Improving Eigenface Face Recognition by using Image Registration Preprocessing Methods

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ABSTRACT

This paper investigates using image registration through spatial transformation to incrementally improve eigenface detection in training sets containing non-centered head orientation. In identifying a new face, a training set of faces is created from a scene. After face detection in an image, these faces may exhibit different head orientations. The use of several images combined through image registration offers the possibility of improving eigenface recognition through center normalizing the head orientation of the training sets collected in a dynamic environment.

Keywords: Eigenface, Face Recognition, Spatial Transformation.

1. INTRODUCTION

Face recognition is a weak biometric because it is unable to reliably identify persons or worse it will identify the wrong person. Face recognition uses images of people that have different facial expressions and angles to the camera. The ideal center, portrait type environment greatly improves face recognition. However, in reality this environment is not always available in real applications due to tilted camera angles.

Face recognition works well for small groups of data but as the number of individuals are added to the database, the number of false identifications increases. If a system can reliably identify over 99% of subjects that at first seems like excellent reliability. However, that 1% represents a considerable waste of time. The 1% of subjects falsely identified means that in a terrorism situation for a large population, significant resources must be spent manually excluding false positives. Alternatively, it also means there is a remote chance that a person may be misidentified as someone else and slip past security. Any incremental improvement designed to enhance face recognition performance is worth considering.

In addition to any initial filtering, the face is first identified (called face detection) out of the scene using software such as Intel's OpenCV image-processing library. Next various algorithms can be used to do the face recognition. One approach uses Eigenfaces which approaches face recognition not from the standpoint of features such as ears, eyes, mouth, and nose but from encoding of the variations in the face. These variations are described mathematically in a form called eigenvectors each one describing a variation in the face. These vectors are combined to form a ghostly image called an eigenface. A set of weights are calculated permitting comparison and thereby identification.

Image registration combines and aligns two different images of the same scene to provide a combined image. These two images are usually used to represent the change in an overhead shot taken from an aircraft or satellite for instance to indicate building city growth or vegetation changes over time. One of the images is the base and the other image is the difference under evaluation. The images can be taken from different cameras and camera angles and like a rubber sheet stretched, the images are aligned to form one image. Another example is to indicate the progression of diseases such as cancer where one medical diagnostic image was taken a month ago and another more recently. The aligned and combined image shows the progression of the cancer.

In security environments, variations in the face can be caused by shadows caused by camera angle and angle to the sun including reflections off nearby surfaces. The face is constantly moving and images taken will have different head orientations. In this difficult environment, an eigenface would be different for the same person depending on the head orientation. A camera positioned near an entryway would expect to obtain images of persons at different angles from the camera. The face area must be detected in the scene and tracked. The face will not appear centered but at different head orientations. Some means of averaging these differences before vectorizing the face would be useful. This project proposes to examine using image registration to do this.

2. RELATED WORKS AND BACKGROUND

Turk and Pentland [1] originally developed face recognition using eigenface techniques. The project provides for a form of computational pattern recognition for the face. The term eigenfaces is used because mathematical algorithms using eigenvectors represent the primary components of the face. Weights are used to represent the eigenface features so a comparison of these weights permits identification of individual faces from a database. They also discuss the problems of not having a perfect centered face image, which results in some performance degradation not so much effected from sideways tilt of the head but by a non-upright view. They suggest two approaches to solving it by calculating the head orientation and performing rotation.

The face must be identified in a scene first before recognition can take place. This is called face detection. It is fully described as active research projects in Frischholz [2] for finding faces in arbitrary scenes. A rectangular image containing the face is created which is separate from other objects in the scene.

The Automatic Identification and Data Capture (AIDC) site at Western Carolina University [3] describes eigenface technology. The eigenface recognition system commonly takes all of the faces and forms a mean face image. It then compares the differences and similarities for each face between the mean image and the input face being subject to face recognition. The input face gets a fitness score assigned to it which indicates if the face is in the database. The fitness score also determines if the image is a face and can then be stored as a new face in the database if the fitness score does not match a current face in the database. The advantage of the eigenface is that it is fast and does not require a high storage of data. The disadvantage is that it has problems identifying faces that do not face the camera directly and under different light levels. The eigenface approach also has problems dealing with facial hair and skin scarring. Another approach called eigenfeatures measured facial metrics such as the distances between eyes and nose. Combining eigenfaces with eigenfeatures improves face recognition considerably.

Heseltine, Pears, and Austin [4] describe pre-processing techniques used to improve eigenface face recognition. Tests are performed to compile data on false acceptance rates (FAR) and false rejection rates (FFR). Factors affecting face recognition include changes in intensity and direction of light, partially covered faces through sunglasses, hats, and facial hair, and changes in expressions on the face. The paper discusses the problems occurring when light illuminates one side of the face resulting in a principal component, which provides errors in identification of faces.

Lanitis [5] describes an algorithm that uses the non-occluded part of the face for face recognition. The hidden part of the face is excluded from interfering with the face recognition process so that identification is improved. The paper focuses on excluding non-systematic facial appearance variations caused by sunglasses, hats, etc. instead of systematic variations caused by aging, illumination, viewpoint, and expression.

Gupta and Jain [6] describe a visual information retrieval (VIR) system using recall of different types of images from a repository, one of which has face retrieval using eigenfeatures. Image transformations are computed for each face. A limitation found is that as the database increases the computations become too intense and difficult to automate requiring human intervention along with high associated training costs.

Graham and Allinson [7] states that if the image of the person in the database is different from the test image, the system should recognize the person, which is defined as pose invariant recognition. When test images have different poses, the system should still be able to recognize the individual. For a computer this task may be unlikely because computers view images in pixels. To make the computer capable of invariant recognition, features must be removed. Pose invariant recognition is based on using different images of people for training, or by creating a 3D model, which can be used to generate more images.

3. METHOD

There are various programs available to do Eigenface recognition experiments. Luigi Rosa developed a m-file program called Face Recognition System [8] using the Mathworks Matlab language based on the eigenface methods described by Turk and Pentland [1]. It uses the Mathworks Image Processing Toolbox to do the image processing and perform the matrix calculations. The program permits input of images for each person as part of training sets. After the training sets are loaded in for multiple persons, the input image can be selected for face recognition. The result indicates the nearest class (training set), the distance from the averaged eigenface of the set, and the distance from the facespace, which indicates if the image is a face.

The test faces are obtained from the AT&T Laboratories Cambridge, ORL face database [9], which contains ten images of 40 persons with each image undergoing different lighting, head orientation, and facial expressions.

4. RESULTS

Two images were read into the Matlab command window and converted successfully to matrices representations. The two images were then selected for interactive selection of control points using the cpselect command. This tool is shown in Figure 1. The base image is on the left and a different head orientation is shown on the right.

Figure 1 - Selecting Control Points

Unfortunately, there are problems creating matching control points for the faces. Only two matching control points can be selected and three are needed to use transformation type affine, which combines scaling, rotation, shearing, and translation [10]. Once the spatial transformation is applied using transformation type affine, errors occur because not enough control points have been selected. The commands used are listed below:

```
image1 = imread('c:\1.pgm')
image2 = imread('c:\2.pgm')
cpselect(image1(:,:,1),image2(:,:,1))
mytform =
cp2tform(input_points,base_points,'affine');
```

The cp2tform command fails because not enough control points (also known as tie points) have been selected. At most only two control points are successfully selected at one time and at least three are needed for the affine type transformation.

5. CONCLUSION

The selection of control points used to align two images for image registration can be easily done for backgrounds that are fixed such as a highway as was done previously in [11]. The selection of control points could also be performed using a test pattern background in a portrait for faces using different head positions. But in a dynamic video motion environment there is no standard test pattern background to align control points with.

It was thought that the face’s eyes and mouth could be used for alignment of the control points. At least predictive tie points could be used. However, the face images at different angles even if filtered are hard to obtain control points from.

It is suspected that a different transformation type than 'affine' could be used such as 'projective' which might not require as many control points would result in some success. However, introducing inaccuracies may cause a deformation in the eigenface detection, which was the opposite from the intent of this paper, which was to enhance Eigenface detection.

Therefore, the use of spatial transformation techniques to improve Eigenface detection for different head positions cannot be satisfactorily resolved due to difficulties aligning the exact pixel positions for the control points required for image registration. In a perfect environment under controlled conditions, the use of image registration on the training sets may improve Eigenface detection but under sensible conditions using changing real time video frames, this approach is not sustainable.

6. ACKNOWLEDGEMENTS

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