A Review of Iris Recognition System ROI and Accuracy

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2 authors:

Robby Alphonsus Halim

Andi Wahju Rahardjo Emanuel
Universitas Atma Jaya Yogyakarta

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Robby Alphonsus Halim
Magister Informatic
Universitas Atma Jaya Yogyakarta
Yogyakarta, Indonesia
robby7370@gmail.com

Andi Wahju Rahardjo Emanuel
Magister Informatic
Universitas Atma Jaya Yogyakarta
Yogyakarta, Indonesia
andi.emanuel@uajy.ac.id

Abstract— **Iris contains some information about human body and organ condition. Iridology is a scientific study of the iris structure to get some information that represents the condition of the various organs by examining the tissue strengths and weaknesses in the iris. With the rapid development of image processing, iridology has become more popular and reliable. In recent years, many systems that adopt iridology have been developed to diagnose a disease by analyzing a certain part of the iris or so-called Region of Interest (ROI). Typically, iris recognition systems consist of three main functions namely image pre-processing, feature extraction, and classification. This paper shows all the regions that have been studied and the accuracy of their iris recognition system.**

Keywords— Iridology, Iris Recognition System, ROI, System accuracy.

I. Introduction

The human iris is a ring-shaped part between cornea and pupil (Figure 1). Even though iris is considered as human inner organ, iris can be observed with ease from the exterior [1]. Iris is a screen where nerve systems are located and contain pieces of information about the human body [2]. The scientific study to analyze this information and specify weaknesses in the human body is called iridology. Iridologists examine the iris fiber, color, brightness, and shadings by looking at the iris and claim that iridology can predict the risk of disease because signs that represent body debility will appear in iris earlier than the organ itself. [3].

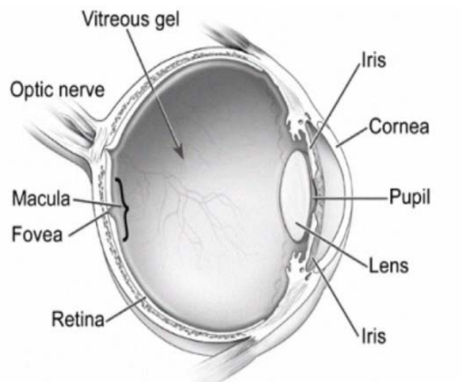


Figure 1. Human iris [1].

In iridology, there is a chart that can be used to find the organ that the iris represents namely the iridology chart (Fig. 2). The iridology chart shows the left side and the right side of an iris image with highlighted regions for each organ. This chart used by iridologists to compare the signs such as a circular iris fiber, circular ring, dark spot, etc, of the patient iris with the healthy iris. Based on the observation, they will specify which part of the body is weak or susceptible to suffer from diseases sooner than actual symptoms[4]. Typically, iridology charts divide an iris image into 80 to 90 regions [3].

The iris recognition system usually only analyze one region of the iris. Every iris recognition system consists of three main functions. The three main functions of this system are image pre-processing, feature extraction and classification. The image pre-processing function is used to obtain the ROI of the iris from the iris image. Generally, pre-processing is consists of five steps: transform into a greyscale image, iris localization, normalization, histogram equalization, and separating the ROI. The feature extraction function used to extract features from the cropped ROI image using one or more texture analysis methods. The extracted features are used for classification purposes. The classification function is an algorithm to predict and make a decision either the testing data is suffered from the disease or not.

The rest of this paper is structured as follows: Section 2 provides an overview of image pre-processing. Section 3 explains an overview of feature extraction. Section 4 provides an overview of classification. Section 5 serves the graph that shows all the regions that have been studied, the feature extraction used, the classification used, and the accuracy of their iris recognition system since 2017 and the conclusion of the paper in section 6.

II. Image Pre-Processing

The image preprocessing function is used to obtain the ROI of the iris from the iris image. Generally, preprocessing is consists of five steps:

A. Transform Into A Grayscale Image

The purpose of converting the image into gray level image is to enable the process to localization the iris or separating it from the sclera and the pupil and then normalize the iris and matched it with the iridology charts [5]. Generally, this formula can convert color image to grayscale image: [6]:

$$I = a\ x\ R + b\ x\ G + c\ x\ B, a + b + c = 1 \quad (1)$$

$$I = 0{,}2989\ x\ R + 0{,}5870\ x\ G + 0{,}1141\ x\ B \quad (2)$$

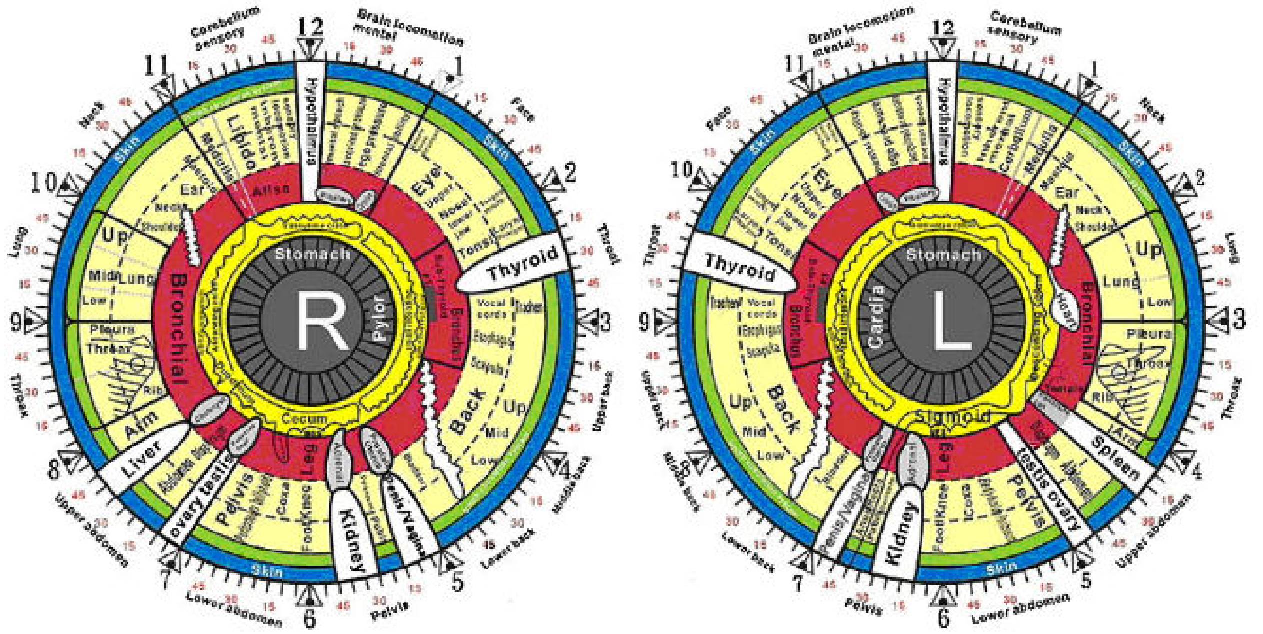
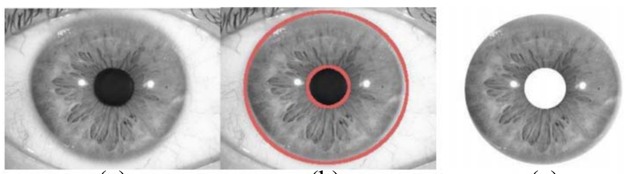


Figure 2. Iridology chart [5].

B. Iris Localization

The purpose of iris localization is to locate the outer boundaries and inner boundaries of the iris [5]. The difference of intensity between sclera, iris, and pupil can be used to locate the outer and inner boundaries. Hough Transform (CHT) is a technique that usually used for iris localization. CHT is a computer vision algorithm to determine parameters from geometric objects, such as circles and lines, in the image. The CHT technique is used to deduce the center coordinates of the pupil, the radius of the pupil, and iris regions [7].

In this transform, firstly, the first derivative of the intensity from an eye image is calculated. After that, thresholding the first derivatives result and generating the edge map. Afterward, parameters of the circle were calculated as the circle passing through each maximum edge point in the edge map. The main parameters of this algorithm are the radius and center coordinates of iris and pupil [8]. Figure 3 illustrates the process of iris localization.



(a) (b) (c)

Figure 3. Iris localization stages. (a) An eye image (grayscale). (b) Two circles for pupil and iris boundaries. (c) Result of segmented iris [5].

C. Normalization

After localizing the iris, the image will be transformed into a rectangle form from a ring form to make it easier for analysis the image. This step is called normalization [9]. The technique that usually used to normalized the image is the rubber-sheet model. This technique remaps the iris localization image into a rectangle where one axis represents the radial angle and the other one represents the radius. Figure 4 shows the result of iris normalization. This remapping can be modeled as follows [8] and the results can be seen in figure 4:

$$I(x(r,\theta), y(r,\theta)) \rightarrow I(r,\theta) \quad (3)$$

With

$$x(r,\theta) = (1-r)x_p(\theta) + rx_i(\theta) \quad (4)$$

$$y(r,\theta) = (1-r)y_p(\theta) + ry_i(\theta) \quad (5)$$

Where:

$I(x, y) = Iris\ region$

$(x, y) = Original\ coordinates$

$(r, \theta) = Corresponding\ polar\ coordinates$

(x_p, y_p) and $(x_i, y_i) =$ *Inner and outer boundaries coordinates along with* θ *direction*

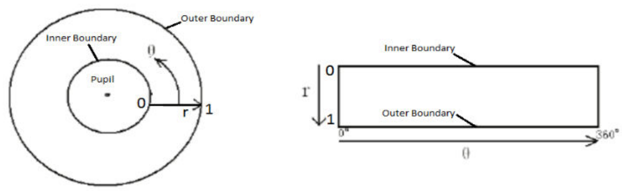


Figure 4. Iris normalization.

D. Histogram Equalization

Histogram Equalization is an image processing technique for improving image contrast. This technique is spreading out the intensity values that appear the most and the intensity range of an image. Histogram equalization can be performed by calculating probability and cumulative density function, calculating the number of pixels for every color, producing the total of the count, and then scaling the results. This technique is used when the usable data have close values of contrast. Therefore, this technique is suitable for iris image because the image pixels generally occupy the entire range of gray levels (0 to 255). In addition, the image has a high contrast appearance and has a large variety of gray tones [10]. Figure 5 shows the result of histogram equalization.

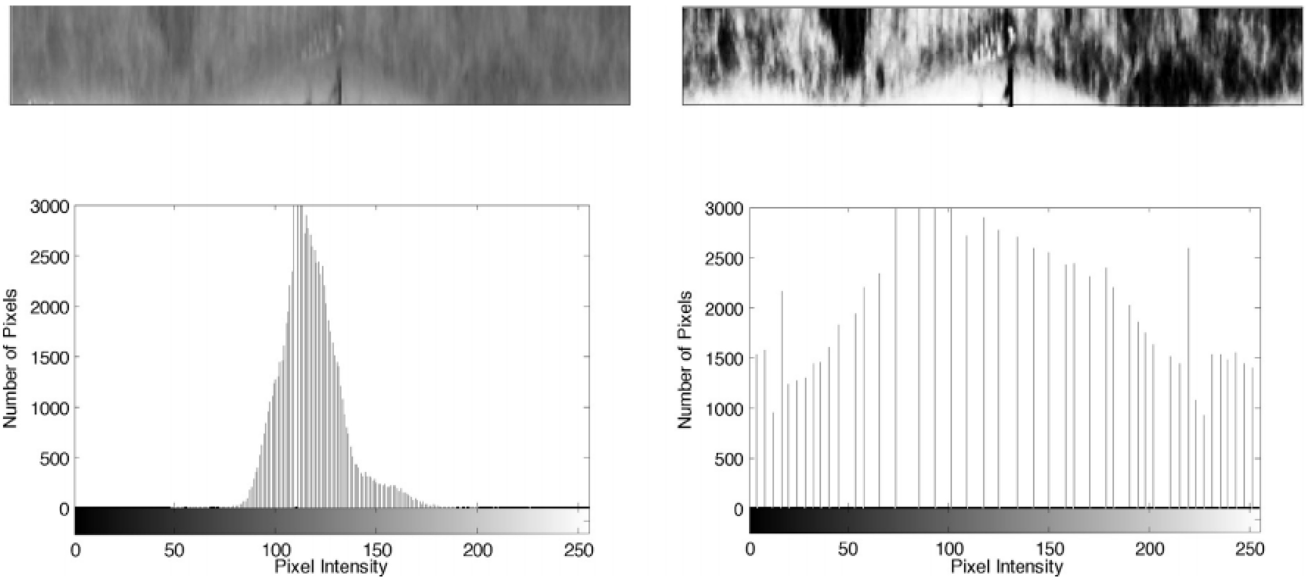


Figure 5. Histogram Equalization of an iris normalization image. Left, iris normalization image and its histogram before histogram equalization. Right, iris normalization image and its histogram after histogram equalization [5].

E. Separating the ROI

ROI is a particular part of a dataset or an image that will be identified or operate or filter for a specific purpose. In iridology, the ROI is a particular part of an iris image that represents a particular part or organ of a human body. This region will be analyzed to determine the health condition of that organ. [4].

III. Feature Extraction

The feature extraction function used to extract features from the cropped ROI image using one or more texture analysis methods. The extracted features are used for classification purposes. Each researchers employed various algorithm to extract features [11]. There are some common methods to extract features:

A. Black White Ratio

Black White Ratio is a feature extraction method that calculates the white and black pixels from a binary image and divides the total number of white pixels and black pixels with the total pixels of the image. Following is the formula to calculate the ratio [12]:

$$White\ Ratio = \frac{Total\ of\ White\ Pixels}{Total\ Pixels} \quad (6)$$

$$Black\ Ratio = \frac{Total\ of\ Black\ Pixels}{Total\ Pixels} \quad (7)$$

The average accuracy of this method regardless of the type of classifier is 81.91%, with the highest accuracy of 92%. Most studies using this extraction feature use thresholding algorithms as classifiers and also apply the auto-cropping function to their systems.

B. Gray Level Co-Occurrence Matrix (GLCM)

Gray Level Co-Occurrence Matrix (GLCM) is a feature extraction to obtain the gray level from an eye image [13]. The grayish value of an eye image is different from each other. Following is the steps to use GLCM feature extraction:

1) Initialize the matrix area.

2) Set the spatial relation of the neighbor and the reference pixel, and set the distance d and the angle θ.

3) Calculating the concurrency matrix with the transposes concurrency matrix to make it symmetric.

4) Transform the matrix to probability form (Pd) by normalizing it.

The following is the statistics characteristics of Gray Level Co-Occurrence Matrix (GLCM): 1) Energy, 2) Homogeneity, 3) Contrast, and 4) Entropy [14]. The average accuracy of this method regardless of the type of classifier is 87.31%, with the highest accuracy of 97.78%.

C. 2D Gabor Filter

The 2D Gabor filter is a feature extraction that has a good ability to distinguish space dan frequency domain. The Daughman's iris recognition often uses this feature extraction [11] [15]. The average accuracy of this method regardless of the type of classifier is 88.6%, with the highest accuracy of 91.8%.

IV. Classification

The classification function is an algorithm to predict and make a decision either the testing data is suffered from the disease or not. There are some common method for classification:

A. Tresholding Algorithm

The thresholding algorithm is a classifier that classified the ratio in the image. This classifier usually used for black and white ratio feature extraction. The thresholding algorithm steps are as follow [16]:

1) Set the limit or threshold.

2) Determine the class label. The label will be used to classify the data whether it is less or over the threshold. In the research about iridology, the labels usually are named abnormal and normal.

3) Input the data (segmented eye image) that will be classified.

4) Classify and labeling the data based on the value of the data, whether it is less or over the threshold that was set in the first step.

The average accuracy of this classifier regardless of the type of classifier is 81.91%, with the highest accuracy of 92%.

B. Backpropagation Neural Network.

The backpropagation neural network is an artificial neural network that has learning techniques. The backpropagation neural network is a method for solving a problem by feeding a set of data as the learning or training process [17]. This method widely used because of its ability to minimize the error of the output [14]. The average accuracy of this classifier regardless of the type of classifier is 82.5%, with the highest accuracy of 83.33%.

C. Support Vector Machine (SVM)

Support Vector Machine (SVM) is a binary classifier that uses the structural risk minimization principle. Vapnik was the proposer of this method [18]. Currently, the S method is often used for various fields such as image recognition, pattern recognition, text classification, etc [19]. Paper Cristianini [20] and Burges [21] provide more in-depth information about Support Vector Machine. The average accuracy of this classifier regardless of the type of classifier is 93.33%, with the highest accuracy of 96%.

V. Iris Recognition System ROI and Accuracy

Figure 6 shows all the regions that have been studied and the accuracy of their iris recognition system since 2017. All paper that we used to make this survey are all journals and conferences which are show in the list of google scholar with the keyword of ““iridology” and “image processing.”” And also we only use English and Indonesian paper. The total of the paper used to make figure 6 is 26 paper. Table 1 shows detailed data from the paper used to make the figure 6.

The most frequently studied ROI is Arcus Senilis and Pancreas with a total of 7 papers since 2017. The highest accuracy is found in paper Ridza [23] with an accuracy value of 97.78% using Gray Level Co-Occurrence Matrix (GLCM) as the feature extraction and Bayesian regularization (BR) classifier as the classifier.

VI. Conclusion

As we can see in figure 6, most popular ROI that have been researched is Arcus Senilis and Pancreas, with the highest accuracy of 97.78% for ROI of Arcus Senilis and 95.81% for ROI of Pancreas. The iris recognition system with the highest accuracy is in paper Ridza [23]. In this paper, they use Gray Level Co-Occurrence Matrix (GLCM) feature extraction and Bayesian regularization (BR) classification to diagnose either the subject is suffering from the disease or not.

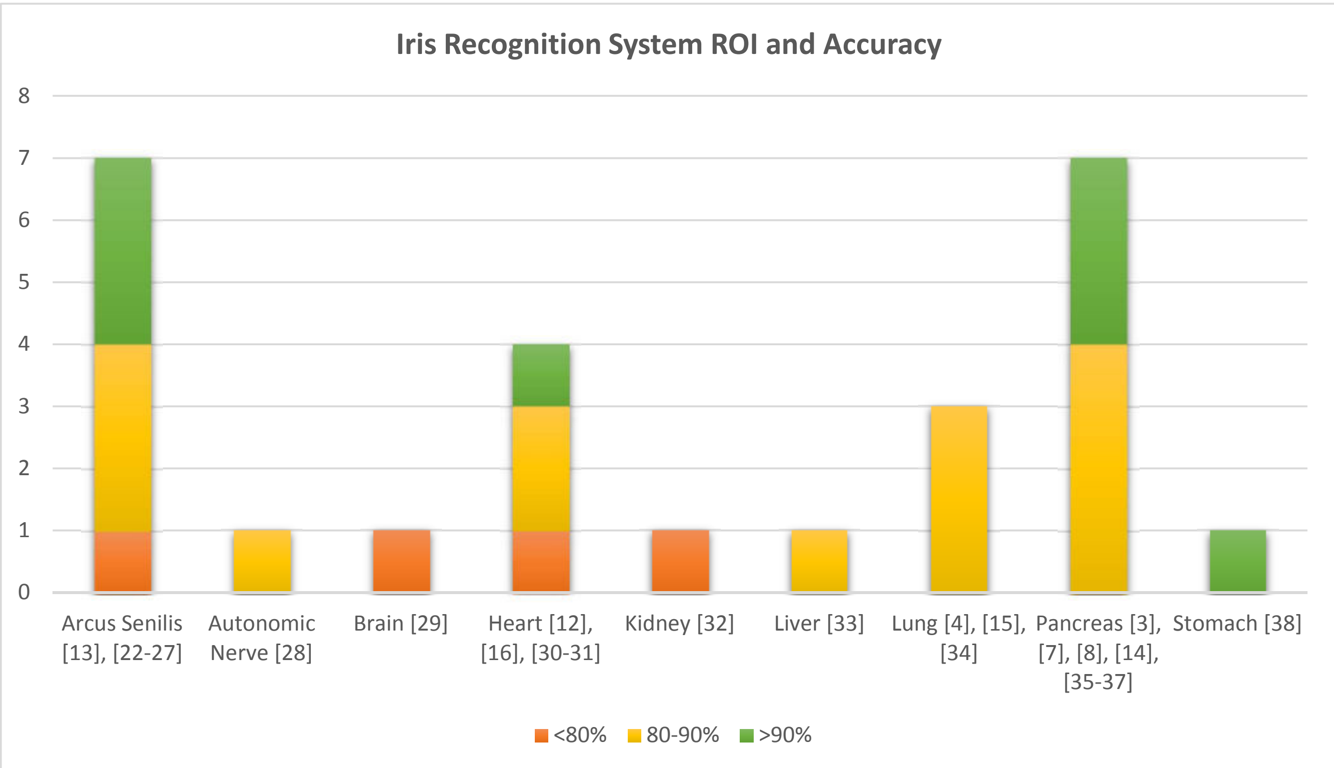


Figure 6. Graph of all paper ROI and accuracy results about iridology and image processing.

TABLE I. DETAILED DATA OF THE 26 REVIEWED PAPERS.

ROI	Feature Extraction	Classifier	Accuracy
Arcus Senilis	Gray Level Co-Occurrence Matrix (GLCM)	Backpropagation Neural Network	81.81% [13]
	Gabor Filter	Otsu Threshold	86.00% [22]
	Grey Level Co-occurrence Matrix (GLCM)	Bayesian Regularization (BR) Classifier	97.78% [23]
	Fuzzy Local Binary Pattern (FLBP)	Linear Regression Analysis	91.40% [24]
	-	RBF	89.00% [25]
	-	RBF	53.33% [26]
	Histogram Of Oriented Gradients (HOG)	Artificial Neural Network (ANN)	93.00% [27]
Autonomic Nerve	Principal Component Analysis (PCA)	Backpropagation Neural Network	83.33% [28]
Brain	Average Intensity, Average Contrast of Standard Deviation, Mildness, Third Moment, Uniformity of The Histogram, Entropy	Naïve Bayes	61.96% [29]
Heart	Black And White Ratio	Thresholding Algorithm	70.00% [12]
	Black And White Ratio	Thresholding Algorithm	83.33% [16]
	Black And White Ratio	Thresholding Algorithm	82.30% [30]
	SURF-Features	MCO-SVM (Multi-Class Oriented SVM)	96.00% [31]
Kidney	Gray Level Co-Occurrence Matrix (GLCM)	Euclidean Distance	70.00% [32]
Liver	Grey Level, Enhancing and Sobel Operator	Histogram	84.00% [33]
Lung	2D Gabor filter and 2D Discrete Wavelet Transform (DWT)	Support Vector Machine (SVM)	89.00% [4]
	2D Gabor Filter	Support Vector Machine (SVM)	88.00% [15]
	Gabor Features Based Blob Detector	Support Vector Machine (SVM)	88.00% [34]
Pancreas	Pixel Information, Gabor Filter, HOG, and LBP	Adaboost	91.80% [3]
	Discrete Wavelet Transform (DWT)	Random Forest	89.66% [7]
	Statistical, Texture And Discrete Wavelength Transformation Features	Random Forest	89.63% [8]
	Gray Level Co-Occurrence Matrix (GLCM)	Artificial Neural Network Backpropagation	82.35% [14]
	Statistical, GLCM And GLRL Features (With T-Test Feature Selection)	EBoT (Boosted Tree)	95.81% [35]
	Black And White Ratio	Thresholding Algorithm	92.00% [36]
	Statistical, Texture Analysis, And Two-Dimensional Discrete Wavelet Transformation	Random Forest	89.66% [37]
Stomach	RGB Components And The Gray-Scale Transformation	Support Vector Machine (SVM)	96.00% [38]

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