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Recent Advance Reviews In Biometric Recognition Using Human Iris

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ABSTRACT : *In this paper, a brief survey of the various research works which were carried out by various authors / researchers in the field of biometric recognition under constrained and unconstrained environments is being presented in a nutshell. The review / survey paper finds as a ready reckoner to various authors / researchers who want to do research in the field of biometrics using iris recognition so that once they understand the basics of the works done by various authors, they can formulate their own problem and start their research work and arrive at some new contribution in this exciting field of biometrics& also a part of the research scholar's Ph.D. thesis.*
KEYWORDS *-Biometrics, Iris, Authentication, Recognition, Identification.*

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I ORGANIZATION OF THE RESEARCH PAPER

The paper is organized as follows. A brief introduction about the iris recognition systems is presented in section II followed by the exhaustive summary of the research works presented by various authors in section III. The section IV concludes the paper with conclusions followed by the references& the author biographies.

II INTRODUCTION

Biometric plays a very important role in the identification of any human being in any type of work-place. A brief overview of the work done in the relevant field is conducted on the chosen Ph.D. research topic, "Design and development of efficient algorithms for IRIS Recognition system for different unconstrained environments" and the same is presented in the form of an exhaustive literature survey [1] – [30] in the following paragraphs. To start with, a large number of research papers in the relevant field were collected from various sources, studied @ length & breadth and a review paper is being presented in the form of this one such.

Iris recognition methods have been investigated and developed over the past decade & the most recent implementations have shown very reliable recognition rates under constrained environments. A majority of the previous iris recognition research was focused on the complete & clean iris images. The image quality was supposed to affect the performance of the iris recognition. Less constrained iris identification systems at a distance and moving images suffer from poor resolution and from poor quality of the captured iris images, which significantly degrades the iris recognition performance. The non-ideal iris images are defined to be the iris images with the problems such as acquisition angle, occlusion, and pupil dilation, image blurry and low contrast. Majority of the work were not done in this unconstrained environment context & the same is taken up as the research work under by us in this thesis.

Many works have been proposed on iris biometric recognition system for secure authentication till date. Majority of the researchers had worked on the recognition systems under constrained environments, in the sense that the camera should be pointing directly towards the eye, the person should be looking directly, there is no parallax, eyes should be wide open to capture the iris, good illumination should be there while taking the picture, etc….. But, very few of them have worked on the iris recognition systems under unconstrained environments, which is the topic of concern in our research work. Even if the algorithms developed in constrained environments work efficiently, they may or may not work efficiently for unconstrained

environments. It has to be noted that for unconstrained environments, many constraints need to be kept in mind for proper & accurate functioning of the system, which has been discussed in the earlier papers published by us.

III REVIEW OF THE WORK DONE BY VARIOUS AUTHORS

The following sequences explain how the researchers have contributed to the field of biometric authentication using IRIS along with merits and demerits of their proposed techniques in the recognition of iris under unconstrained environments (no constraints at all for taking the iris images) till date.

J. Daugman [1]-[5] the father of IRIS recognition had proposed numerous algorithms for recognizing persons by their iris patterns and they have now been tested in many field deployments, producing no false matches in millions of iris comparisons across the world. The recognition principle was based on test of statistical independence on iris phase structure, as encoded by multi-scale quadrature 2D Gabor wavelets. The combinatorial complexity of the phase information across different persons spanned about 249 DOF and generated a discrimination entropy of about 3.2 bits/mm2 over the iris, enabling real time (RT) decisions about personal identity with extremely high confidence, but the number of computations involved in the recognition process was very high.

J. Daugman's proposed a new iris model as two circles between the pupil and sclera limitations in many of his research paper [1]-[5]. The model was concentric in his case. Each circle was defined by using 3 parameters (xo, yo, r), where (xo, yo) was located in the middle of the circle of radius r. An integro-differential operator was used to estimate the 3 parameter values for each round boundary of the iris. The segmented iris photo was then normalized & converted from Cartesian image coordinates & then further into polar image coordinates.

The 2D Gabor filter was finally used to encode the iris photo to a binary code of 256 bytes. In his research work, the hamming distance was used to confirm the similarity of iris codes. Methodology gave good results, but failed in couple of cases due to noise like mirrored image in the photographs. Epigenetic randomness, complexity, and singularity of human iris patterns was presented by J.G. Daugman in his research paper in [5]. Like this, Daugman did huge works on iris recognitions (mainly on constrained environments), a number of papers are published by him, but in this context only the relevant ones are presented here in this thesis report [1]-[5].

Daugman's 1994 patent described an operational iris recognition system in some detail. In 2004 his new paper said that image acquisition should use NIR illumination so that the illumination could be controlled. NIR also helps reveal the detailed structure of heavily pigmented (dark) irises. The next step is localizing the iris from image. Daugman's approximated the pupil and iris boundaries of the eye as circles. So, he proposed an Integro-Differential operator for detecting the iris boundary by searching the parameter space. Because not all images of an iris are in the same size (e.g., the distance from the camera affects the size of the iris in the image, illumination variations and angle of the image capturing), Daugman proposed the rubber sheet model to normalize the segmented iris [1]-[5].

This model representing the iris using a fixed parameter interval in a doubly dimensionless pseudo polar coordinate system. The iris is remapped from raw Cartesian coordinates (x,y) to the dimensionless polar coordinate system, which consists of pairs of real coordinates (r,θ), where r is in the unit interval [0,1] and θ is an angle in $[0,2\Pi]$. This makes all irises have the same size and also simplifies subsequent processing. To extract the features from the normalized iris Daugman applied a 2 dimensional texture filter called Gabor filter to an image of the iris and extracted a representation of the texture, called the iris code [1]-[5].

Fancourt et.al. [6] discussed the hassle & the problems of the iris recognition by the usage of images received upto 10 meters away, i.e., not so good images / blurred / low resolution ones (unconstrained case). The pictures were captured with the help of a telescope. The manual iris segmentation was used as a bootstrap to the automated segmentation process to detect the iris of the human eye. The similarity between the gallery image and the probe photograph was measured by using the common correlation coefficient over sub-blocks with a size of (12 x 12) pixels. The disadvantage of this approach was the excessive execution and computation time required for the identification process.

Zhou [7] proposed a method that upgraded the traditional iris recognition system to work in non-ideal situations (unconstrained environments). The proposed method took into consideration not only the effect of image quality, but also the segmentation accuracy. He employed video-based IP techniques to quickly identify & eliminate the bad quality images from iris videos for further processing. The proposed method was tested on public databases using in-house recognition algorithms and also evaluated his work using a commercialized system.

Proenca H. in his research paper presented in [8] made a lot of continuous efforts in order to improve the robustness of iris coding methodologies, since the Daugman's work on iris recognition was already published and did a very good extension of Daugman's work. He showed that iris recognition could be used in several scenarios (airport check-in, refugee control etc.) with very satisfactory results. But, one of the drawback

in his work was, in order to achieve acceptable error rates several imaging constraints were enforced (considered/assumed), which reduced the fluidity of the iris recognition system. Because of this drawback, the algorithm worked in a constrained environment & failed in many of the unconstrained environments.

A high efficient biometrics approach for unconstrained iris segmentation and recognition was presented by Yu Chen in his Ph.D. thesis in [9]. Various unconstraint issues of the image iris was considered in his work & his method yielded fruitful results compared to the constrained ones. Chun-Wei tan & Ajay Kumar [10] provided a joint strategy that extracted and integrated each of the global and localized iris functions for accurate iris recognition from the distantly acquired face or eye photographs for each of the NIRs, that too under less confined environments-unconstrained case (subjected to less illumination, resolution, clarity, glare, blurr). For photo enhancement, the histogram and binarization concepts were used, while for coarse segmentation, random walker algorithm was used.

The authors used the iris bit-stabilization encoding and localized ZMs segment-based encoding to get better features of the iris. Their concept determined the matching data from the neighborhood vicinity pixels and for the capabilities w.r.t. the global areas. One of the drawback in their work was the neighborhood vicinity pixels were prone to distortion, while the global area parameters were solid. The hamming distance concept was used for finding the similarity of the iris functions. The main drawback of this methodology was the requirement of excessive time, price & area complexity for secure authentication.David & Borda in [11] developed a personal authentication technique using human iris recognition, which was very useful in crowded environments (unconstrained case). Sim Hiew Moi et.al. in [12] presented a unified approach for unconstrained off-angle iris recognition and tested the performance of off-angle iris recognition. We tested and evaluated the performance of the framework with four different iris datasets, consisting of iris images taken from different ethnic groups, under different environmental conditions, using image capturing devices with different specifications. But, they did not focus more on other non-cooperative iris images such as occlusions or images affected by flashlight and other environmental factors.

An efficient iris segmentation method in unconstrained environments was proposed by Shaaban A. Sahmoud & Ibrahim S. Abuhaiba in their research paper in [12] by capturing the iris images in visible wavelength. The algo (K-means clustering) which they had used reduced the error percentage even in the presence of types of noise, which included the iris obstructions and specular reflections. Also, the segmentation, accuracy, time of compilation was reduced in their case. UBIRIS database [70] was used by them as the input to their algo. The new algorithm proposed by them was to segments iris images captured in visible wave length under unconstrained environments in their research paper in [12]. The proposed algorithm reduced the error %age even in the presence of types of noise such as iris obstructions & specular reflections. To start with, they found the ROI of the iris using the K-means clustering algorithm, followed by the use of circular Hough transform to estimate the iris radius and center. An efficient algorithm was developed to detect and isolate the upper eyelids of the human eyes by removing the non-iris regions. They applied their algorithm on UBIRIS iris image data bases & demonstrated that it improved the segmentation accuracy and time, but the main drawback was it was assumed that both the iris and the pupil should have circular forms.

Peihua Li & Hongwei Ma [13] performed extensive studies on the iris recognition problems in the degraded iris images which were captured in non-ideal imaging conditions. They introduced a robust algorithm based on the Random Sample Consensus for localization of non-circular iris boundaries. The recognition performance was greatly improved with a very small number of filters selected. They conducted experiments on the UBIRIS-2 iris database and promising results were obtained by them, thus achieving gains in both computation and memory usage. But, promising results were not obtained when the iris images were severely degraded due to the off angle imaging, pose variation, image blurring, illumination changes, occlusion, and specular highlights [14].

Mahmoud Mahlouji1 & Ali Noruzi presented a human iris recognition system in unconstrained environments (localized with high precision, and with particular attention to the issue of low variations of illumination intensity) in which an effective method is proposed for localization of iris inner and outer boundaries in [15]. In this method, after pre-processing stage, circular Hough transform & Canny edge detection was utilized for localizing circular area of iris inner and outer boundaries. They experimented on the images available in CASIA database & show that their proposed method has an accuracy rate of 97.50 %.

A novel approach for iris recognition in unconstrained environment (no constraints are applied on the lightening environment and for the person whose eye image is taken) was worked upon by Navjot Kaur & Mamta Juneja in their paper in [16]. The authors proposed a fuzzy clustering C-means algo based technique used at the initial stage of iris segmentation & thus enhanced the accuracy of their iris segmentation stage. Accurate edge maps were generated by using canny edge detectors and circular Hough transform. UBIRIS iris database was used for performing experiments in their work. However, their method failed to detect the noisy iris images and more blurred images.

Yao-Hong Tsai presented a weighted approach to unconstrained iris recognition in his work in [17] & used an Adaboost algorithm by designing Gaussian functions according to the distance to the center of the iris & then he used local binary pattern (LBP) histogram to the texture classification. The methodology worked for few images, but could not work for large number of images. Kaushik Roy & et.al. [18] did extensive work on the unideal iris segmentation using region-based active contour model & processed the unideal iris images that are acquired in an unconstrained situation and are affected severely by gaze deviation, eyelids and eyelashes occlusion, non-uniform intensity, motion blur, reflections, etc.. & produced fruitful results.

The ability to extract the texture of the iris in non-cooperative environments from eye images captured at different distances, containing reflections, and under visible wave-length illumination was researched upon by a team of researchers comprising of Anis Farihan et.al. in their research work presented in [19] titled, "Feature extraction for different distances of visible reflection iris using multiscale sparse representation of local Radon transforms". This research was tested using 1000 eye images from the UBIRIS.v2 database. The results showed that the proposed method performed better than existing methods when dealing with iris images captured at different distances. But, they did not work on the combination of different scales with Hessian local text orientation, which would have lead to good iris recognition even in unconstrained environments.

Farmanullah Jan worked on the segmentation and localization schemes for non-ideal iris biometric systems in their survey paper in [20] & used the visible wavelength (VW) or NIR illumination while acquiring image data. This paper served as the ready reckoner regarding recent developments in non-ideal iris biometrics, supplemented with some in-dispensable prerequisites for beginners and professional researchers to start the work on iris recognition.

New iris recognition method for noisy iris images was proposed by Kwang Yong Shin et.al. in [21]. They used a 3-step algorithm, viz., to distinguish left-right eye, increasing the separatability b/w intra and inter-classes, using textural info of iris for classification along with HD. But, they didn't work on the detection of the medial canthus and the lateral canthus which would lead to improved classification accuracy of the left & right eye images.Gil Santos & Edmundo Hoyle worked on the fusion approach to unconstrained iris recognitions in [22]. They proposes a novel fusion of different recognition approaches and described how it can contribute to more reliable non cooperative iris recognition by compensating for degraded images captured in less constrained acquisition setups and protocols under visible wavelengths and varying lighting conditions. The proposed method was tested at the NICE-II (Noisy Iris Challenge Evaluation – Part 2) contest, and its performance was corroborated by a third-place finish. But, one of the drawback was it the methodology was more likely to be affected by strong variations in imaging conditions, thus producing globally unsatisfactory results.

Unsupervised detection of non-iris occlusions was worked upon by Michal Haindl & Mikuláš Krupiˇcka in [23]. The method was developed for color eye images from unconstrained mobile devices by the use of recursive prediction analysis & tested on the UBIRIS v2 eye database, which gave good results. But, the authors didn't generalize their algo for gradually changing (e.g., illumination, color, etc.) iris texture defect detections using adaptive learning capabilities & hence their methodology failed.

A study of how gaze angle affects the performance of iris recognition was studied by Mahmut Karakaya in [24]. They investigated how eye structures related to the iris recognition affected the performance of iris biometrics for different gaze angles and then they quantified the effect of gaze angle on the inter-class and using intra-class Hamming distance distributions. They showed that as gaze angle of the probe image increases, the Hamming distance scores increases in intra-class distribution. But, the performance degradation was caused by the existence of less area in the segmented off-angle image for normalization compared with frontal images, which was a drawback.

Soubhagya S.B. et.al. worked on the region based feature extraction from non-cooperative iris images using triplet half-band filter bank in their research paper in [25]. The authors proposed an energy based feature using a multi-resolution analysis (MRA) on the iris images, which was based on THBF bank & thus removed the noises in the eyelids & lashes showing superior performances w.r.t. FAR, GAR and AUC. But, it was observed that IDO resulted in segmentation failure on many iris images in all the 3 databases.

Hugo Proença & João C. Neves studied on the visible-wave length iris/periocular imaging and recognition surveillance environments & presented their work in [26] & addressed the feasibility of using data acquisition paradigm for imaging iris/periocular data with enough discriminating power to be used for that could be used for biometric recognition purposes by using fish eye lenses.Yang Hu et.al. proposed a novel iris weight map method for less constrained iris recognition based on bit stability and discriminability in [27]. The proposed iris weight map considers both intra-class bit stability and inter-class bit discriminability of iris codes. The experimental results demonstrate that the proposed iris weight map achieves generally improved identification and verification performance compared to state-of-the-art methods, but large databases was not worked upon.

Low-resolution (LR) iris images are inevitable, especially in the iris recognition systems under less constrained imaging conditions which are desirable to extend the applicability of iris biometrics. This was a challenging problem & was researched upon by Jing Liu et.al. in [28] & they presented a distance metric

learning for recognizing low-resolution iris images. A novel method of based feature extraction method for iris recognition under variable image quality conditions was proposed by Yuniol Alvarez et.al. in [29] & they used 3 detectors to identify distinctive key points, viz., Harris-Laplace, Hessian-Laplace and Fast-Hessian concepts & it was demonstrated that it could also work under extreme conditions if the database images were highly proper, but no info was presented if the database is not clear.

Kamal Hajaria et.al. in [30] worked on the neural network approach to iris recognition in noisy environment & proposed 2 algos, viz., a novel method for removing noise from the CASIA & MMU DB iris image set and second, a texture feature extraction method using a combined approach of Local Binary Pattern (LBP) and Gray Level Co-occurrence Matrix (GLCM) & their proposed approach gave highest recognition rate of 96.5% and low error rate and requires less execution time, but the drawback back was removing other noisy artifacts present on different databases such as PHOENIX, UBIRIS was not worked upon.

Some of the drawbacks [1] – [30] of the works that were carried out by the earlier researchers were considered in our research work, studied in brief & algorithms were developed in order to overcome some of the deficiencies of the existing algos. The research work is verified through effective simulation results in the Matlab & in LabVIEW environment in order to substantiate the research problem undertaken in our Ph.D. thesis.

IV CONCLUSIONS

A brief review of the various work done by various authors in their research papers is being presented in a nutshell in this research – survey paper w.r.t. iris recognition of biometric systems.

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