepted by the user due to the low quality of 3D face data. In today's scenario, there are lots of cheap and efficient 3D sensors are available which have opened a new door for research in the direction of 3D face recognition. For dimensionality reduction of face space, Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA), Single Value Decomposition (SVD) are widely used methods for efficient feature extraction and classifying face images. Some examples of face scan highlighting these issues are illustrated in Fig 1

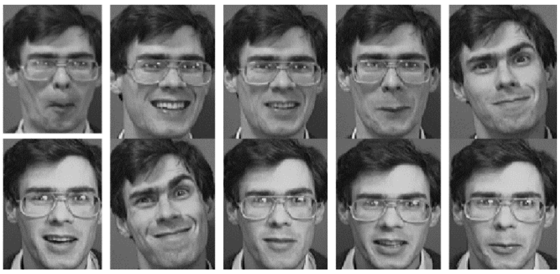

Fig 1: different expression, missing data, occlusion

The face is a natural assertion of identity i.e. we get recognized by our faces because the face is most widely accepted biometric modality. In the context of face recognition, it is common to distinguish between the problems of authentication and that of recognition. Initially the enrolled individual claims identity of a person whose template is stored in a database (gallery). The face recognition algorithm needs to compare a given face with a given template verify their equivalence, such a one-to-one matching can occur when biometric technology is used to secure financial transaction for ex: consider in an ATM. Secondly, recognition implies that the probe subject should be compared with all the templates stored in the database. The face recognition algorithm should then match a given face with one of individual in database for ex: finding a terrorist in a crowd

LITERATURE REVIEW

In this section, the works carried out by various researchers are as follows:

Michael M. Bronstein, Alexander M. Bronstein, Ron Kimmel. In this, the enrolled individual (probe) claims the identity of a person whose template is stored in the database (gallery). We refer to the data used for a specific recognition task as a template. The face recognition algorithm needs to compare a given face with a given template and verify their equivalence [5]

In [1] how to remove occlusion parts and then recover the missing parts using radial curve analysis

The authors in [6] have, at first registered the occluded images using an adaptive based registration scheme, restored occlusions using a masked projection scheme and then performed classification using Fisherface projection. Hassen et. al [1], have used radial curves as a method to remove occlusions from the 3D facial surfaces but, by experimentation, they have fixed the initial threshold to detect occlusions.

In [2], Passalis et al. they use automatic landmarking to estimate the pose and to detect occluded parts. The facial symmetry is used to overcome the challenges of missing data here. Similar approaches, but using manually annotated models, are presented in [3] and [4]. For example, Lu and Jain [4] use manual landmarks to develop a thin-plate-spline-based matching of facial surfaces.

PROPOSED SYSTEM

To recognise the Face where some occlusion or some missing data is present to handle the same we use different steps.

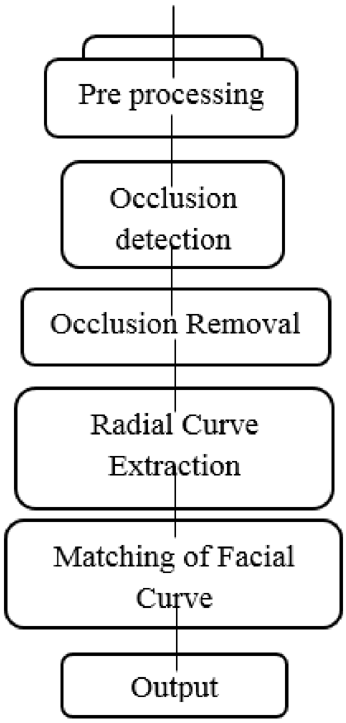

Fig 2: Block diagram

The different steps are shown in below Fig 2. Fig 2 represents the block diagram which shows different steps to handle occlusion and missing part and matches the occluded image in the database and generates the result as found or not.

Implementation Details

Input image

Input is taken from ORL Database. In ORL database, there are ten different images of each of 40 distinct subjects shown in Fig 3. For some subjects, the images were taken at different times, varying the lighting, facial expressions (open / closed eyes, smiling / not smiling) and facial details (glasses / no glasses). All the images were taken in a dark background with the subjects in a different position with some side movement. The size of each image is 92x112 pixels, with 256 grey levels per pixel. The images are arranged in different forty directories one for each subject, who are names from sX, where X indicates the subject number between 1 and 40. In each of these directories, there are ten different images of that subject, which have names of the form Y.jpeg, where Y is the image number for that subject (between 1 and 10).

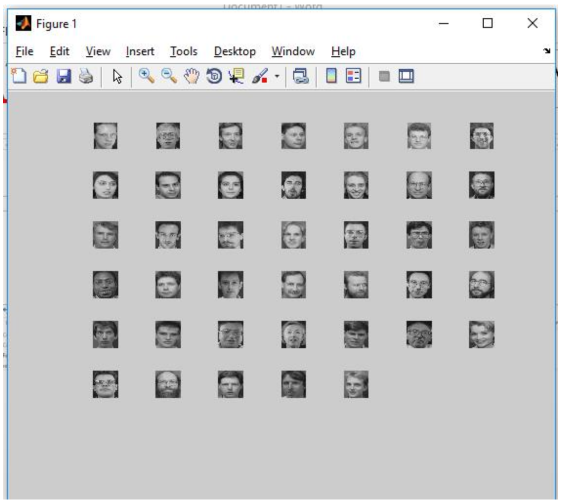

Fig 3: database of 40 subjects

Image Pre-processing
Usually, the image consists of noises in the form of missing data, occlusion etc. In order to avoid that, images are subjected to various image pre-processing techniques. Pre-processing is done to removes the noise. The different filtering methods are Fast Median Filtering, Median Filter, Gaussian filtering, Colour filtration technique. Gaussian filtering is used for reduce detail Minimizing, noise removal and edge preservation.

Data processing: First automatic noise is removed and then segmentation is carried out for 3D data obtained. Then we detect a face from arbitrary scene data and extract the face and it region part automatically mark character point needle on the face such as outer eye, inside eye point, nose needlepoint corner of mouth etc. Finally the transform of scale, rotation & translation of face is calculated to get the real position of the face during taking a photograph of a face.

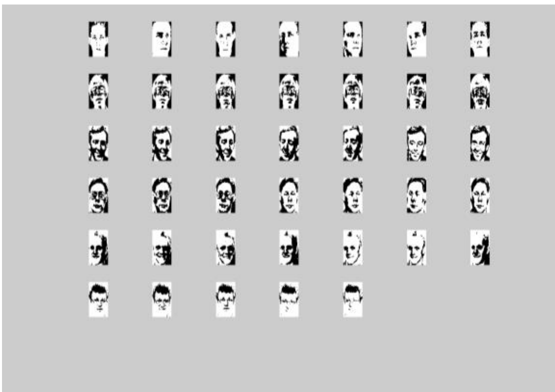

Fig 4: Extracted Features

NODAL POINTS (Fig 5) Most face recognition system work with numeric codes called face prints such system identify 80 nodal points on the human face. Nodal points are endpoints used to measure variables of persons face such as length or width of the nose, depth of eye sockets & shape of cheekbones. Only 14 to 22 nodal points are required for the software to complete the recognition process [1].

Fig 5: Nodal Points

Occlusion Detection and Removal

Occlusion detection and removal (Fig 6) is done using a different algorithm that is: Principal Component Analysis (PCA) and Single value Decomposition can be used as a dimension reduction method to represent multidimensional, highly correlated data, with fewer variables. Feature selection refers to a process whereby a data space into feature space, in theory, has exactly the same dimensions as the original data space (Fig 4). The main aim of PCA is dimensionality reduction [8].

PCA Method:

1) Image-to-vector conversion

A 2-dimensional image is transformed to a 1-dimensional vector by placing the rows side by side, i.e. $x = [p1, p2, . . . , pr]^T$ where pi is the ith row of p and r is a total number of rows.

2) Subtract the Mean

The mean is subtracted from each vector to produce a vector with zero means. Let I_0 represent the mean then it is calculated as $I_0 = 1/N \sum I_J$, where N is the number of variables I.

3) Calculate the covariance matrix

The covariance of the mean centered matrix is calculated as $Cov = W^T W$, where W is an r-by-c sized matrix composed of the column vectors $(I_I – I_0)$. Cov is a square matrix of size r-by-c.

4) Calculate the eigenvectors and eigenvalues of covariance matrix

Using Singular Value Decomposition Method (SVD):

SVD algorithm:

Step 1. Compute transpose of an image (say A^T) and perform and $A^T A$

Step 2. Determine the eigenvalues of $A^T A$ and sort these in descending order, in the absolute sense. Square roots these to obtain the singular values of A.

Step 3. Construct diagonal matrix S by placing singular values in descending order along its diagonal. Compute its inverse, S^{-1}.

Step 4. Use the ordered eigenvalues from step 2 and compute the eigenvectors of $A^T A$. Place these eigenvectors along the columns of V and compute its transpose, V^T

Step 5. Compute U as $U = AVS^{-1}$. To complete the proof, compute the full SVD using $A = USV^T$.

Mathematical Expression:

- SVD Any $N \times d$ matrix X can be uniquely expressed as:

X = U x Σ x VT

$$\boldsymbol{N \times d = N \times r \, * \, r \times r * r \times d}$$

- r is the rank of the matrix X (# of linearly independent columns/rows).
- U is a column-orthonormal $N \times r$ matrix.
- Σ is a diagonal $r \times r$ matrix where the singular values σi are sorted in descending order.
- V is a column-orthonormal $d \times r$ matrix.
- Calculate the SVD of X=U Σ VT.
- V corresponds to the right singular vectors.
- Project the data in an m dimensional space: Y = X V

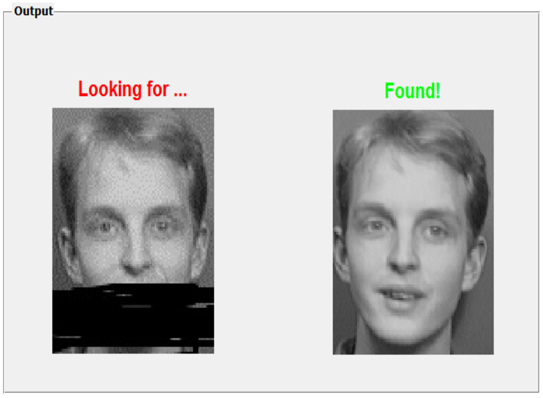

Fig 6: occluded image search

Radial Curve

The radial curves pass from different regions of facial expression so the differences in shapes of curves in the upper half of face can be loosely connected to interclass variability, while other curves which passes through lips can largely due to change in expressions.

Fig 7: Radial curve

Matching of Facial Surface

We calculated the distance between pairwise of radial curves on gallery and probe meshes. The length of one geodesic measures the degree of similarity between one pair of curves. The scores on good quality curves, produced a similar score between the faces probe face P and gallery face G. Based on that score the faces will be recognized(Fig 8).

Fig 8: Match

RESULTS

I have collected ORL dataset of 40 subjects' images from the internet. Seven images are kept in training and rest three images are taken as testing for each subject. They were undergone from various pre-processing techniques such as features are extracted using Eigen value and Eigen vector and with help of SVD different values of features are extracted. And then finally occlusion detection and removal step have done using Radial curve extraction. And minimum distance is calculated among training images which image has a lesser distance that is shown in output as image found.

Accuracy is calculated by using following formula.

Accuracy = $\frac{TP+TN}{TP+FP+FN+TN}$

Conclusion

It can be easily concluded that the proposed system of image recognition which helps to detect and remove occlusion is implemented using SVD and Radial curve, which gives output as match found or not in a database. The accuracy of proposed system is good as the dataset has a total of 400 images.

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