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RESEARCH ARTICLE

Fast and Efficient Automated Iris Segmentation by Region Growing

Ms. Sruthi.T.K
Post Graduate Scholar, Department of Computer Science & Engineering, Nehru College of Engineering & Research Center, Thrissur, Kerala, India

sruthimenon48@gmail.com

Abstract— Remote human identification using iris biometrics has high civilian and surveillance applications and its success requires the development of robust segmentation algorithm to automatically extract the iris region. Here, a new iris segmentation framework based on region based segmentation has been employed, which can robustly segment the iris images acquired using near infrared or visible illumination. This approach exploits multiple higher order local pixel dependencies to robustly classify the eye region pixels into iris or non-iris regions. The experimental results provide significant improvement in the segmentation accuracy.

Key Terms: - iris recognition; biometrics; iris segmentation; region based segmentation; circular hough transform

I. Introduction

In the recent years, drastic improvements have been accomplished in the areas like iris recognition, automated iris segmentation etc. Iris recognition is a biometric recognition technology that utilizes the pattern recognition techniques based on the high quality images of iris. In comparison to other visual recognition techniques, the iris has a great advantage, that there is huge variability of the pattern between individuals, meaning that large databases can be searched without finding any false matches. An iris recognition system mainly uses infrared or else the visible light. The systems which are based on near infrared light (NIR) are very common because NIR will not generate reflections that makes iris recognition complex. But, NIR images lacks pigment coloration information, thus recognition algorithms must entirely depend on the patterns that are unrelated to color. Iris recognition which is based on visible light raise up pigmentation, thus the recognition systems will be able to exploit the color patterns, which make identification much easier. But the visible light reflections in these types of systems can result in an extensive amount of noise in the gathered images. A typical iris recognition system consists of mainly three modules. They are image acquisition, pre-processing stage as well as feature extraction and encoding. Many iris segmentation has been proposed till now. But each and every approach has its own advantages as well as disadvantages in the area of segmentation. Thus, here a new iris segmentation approach has been introduced which can robustly segment the iris portion using the technique known as region growing.

II. Existing Methods

Many iris segmentation approaches has been explored till now. Daugman introduced an Integrodifferential operator [1] for segmenting the iris portion, which is regarded as one of the most cited approach in the survey of iris recognition. It finds both inner and the outer boundaries of the iris region. Wildes introduced Hough transform [2], which constitute a major part in the iris recognition techniques. In this paper, in order to perform personal identification and also the verification, an automated iris recognition system has been examined as the biometrically based technology. This paper also defines the technical issues which are being produced while designing an iris recognition system. The technical issues involve three parts viz. while image acquisition, iris localization and also matching of the extracted iris pattern. Masek introduced an open iris recognition system [3] for the verification of human iris uniqueness and also its performance as the biometrics. The iris recognition system consists of an automated segmentation system, which localise the iris region from an eye image and also isolate the eyelid, eyelash as well as the reflection regions. This Automatic segmentation was achieved through the utilization of the circular Hough transform in order to localise the iris as well as the pupil regions, and the linear Hough transform has been used for localising the eyelid occlusion. Thresholding has been employed for isolating the eyelashes as well as the reflections. Now, the segmented iris region has got normalized in order to eliminate the dimensional inconsistencies between the iris regions. Proença *et.al* introduced Fuzzy K-means algorithm [4] in order to classify each and every pixel and then generate the intermediate image. A new iris segmentation approach, which has a robust performance in the attendance of heterogeneous as well as noisy images, has been developed in this. He *et.al* proposed a novel puling and pushing (PP) [5] procedure has been developed in order to accurately localize the circular iris boundaries. Thus, a perfect (accurate) as well as a rapid iris segmentation algorithm for iris biometrics has been developed in this. Tan *et.al* introduced a novel region growing scheme known as the eight-neighbor connection based clustering [6] has been proposed in order to cluster the whole iris image into different parts. Puhan *et.al* introduced a new segmentation method for noisy frontal view iris images which is captured with minimum cooperation based on the Fourier spectral density [7] has been developed in order to compute fourier spectral density for each pixel with the aid of its neighborhood and then executes row-wise adaptive thresholding, and thus results in a binary image which gives the iris region in a fairly accurate manner. Radman *et.al* states that, segmentation of iris is one of the most vital as well as difficult task in iris recognition. [1] and [2] are widely used for iris texture segmentation. But their computational time consumption is high. Time consumption is mainly required in order to recognize the initial centers of both iris as well as pupil circular boundaries. A simple solution for this problem has been given in this paper. Thus, circular Gabor filter (CGF) [8] has been utilized in order to localize the initial pupil center. Tan *et.al* unified framework approach [9] has been introduced, which automatically provide the localized eye images from face images for iris recognition. And also, an efficient post processing operations has been introduced in order to mitigate the noisy pixels which have been formed by the misclassification. All these approaches have its own advantages as well as disadvantages.

III. PROPOSED SYSTEM

The existing methods like iris segmentation using Circular Hough Transform is effective in segmenting the iris portion. But the segmentation accuracy should be improved. Thus a novel segmentation approach based on region growing has been provided. Region growing segmentation is a direct construction of regions. Region growing techniques are generally better in noisy images where edges are extremely difficult to detect**.** The region based segmentation is partitioning of an image into homogenous areas of connected pixels through the application of homogeneity criteria among candidate sets of pixels. Each of the pixels in a region is similar with respect to some characteristics or computed property such as colors, intensity and texture.

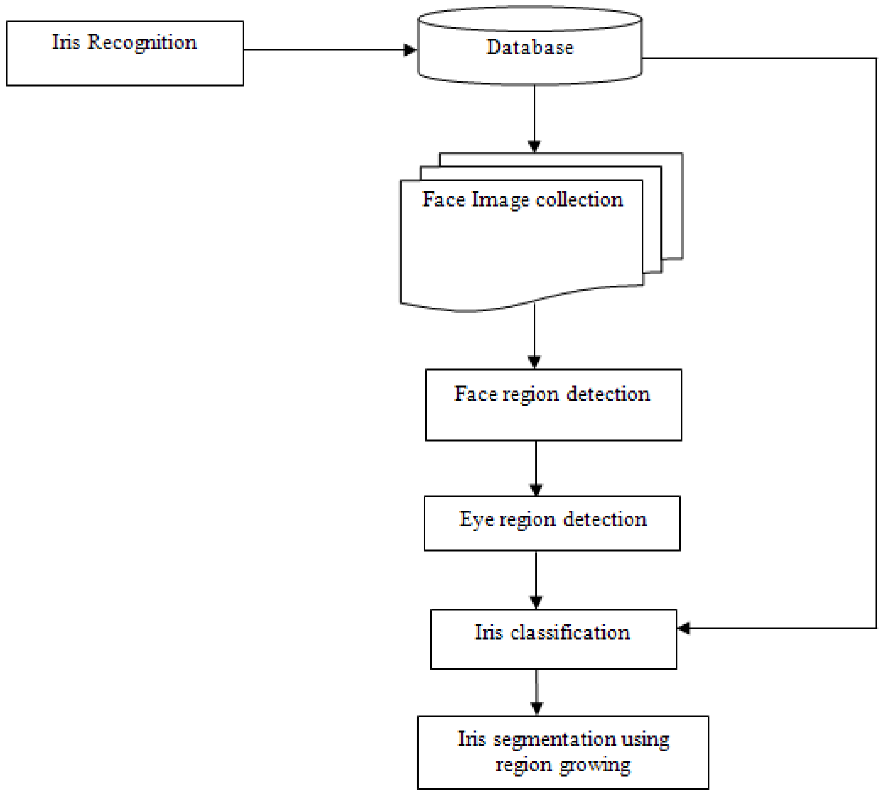

Fig. 1 System Architecture

A. Face and Eye Detection

Face detection is the most fundamental step for the research on image-based automated face analysis such as face tracking, face recognition, face authentication, facial expression recognition and facial gesture recognition. When a novel face image is given, the first thing to know is that, where the face is located, and how large the scale is to limit our concern to the face patch in the image and normalize the scale and orientation of the face patch. Usually, the face detection results are not stable; the scale of the detected face rectangle can be larger or smaller than that of the real face in the image. The eyes have salient patterns in the human face image, they can be located stably and used for face image normalization. The eye detection becomes more important when there is a need to apply model-based face image analysis approaches. Here, an automated segmentation of eye region images, from the given face images have been provided here, as locating eyes in face images is an important step for automatic face analysis and recognition. A hierarchical detection strategy has been adopted by firstly detecting the face region. Then, an eye-pair detector has been applied on the localized face region. The hierarchical detection approach improves the robustness to detect the eye region by confining the area of interest at each and every level. For face and eye detection, an AdaBoost-based face and eye-pair classifiers have been employed. The output from the AdaBoost based eye pair detector has been further advanced by classifying each eye into left or right eye category. The left or right eye classification is done by separating the width of the detected eye-pair region, as the first half as right eye and the second half as left eye.

B. Image Enhancement

Illumination variation poses the difficulties for both iris segmentation and recognition. The influence of the illumination conditions is even more noticeable when the acquisition is performed in the unconstrained environments using visible imaging. Although the problem has usually been addressed, none of the approaches provides the solution especially in the context of iris segmentation for images acquired in the unconstrained environments using visible imaging. Thus, for this reason, the advantages of single scale retinex (SSR) algorithm has been taken for improving color consistency regardless of illumination variation. Retinex is an image enhancement algorithm that is used to improve the contrast, brightness and sharpness of an image primarily through dynamic range compression. The algorithm also simultaneously provides color constant output and thus it removes the effects caused by different illuminants on a scene. It synthesizes contrast enhancement and color constancy by performing a non-linear spatial or spectral transform. The SSR is applied on the localized eye region for image enhancement prior to the feature extraction operation. SSR is actually an image enhancement algorithm, which is used to improve the contrast, brightness and sharpness of an image primarily through dynamic range compression. It also produces color constant output, and thus removes the effects caused by different illuminants on a scene. The SSR is defined for a point (x, y) in an image as:

$R_i(x, y) = \log I_i(x, y) - \log[F(x, y) * I_i(x, y)], i = 1, \ldots, S,$

where the sub-index i represents the i-th spectral band, S is the number of spectral bands, R (x, y) is the Retinex output and I (x, y) i is the input image distribution in the i-th spectral band. The symbol "*" denotes the convolution operation, F(x, y) is the normalized surround function.

C. Feature Extraction

In this module, Localized texture description based on Zernike Moments (ZMs) has been shown to outperform other alternatives in terms of noise resilience, information redundancy, and image representation. Therefore, ZM is used as the feature extractor to compute higher order local pixel dependencies in the local region. Zernike moments are the mappings of an image onto a set of complex Zernike polynomials. Since Zernike polynomials are orthogonal to each other, Zernike moments can represent the properties of an image with no redundancy or overlap of information between the moments. Also, the ZM provide the property of rotational invariance. The ZM have rotational transformation properties i.e., each Zernike moment merely acquires a phase shift on rotation. Thus, the magnitude of ZM of rotated image function remains identical to those before rotation. Here, the complete orthogonal and rotation invariance properties of the ZMs are effectively exploited in this segmentation approach for the noisy iris images acquired under visible illumination in unconstrained environments. To achieve translation and scale invariance, extra normalization processes are required. To compute the Zernike moments of a digital image, the range of the image should be mapped to the unit circle first with its origin at the image's center. The pixels falling outside the unit circle are discarded in the computation process. Thus, this segmentation approach works at pixel level by exploiting the localized ZM at different radii to classify each pixel into iris or non-iris category.

D. Training and Classification

The goal of classification is to find a generalized solution which can optimally separate the data into their corresponding classes or categories. Support vector machine (SVM) offers a computationally simpler model to obtain the solution which is global minimum and unique. SVM are supervised learning models with associated learning algorithms that analyze data and also recognize patterns used for classification and regression analysis. The basic SVM takes a set of input data and predicts, for each given input, which of two possible classes forms the output, making it a non-probabilistic binary linear classifier. Given a set of training examples, each marked as belonging to one of two categories, an SVM training algorithm builds a model that assigns new examples into one category or the other. An SVM model is a representation of the examples as points in space, mapped so that the examples of the separate categories are divided by a clear gap that is as wide as possible. New examples are then mapped into that same space and predicted to belong to a category based on which side of the gap they fall on. In addition to performing linear classification, SVMs can efficiently perform non-linear classification using what is called the kernel trick, implicitly mapping their inputs into high-dimensional feature spaces. This SVM classifier is trained with the same training images, which are independent from the test images. Features are extracted for each image pixel which forms a set of feature vectors. Very least amount of positive and negative training samples is used for training the SVM classifiers. Also SVM is less dependent on the training data and is fully determined by the support vectors. Classification of iris pixels is performed by using the trained classifier. Features are extracted for each pixel in order to form a collection of feature vectors. The set of feature vectors is fed into the trained classifier to induce labels such as iris or non-iris for each image pixel.

E. Postclassification Processing

The operations developed in this process play a vital role to further refine the classification results produced by the trained SVM classifier. The pixels classified by the trained SVM classifier often include noise resulting from false negative and false positive errors in the classification stage. Therefore, the robust postclassification processing steps are developed to mitigate the errors and improve the segmentation accuracy of the algorithm. This postclassification process involves several sub processes like Iris Center Estimation and Boundary Refinement, Eyelid Localization, Reflection Removal, Eyelashes and Shadow (ES) Removal, Pupil Masking. In Iris Center Estimation and Boundary Refinement, iris center is estimated by fitting a circle to an edge map generated using the classified iris mask which is firstly processed with morphological operations. There are two parameters required for the operation. They are initial iris center and range of radius, which both can be easily estimated from the classified binary iris mask B. The pixels in B which are fallen outside the best fitted circle are removed, resulting in a boundary refined iris mask. In Eyelid Localization, the estimated iris center and the radius r obtained in the previous step are employed here. The iris center serves as a reference point to partition the localized iris into upper and lower eyelid regions. In Reflection Removal process, the reflections occurred in the classified image has been removed. The reflection problems appear to be more challenging in unconstrained environments for visible imaging acquisition images due to multiple sources of the reflections. The dynamic nature of the reflection in visible imaging acquired images justifies that the reflection removal technique in previous approaches is not sufficient for capturing the reflection regions in unconstrained environments. For this reason, a relativity propagation reflection pixel detection approach has been introduced, which can robustly localize the reflection regions. In Eyelashes and Shadow Removal process, the intensity distribution of the classified or localized iris region has been exploited. The localized iris region is first divided into two sub regions, namely, ES region, and iris (IR) region. In Pupil Masking, localization of pupil region takes place. Accurate localization of the pupil region for VW acquired images is more challenging as compared to those for NIR acquired images. The image enhancement technique plays an important role to address this problem.

F. Region Growing

Region growing segmentation is a direct construction of regions. Region growing techniques are generally better in noisy images where edges are extremely difficult to detect**.** The region based segmentation is partitioning of an image into similar or homogenous areas of connected pixels through the application of homogeneity or similarity criteria among candidate sets of pixels. Region growing is a simple region based image segmentation method. It is also classified as a pixel based image segmentation method since it involves the selection of initial seed points. This approach to segmentation examines neighboring pixels of initial seed points and determines whether the pixel neighbors should be added to the region. Firstly, an initial set of small areas are iteratively merged according to similarity constraints. It starts by choosing an arbitrary seed pixel and compare it with neighboring pixels. Then, the region is grown from the seed pixel by adding neighboring pixels that are similar, increasing the size of the region. When growth of one region stops, and then simply chooses another seed pixel which does not yet belong to any region and start again. The main advantages involved in the proposed method is that, the region growing methods can correctly separate the regions that have the same properties. Also, these methods can provide the original images which have clear edges with good segmentation results. The multiple criterias can be chosen at the same time. It performs well with respect to noise.

IV. EXPERIMENTAL RESULTS

The experimental result given here illustrates that the proposed method using region growing provides comparatively better segmentation accuracy as that of the existing systems.

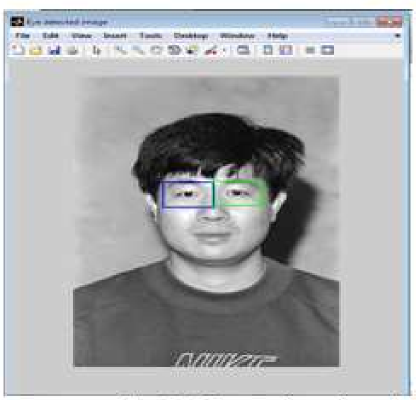

Fig. 2 a) Face and eye detection

Fig. 2 b) Enhanced Eye Image

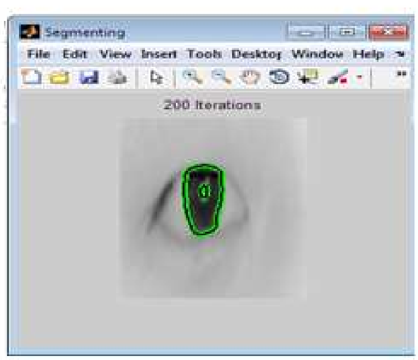

Fig. 2 c) Segmented iris image using region growing

The segmentation accuracy rate of both existing, as well as the proposed method has been provided in the given below diagram.

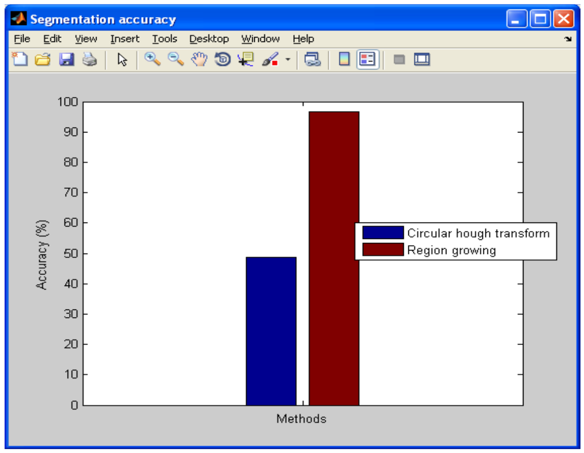

Fig. 3 Segmentation accuracy rate of existing and proposed system

V. CONCLUSION

Iris segmentation is probably one of the most crucial operations involved in iris recognition. Accurate iris segmentation is fundamental for the success and precision of the subsequent feature extraction and recognition, and consequently allowing the iris recognition system to achieve desired high performance. Three major procedures involved in the proposed iris segmentation approach, namely papillary detection, limbic boundary localization, and eyelids and eyelash detection, were carefully designed in order to avoid unnecessary and redundant image processing, and most importantly, to preserve the integrity of iris texture information. Besides its real-time applications, the proposed iris segmentation method is also intended to maximize correct iris segmentation rate whether occlusions on iris texture are severe or not. Such a quality makes the proposed approach less dependent, if not completely independent of employed optical cameras for iris image acquisition. The proposed segmentation approach using the region growing is simple but extremely robust in terms of being less sensitive to large variations of input iris images which can be applied to other similar eye images. Experimental results demonstrate that the proposed algorithm outperforms some well-known methods in both accuracy and processing speed.

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