Review on the proportional study of segmentation techniques for iris acknowledgment

Divya C D\textsuperscript{1} and Rajendra A B\textsuperscript{2}

\textsuperscript{1}Dept of CSE, Vidyavardhaka College of Engineering, Belgaum, India
\textsuperscript{2}Dept of ISE, Vidyavardhaka College of Engineering, Belgaum, India

E-mail: divyaed@vvce.ac.in, abrajendra@vvce.ac.in

Abstract. Biometrics is one of the fields that are emerging now a days, Iris biometrics was found to yield better consequences on account of persistency, accuracy and security. Iris is a thin, annular arrangement that is existing in the eye, which is colored slice of the eye that controls the extent of the pupil. In this paper we are going to review different techniques that are applied to segment the iris region from the eye along with the available databases using which we will be able to fetch the image of the iris from different categories.

Keywords: Hough Transform, Integro differential operator, Segmentation, Fuzzy Clustering.

1. Introduction

Biometrics is one of the fields that is emerging now a days. It is well known for its security applications. When we say the word Biometrics, it may be either physiological or behavioral biometrics. Pertaining to physiological biometrics we have Iris, Fingerprint and Face Biometrics as three major types. Out of these three types, Iris biometrics was found to yield better consequences on account of persistency, accuracy and security. Iris is a thin, annular arrangement that is existing in the eye, which is colored slice of the eye that controls the extent of the pupil. The pattern and assembly of two irises is inherently linked but the particulars of patterns are not. They have stable and distinctive features for personal identification. They are almost steady with age factor. It is enormously enhanced data assembly consisting of large number of features. It is surgically impossible to modify the iris structure. In this paper we are going through the databases that are available for study of Iris biometrics and also methods involved during segmentation of iris by removing unwanted aspects such as eyelid, eyelashes. Along with that we just got to know the major and the best methods that are basically used for the segmentation of iris form the eye.
2. Basic structure of Iris

Iris contains two layers which are front pigmented fibrovascular layer called as stroma, beneath stroma, there exists epithelial cells which are pigmented. Stroma is linked to sphincter muscle, where pupil and dilator muscles pulls the iris in a radial manner to expand pupil. The iris inner circle circumference alters size during constriction or dilation whereas outer larger circumference of the circle will not vary. The constricting muscle is located on the iris inner smaller circle-circumference. Rear surface is enclosed by a severely pigmented epithelial layer consists of two cells that are thick, whereas anterior surface does not contain epithelium. External edge of iris, which is identified as root, is dedicated to sclera and anterior ciliary body. Iris along with ciliary body is called as anterior uvea. Anterior part of the iris region is referred as trabecular meshwork, using which aqueous humor continually drains from the eye, if there is any disease that is pertaining to eye. Irises with anterior ciliary body offers minor passageway in order to aqueous humor from the eye. Division of iris is considered into two regions namely pupillary zone which is called boundary of the pupil and ciliary zone extends the remaining portion of the iris extends its beginning at ciliary body.

3. Database available for Iris

3.1. Bath Iris Database
This is the that is used as an example for NIR images databases [43]. Which was created by Bath University with the help of Smart sensor limited. It contains 32,000 enhanced iris images, which are taken from 800 diverse traditional subjects (1600 classes, left as well as right eye) including resolution (pixel) 1280×960.

3.2. MMU Iris Database
Multimedia University has offered databases [44]. Initial one used is MMU1 containing 450 images, taken with the help of a semi-automated and dedicated camera capturing irises at 7-25 cm distance, and latter one is called MMU2, which contains 995 images, captured using Panasonic (BM-ET100US) Camera with a distance range of 47-53 cm from human focus. Images are obtained from 100 volunteers, belonging to varied ages as well as nationalities, individual volunteer giving 5 images from every eye.

### 3.3. UPOL Database

UPOL, called by the name University of Palackeho and Olomouc [46], is the primary one among the databases which made use of framework of imaging through visible wavelength source of light. It comprised of 384 images which are captured from 64 individuals, with every subject giving 6 images (3 left as well as right eye) with a suitable camera attached to an optical device for capturing irises, along with a certain resolution of 24-bit color distance. UPOL iris database [10] images were taken at a nearby distance with human collaboration. Output contained enormously free of images with homogeneous appearances, making this database not suitable particularly for testing unrestricted acknowledgment algorithms.

### 3.4. ICE Database

National Institute Of Standards and Technology called NIST achieved project underneath the tag of Iris Challenge Evaluation [45] to progress and improve iris acknowledgment technology which provisions existing iris acknowledgment schemes in US government. The advances in the approach were prepared by issuing the glitches familiarized by stimulating iris recognition schemes to potential applicants. Later, NIST enabled the chance for cooperation among participants in enormous rules and autonomous estimation for challenging the algorithms on a novel superior database by making use of their individual frameworks. It consists of 2954 images, assimilated with expression as well as stair, nearby distance and Near Infrared light source restrictions. It also presents standard noise issues associated with reduced effort and obstruction of eyelashes. These images found to be not suitable for the assessment of unrestricted iris acknowledgment systems.

### 3.5. CASIA Iris Database

Iris database available for free of cost, created by Chinese Academy of Science - Institute of automation, addressed as CASIA [47]. CASIA databases of iris employ ideal acquisition atmosphere, with halt and gaze, at nearby distance using Near Infrared sources of light that simulates same conditions, used by
Daugman’s iris recognition system. This database had produced four forms of CASIA databases CASIA V1, V2, V3 and V4 for iris.

3.6. UBIRIS Database

Reason existing behind creating of UBIRIS database [48] is the requirement of a novel noisy images of iris dataset that simulates less controlled environment in the capturing framework considering it to be a tool for growth of healthy recognition. This database is called the noisiestone that familiarizes novel noise factors produced by rotated images from subjects, less focus images, obstacle of eyelids as well as eyelashes, specular as well as light reflection from lightsource that makes it visible, and finally iris images of closed eye. The above noise factors enables database suitable for the expansion of unrestricted iris acknowledgment algorithms. In 2010, University of Beira presented another variety of UBIRIS database which is called UBIRIS.v2 [49] database of iris, that is called as a multisession database of iris that comprises of images taken at a distance of 4 to 8 meters, Artificial source made of visible wavelength light, is also a motive in this database.

| Database | Noise Attributes |
|----------|------------------|
|          | Using Eyelashes  |
|          | Using Eyelids    |
|          | Reflection - Specular |
|          | Reflection - Light |
|          | Indistinct Motion |
|          | Reduced Focus    |
|          | Diverged Gaze    |
|          | Partly Obstructed |
|          | Out Of Iris      |
|          | Over Distance    |
|          | On The Move      |
|          | Rotated          |
|          | Glasses          |
|          | Visible Wavelength |

Table 1. Comparison of Databases.
4. Review of the approaches for Segmentation of Iris

| Reference | Technique/Method                                                                 | Database               | Observations                                                                 |
|-----------|----------------------------------------------------------------------------------|------------------------|-----------------------------------------------------------------------------|
| [1]       | Placing the contour of iris in the space by making use of active ellipse which is robust | 327 monochrome test images were captured based on the iris occlusion, blur, stare, color of the skin, eye shape and also with and without spectacles | Integration of stereo constraints is considered here in different location transforms. |
| [2]       | Coarse iris localization scheme based on clustering to excerptirregular position of the iris. Novel integro-differential Constellation is then assembled for localizing pupillary as well as limbic boundaries. Rank filter which is horizontal in 1D, model for curvature of eyelid have been agreed to deal with eyelashes, shape abnormality. Eyelash as well as shadow obstructions are noticed through prediction model (learned) on the basis of statistics of intensity among different regions of iris. | UBIRIS                 | Eyelash and shadow obstructions can be noticed by making use of processes among dissimilar iris regions. |
| [3]       | Limbic Boundary algorithm for localization associates clustering by K-means based on Gray level Co-Occurrence Histogram along with the improvised Hough transform, Detection of eye using Adaboost algorithm. Upper eyelid recognition methodology is accessible, by combining Parabolic Integro-differential Operator, Random SAmple Consensus like technique by utilizing edges noticed by edge detector(1D). | UBIRIS, v2             | Eyelash detection can be handled, developing Algorithms (parallel) so that software will execute live. |
| [4]       | GLCM(Grey level Cooccurrence Matrix)method is used while                          | CASIA                  | Uneven lighting and imperceptible                                            |
| Reference | Methodology | Dataset | Additional Comments |
|-----------|-------------|---------|---------------------|
| [5]       | AdaBoost for detection of eye, so as to recompense for detecting iris inaccuracy produced by means of two edge (circular) finding operations. Color segmentation is used to notice obstructions by flashing effects of visible light. | UBIRIS.v2 | Color Segmentation arrangement can also be useful to images of iris which are taken with near IR light. |
| [6]       | Based on pixels labeled by the user, Image is divided automatically by using Cellular Automaton in an iterative process. | DICOM Image Samples | Automatic Segmentation of Images. |
| [7]       | Histograms Of Oriented gradients descriptor and support Vector machine is used for segmentation | UBIRIS.v2 and MICHE, NICE II iris databases | Segmentation Accuracy can be improved to still greater extent |
| [8]       | Active contour model to precisely sense the boundaries of pupil. | CASIA | Detection of limbus boundaries in presence of Eyelids and Eyelashes |
| [9]       | Integro-differential (ID) operator by Daugman is used for Segmentation | CASIA | Better evaluation of Iris recognition and evaluation schemes can be done on color images captured from the mobile devices. |
| [10]      | Integro-differential operator by Daugman and Hough transform are used for finding circles, and another method based on the study of the edge points distribution. | MMU Iris Image Database. | Combination of Daugman's integro-differential operator with any other method can be checked to yield better results. |
| [11]      | Daugman's ID Operator, Hough transform is used for segmentation of iris | CASIA Iris V3 | Applying the same methodology with other databases as well |
| [12]      | Iris texton features used as effective and robust in anti-counterfeit iris. Textural features were extracted by making use of grey level co-occurrence matrices | CASIA AND BATH | Usage of Daugman's method for iris with the contact lenses as well. |
| [13]      | FCN based segmentation was used for endwise iris acknowledgment application. | CASIA | Adapting active contour for Irises which are not circular by making use of active contour. |
| [14]      | OSIRIS (open-source academic matcher) outfits the principles of novel concept of Daugman, | Database of iris videos taken in Near Infrared | More automatic techniques can be explored |
including Iris segmentation by making use of Circular Hough Transform, successive fine-tuning with active contour.

| Reference | Method Description | Dataset | Note |
|-----------|--------------------|---------|------|
| [15] | Active contour method was used for segmentation | Internet | Obtaining accurate segmentation for some of the selected images |
| [16] | Densely Connected Fully Convolutional Network (IrisDenseNet) is used | NICE-II chosen from UBIRIS.v2, MICHE-CASIA V4.0 | Reducing quantity of layers to mark it memory efficient |
| [17] | Various methods like Integro Differential Operator, Hough Transform, Liber Masek’s Encoding algorithm, Fuzzy clustering algorithm, Pushing and pulling Method, Eight-neighbor connection based clustering were used frequently. | CASIA | More methods can be integrated for better results. |
| [18] | Novel algorithmic method was used to select good quality iris frame from a set of images of a person. | CASIA | To work with low quality frame images using the same method |
| [19] | Integro Differential Operator, Hough transform was used for segmentation | CASIA | Try out with different methods combination to increase the accuracy |
| [22] | Iris after pre-processing is signified by a feature vector. By considering this as vector input signal, the Neural Network is used to detect the iris patterns. | CASIA | Accuracy rate for feature extraction can be increased |
| [23] | Hough transform was used for segmentation | CASIA | Apply it to beyond lines, circles, or ellipses present the image |
| [25] | Iris is estimated by Two circles, boundary of iris or sclera and iris/pupil boundary. An automatic segmentation algorithm was accessible, which would localize the iris area from an eye image and segregate eyelid, eyelash and reflection areas. | CASIA | Automatic segmentation can be done by making use of several features. |
| [27] | Coarse center detection and fine | Equal Error Rate can be |
boundary Localization joined using outdated methods basically are not coupled. adaptive Hough transform is used at numerous resolutions in evaluating estimated location of center of the iris.

| Reference | Method                                                                 | Institution/Location | Additional Details |
|-----------|------------------------------------------------------------------------|-----------------------|--------------------|
| [28]      | Densely Connected Fully Convolutional Network is used.                 | IIT Delhi             | Refine layers and transform it to be memory efficient in cases of mobile, handheld devices with compact limitations. |
| [29]      | Mathematical Morphology for its usage in polar/radial invariant filtering of image, Circular segmentation by making use of shortest pathways from general grey level distance. | NICE-I                | Applied to eyes fully closed at a distance. |
| [30]      | Generalized structure tensor (GST) also contains eyelid recognition technique. | Database of Oriental people | Refining eyelids localization and eyelashes detection can be considered. |
| [32]      | Calculating intensity of the darkest point created on threshold value.  | http://chungbuk.ac.kr/Iris/index.html | Other aspects along with intensity can be considered. |

Table 2: Analysis based on the various segmentation techniques

5. Most Commonly used Techniques

![Survey of Techniques usage](image-url)

**Figure 2.** Usage of segmentation process on various databases.
5.1. Circular Hough Transform

Used to restrict iris limits [50]. Hough transform examines optimal limits of next altered settings of threshold standard that will result in unlike edges, resulting in the Hough Transform results.

\[ H(x_c, y_c, r) = \sum_{i=1}^{n} h(x_i, y_i, x_c, y_c, r) \]

Where \( h(x_j, y_j, x_0, y_0, r) = (x_j-x_0)^2 + (y_j-y_0)^2 - r^2 \) for edge point \((x_j, y_j)\), \( j=1...,n \). Unique weak fact of edge Detection, Hough transform Approach is usage of thresholds in case of detecting edge.

5.2. Integro-differential Operator

Difference in illumination concerning inner and outer pixels in the Iris edge Circle found to be maximum[51]. If you compute difference in pixel values, gray level in circle of the iris, value is enhanced when compared with other circles in images. This detail shots to iris as well as sclera color. Sclera called as white region is found out of iris. The algorithm for locating inner as well as outer boundaries of iristhrough the optimization is given by

\[ \max(r, x_p, y_0) = \left| \frac{\partial \delta(r) \ast I(x, y)}{\partial r} \right| \]

In the above equation \( I(x, y) \) is the Integrodifferential operator search concluded on the Image area \((x, y)\) required for extreme indistinct restricted derivative regarding growing radius \( r \) of Normalized Outline integral \( I(x, y) \) beside a rounded arc \( ds \) of Radius \( r \) along with Coordinates of the center \((x_0, y_0)\). * Symbols signifies complexity. \( \delta(r) \) denotes Function used for smoothing. ID Operator actually behaves like detector in detecting the circular edge. The Integro-differential Operator examines the maximum gradient above 3D factor space. Thus, it was not favorable to apply any threshold as the outdated canny Edge detector. Integro-differential Operator recommends that, radius of boundary of pupil can differ from 0.1 to 0.8 of limbus boundary radius

The GAC energy functional given by

\[ E^{GAC}(C) = \int g(\nabla u_0(\alpha(s)))|C'(s)| ds \]

Here \( C(s) \) is the developing curve parameterized through \( s \), and \( s \) denotes curve of length arc.

where \( u_0 \) denotes image, \( g \) is severely declining function in such a way that \( g(w) \to 0 \) as \( w \to \infty \) The equation for evolution of the curve is acquired via Euler-Lagrange construction as

\[ \frac{\partial \Phi}{\partial t} = g(|\nabla u_0|)|\nabla \Phi|k - \nabla g(|\nabla u_0|) \cdot \nabla \Phi \]

Curvature \( \kappa \) is calculated based on level sets \( \Phi \), specified as curvature of the mean. The model(GAC) model only reflects the resident information. Furthermore, it needs initializationsuch that it is either totally outside or else inside actual border.

5.3. Fully convolutional Network

Variety of designs of Convolutional Neural networks are AlexNet[52]: which is called the champion by gaining top-5 error rate of 16.4%. AlexNet is called as scrambled version of Convolutional GoogLeNet,
containing 25 layers. CNN Types are produced for recognition of the iris assignment by removing two completely associated layers and produces 5 Convolutional Layers. GoogLeNet is the champion in one of the prestigious competition, by top-5 error-rate of 6.7%. [53] Introduction of Inception V1 design with GoogLeNet by new intuition Usage of convolutional blocks to condense and combine the quantity of features. Enhancement was combined by using additional modules of inception, reforming filtering in the inception units [43,44]. Where, CNN Types are created basically for iris acknowledgment duty by removing 12 layers of inception and the outputs of single layer of convolution. Very deep Convolutional networks used for large scale Image recognition is another consideration, [54] Another aspect is using small filter 3 × 3 in every Convolutional Layer for upgrading performance. Variety of forms of Very Deep Convolutional Networks have been familiarized from the earlier years but 2 best popular ones are: Very Deep Convolutional Networks 16 and Very Deep Convolutional Networks 19 that in turn comprises 16 and 19 layers correspondingly. At this point, CNN types are produced for Iris recognition task by taking out 2 completely associated layers along with the outputs of 16 Convolutional layers. Residual Network is the CNN taken from ImageNet group with a group of remaining networks producing 3.6% error [55]. Now, the CNN features are produced for iris acknowledgment job by removing 17 Bottleneck Layers along with the output of one convolutional layer. Another one is the DenseNet (Dense Network), DenseNet[56] to connect every layer found in CNN in a Feed Forward Fashion. CNN Types are created for Iris acknowledgment job by removing Outputs of nominated 15 Compact layers.

5.4. Active Contour

Active contour [52] is among the segmentation approaches that are well-defined as the procedure forces of energy, limitations applied to separate pixels that are of interest in particular image required particularly for additional Processing as well as inquiry. Active contour selected as active model aimed at procedure for segmentation. contours defined as borders considered up to the extent of interest that are essential in the image. Contour is also defined as cluster of points required to experience interpolation procedure. Interpolation course defined as linear, splines as well as polynomial that describes curve in an image.

6. Conclusion

As per the review done on the segmentation techniques, we understood that various segmentation techniques can be integrated together on number of databases and it was specifically stated that usage of CASIA Iris database along with the Integro-differential operator was one of the widely used method. We understood that still there are many challenges that needs to be addressed when dealing the automatic iris segmentation and also with low quality images captured at a distance.

Based on the above survey integrating various segmentation approaches like Hough Transform, Active Contour model, Integro-differential operator and Fully Convolutional Neural Network can be done based on the iris database that we are going to consider. We may deal with different distance criteria’s along the restrictions that arises in the process of iris image capture. Reduction of Error rate and improving the Automatic segmentation procedures by considering low quality iris images along with the detection of the limbus boundaries for non-circular irises can be some of the concepts that can be implemented as a part of further study.
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