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IRIS RECOGNITION USING BLOOD VESSELS SEGMENTATION

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Abstract— Iris Recognition is found to be one of the most reliable and efficient technique for biometrics identification. In this paper iris recognition using blood vessel segmentation is proposed. After blood vessel segmentation, the segmented iris image is recognized using global texture features. The GLCM, Gabor and Local Binary Patterns are used for feature extraction. For iris recognition well known SVM,KNN and Naïve Bayes classifiers are used.. The performance of the system is evaluated on DRIVE, DRIONS, High Resolution Image Database and real time image databases. The system performs better for the combined features of GLCM, LBP and Gabor as compared to individually. The results of LBP are found to be more promising. This proposed approach of iris recognition using blood vessel segmentation is robust and secure and has the ability to recognize retinal images from the photographs of the known iris images. The system is more efficient in terms of accuracy as well as time complexity.
Keywords—GLCM, Gabor, Local Binary Pattern, Blood Vessel Segmentation, SVM,KNN, Naïve Bayes.

1. INTRODUCTION

For assurance of public security, various biometrics security techniques have been proposed such as face, iris, hand geometry etc. Among the all available biometrics recognition techniques, iris recognition is proved to be the most reliable and efficient technique. In iris recognition, retinal iris image is analyzed using color as well as texture features. Most of the earlier work ignores the application of microvascular network for iris recognition. The retinal blood vessels of iris has unique structure and these patterns are randomly distributed, which can be used for identification of human being.

In this paper, an iris recognition system is proposed based on blood vessel segmentation. Various texture features such as GLCM, Gabor and Local Binary Patterns are extracted from the segmented blood vessel image of the iris. This paper essentially has two prime goals: One of the important objective of this paper is to study the features of iris to investigate their variability of microvascular network depending upon different persons through proper texture features. Another important objective of this paper is to study the different texture based features for classification of the features.

Basic theme of the proposed work is iris recognition by using blood vessel segmentation of retinal image. The proposed system consists of five stages. The main objective is recognition of iris samples. The first step is data collection procedure where iris image samples are taken for further processing and data measurements. Second phase of this experimental study is to pre-process the iris image samples for a standard benchmark and most importantly removal of noises to obtain the enhanced noise free images. Third and one of the most important phases is blood vessel segmentation. Then fourth one is feature extraction. Here in this phase Gabor wavelet, Local Binary Patterns and GLCM texture based features from the enhanced images are extracted by computing. The well-known KNN,SVM and Naïve Bayes classifiers are trained using these features which are then further used for iris recognition.

2. RELATED WORK

In 1936 the ophthalmologist Burch suggested the idea of utilizing the iris in human identification. Aran and Flom in 1987 adopted Burch's idea of identifying people based on their individual iris feature. In 2004, J. Daugman applied Gabor filters to create the iris phase code, he registered excellent accuracy rate on different number of iris datasets. He used Hamming distance between two bits for phase matching [1].

In 2004, Son et al., used linear discriminant analysis (LDA), Direct Linear Discriminate Analysis (DLDA), a Discrete Wavelet Transform (DWT), and PCA and to extract iris features [2].

In 2007, R. Al-Zubi and D. Abu-Al-Nadin applied a circular Hough transform and Sobel edge detector in segmentation process to find the pupil's location. Also, Log-Gabor filter is applied to generate the feature vectors. This method achieved 99% accuracy rate [3].

In 2008, R. Abiyev and K. Altunkaya suggested a fast algorithm for localization of the inner and outer boundaries of iris region using Canny edge detector and circular Hough transform, also, a neural network (NN) was suggested for classification the iris patterns [4].

In 2011, the iris region was encoded using Gabor filters and Hamming distance by S. Nithyanandam [5].

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In 2012, Ghodrati et al. proposed a novel approaches for extracting the iris features sing Gabor filters. The Genetic algorithm was proposed to compare two different templates [6]. Gabor approach was more distinctive and compact on feature selection approach.
In 2013, G. Kaur [7] suggested two different methods using the Support Vector Machine (SVM). SVM results were FRR=19.8%, FAR = 0%, and overall accuracy rate = 99.9%. Choudhary et al. in 2013 [8], proposed a statistical texture feature depended iris matching method using K-NN classifier. Statistical texture measures include standard deviation, mean, skewness, entropy etc., K-NN classifier matches the current input iris with the trained iris images by computing the Euclidean distance between two irises. The system is tested on 500 iris images, which gives good classification accuracy rate with reduced FRR/FAR.
Jayalakshmi and Sundaresan in 2014 [9] proposed Kmeans algorithm and Fuzzy C-means algorithm for iris image segmentation. The two algorithms were executed separately and the performances of them were 98.20% of accuracy rate with low error rate.
In 2015, Homayon [10] suggested a new method based neural network for iris recognition. The proposed method is implemented using LAMSTAR classifier that utilized CASIA-v4.0 database. The accuracy rate was 99.57%.
In 2016, A. Kumar and A. Singh suggested a novel method for extracting the feature and the recognition was implemented on 2D discrete cosine transform (DCT). They applied the DCT to extract the most discriminated features in iris [11]. The patterns have been tested on two iris datasets; IIITD and CASIA v.4.0 for matching the iris phase using Hamming distance. The accuracy rate were 98.4% and 99.4% for IITD and CASIA V4 database respectively.

3. DEVELOPMENT OF THE PROPOSED SYSTEM

Proposed approach for Iris category recognition is divided in following steps
Prepare a database of known Iris image samples
Pre-processing (Noise removal using median filtering)
Feature extraction (Combine the features of GLCM, Local Binary Pattern and Gabor wavelet for better performance)
Classification/ Recognition (SVM,KNN and Naïve Bayes classification Algorithm)
Iris images classification using SVM,KNN and Naïve Bayes is a novel approach to measuring similarity between iris images and exploit it for iris recognition. We treat iris recognition in a SVM,KNN and Naïve Bayes classification framework as the problem of finding the stored prototype iris that is maximally similar to that in the query iris image.
Iris classification using blood vessel segmentation can be categorized in various steps as follows.
Pre-process the iris images to remove noise using median filtering.
Blood vessel segmentation from the iris images.
Building an offline database of GLCM, LBP and wavelets features of all training images.
Train the SVM,KNN and Naïve Bayes classifier using the computed features of the training data.
Pre-process the candidate iris image using median filtering to remove noise and obtain GLCM, LBP and Gabor wavelet features of the candidate Iris image.
Recognize the candidate iris image using SVM,KNN and Naïve Bayes classification.
The flow of the proposed system is depicted in figure 1.

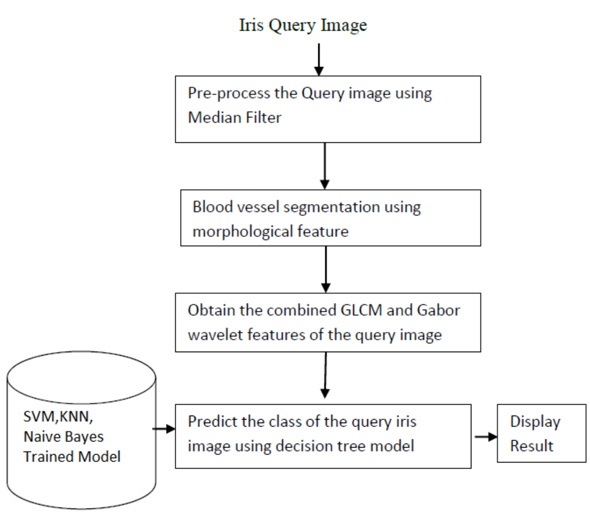

Figure 1: Proposed Iris Recognition system

3.1 Image Preprocessing

Digital images are greatly affected by various noise. While acquiring the image, noise is the unwanted signal introduced. The various types of noise are detected. When the noise is introduced in the image, the pixel vales of the image do not reflect their original intensity. Noise can be introduced in image in various ways. It depends in the way in which image is created. The median filter is used for reducing the noise from the image. It is mostly similar to mean filter.

Blood Vessel Segmentation

The noise free iris images are used for segmentation of blood vessels. The algorithm for blood vessel segmentation is as bellow-

Algorithm:

1. Read Image.
2. Resize image for easier computation.
3. Convert RGB to Gray.
4. Contrast Enhancement of gray image using adaptive histogram equalization.
5. Background Exclusion by using Average Filter.
6. Take the difference between the gray image and Average Filter Image.
7. Threshold the image using the IsoData Method.
8. Convert to Binary
9. Remove small pixels by using morphological open operation
10. Overlay the images

3.2 Feature Extraction

The global feature extraction of the segmented blood vessel images is performed. The various features of the segmented iris image such as Gabor wavelet features, GLCM texture features as well as Local Binary Patterns (LBP) are extracted, which are further used for iris recognition using SVM.

Gabor Features Extraction

We employed Gabor filters to extract textures of different sizes and orientations (i.e. Gabor-based texture feature). A Gabor filter is defined by a two-dimensional Gabor function, g(x, y):

$$g(x, y) = \left(\frac{1}{2\pi\sigma_x\sigma_y} \right) \exp\left[-\frac{1}{2}\left(\frac{x^2}{\sigma_x^2} + \frac{y^2}{\sigma_y^2} \right) + 2\pi jWx \right] \quad (1)$$

where σx and σy denote the scaling parameters of the filter in the horizontal (x) and vertical (y) directions, and W denotes central frequency of the filter.

3.3 GLCM Texture Features Extraction

The gray-level-co-occurrence matrix (GLCM) is a well-known statistical method for examining the textures which takes into account the spatial relationship of pixels. For representing the texture of the image, GLCM functions calculate the frequency of pairs of pixels having specified values and having specific spatial relationship. Then GLCM is created and statistical measures are extracted from matrix.

We have extracted four features – GLCM contrast, GLCM homogeneity, GLCM correlation and GLCM energy. GLCM contrast deals with measuring the variance in grayscale levels in the image. GLCM homogeneity deals with the similarity of grayscale levels across the image. Thus, if the changes in grayscale are larger, the GLCM contrast is more. Similarly GLCM homogeneity will be less. Finally, the overall probability of having distinctive grayscale patterns in the image is represented by GLCM energy measures.

3.4 LBP Feature Extraction

The steps involved in creating the LBP features are as follows:

Divide the examined window in to cells (e.g. 8x8 pixels per cell).

Considering each pixel in a cell, perform the comparison of each pixel to its 8 neighbors (on its left-top, left-middle, left-bottom, right-top, etc.) The pixels are followed along a circle, i.e. clockwise or counter-clockwise.

“0” is written when the value of center pixel is more than the value of the neighbor pixel. “1”is written in the other case. Thus 8 digit binary numbers is produced.

The histogram is computed, by calculating the frequency of occurrence of each number over the cell. (i.e., each combination of which pixels are smaller and which are greater than the center). Thus the feature vector of 256 dimensions is created in the form of histogram

The histogram is normalized optionally.

The normalized histograms of all cells are normalized. Thus the feature vector for the entire window is created.

Classification Using SVM

Once the features have been extracted, these extracted features are then used for iris classification using SVM. Support Vector Machines also known as Kernel Machines are a well-known and most accurate set of algorithms. The SVM is similar to bayes classifier in many ways. The SVM is comparatively difficult to train and slow to evaluate. But it is more accurate. If we increase the dimensionality of the data, it is very easy to separate the data.The N dimensional space is used by SVM where N is the number of samples in the training set. Due to this, SVM is able to classify data with arbitrary complexity. But the major drawback of this method is outliers. They are responsible for sabotaging the classifier easily.

Classification Using KNN

Knn pattern recognition, the k-nearest neighbors algorithm (k-NN) is a non-parametric method used for classification and regression.[12] In both cases, the input consists of the k closest training examples in the feature space. The output depends on whether k-NN is used for classification or regression:

In k-NN classification, the output is a class membership. An object is classified by a majority vote of its neighbors, with the object being assigned to the class most common among its k nearest neighbors (k is a positive integer, typically small). If k = 1, then the object is simply assigned to the class of that single nearest neighbor.

In k-NN regression, the output is the property value for the object. This value is the average of the values of its k nearest neighbors.

k-NN is a type of instance-based learning, or lazy learning, where the function is only approximated locally and all computation is deferred until classification. The k-NN algorithm is among the simplest of all machine learning algorithms.

Both for classification and regression, a useful technique can be to assign weight to the contributions of the neighbors, so that the nearer neighbors contribute more to the average than the more distant ones. For example, a common weighting scheme consists in giving each neighbor a weight of 1/d, where d is the distance to the neighbor.[2]

The neighbors are taken from a set of objects for which the class (for k-NN classification) or the object property value (for k-NN regression) is known. This can be thought of as the training set for the algorithm, though no explicit training step is required.

3.5 Classification Using Naïve Bayes

In machine learning, naive Bayes classifiers are a family of simple "probabilistic classifiers" based on applying Bayes' theorem with strong (naive) independenceassumptions between the features.

Naive Bayes has been studied extensively since the 1950s. It was introduced under a different name into the text retrieval community in the early 1960s,[13]:488 and remains a popular (baseline) method for text categorization, the problem of judging documents as belonging to one category or the other (such as spam or legitimate, sports or politics, etc.) with word frequencies as the features. With appropriate pre-processing, it is competitive in this domain with more advanced methods including support vector machines.[14] It also finds application in automatic medical diagnosis.[15]

Naive Bayes classifiers are highly scalable, requiring a number of parameters linear in the number of variables (features/predictors) in a learning problem. Maximum-likelihood training can be done by evaluating a closed-form expression,718 which takes linear time, rather than by expensive iterative approximation as used for many other types of classifiers.

4. DATASETS USED

Digital Retinal Images For Vessel Extraction: DRIVE Database

The DRIVE database[16] has been established to enable comparative studies on segmentation of blood vessels in retinal images. The photographs for the DRIVE database were obtained from a diabetic retinopathy screening program in The Netherlands. The screening population consisted of 400 diabetic subjects between 25-90 years of age. Forty photographs have been randomly selected, 33 do not show any sign of diabetic retinopathy and 7 show signs of mild early diabetic retinopathy. Each image has been JPEG compressed.

High Resolution Fundus (HRF) Image Database

This database [17] has been established by a collaborative research group to support comparative studies on automatic segmentation algorithms on retinal fundus images. The public database contains at the moment 15 images of healthy patients, 15 images of patients with diabetic retinopathy and 15 images of glaucomatous patients.

DRIONS Database

The DRIONS database [18] consists of 110 colour digital retinal images. Initially, it were obtained 124 eye fundus images selected randomly from an eye fundus image base belonging to the Ophthalmology Service at Miguel Servet Hospital, Saragossa (Spain). From this initial image base, all those eye images (14 in total) that had some type of cataract (severe and moderate) were eliminated and, finally, was obtained the image base with 110 images.

Real Time Images From hospital Dataset

We have obtained real time retinal images of 65 patients from the hospital

MMU Dataset

We chose to work with the Multimedia University (MMU) iris database [19], contributing a total of 450 images, 5 images per iris, 2 irises per subject. All images were taken using the LG Iris Access 2200 at a range of 7-25 centimeters. We chose this particular dataset over the others we found online for the following reasons:

1. It was free.
2. Due to some privacy issues, most iris datasets require lengthy registration processes, official paperwork, and administrative contacts. How- ever, we had no trouble acquiring this dataset within a few days.

3. Most datasets offer 3 or fewer images per iris. This particular dataset provides 5 images per iris, giving our machine learning algorithms some functional ease.

5. PERFORMANCE ANALYSIS

5.1 Dataset

Datasets used for evaluating the image enhancement techniques are
DRIVE Dataset (40 Instances)
DRIONS Dataset (110 Instances)
High Resolution Fundus Dataset (45 Instances)
Real Time Hospital Images Dataset (65 Instances)

5.2. Evaluations and Results

Performance of the following feature extraction techniques is evaluated using well known SVM classifier
GLCM Features
Gabor Features
LBP Features
Combined (GLCM+Gabor+LBP) Features
The effect of radon transform is evaluated on the performance.
Figure 2 shows the system developed for performance evaluation of various feature extraction techniques.

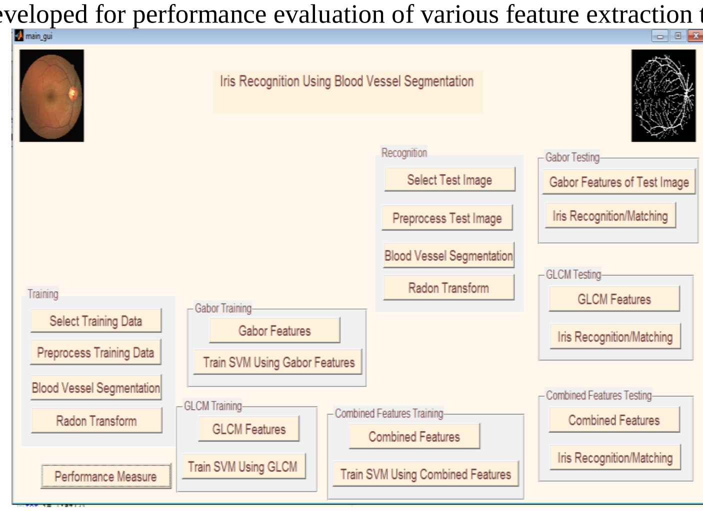

Figure 2: Performance Evaluation of Various Features Extraction Techniques

The performance of various feature extraction techniques using well known SVM classifier is depicted in table 1. The effect of radon transform on performance is also evaluated.

Feature Extraction		
DRIVE Dataset	40 Instances	
	Without Using Radon Transform	Using Radon Transform
Gabor	62.5	62.5
GLCM	90	100
GLCM+ Gabor +LBP	87.5	87.5
LBP	100	100
DRIONS Dataset	110 Instances	
	Without Using Radon Transform	Using Radon Transform
Gabor	83.8384	83.6735
GLCM	74.7475	98.9796
GLCM+ Gabor +LBP	93.9394	93.8776
LBP	90.9091	97.9592
High Resolution Fundus Dataset	45 Instances	
	Without Using Radon Transform	Using Radon Transform
Gabor	66.6667	66.6667
GLCM	73.3333	100
GLCM+ Gabor+LBP	88.8889	88.8889
LBP	97.7778	100
Real Time Images From hospital	65 Instances	

Dataset		
	Without Using Radon Transform	Using Radon Transform
Gabor	76.9231	76.9231
GLCM	81.5385	100
GLCM+ Gabor +LBP	92.3077	92.3077
LBP	100	100

Table 1: Performance Evaluation of Various Feature Extraction Techniques

As depicted in table 4, the radon transform can result in better recognition accuracy for GLCM and LBP. But the accuracy remains same for the gabor features as well as combined features. As analyzed from the results, the LBP gives higher classification accuracy, but GLBM when combined with gabor and LBP also gives better accuracy.
To evaluate the classification performance on various features, we have used the MMU dataset.

Table 2 shows the classification performance of SVM, Naïve Bayes and KNN classification.

	MMU Dataset		50 % Training
	SVM	KNN	Naïve Bayes
Gabor	73.7778	73.3333	83.3333
GLCM	68.8889	73.7778	63.1111
GLCM+ Gabor +LBP	74	78.8889	76
LBP	66.6667	92.4444	71.7778

The KNN classifier gives better performance for almost all features.

6. CONCLUSION

For iris recognition, we have performed the blood vessel segmentation. After segmentation of blood vessels, instead of considering the structure of the vascular pattern of the iris, we have considered the global texture features of the segmented blood vessels of the iris. In this proposed system, the person is authenticated using his own unique retina pattern. Though, the number of images used to evaluate the performance of the proposed system is not more, the performance of the system and the results are interesting. The GLCM, Gabor and LBP texture features are considered separately. For classification, we have used SVM, KNN and Naïve Bayes classifier. For the performance evaluation of DRIVE and HRF standard image dataset, iris recognition process is carried out by using blood vessel segmentation. Though the GLCM and Gabor features when considered separately, does not give promising results, the combined results shows more accuracy. The system has shown the outstanding performance using LBP features. To evaluate the performance of various classifiers, we have used the MMU dataset. The KNN classifier is found to be better as compared with SVM and Naïve Bayes.

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