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FACE RECOGNITION SYSTEM BY IMAGE PROCESSING

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ABSTRACT

A wide variety of systems require reliable person recognition schemes to either confirm or determine the identity of an individual requesting their services. The purpose of such schemes is to ensure that only a legitimate user and no one else access the rendered services. Examples of such applications include secure access to buildings, computer systems, laptops, cellular phones, and ATMs. Face can be used as Biometrics for person verification. Face is a complex multidimensional structure and needs a good computing techniques for recognition. We treats face recognition as a two-dimensional recognition problem. A well-known technique of Principal Component Analysis (PCA) is used for face recognition. Face images are projected onto a face space that encodes best variation among known face images. The face space is defined by Eigen face which are eigenvectors of the set of faces, which may not correspond to general facial features such as eyes, nose, lips. The system performs by projecting pre extracted face image onto a set of face space that represent significant variations among known face images. The variable reducing theory of PCA accounts for the smaller face space than the training set of face. A Multire solution features based pattern recognition system used for face recognition based on the combination of Radon and wavelet transforms. As the Radon transform is in-variant to rotation and a Wavelet Transform provides the multiple resolution. This technique is robust for face recognition. The technique computes Radon projections in different orientations and captures the directional features of face images. Further, the wavelet transform applied on Radon space provides multire solution features of the facial images. Being the line integral, Radon transform improves the low-frequency components that are useful in face recognition.

Keyword: Introduction, Face Detection, Principal Component Analysis, Eigen Face Approach, Radon Wavelet Transform, Principal Component Analysis, Result and Conclusion, Bibliography.

INTRODUCTION

Within today's environment of increased importance of security and organization, identification and authentication methods have developed into a key technology in various areas: entrance control in buildings; access control for computers in general or for automatic teller machines in particular; day-to-day affairs like withdrawing money from a bank account or dealing with the post office; or in the prominent field of criminal investigation. Such requirement for reliable personal identification in computerized access control has resulted in an increased interest in biometrics. Biometric identification is the technique of automatically identifying or verifying an individual by a physical characteristic or personal trait. The term automatically means the biometric identification system must identify or verify a human characteristic or trait quickly with little or no intervention from the user. Biometric technology was developed for use in high-level security systems and law enforcement markets. The key element of biometric technology is its ability to identify a human being and enforce security. Biometric characteristics and traits are divided into behavioral or physical categories. Behavioral biometrics encompasses such behaviors as signature and typing rhythms. Physical biometric systems use the eye, finger, hand, voice, and face, for identification. Humans have used body characteristics such as face, voice, and gait for thousands of years to recognize each other. Distinctiveness of the human fingerprints has given significant and practical discovery of person recognition. Soon after this discovery, many major law enforcement departments embraced the idea of first booking the fingerprints of criminals and storing it in a database (card file). Later, the leftover (fragmentary) fingerprints (latents) at the scene of crime could be lifted and matched with fingerprints in the database to determine the identity of the criminals. Recently biometrics is increasingly used to establish person recognition in a large number of civilian applications. Any human phys1iological and/or behavioral characteristic can be used as a biometric characteristic as long as it satisfies universality, distinctiveness, permanence, collectability, performance, acceptability, and circumvention. A practical biometric system should meet the specified recognition accuracy, speed, and resource requirements, be harmless to the users, be accepted by the intended population, and be sufficiently robust to various fraudulent methods and attacks to the system.

FACE DETECTION

Human face detection is often the first step in applications such as video surveillance, human computer interface, face recognition, and image database management. The aim of face detection is to classify the segment of image as face or non-face(background of image). The task of describing the human face is difficult due to the fact that the image varies based on external factors like viewpoint, scale, different individual, occlusion, lighting, environmental conditions and internal factors like facial expression, beard, moustache, glasses. Various approaches to face detection are discussed in [18]. These approaches utilize techniques such as neural networks, machine learning, (deformable) template matching, Hough transform, motion extraction, and color analysis. The neural network-based [22] and view-based [35] approaches require a large number of face and non-face training examples, and are designed to find frontal faces in grayscale images. A recent statistical approach [35] extends the detection of frontal faces to profile views by training two separate classifiers. Model-based approaches are widely used in tracking faces and often assume that the initial locations of faces are known. Skin color provides an important cue for face detection. Detection of skin color in color images is a very popular and useful technique for face detection. Many techniques have reported for locating skin color regions in the input image. While the input color image is typically in the RGB format, these techniques usually use color components in the color space, such as the HSV or YIQ formats. That is because RGB components are subject to the lighting conditions thus the face detection may fail if the lighting condition changes. In the Y CbCr color space, the luminance information is contained in Y component; and, the chrominance information is in Cb and Cr. Therefore, the luminance information can be easily de embedded. The RGB components were converted to the Y CbCr components using the equation 3.1, equation 3.2, equation 3.3.

$$Y = 0.299R + 0.587G + 0.114B \quad (3.1)$$
$$Cb = 0.169R0.332G + 0.500B \quad (3.2)$$
$$Cr = 0.500R0.419G0.081B \quad (3.3)$$

In the skin color detection process, each pixel was classified as skin or non-skin based on its color components. The detection window for skin color was determined based on the mean and standard deviation of Cr component, obtained using training faces. The following steps are required to conduct for face detection.

1. To detect the skin pixels threshold the face image with threshold of Cr = 102
2. If the Cr value is less than 102 darken the pixel i.e. make pixel value equal to zero, otherwise retain the pixel value. The obtained image is then binaries.
3. Number of regions we get after thresholding are required to reduce after finding the area of that region. If the area of region is greater than the 1000 pixel it is a face image.
4. Find the bounding box which fits the area detected as face region.
5. Crop the face image from the original image using the coordinate of bounding boxes.
6. Display the detected face image The result of different steps of face detection are as given below shows the original face image. We implement the algorithm successfully on the Face 94 and Face 96 databases. We implement a face detection algorithm for color images in the presence of varying lighting conditions as well as complex backgrounds.

PRINCIPAL COMPONENT ANALYSIS (PCA)

Principal component analysis (PCA) was invented in 1901 by Karl Pearson. PCA is a variable reduction procedure and useful when obtained data have some redundancy. This will result introduction of variables into smaller number of variables which are called Principal Components which will account for the most of the variance in the observed variable. Problems arise when we wish to perform recognition in a high-dimensional space. Goal of PCA is to reduce the dimensionality of the data by retaining as much as variation possible in our original data set. On the other hand dimensionality reduction implies information loss. The best low-dimensional space can be determined by best principal components. The major advantage of

PCA is using it in Eigen face approach which helps in reducing the size of the database for recognition of a test images. The images are stored as their feature vectors in the database which are found out projecting each and every trained image to the set of Eigen faces obtained. PCA is applied on Eigen face approach to reduce the dimensionality of a large data set.

EIGEN FACE APPROACH

It is adequate and efficient method to be used in face recognition due to its simplicity, speed and learning capability. Eigen faces are a set of Eigen vectors used in the Computer Vision problem of human face recognition. They refer to an appearance based approach to face recognition that seeks to capture the variation in a collection of face images and use this information to encode and compare images of individual faces in a holistic manner. The Eigen faces are Principal Components of a distribution of faces, or equivalently, the Eigen vectors of the covariance matrix of the set of the face images, where an image with N by N pixels is considered a point in N 2 dimensional space. Previous work on face recognition ignored the issue of face stimulus, assuming that predefined measurement were relevant and sufficient. This suggests that coding and decoding of face images may give information of face images emphasizing the significance of features. These features may or may not be related to facial features such as eyes, nose, lips and hairs. We want to extract the relevant information in a face image, encode it efficiently and compare one face encoding with a database of faces encoded similarly. A simple approach to extracting the information content in an image of a face is to somehow capture the variation in a collection of face images. We wish to find Principal Components of the distribution of faces, or the Eigen vectors of the covariance matrix of the set of face images. Each image location contributes to each Eigen vector, so that we can display the Eigen vector as a sort of face. Each face image can be represented exactly in terms of linear combination of the Eigen faces. The number of possible Eigen faces is equal to the number of face image in the training set. The faces can also be approximated by using best Eigen face, those that have the largest Eigen values, and which therefore account for most variance between the set of face images. The primary reason for using fewer Eigen faces is computational efficiency.

Eigen Values and Eigen Vectors

In linear algebra, the eigenvectors of a linear operator are non-zero vectors which, when operated by the operator, result in a scalar multiple of them. Scalar is then called Eigen value (λ) associated with the eigenvector (X). Eigen vector is a vector that is scaled by linear transformation. It is a property of matrix. When a matrix acts on it, only the vector magnitude is changed not the direction.

$$AX = \lambda X, \quad (4.1)$$

RADON WAVELET TRANSFORM

1. Radon transform

Radon transform is based on the parameterization of straight lines and the evaluation of integrals of an image along these lines. Due to inherent properties of Radon transform, it is a useful tool to capture the directional features of an image [6] [7]. The classical Radon transform of a two variable function u is Ru defined on a family of straight lines. The value of Ru on a given line is the integral of u along this line [24]. Let the line in the plane (t, q) is represented as t = τ + pq (5.1) where p is the slope and t is the offset of the line. The Radon transform of the function over this line is given as (5.5) where N is the radius in pixels [33]. The Radon transform has been extensively used to extract the local features in edge detection, texture and fingerprint classification and image retrieval in computer tomography. In these approaches, images are divided into sub-blocks and minimum number of Radon projections as specified by equation 5.4 and equation 5.5 of each block is computed to derive the local features. However, these approaches are not computationally efficient (because of large dimensionalities) Facial features are the directional low-frequency components. Earlier studies show that information in low spatial frequency band plays a dominant role in face recognition. The low-frequency components contribute to the global description, while the high frequency components contribute to the fine details [6]. Radon transform preserves the variations in pixel intensities. While computing Radon projections, the pixel intensities along a line are added. Improves the spatial frequency components in a direction in which Radon projection is computed. When features are extracted using Radon transform, the variations in the spatial frequency are not only preserved but boosted also. With the proposed approach, global Radon projections for relatively less number of orientations (compared to number of projections stated by equation 5.4 and equation 5.5 achieve maximum recognition accuracy. It has been experimentally proved that the number of projections required to attain the maximum recognition accuracy is approximately one-third of that required for reconstruction. Discrete Wavelet Transform (DWT) applied on Radon projections derives multire solution features of the face images. Hence, the approach reduces the dimensionality and becomes computationally efficient. The advantage of the proposed approach is its robustness to zero mean white noise. Suppose an image is represented as

$f'(x, y) = f(x, y) + \eta(x, y)$ (5.6)

where $\eta(x, y)$ is white noise with zero mean. Then its Radon transform is

$R(r, \theta)[f'(x, y)] = R(r, \theta)[f(x, y)] + R(r, \theta)[\eta(x, y)]$ (5.7)

Being the line integral, for the continuous case, the Radon transform of white noise is constant for all of the points and directions and is equal to its mean value (if integrated over infinite axis), which is assumed to be zero. Therefore,

$R(r, \theta)[f'(x, y)] = R(r, \theta)[f(x, y)]$ (5.8)

However, this is not true for digital images because they are composed of a finite number of pixels.

2. Wavelet Transform (Multire solution features)

Wavelet Transform has the nice features of space frequency localization and multire solution. The main reasons for Wavelet Transforms popularity lie in its complete theoretical framework, the great flexibility in choosing the bases and the low computational complexity. Let L2(R) denote the vector space of a measurable, square integrable, one-dimensional signal.

EXPERIMENTATION AND RESULTS

The project work is implemented on i-5 system with 4Gb Ram. The Matlab 2008a is used for implementation and testing of algorithm. The four methods are implemented for the face recognition as Principal component Analysis, Radon Transform, Wavelet Transform, Radon Wavelet Transform.

Details of database

A database of OTCBVS colored face image is used for testing the algorithm. the database consist of 23 personnel and each having 3 photos. For the further experiments the Database of Face 94, Face 96 and AT and T are used.

1. Face 94 database consist of 150 subjects and 20 images per subject are given with different poses and expression on the faces with simple background.
2. Face 96 database consist of 72 subjects and 20 images per subject are given with different poses and expression on the faces and complex background.
3. AT and T database consist of 40 subjects and 10 images per subject

Results of face detection

The database is applied with the face detection algorithm for segmenting the face region from the complex background.

Principal Component Analysis

The detected colour face image is then converted to gray scale image as grey scale images are easier for applying computational techniques in image processing due to reduction in dimension and there is no colour space constraints are required to take into account. A grey scale face image is scaled for a fix pixel size as 24 _ 24 because different input images can be of different size whenever we take a input face from database for recognition.

Mean Face, difference face and covariance matrix

Mean face is obtained by equation. Then the difference image is calculated by equation and covariance matrix are calculated by using equation 4.7

1. Eigen Face

Calculate the eigenvectors µk and eigenvalues λk of the covariance matrix. find the weights for each image and save it in database. Threshold value of the test face image to Eigen face space which is Euclidean distance is taken minimum distance defines the matched image which classifies the face. The algorithms for face recognition was tested on OTCBVS database to compute recognition rate. The recognition rate for above proposed algorithms is carried out on the 23 personnel images. The recognition
rate (GAR) is calculated to 59 percent for 69 images. Thus the face recognition system using Principal Component Analysis and Eigen face approach is implemented successfully.

2. Radon Wavelet Transform

Table 1: Recognition Rate for Face Recognition

Algorithm	FACE 94	FACE 96	AT and T
Radon Transform	94	70.62	82.04
Wavelet Transform	92.79	67.50	79.30
RDWT	94.48	87.50	90.70

The Experimentation is done on the three databases namely Face 94 Face 96 and AT and T database. The detected Colour face image is then converted to gray scale image as grey scale images are easier for applying computational techniques in image processing due to reduction in dimension. The Radon Transform is the applied on the detected Face images. The feature vector is formed for each face. The similarity measure of Euclidian distance is applied for face recognition. The result for different databases are mentioned in Table 1. The Discrete Wavelet Transform is applied on the detected face images. The feature vector is formed for each face. The similarity measure of Euclidian distance is applied for face recognition. The result for different databases are mentioned in Table 1. The recognition rate is improved by cascading the Radon Transform and Discrete Wavelet Transform. First the Radon Transform is the applied on the detected Face images. The obtained feature vector is the processed with the Discrete Wavelet Transform to decompose up to the third level. The LL3 component is used for the feature vector formation for each face. The similarity measure of Euclidian distance is applied for face recognition. The result for different databases are mentioned in Table 1. For testing the Radon Transform, Discrete Wavelet Transform(DWT), Radon Discrete Wavelet Transform(RDWT) algorithm the databases are as mentioned below For experimentation we use Face 94, Face 96, AT and T(ORL) databases

1. Face94 which contains the 152 subjects and 20 images per subject
2. Face 96 which consist of 150 subjects and 20 images per subject
3. AT and T which contains the 40 subjects and 10 images per subject

RESULT AND CONCLUSION

Face recognition has been an attractive field of research for both neuroscientists and computer vision scientists. Humans are able to identify reliably a large number of faces and neuroscientists are interested in understanding the perceptual and cognitive mechanisms at the base of the face recognition process. Those researches illuminate computer vision scientists studies. Although designers of face recognition algorithms and systems are aware of relevant psychophysics and neurophysiological studies, they also should be prudent in using only those that are applicable or relevant from a practical/implementation point of view. Eigen-faces algorithm has some shortcomings due to the use of image pixel gray values. As a result system becomes sensitive to illumination changes, scaling, etc. and needs a beforehand pre-processing step. Satisfactory recognition performances could be reached by successfully aligned face images. When a new face attend to the database system needs to run from the beginning, unless a universal database exists. In this presented work, a approach to face recognition with Radon Discrete Wavelet Transform is presented. The method uses Radon Discrete Wavelet Transform for both finding feature points and extracting feature vectors. From the experimental results, it is seen that the method achieves better results compared to the Eigen-face methods, which are known to be the most successive algorithms. A new facial image can also be simply added by attaching new feature vectors to reference gallery while such an operation might be quite time consuming for systems that need training.

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