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Comparative Study of IRIS Boundaries Segmentation

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ABSTRACT

Biometrics allows an individual to be recognized and legitimate based on a set of identifiable and provable data, which is unique and explicit to them. During the authentication process we compare the data for the individual distinctiveness to that of individual's biometric "template", which was already stored in a database of a secured portal in order to establish authentication. It further depends upon the inconsistency in processing data which includes capturing process i.e. how data is procured, treated and handled/ sampled. So it is necessary to first analyze the process of capturing and sampling of the data to understand which identification system, suits the needed biometric quality. Despite the fact that number of definitions of quality exist, but because of need of time and processes, a particular interpretation of quality is needed. In this paper we try to present an review of different detracting features, definitions' and interpretations of qualities so that a comprehensible image of existing status can be presented by comparing features, strength and limitations of different biometric system. We further discussed the factors that control the features of biometric samples, which make the processes complicated. We tried to present different bottlenecks present in system design for various applications.

1. Introduction

Biometric in general describes as a process used for recognition. The processes have been rapidly recognized as the most relevant way of authenticating and identifying the persons in a trustworthy and quick way, through the use of exclusive biological feature. Thus we can say it is the science deals with analysis of physical or behavioral individuality to each individual in order to validate and confirm their individuality or we can say, the "measurement of the human body". Initially we can classify the technology of in to two ways. These are:

Physiological measurements which are morphological analyses (includes fingerprints, the features of the hand, and the finger, pattern of vein, the morphology and features of eyes, and the facial features) or biological exploration (includes DNA analysis, blood group analysis , urine & body fluids including salvia may be used by forensics & medical teams). Examples of systems based on physiological measurements are US-VISIT, UK-IRIS, UAE-IBASS, and India's Aadhar project.

Behavioral measurements which includes voice recognition system, signature and keystroke dynamics system which is based on pen's movement and external physical entities, the method we use pen or paper to write , writing gestures, etc. Still, the reliability level of system depends on the acquisition mode and method, for example Banking PSD2 system (Revised Payment Service Directive).

Since physiological measurements remains steady throughout the life of a person so we prefer it and use to identify the individual. This feature does not change with mental stress, environment, behavior, old age etc. So in this paper we will study the biometric systems based on Physiological measurements only.

2. Biometric System

In general any biometric system consists of three modules i.e. *sensor module, Feature extraction module, and decision making Module*.

Sensor Module includes recognition processes, defines the relation between human and the system, thus it is essential for the implementation of the biometric system.

Feature Extraction also includes Quality Assessment Module, the output data of the sensor module is processed and the extracted feature is stored as "template" in the database representing its identity.

Decision-Making Module consists of Matching sub Module for "verification", and "identification" processes. Here individual's identity is verified by comparing the input biometric data of an individual with the template, already stored in database.

Thus biometric systems not only maintain present technology but also improve it to deal with new challenges for example recognizing different patterns, in making system intelligent while using concepts of machine learning, and in measuring quality of given sample etc. During our studies, we found that the sample's quality is prone to irregularities during the recognition processes.

2.1 Deviation in quality

As input to biometric system are numbers of samples of a large collection of quality, so we need an effective quality assessment metrics to treat the challenge, and to measure these variations in quality, to get the desired results which is essential to an automated biometric system. So depending upon different definitions, large no of algorithms is designed to measure/deal with "Quality Assessment" as published in

literature [1-10]. The interpretation of these literatures is tabulated as Table1. We found from literature that noise, blur, and adverse illumination (called as environmental distortions factors), influence the performance of the algorithms.

Table 1: Literature survey of Biometrics qualities

Reference	Biometric system	quality used for design of biometric system
Chen et al. [3]	Fingerprint	Based on the concept of "strength of ridges".
Grother & Tabassi[4]		Automatic matching of images.
Youmaran and Adler[5]	Face	Increase in probability to identify the quality of given sample.
Kryszczuk et al.[6]		Conditionally relevant class predictors.
Beveridge et al.[7]		Predictor of performance using various quality features.
Kalka et al.[8]	Iris	Discus various degradations factors which affect recognition & matching iris.
Kumar & Zhang[9]		Assurance of generating dependable matching templates from user's data.
Poh & Kittler[10]	Framework	Quantity of data matching for recognition of given feature.
BioAPI[11]		Selection & Matching of biometric data that for better performance of system.

3. Quality Assessments

To collect high-quality data it is necessary to have Quality feedback mechanism during enrolment processes. A good system with feedback mechanism enables the user to maintain desired quality standards, and evaluate concurrently during the process of enrolment [12]. During the data capturing processes it acts as a technique to measure performance of designed system [13]. To reduce generation of false tags and mis-matching, feedback mechanism is employed during verification processes and because of it the efficiency of system increases. To increase further efficiency, verification is only done if the image has well defined quality and matching time is within limits during the process of data re-acquisition. To improve system usability and to reduce computational complexity we improve algorithm related to identification processes. Features used at different stages are:

- Preprocessing : The given sample of image may degraded due to "environmental conditions", so image restoration techniques is used to improve image quality by using correct parameters.
- Recognition: From literature [6, 10, 14-17] we found that quality estimation "scores" is used for processing and matching of the sample with data present in data bank.
- Context switching: In reference to the quality of the sample, we select different classifiers based on distance metrics we use "fusion algorithm" as illustrated in literature [17-19]
- Decision Quality: Decision-level fusion depends upon the assessment scores obtained above in step 2, which depends on the notion of strong or weak classifiers and value of distance metrics as discussed in literature [20-21].

4. Biometric Quality

The sensitivity of an image changes with respect to the application and the biometric system we want to use; so the sample quality (for matching) depends on the type of acquisition system and on the technology on which it is based. Factors that influence the system quality are:

- Behavioral traits which include emotions, mental pressure, fear, cooperation, and motivation levels;
- Physiological traits i.e. facial shape and features including hair, reflecting light;
- Unavoidable traits which includes old age problem, customs of society, physiology of genders, and injuries etc.;
- Operational technical constraints;
- Influence of environmental which includes temperate, quality of illumination, and humidity, etc; and,
- Training of handlers, technology they are using and system health.

Some possible factors that affect the sample quality are illustrated in table 2.

Table 2: Factors affecting quality of sample

Factors	Possible causes
User behavior	Stress, Mental pressure, fear, cooperation, motivation fatigue, distractions, makeup, appearance, facial features, clothes, etc.
Interactions & Environment	temperate, quality of illumination, and humidity, background, Indoor/outdoor view, and ambient noise
Operational	Feedback mechanism, sensor type, health of system, Familiarity, Training of handlers, technology and time between acquisition.

4.1 Affect on images due to Degradations

The degradation in biometric images are sub divided into two sub modules, these are image-based degradations and Biometric-modality-specific degradations *Image-based degradations:* It depends on the property of capturing devices, interaction with machine. The various types are:

- Blurring: It is due to incorrect focus, shaking of capturing devices, environmental conditions etc. Mostly it has an effect on "edge information".
- Illumination: light intensity is crucial for the capturing good quality of image, so the light intensity, brightness and luminance cause significant affects on the image quality.

- Noise: Due to environmental factors, light intensity, incorrect sensors, and transmission error a noise is introduced while capturing and processing of image, which significantly affects the performance of biometric systems.
- Distortions due to optics: The image gets distorted due to nonconformity in rectilinear projection, which is due to various interactions and environmental factors (such as quality of illumination, type of lenses and mirrors, background, indoor/outdoor view, source of light, and malfunctioning of sensors).

Degradation due to "Modality": It depends on the biometric features being captured. For example, some systems have multiple degrees of movement (such as iris and face) so the angle and distance at which we capture image can affect quality of image [22]. Some common causes of degradation of face image are facial hair, use of facial cosmetics, scars, or due to deformation in skin because of climatic conditions. Some quality can be easily measured while others are difficult, for example, the aesthetic changes of the face made by facial cosmetics, hair style, or art work.

4.2 Images Quality

The quality of image depends on the health of biometric samples and the way image is captured, the different features which affect image quality are:

- Orientation of image: The performance of system depends on the edge information; blurring, Quality of optics, illumination, and noise degrade the edge information. Hence, the sharpness of edges/boundaries provides a health of a biometric sample.
- Power spectrum: The power of the image signal provides information about the quality of an image and the region in which it is present. So, spectral energy is used to identify image regions to obtain local assessment about image.
- Intensity statistics: It is the statistical method based on the estimation of intensities of pixels. The measured values obtained are compared with the reference values taken from the ideal images to work out the degree of degradation.

5. Quality Assessments

Numerous techniques have been predicted in literature to assess the affect of degradation in quality of a biometric sample. Here, we present a literature survey of "quality assessment algorithms" related to three popular technologies, i.e. fingerprint, iris and face.

5.1 Fingerprint Assessment

The degradation in system or its efficiency to recognize the fingerprint depends upon the quality of fingerprint images and depends upon edge boundaries and power spectrum analysis. A detailed review of various assessment techniques is presented as a tabular form in Table3

Techniques	Algorithm	Description
Power spectrum method	Chen et al.[3]	Spectral energy is used to identify image regions to obtain local assessment.
Pixel intensity model	Chen et al.[23]	Depends on distribution of Grey level segmented ridges.
Wavelet Model	Vatsa et al.[24]	Depends on RDWT & edge information
Combined features	NFIQ[25]	To model valid ridges author use variation in frequency, amplitude, etc.
Tensors Model	Fronthaler et al.[26]	Used parabolic symmetry features with Encoded orientation.

5.2 Iris quality

The degradation in system or its efficiency to recognize depends upon the quality of the sample. The different covariates include motion blur and focusing, dilation, off-angle, constriction, occlusion and resolution. A detailed review of various assessment techniques is presented as a tabular form in Table 4

Table 4

Category	Algorithm	Description
Combined features	Kalka et al.[9]	Based on fusion algorithm, used seven quality parameters.
	Daugman[27]	Uses Focus estimation and off-angle measuring technique.
Power spectra	Chen et al.[28]	Depends on spectral energy.
Combined features	Zuo et al.[29]	Quality used are interlacing, focus, off-angle, illumination,, blurring.
Combined features	Proenca.[30]	used seven quality parameters

5.3 Face quality assessment

The detailed review of various assessment techniques is presented as a tabular form in Table5.

Table 5: A list of face quality assessment algorithms

Application	Algorithm	Description
Still-image	Youmaran and Adler[5]	Use information coding theory
	Subasic et al.[31]	*ICAO* face images with Seventeen features for testing
	Hsu et al.[32]	Used ISO/JEC 19794-5 face standards
	Gao et al.[33]	Used LBP features to measure image features

	Zhang et al.[34]	Uses SIFT features
Video-frame	Wong et al.[35]	Evaluation of a *ideal (reference)* face with image.
	Nasrollahi & Moeslund[36]	Uses "face bounding box model"
	Long et al.[37]	Uses resolution, brightness, roughness, and pose.
	Yao et al.[38]	Based on boundaries/edge method.
	Nasrollahi & Moeslund[36]	Based on Geometrical pose estimation method

6. Iris Boundaries Segmentation

Here, using graph theory we presented the model for boundary segmentation of iris. The designed algorithm based on hierarchical approach and subdivided in two steps, i.e. 2-level. Starting pupil segmentation in step 1, and followed by the limbic segmentation (boundary). The segmentation process is further sub divided into two sub processes using Newton-Rapson scheme integrated with initial boundary value approximation followed by boundary segmentation processes. The advantage of the designed algorithm is that it can track and rectify the errors generated during initial processes and reduce the rate of failure. Figure 5, shows the block diagram of the designed algorithm. Initiating with pupil boundary value approximation using circular Hough transform followed with refining the obtained value based on GCBAC model. After segmentation processes, we apply same process to segment the iris limbic boundary. The designed model reduces processing time and improved performance compared to other methods. The final segmentation of the iris boundaries is carried out in the following steps.

1. Set the index to $i = 0$.
2. On obtained image initialize a contour C.
3. Dilate the current contour C_i into its neighbourhood contour $CN(C_i)$.
4. Identify initial contour C, source S_1 and sink t_i, respectively.
5. Using new boundary conditions Compute the S-t min cut.
6. Terminate the algorithm if the resulting contour c reoccurs, otherwise set I = I + 1, and return to step 1.

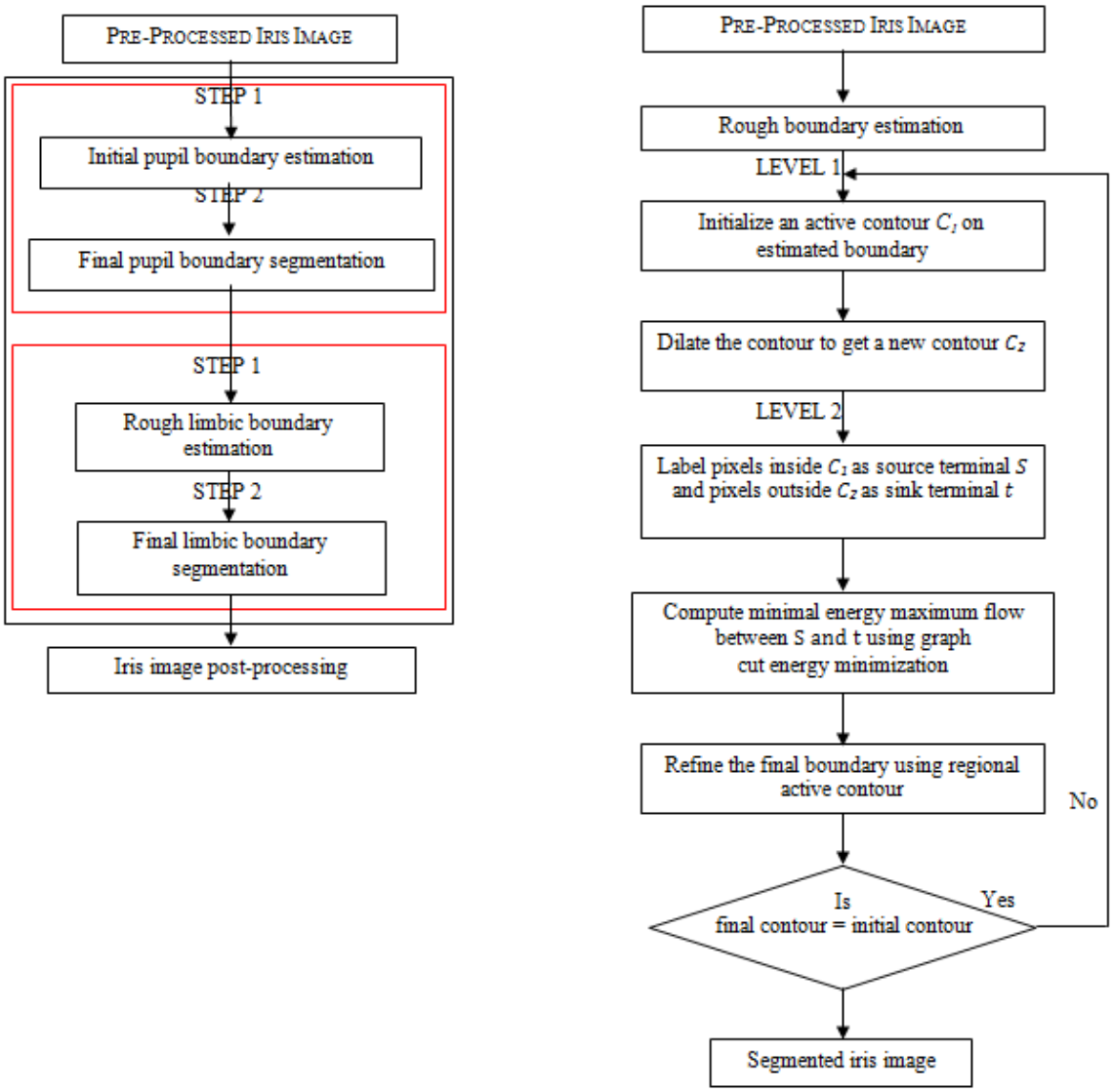
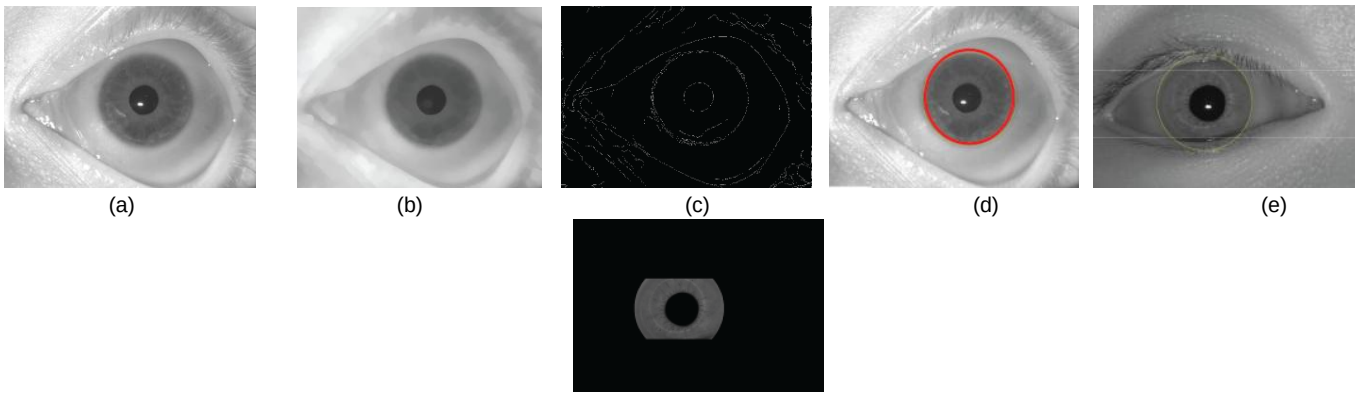


Figure 1: Block diagram illustrating the 2-level hierarchical segmentation approach for the iris inner and outer boundaries of the iris. (a) The 2-level hierarchical pupil and limbic boundary segmentation process. (b) Detailed block diagram showing the segmentation process at each step.

7. Experimental Results

Our performance which is better than that compared with characteristically features of others, we find difference in image quality. The results are shown in sequential manner in figure 2. The binaries behavior of original grayscale images of iris, which is used for further segmentation of iris and for the processes.



(a) (b) (c) (d) (e)

(f)

Figure 2: Segmentation of Iris using regional active contour model: (a) original iris image, (b) pupil detection using regional energy based active contour, (c) iris detection using regional energy based active contour (d) pupil segmentation using active contour based on level-set method, (e) complement of the iris image showing the pupil candidates, (f) segmented pupil.

The results obtained are compared with the research work published in literature is described in Table 6. The features of human iris images and accuracy has been derived after enhancing the quality of different subjects obtained from the CASIA data source [7].

Table 6 Recognition accuracy with different feature vector on CASIA image database

Methodology	Accuracy (%)	False acceptance rate (%)
SVM with Haar	91.33	8.66
Hamming distance	99.60	0.33
Proposed work 1	94.76	5.21
Proposed work 2	94.76	5.22

8. Conclusions

The evaluation of samples and complex algorithm are the bottle neck to develop new systems for the biometrics research community. In this paper, we tried to discuss various approaches used by researchers to design biometric system.

In this paper we try to present an review of different detracting features, definitions' and interpretations of qualities so that a comprehensible image of existing status can be presented by comparing features, strength and limitations of different biometric system. We further discussed the factors that control the features of biometric samples, which make the processes complicated. We tried to present different bottlenecks present in system design for various applications.

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