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A Survey on Iris Recognition Techniques

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Abstract: **A biometric system provides automatic identification of an individual based on a unique feature or characteristic possessed by the individual. Iris recognition is regarded as the most reliable and accurate biometric identification system available. In this paper, we describe the novel techniques that are developed to create an Iris Recognition System, A recent survey of iris biometric research from its inception till now lists approximately 29 publications. This new survey is intended to update the previous one, and covers iris biometrics research over the period of roughly 2008 to 2015. Research in iris biometrics has expanded so much that, although covering only these years and intentionally being selective about coverage, this new survey lists a larger number of references.**

Keywords: **Biometric system, Iris Recognition.**

1. INTRODUCTION

Iris recognition is a method of identifying people based on unique patterns within the ring-shaped region surrounding the pupil of the eye. The iris usually has a brown, blue, gray, or greenish color, with complex patterns that are visible upon close inspection. Because it makes use of a biological characteristic, iris recognition is considered a form of biometric verification.

The main body of this survey is organized into the following sections:

1 - Iris Image Acquisition

2. - Non-Ideal Images and Quality Metrics

3 – Image Compression

4 - Iris Region Segmentation

5 - Texture Coding and Matching

6 - Applications

7 – Future Scope

2. IRIS IMAGE ACQUISITION

There are major research issues in the area of iris image acquisition. One issue involves imaging the iris with a sensor system that allows the person to be more “at a distance” and “on the move”. Matey and Kennell [20] present the issues involved in acquiring iris images at a distance of greater than one meter. Various acquisition issues including the wavelength of light used, the type of light source, the amount of light reflected by the iris back to the sensor, required characteristics of the lens, signal to noise ratio, eye safety, and image quality are discussed. Wheeler et al. [27] describe a prototype “stand-off” iris recognition system designed to work at sensor-to-subject distances of up to 1.5 m. The system uses two wide-field-of-view cameras to perform face location in the scene and an iris camera and illuminator to image the

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iris. Dong et al. [6] discuss the design of a system to image the iris "at a distance", allowing a standoff of 3 meters. Although current commercial iris biometrics systems all use near-infrared (NIR) illumination, and most research assumes NIR imaging similar to that used in current commercial sensors, Proenca argues for visible wavelength imaging as the more appropriate means to achieve "at a distance" and "on the move" imaging. Boddeti and Kumar investigate the use of wavefront-coded imagery for iris recognition. Boddeti and Kumar use a larger data set and present experiments to evaluate how different parts of the recognition pipeline (e.g. segmentation, feature extraction) are affected by wave front coding. Grabowski describe an approach to iris imaging that is meant to allow characterization of structures in the iris tissue over changes in pupil dilation. They use side-illumination, fixed to glasses frames worn by the subject, with imaging resolution that allows an 800-pixel iris diameter. This is many more "pixels on the iris" than in current commercial sensors. Chou describe an iris image acquisition system meant to handle off angle views of the iris and to make iris segmentation easier and more reliable.

3. NON-IDEAL IMAGES AND QUALITY METRICS

Another issue of image quality is important and complex. For our purposes, "non-ideal" means something more than just the presence of specular highlights or occlusion by eyelashes or eyelids. While it is not part of the image acquisition step per se, iris biometric systems typically evaluate the focus quality, and possibly other factors, of each candidate image in order to select usable images. Ren and Xie [22, 24] propose approaches to evaluating image focus quality that involve finding the iris region before computing the focus value. While iris biometric systems select images based in part on focus quality, there are few publications dealing with deblurring of iris images. Huang et al. [84] investigate image deblurring algorithms that exploit context specific to iris imagery. He estimate the user distance from the sensor in order to estimate the appropriate point spread function (PSF) for image restoration. They measure the distance between two specular highlights on the iris. Using this information, plus knowledge about the positions of the two infrared LEDs, they get the user's distance from the camera without using a special distance sensor. The knowledge of the distance from the sensor is used in estimating the PSF. Belcher and Du [3] combine percent occlusion, percent dilation, and "feature information" to create an iris image quality metric. To compute "feature information", they calculate the relative entropy of the iris texture when compared with a uniform distribution. To fuse the three types of information into a single score, they first compute an exponential function of occlusion and an exponential function of dilation. The final quality score is the product of the three measures. Kalka et al. [14] investigate a number of image quality factors, including percent occlusion, defocus, motion blur, gaze deviation, amount of specular reflection on the iris, lighting variation on the iris, and total pixel count on the iris.

4. IMAGE COMPRESSION

Daugman and Downing [5] present a detailed study of the effects of compression of the original iris image on the performance of iris biometrics. They present schemes that combine isolation of the iris region with JPEG and JPEG 2000 compression, evaluate their approach on images from the Iris Challenge Evaluation (ICE) 2005 dataset [23] and conclude that it is "possible to compress iris images to as little as 2000 bytes with minimal impact on recognition performance." Ives et al. [13] explore the effect of varying levels of JPEG 2000 compression, using the ICE 2005 dataset [23], and find that the false reject rate increases with increasing level of compression, but that the false accept rate is stable. Konrad aim to compress iris data without degrading matching results. They use JPEG compression on unwrapped polar iris images. They design and compare different quantization tables to use with the JPEG compression. Two of their tested Q-tables are designed to preserve more angular iris texture than radial iris texture (i.e. the horizontal texture in the unwrapped image). The other two Qtables are derived from the first two through genetic optimization. There is no clear winner among their tested Q-tables, and they conclude that custom Q-tables for iris recognition should be optimized to a specific target bitrate for best performance. Kostmajer apply compression to the original, rectilinear iris images. They propose custom JPEG quantization tables for iris recognition.

5. IRIS REGION SEGMENTATION

Publications related to segmenting the iris region constitute a significant fraction of the published work in iris biometrics. Many of these publications can be grouped as tackling similar versions of the traditional iris segmentation problem; e.g.,

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given one still image, find the pupillary and limbic boundaries. However, there are also a variety of approaches being explored to find occlusion by specular highlights and eyelashes, to segment the iris using less-constrained boundaries, and to refine initial segmentation boundaries. Iris segmentation algorithms that assume circular boundaries for the iris region continue to appear in some conferences. The current frontier in iris segmentation is generally now focused on removing the assumption of circular boundaries and on refining the segmentation to account for various occlusions and distortions of the iris texture. The use of the CASIA v1 dataset to evaluate iris segmentation algorithms is inherently problematic. This is because the images have been edited to have a circular region of constant intensity value for the region of each iris. Therefore, any segmentation algorithm built around the assumption of a circular region of constant dark intensity value should naturally meet with great success on this dataset, even though these conditions are generally not present in the iris region of real images. Wibowo and Maulana [28] evaluate an approach using the CASIA v1 data and their own dataset of 30 visible-light iris images. Labati et al. [18] propose methods to find the pupil center and then to find the inner and outer iris boundaries, presenting experimental results on CASIA v3 and UBIRIS v2 images. Kheirolahy et al. [15] propose a method of finding the pupil in color images, with experiments on the UBIRIS dataset. Pundlik treat the image as a graph where pixels are nodes and neighboring pixels are joined with edges, Their first goal is to assign a label - either “eyelash” or “non-eyelash” - to each pixel. After removing specular reflections, they use the gradient covariance matrix to find intensity variation in different directions for each pixel. Then they create a probability map, P, that assigns the probability of each pixel having high texture in its neighborhood. The “energy” corresponding to a particular labeling of the images is written as a function of a smoothness term and a data term. The data term is based on a texture probability map. The second goal was to assign each pixel one of four labels: eyelash, pupil, iris, or background. They use a method similar to the initial eyelash segmentation; however, this time theyuse an alpha-beta swap graph-cut algorithm. Finally, they refine their labels using a geometric algorithm to approximate the iris with an ellipse. Vatsa et al. [26] improve the speed of active contour segmentation by using a two-level hierarchical approach. Thompson and Flynn present a method of improving the recognition performance of iris biometrics by perturbing parameters of the iris segmentation. The perturbations generate a set of alternate segmentations, and so also alternate iris codes, which effectively result in an improved authentic distribution.

6. TEXTURE CODING AND MATCHING

Performing texture analysis to produce a representation of the iris texture, and the matching of such representations, is at the core of any iris biometric system. A large fraction of the publications in iris biometrics deal with this area. It is not necessarily straightforward to organize these publications into well-defined and meaningful categories. They are grouped here in a way intended to represent important common themes.

6.1 EXPERIMENTS USING THE CASIA V1 DATASET:

One cluster of publications compares different texture filter formulations and presents experimental results on the CASIA v1 dataset. The small size of the dataset and the many papers in the literature that report near-perfect performance on this dataset make it nearly impossible to use it to document a measurable improvement over the state of the art. Therefore, for space considerations, we do not cover this subarea of publications in this survey. Fatt et al. [9, 10] implement a fairly typical 1D log-Gabor iris biometric system on a digital signal processor (DSP), and show results on CASIA v1 dataset. Showing the relative speed of soft ware versus DSP implementations of an algorithm is an example of a context where using the CASIA v1 dataset may be reasonable.

6.2 “EIGEN-IRIS” APPROACHES:

One group of papers might be characterized, by analogy to “eigen-faces” in face recognition, as using an “eigen-iris” approach. Chowhan and Sihinde propose using PCA for iris recognition, in an eigen-face style of approach. Moravec also use a PCA-based approach, with color images of 128 irises. Zhiping et al. [29] use a 2D weighted PCA approach to extracting a feature vector, showingimprovement over plain PCA. Chen et al. [4] use 2D PCA and LDA, on UBIRIS images, showing an improvement over PCA or LDA alone. Eskandari and Toygar [8] explore subpattern-based PCA and modular PCA, achieving performance up to 92% rank-one recognition on the CASIA v3 dataset. Erbilek and Toygar [7] look at recognition in the presence of occlusions, comparing holistic versus subpattern based approaches, using PCA and

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subspace LDA for iris matching, with experiments on the CASIA, UPOL and UBIRIS datasets. Xu and Guo propose to extract iris features from the normalized iris image using a method that they call Complete 2D PCA.

6.3 ALTERNATIVE TEXTURE FILTER FORMULATIONS:

Many researchers have looked at different mathematical formulations of filters to use in analyzing the iris texture. Patil and Patilkulkarni use wavelet analysis to create a texture feature vector, with experiments on the CASIA v2 dataset. Velisavljevic experiments with the use of oriented separable wavelet transforms, or directionlets, using the CASIA v3 dataset, and shows that they can give improved performance for a larger-size binary iris code. Sun and Tan propose using ordinal features, which represent the relative intensity relationship between regions of the iris image filtered by multi-lobe differential filters. Krichen et al. [16] explore using a normalized phase correlation approach to matching, as an alternative to the standard binary iris code. They compare results to the OSIRIS and Masek algorithms, on the ICE 2005 and the CASIA-BioSecure iris datasets. Al-Qunaieer and Ghouti use quaternion log-Gabor filters to analyze the texture of images in the UBIRIS color image dataset, and also [11] use a quaternion Fourier Transform and phase correlation to improve performance. Bodade and Talbar [18] use a rotated complex wavelet transform in matching iris textures, with experimental results on the UBIRIS dataset, but do not improve recognition performance

over the Gabor wavelet. Tajbakhsh et al. [25] present a method of feature

extraction based on Ma et al.'s earlier method of analyzing local intensity variation [18], and propose four improvements to the earlier method to make it work with the noisy images in the UBIRIS data set. Tajbakhsh et al. [23] use a 2D Discrete Wavelet Transform applied to overlapping 32x32 pixel blocks, and achieve 0.66% EER on the UBIRIS data. The motivation behind Miyazawa's proposed method [21] is that Daugman-like, feature-based iris recognition algorithms require many parameters, and that their proposed algorithm should be easier to train.

6.4 ALTERNATIVE METHODS OF TEXTURE ANALYSIS:

Another group of papers explores texture representation and matching approaches that do not map directly to the typical texture filter framework. Gray level co-occurrence matrices (GLCM) can be used to describe texture in an image. A GLCM is formed by counting the co-occurrences of brightness values of pixel pairs in the image at a certain distance and direction. propose a modified GLCM based on looking at triples of pixels instead of pairs. They call their modified method a "3D-GLCM", and use it to describe the texture of iris images in the UBIRIS data set. Using equal error rate, the 2D-GLCM method performs better, but for a FAR of 0%, the 3D-GLCM performs better. Kannavara and Bourbakis explore using a local-global graph methodology to generate feature vectors, with experiments on color iris images. Sudha compute local partial Hausdorff distance based on comparing the edge detected images of two irises, obtaining 98% rank-one recognition on a UPOL dataset representing 128 irises. Kyaw explores using simple statistical features such as mean, median, mode and variance within concentric bands of the iris, but presents no experimental results. Wu and Wang use intensity surface difference between irises for matching and report relatively low performance on the CASIA v1 dataset.

6.5 ALGORITHMS THAT ANALYZE THE IRIS IN PARTS:

Several researchers have proposed approaches that analyze the iris region in multiple parts and combine the results. One motivation for this type of approach is to reduce the impact of segmentation errors and noise in the imaging process. Adam et al. [1] analyze iris texture in eight sub-regions of the iris and fuse the distances from these local windows, with experiments on data from the CASIA v3 dataset. Bastys et al. [2] divide the iris into sectors and calculate a set number of local extrema in each sector at a number of scales. They achieve perfect separation between genuine and impostor scores for CASIA v1 and CASIA v3 interval, an EER of 0.13% for the CASIA v2 data, and 0.25% for the ICE 2005 data. Garg propose a method that uses a grid on the iris image and a vector of the average pixel values in the elements of the grid for representing and matching the iris texture. skandari and Toygar explored subpattern-based PCA and modular PCA, achieving performance up to 92% rank-one recognition on the CASIA v3 dataset. Erbilek and Toygar look at recognition in the presence of occlusions, comparing holistic versus sub-pattern based approaches, using PCA and subspace LDA for iris matching, with experiments on the CASIA, UPOL and UBIRIS datasets. Lin et al. divide the iris area into four local areas and the face into sixteen local areas in their approach to iris and face multi-biometrics. Campos et al. [26] propose an alternative method of feature extraction. They apply histogram equalization and binarization to the unwrapped iris image, and use a Self-Organizing Map neural network to divide the binary image into nodes. From the topological graph of the image, they compute corresponding Voronoi polygons. Next they calculate the mean, variance, and skewness of the image in each polygonal region. They achieve 99.87% correct recognition on the Bath University iris data.

7. APPLICATIONS

Iris recognition, like facial recognition, is most often used for security-related applications. Some countries have implemented iris-recognition systems in airports, points of entry or exit, and government buildings. The technology has also been used to prevent unauthorized access of personal computers and mobile devices. A small, portable iris-scanning device is available for consumer use, bypassing the need for cumbersome password entry. Iris recognition applications are also available for the iPhone and other smartphones.

8. FUTURE SCOPE

The term "multi-biometric" is used to refer to techniques that use more than one biometric sample in making a decision. Often the samples are from different sites on the body; for example, iris and fingerprint Using multi-biometrics we can (a) increase the fraction of the population for which some usable sample can be obtained, and / or (b) increase recognition accuracy, and / or (c) make it more difficult to spoof a biometric system.

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