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IRIS SEGMENTATION AND EXTRACTION IN EYE IMAGES USING WINNER FILTER

MASTER THESIS

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MASTER THESIS

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Thesis Defense Date: 04.05.2017

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TO THE INSTITUTE OF SCIENCES AND TECHNOLOGY

I hereby declare that all information in this study I presented as my Master's Thesis, called: "Iris Segmentation And Extraction in Eye Images Using Winner Filter", has been presented in accordance with the academic rules and ethical conduct. I also declare and certify with my honour that I have fully cited and referenced all the sources I made use of in this present study.

04.05.2017

Mohammad AL ZAWKI

ABSTRACT

IRIS SEGMENTATION AND EXTRACTION IN EYE IMAGES USING WINNER FILTER

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Master Thesis, Department of Electrical and Electronics Engineering

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Most eye images have a high degree of resolution and when used in the clinical area offer features that can diagnose and treat many diseases. The development of an automatic system could provide great convenience for doctors and practitioners in the field. In this thesis, we presented a robust method for eye iris segmentation and some automatic algorithms for analyzing the iris segmentation. In this thesis some classical methods implemented then with winner filter which. Finally we compared our result with other methods and we that our result has good performance than the other methods. In this thesis for the testing of proposed method we used Chinese Academy of Sciences Institute of Automation (CASIA) database. For Lamp database the corrected detected iris was 32%. For Interval we got 67.4% corrected iris detection. For Twins the best result was 74%. In finally we compared our result with median filter and Gaussian filter. With comparison we found that the proposed method has the best result than the other methods.

Keywords: Iris Segmentation, Image processing, Eye Images

ÖZET

WIENER FILTRESI KULLANARAK
GÖZ GÖRÜNTÜLER İRIS SEGMENTASYON VE EKSTRAKSIYON

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Mayıs - 2017, 57 sayfa

Çoğu göz görüntüsünün çözünürlüğü yüksektir ve klinik alanda kullanıldığında birçok hastalığa tanı koyabilen ve tedavi edebilen özellikler sunar. Otomatik bir sistemin geliştirilmesi, doktorlar ve uygulayıcılar için bu alanda büyük rahatlık sağlayabilir. Bu tezde, göz irisi bölütlemesi için sağlam bir yöntem ve iris segmentasyonunu analiz etmek için bazı otomatik algoritmalar sunacağız. Bu tezde, klasik yöntemlerden bazıları uygulanıyor ve kazan filtresi ile iris segmentasyonunu parçalayacağız. Son olarak, sonuçlarımızı diğer yöntemlerle karşılaştıracağız ve sonucumuzun diğer yöntemlerden daha iyi bir performans gösterdiğini göstereceğiz. Önerilen yöntemin test edilmesine yönelik bu tezde, Çin Bilimler Akademisi Otomasyon Enstitüsü (CASIA) veritabanını kullandık. Nihayet sonuçlarımızı medyan filtre ve Gauss filtresi ile karşılaştırdık.

Anahtar Kelimeler: İris Segmentasyon, Görüntü işleme, Göz Resimleri

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ABBREVIATIONS

CASIA	Chinese Academy of Sciences Institute of Automation

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1. INTRODUCTION

1.1. Background

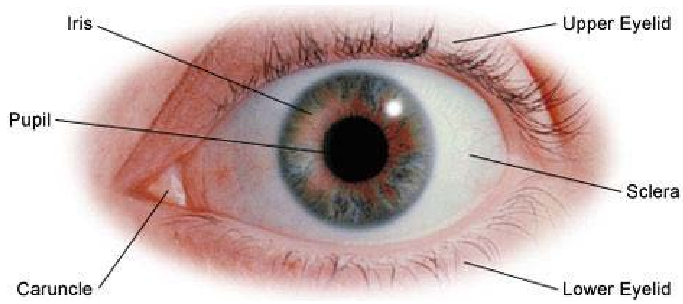
In addition to technological development, significant progress and a number of advances have been recorded in the computer techniques used in biometric applications. Automatic image processing and analysis are widely used in the area of biometric. Recent developments in the field of biometric image processing in particular enable the automatic detection of various characteristics, changes, diseases and degenerative problems via eye images. Eye image analyses uses image processing techniques and is aimed at determining and monitoring diseases that can be detected via changes in the structure of the eye.

Fluorescein angiography is an early method for taking photographs of the fundus, or back of the eye, required the injection of fluorescein into blood stream to enhance the contrast of eye. However, with regarding advances in information and communication technology during last decade, digital fundus photography of eye has been developed. Fundus imaging is the process of obtaining the projection of the 3-D semitransparent eye tissue onto the imaging plane as a 2-D representation using the reflected light and the image intensities to represent the amount of a reflected quantity of light. There are several reasons why digital fundus images have been widely used in many projects. Firstly the publicity available databases have used fundus photographs of patients. Secondly this kind of photography is very useful for population-based and diagnose various type of systemic diseases such as diabetics, arteriosclerosis, and hypertension. Lastly and the most important advantage of corresponding images is possibility of precise measurement and monitoring of width and tortuosity of eye. Figure 1.1 illustrate an example of digital fundus image and a patient being examined with a digital fundus camera.

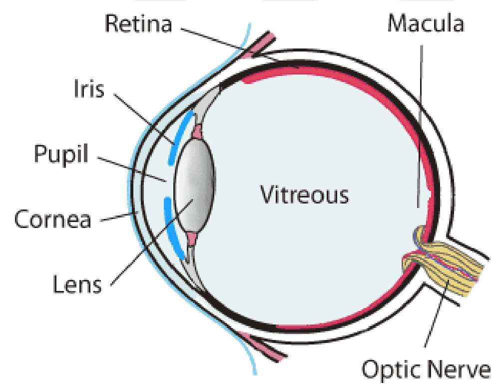
Figure 1. 1. A general iris camera system

1.2. Iris and Its Structure

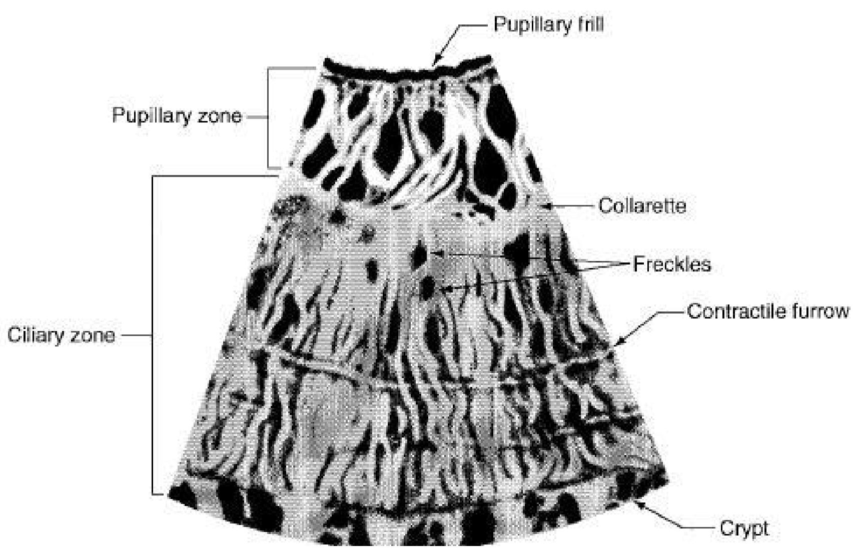
The colored part of the eye is called iris that is in the form of a circular narrow diaphragm and is located between cornea and pupil of human`s eyes. An image of the iris and image of eye anatomy are shown in Figure 1.2. The duty of the iris is to control the amount of the light entering the pupil that is done by radial expanding and binding mussels existing in the iris. Average diameter of the iris is 12 mm and size of the pupil could change from 10% to 80% of the iris diameter. As it was shown in Figure 1.2, iris texture consists of some main parts like: Crypt holes, Freckles, Spots and Collarettes. The Collarettes are zigzag-like branched tapes disjoining two muscular areas from each other.



(a)



(b)



(c)

Figure 1. 2. Sample of iris image (a) a pattern of the iris texture, (b) structure of the eye and manner of positioning the iris, (c) more accurate view of the structure of the iris texture and its important forming elements.

1.3. Problem definition

Most eye images have a high degree of resolution and when used in the clinical area offer features that can diagnose and treat many diseases. The development of an automatic system could provide great convenience for doctors and practitioners in the field. The image processing techniques proposed in this study can contribute to more effective analysis and more accurate regardless of the individual levels of experience of the users or particular situations and conditions such as fatigue or image quality. Obtaining eye images is extremely important in the diagnosis of eye disorders that progress to blindness if not detected early. Also for tracking eye it's very important that the automatic system use for correctly find the center of the eye. For finding the center of the eye we need find the iris or pupil. Then with finding of the iris we can find the center of the iris after that the center of the eye will be detect. The main problem here is the finding of the iris. For best detection we will find the pupil and then with information of the pupil we can find the iris. Segmentation and detection of the pupil is easy than the iris. Also with finding the pupil the detection of the iris will be easy.

1.4. Proposal work

For iris detection we used image processing techniques. Our work can use for eye tracking. Some people has problem about healthy and they can't to walking or do anything, for this reason the eye tracking is good way for solving of their problem. The iris detection can use for eye tracking. Therefore, we proposed a new method for iris detection and some automatic algorithms for analyzing the iris detection. Also in this study Gaussian filter and Median filter implemented for evaluation of the result for iris detection. In proposed method we used two dimensional Wiener filter. The two dimensional Wiener, estimates the local mean and variance around each pixel.

$$\mu = \frac{1}{NM} \sum_{n_1, n_2 \in \eta} a(n_1, n_2) \qquad (1.1)$$

And

$$\sigma^2 = \frac{1}{NM} \sum_{n_1, n_2 \in \eta} a^2(n_1, n_2) - \mu^2 \qquad (1.2)$$

Where η is the *N*-by-*M* local neighborhood of each pixel in the image A. Two dimensional Wiener then creates a pixelwise Wiener filter using these estimates,

$$b(n_1, n_2) = \mu + \frac{\sigma^2 - v^2}{\sigma^2}(a(n_1, n_2) - \mu) \qquad (1.3)$$

where v^2 is the noise variance. If the noise variance is not given, Wiener uses the average of all the local estimated variances.

1.5. Aim

The aim of our thesis work is to get the high accuracy of iris segmentation in eye images. We will try to get good answer and good segmentation percent. We will compare our result with other methods. Also for simulation result we will implement on CASIA iris V3 interval database.

In this thesis for the testing of proposed method we used Chinese Academy of Sciences Institute of Automation (CASIA) database. In this database there are three type of the database as Interval, Lamp and Twins. In the Interval database there are 249 image with left and right iris. In the Lamp there are 411 images and in the Twins there are 100 images

2. LITERATURE REVIEW

2.1. History of Iris Biometric System

In 1936, an oculist called Frank Burch proposed the concept of utilizing the iris pattern as an approach for recognizing people. In 1985, Dr. Leonard Flom and Aran Safir the oculists claimed that irises of no two eyes are the same and in 1987 the exclusive prominence of the iris recognition were given to Dr. Flom that in this direction in 1994 Daugman presented an automatic algorithm order to recognize people through iris images [1]. In 1994, the exclusive prominence of the automatic algorithm were given to Daugman and also in 1995, its first commercial production were developed. He presented it as an approach for recognizing people. In 2005, the exclusive prominence of the concept of the iris recognition ended and marketing become possible for other firms. Although Daugman`s system is the most trusted and successful of the kind but other systems were designed and implemented as well that one of the known systems is Wildes system. Boles and Boashash, Lim and Noh are the other presented patterns.

2.2. How does Iris Biometric System Work?

Iris biometric system is composed of 5 different parts consisting of: Image Acquisition, iris localization (Segmentation), Normalization and Unwrapping, Feature Extraction and matching (decision-making) related with individual`s identity. Figure 2.1 shows the different steps of iris recognition. Image Acquisition is done under near-infrared wavelength in iris biometric systems [2]. That's because on one side the caught images in this wavelength is less influenced by environmental noisy factors such as light source and on the other hand these waves is not reflected from the cornea and it can penetrate into iris texture and collect relevant information on recognition.

Next stage is iris localization that the center of the pupil, iris and the radius of them are determined during this process. In other words, with having two circles determining the inner and outer boundaries of the iris, the iris is completely extracted from the image. This stage has a beneficial effect on the efficiency of the identification system. If the inner circle determining the boundary with pupil is chosen smaller in size than the actual size or the outer circle determining boundary with sclera consist of white areas of the sclera or some parts of eyelash, the iris texture encounters with non-linear deformation in coordinates conversion stage that this is one of the most formidable challenges existing in iris recognition.

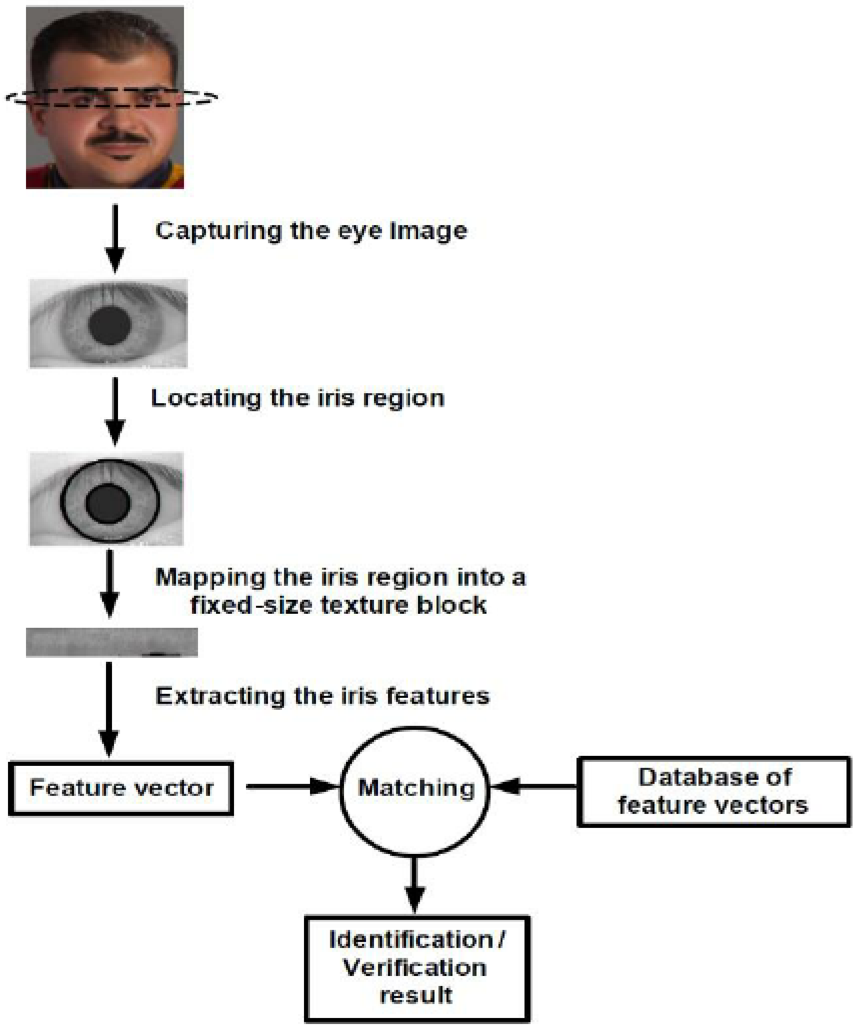


Figure 2. 1. Steps of iris recognition

Another step in iris biometrics system is to change the coordinates of the extracted iris. At this stage, iris is transformed from the Cartesian coordinates to Polar coordinates and all the images are mapped to some quadrangles with determined length and width. A pattern of this process is shown in Figure 2.2a. The purpose of the change in coordinates is to oppose probable expansion and contraction of the pupil or the variable distance of the person to the camera during the image acquisition that these two factors lead to shrinkage and enlargement of the iris region in caught images (Figure 2.2b). This point deserves our attention that changing the coordinates is only able to amend some part of the applied changes to the texture and profound changes of the pupil diameter lead to not recognition of the relevant images. A pattern of the inordinate dilatation of pupil is shown in Figure 2.2c.

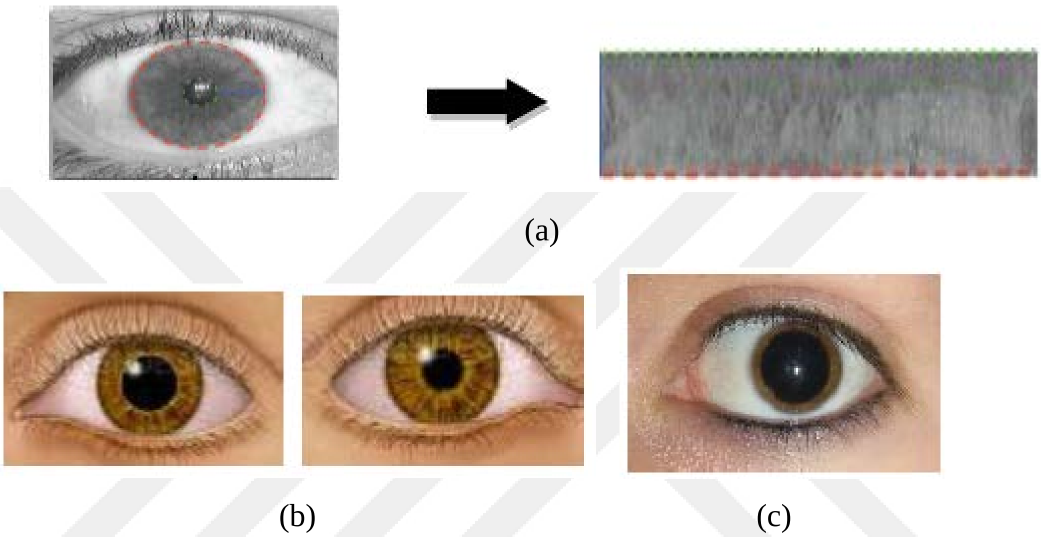


Figure 2. 2. Display of different pupil size and mapping coordinates (a) a display of the changing of the iris coordinates parted from the image of the eye, (b) expansion and contraction of the pupil affected by environmental light source, (c) A pattern of the pupil is wide open and is not recognizable compared with images shown in previous part.

Images taken for iris recognition may be in the infrared or visible band. Figure 2.3 shows the iris images taken in the visible region and the infrared region. If a light source is present in the imaging system, such systems are called active imaging systems. Systems using ambient light are called passive imaging systems.

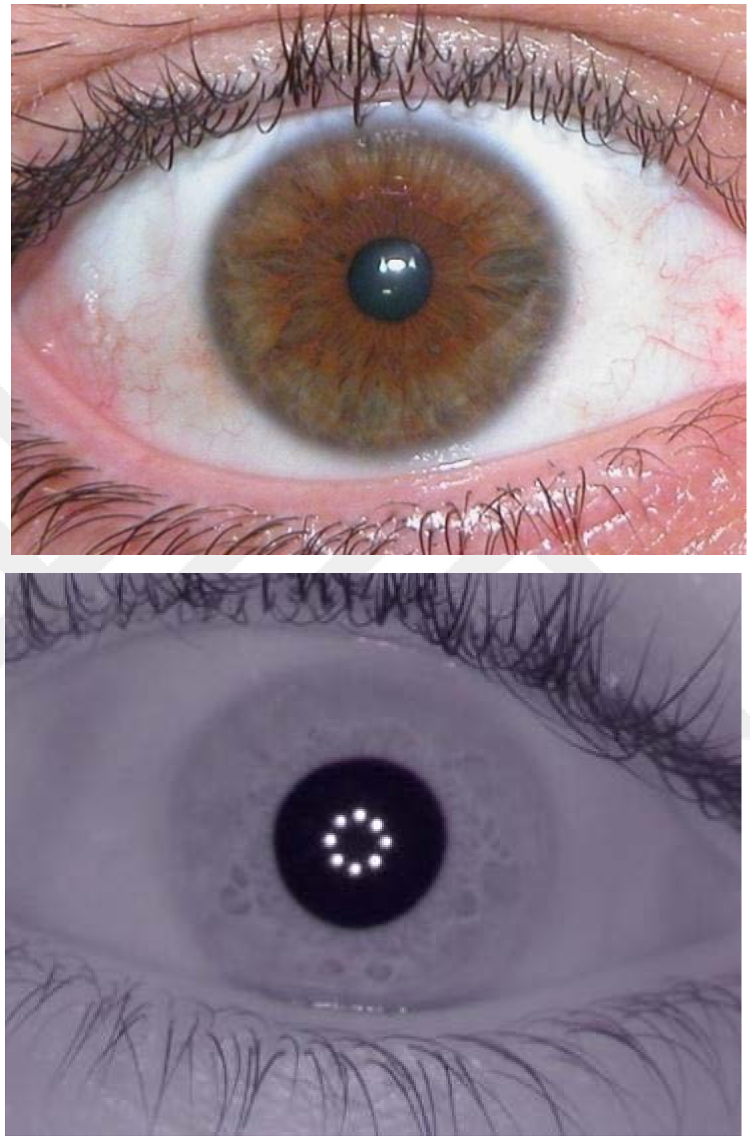


Figure 2. 3.The visible region (left) and the infrared region (right) taken with the camera system are active iris images

Feature extraction is the main base of the iris recognition. At this stage, existing information is extracted in texture level like spots, freckles, directing of the radial and circular mussels. Until now, different methods are introduced with this purpose that operates according to Gabor Filter or wavelet transform. According to the adopted feature extraction method, a binary code or a corresponding feature with each image are developed. However, presenting binary code in iris recognition is so important because execution of the volume of computations decreases and process speed increases. Matching method is generally established based on Hamming Distance and Nearest Neighbor Classifier. This is done whereas complex classifying algorithms like neural networks or Support Vector Machines (SVM) are not widely used due to the large number of the classes and small number of the collected patterns. On the other hand, researchers mainly focused on segmentation, feature extraction and feature vector coding methods not on executing classifier algorithms on feature vectors in the space with relatively ample dimension followed by curse of dimensionality.

In the first stage of this thesis, studies were carried out to find the face region from the view taken from the image. This stage is not used in many iris recognition systems in the literature, and since the images usually cover the eye region of a hundred, they go directly to the eye detection path. After finding the face region, the iris image is obtained by focusing on the face region on the face. The iris region must be detected on the obtained iris image. The information required is the internal and external border regions of the iris. With this information, the iris region can be separated from the entire image and is made up of this iris image with recognition-verification procedures. Face detection may not be used if the captured system can capture the eye image directly.

2.3. Viola and Jones's method [3]

In [3], a new classifier is obtained by using a large number of classifiers that classify using simple features. All of these classifiers are property based. Feature-based methods work faster than pixel-based methods [3]. The method works on grayscale images, a color input image is first converted to gray level. On this image, the templates that can represent the face shape are browsed. These templates are templates created with very simple basic logic. The face represents the levels of light in the specific region. A template produces an output as it is being traversed on the image, and if the region of the template belongs to a face it is not true, otherwise it produces the wrong result. In this sense, different patterns are applied in succession. When the correct result is obtained from all templates, that region is marked as face region. The testing of the templates is the sum of the specified specific regions in the templates. These totals are evaluated and the result is either correct or incorrect.

2.4. Segmentation with face color

There are also methods that work on color images using the color tone of a hundred colors. In these methods, face color modeling is performed first. There are many ways to model a face color. The Gaussian model [4], Gaussian mixture model [5], and elliptic boundary [6] are commonly used models [7]. It is used to separate the face image with the background image after finding the model. With the binary image separating the face region, the inverse of this imge is the result of the edge detection operator VE. Separated regions are obtained. These regions are face candidates. These regions are examined and it is decided whether they are a hundred regions. These regions are examined in terms of wealth. It must be of a certain size in order to be a face region. Look at the width and aspect ratio. [8], there is segmentation in different spaces. Three different spaces are used for this. These spaces are RGB, YCbCr, CIEL * a * b ". After separating the face regions in these different spaces, there are face regions, joined together.

2.5. Literature studies on finding iris

After the detection of the face region, the boundaries of the iris region must be found. Some methods in the literature are given below.

2.5.1. Daugman's integrated-derivative operator

In the Daugman "in method [9], the integrated-derivative operator is used to find the iris region. We try to find this region by making use of the change of the iris boundaries. This operator is not applied on the entire image. Candidate points are found first. At these candidate points, the built-in derivative operator is applied in the predetermined radius range. The maximum point of change is the outer boundary of the iris area. Once this region is found, the inner boundary of the iris can be found in the same way as the change in that region is high. After knowing the outer diameter of the iris, it is known that the inner diameter can be in what range.

2.5.2. Hough transformation

Hough transformation can be used to find iris boundaries because the geometric shape of the iris region resembles a circle. Hough transformation is an image processing algorithm used to detect simple geometric objects. Wildes et al. [6] used to find iris boundaries. In the Hough method, edge detection and thresholding are performed on the image. After this process, each edge points to the geometric shape parameters that provide that point. The maximum point in the Hough space gives the point that best describes the shape specified by this equation. There are 3 parameters for circle, these are x, y center point and r radius.

2.5.3. Active contour models

Ritter et al. [10] applied a circular active contour model to determine the pupil and iris boundaries. First, the original imge change image is created and using this image, the position of the pupil is located. Then, from the starting point in the center of the pupil, the active contour is initiated and moved in the iris image under the influence of the internal and external forces. Active contours include many peaks whose positions are changed by two opposite forces, one of which is an internal force depending on the desired characteristics and the other is an external force connected to the image.

2.5.4. Lash and noise detection

Kong and Zhang [11] offer a method of finding eyelashes that allows two types of problems to be eliminated, including discrete eyelashes that can be imaged in the eye image and eyelashes in the superimposed group. Detachable eyelashes are available with 1D Gabor filters as Gauss smoothing function gives convolutions a low output value. Therefore, if the point from the square to the point is smaller than the threshold, this point is determined as belonging to the hedge. Multiple eyelashes are present in varying intensity. If Eger is smaller than a change threshold of density values in a small window, the window is counted as a point in the eyelashes. At the same time, Kong and Zhang also use binding criteria, since every point on a lash must be tied to another point on the eyelash or eyelid. Mirror reflections in the eye image are due to thresholding, since the intensity values in the regions are higher than all other regions in the image.

2.6. Methods used in the literature for iris standardization

Standardization is performed after the presence of the iris boundaries. This process converts every iris region found into a known pattern.

2.6.1. Daugman rubber sheet model

If the inner and outer rings of the iris are known, the iris normalization process is performed. In the normalization process, the circular region within the inner and outer boundaries of the iris is transformed into a rectangular image. This process is shown in Figure 2.3. R transforms each point in the iris region into a pair of polar coordinates (r, θ), with an angle between the inner and outer boundaries of the iris and an angle θ between, [0, 2π].

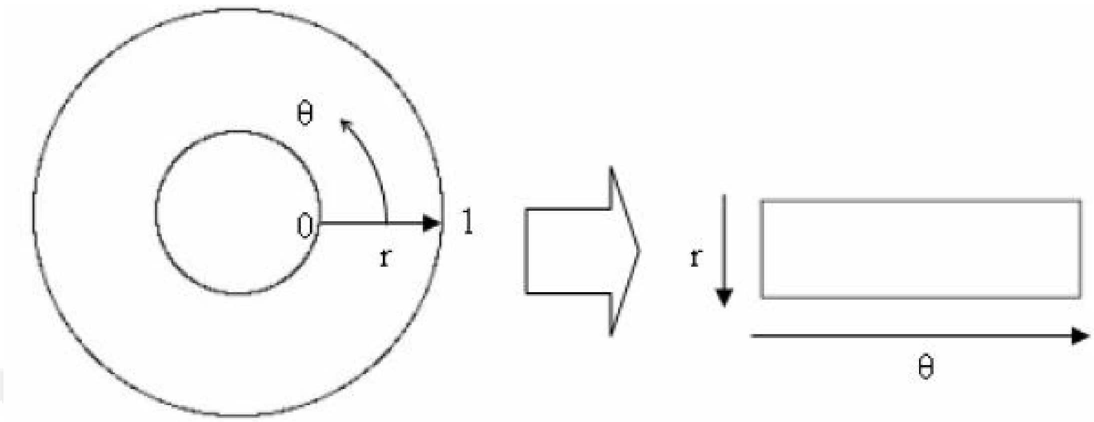


Figure 2. 4. Normalization

2.6.2. Boles' virtual apartments

In the Boles system, iris images are first scaled to a fixed diameter, so two images are compared and one is considered as a reference image [12]. This method; It works differently than the other methods because it does not standardize before it standardizes and does not standardize the two iris regions instead of saving the result for future comparisons. When two irises have the same dimensions; the starting point being at the center of the pupil; the feature vector is obtained from the intensity values along the imaginary concentric circles from the iris region. A standardization resolution is chosen so that the number of data points extracted from each iris is the same. This method is basically the same as the Daugman in rubber sheet model, but in the scaling, matching phase and depends on the compared iris region, not on certain fixed dimensions. Boles does not mention how the reference image taken from the database with the acquired input image, such as eyeball rotation or American rotation, results in the same coordinates.

2.7. Median filter and Gaussian filter

The median filter is a nonlinear digital filtering technique, often used to remove noise. Such noise reduction is a typical pre-processing step to improve the results of later processing (for example, edge detection on an image). In image processing, a Gaussian filter is a filter whose impulse response is a Gaussian function. Gaussian filters have the properties of having no overshoot to a step function input while minimizing the rise and fall time.

For Gaussian filter in [13] they proposed a iris localization method. Their algorithm has three steps. First they used iris image preprocessing, where they applied a suitable Gaussian filter to lessen the influence of noise. In second step they applied the morphological operation to extract the inner and outer iris edge, in finally they determined the iris area.

In [14] they used median filter for human identification with iris recognition. In their method they used 2 dimensional median filter. Also in this model they used a novel encoding technique which can handle images acquired under such conditions.

In [15] they proposed an algorithm based on Otsu threshold value, median filter, image complement, contact labeling and manual tracking for robust detection of the pupil. The flow diagram of finding pupil center and its boundary/radius is shown in figure 2.5.

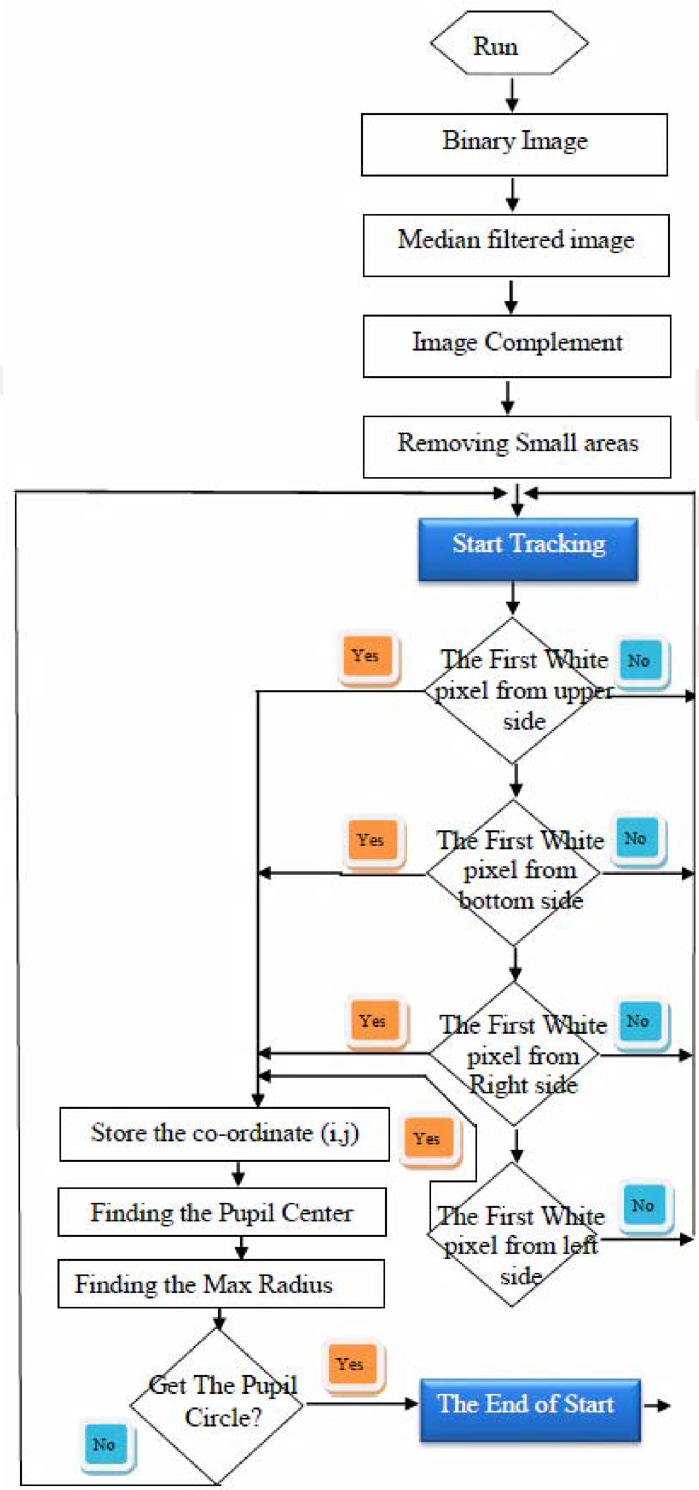


Figure 2. 5. The Flow Diagram of finding Pupil Center and its Boundary/Radius [15]

In this method in the first step the image is read. And then for removing of the noise they used the median filter for smoothing of the noise. Then they convert the image to binary. And then they find the right and left point also the up and down point. Then the pupil part found. After finding the pupil area they found the maximum radius. Finally the all area of the pupil is segmented.

The result that they got it is shown in figure 2.6.

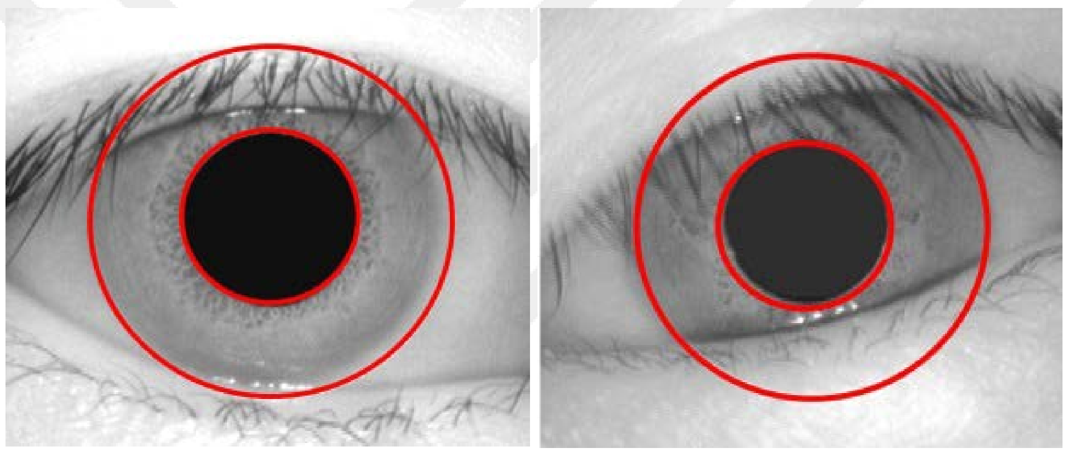


Figure 2. 6. Result for Morphology and Geometry Operation [15]

In [16], Adaptive Histogram Equalization (AHE) and median filtering are employed to segment the iris region from an eye image. The adaptive histogram equalization and median filtering is shown in figure 2.7.

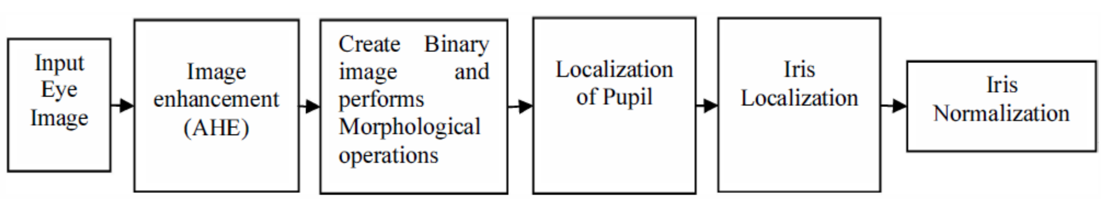


Figure 2. 7. Adaptive Histogram Equalization and Median Filtering [16]

In this method they used Adaptive histogram equalization for enhancement. Then the binarization is used for converting image to binary images. After binarization the pupil is found. Iris segmentation and localization is found after the pupil area.

The result of this method is shown in figure 2.8.

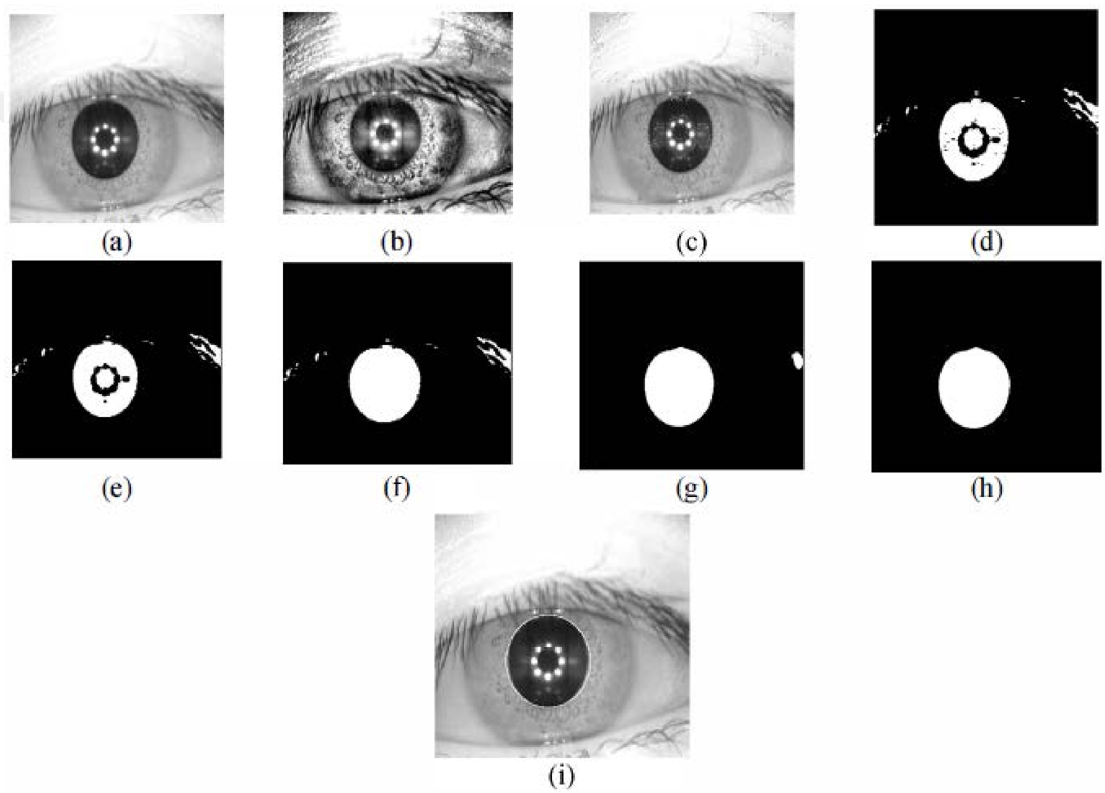
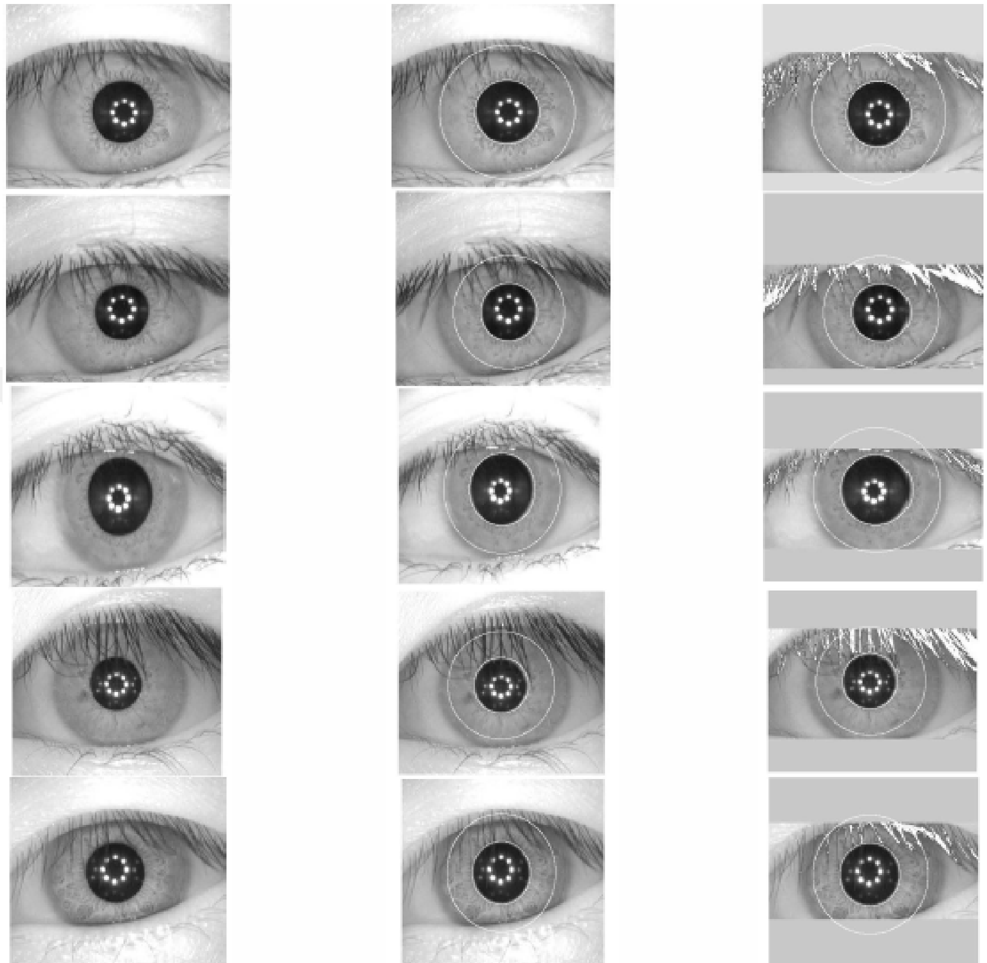


Figure 2. 8. (a) Original Image (b) Image after AHE (c) Image with eyelash removed from the boundary of pupil. (d) Binary image (e) Image after morphological operations (f) Image after flood fill (g) Image after median filtering (h) Detected pupil region (i) Localized pupil [16]

The result of this method is shown in figure 2.9.



(a) (b) (c)

Figure 2. 9. a) Original image, b) Segmented iris, e) Image after removal of eyelids and eyelashes

In [17], they proposed a new iris recognition system. This approach used a new feature extraction method 3D-GLCM which expanded from 2D-GLCM.

For comparison of proposed method we used Median filter and Gaussian filter. Because Gaussian and Median filter has robust information about the smoothing of the image. The Gaussian smoothing operator is a 2-D convolution operator that is used to `blur' images and remove detail and noise. Also Gaussian filter is use low pass filter for smoothing. But wiener filter use two type of filter high pass and low pass.

3. IMAGE SEGMENTATION

Segmentation is a sub-area of digital image processing and machine vision. The generation of content-related regions by combining adjacent pixels or voxels according to a certain homogeneity criterion is called segmentation.

3.1. Classification

Segmentation is usually the first step in image analysis in the process of machine vision and comes after image pre-processing [18, 19]. The process is thus

Scene → Image acquisition → Image preprocessing → Segmentation → Characteristic extraction → Classification → Statement

3.2. Characteristics

One speaks of a complete segmentation, if each pixel is assigned to at least one segment. In the case of non-covering segmentation, each pixel is assigned to a segment at most. In the case of a complete and uncover-free segmentation, each pixel is assigned precisely to one segment. Segmentation is called contiguous when each segment forms a contiguous domain [20].

3.3. Procedures

Many methods for automatic segmentation are known. Basically, they are often divided into pixel-, edge- and region-oriented processes. In addition, one differentiates model-based methods, from which one proceeds from a certain form of the objects, and text-structured methods, in which also an inner homogeneous structure of the objects is taken into account [20].

The boundaries between the procedures are often fluid. It is also possible to combine different methods to achieve better results.

Of course one can also perform the segmentation in a nonautomatic process, ie, a person makes the classification. Since the automatic procedures are far from perfection, there is also the possibility of semiautomatic processing [19].

3.3.1. Pixel oriented Procedure

Pixel-oriented methods make the decision whether to belong to a particular segment or not for each individual pixel. This decision can - but does not - need to be influenced by the environment. Punctor-oriented methods are usually easy to calculate and therefore fast, but do not initially provide any connected segments. Segmentation is called when individual objects are countable on a binarized image. Each segmented object is then, e.g. By a run length coding of the binarized pixels. The binarization is the precursor of segmentation [20].

The most common binarization method is certainly the threshold method. This method is based on a threshold which is best determined by a histogram.

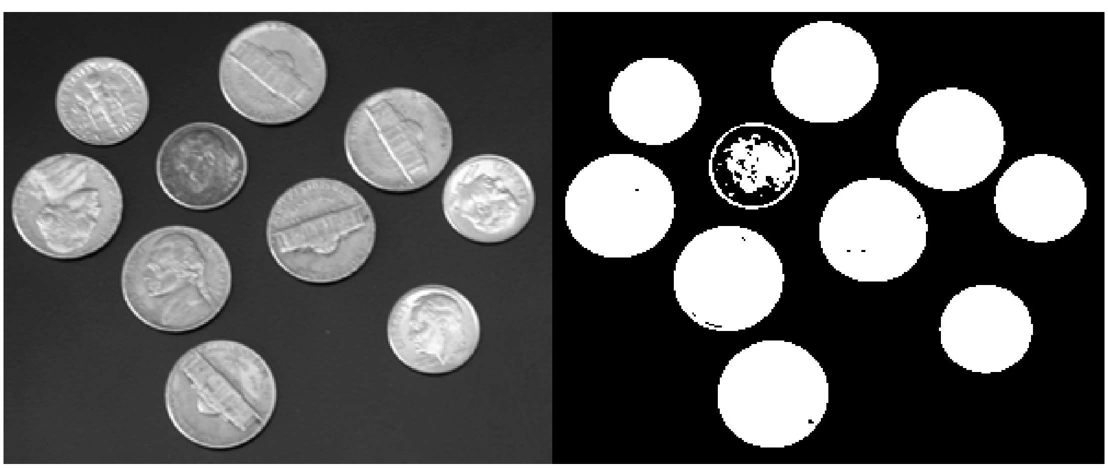


Figure 3. 1. Example picture, Image after binarization with threshold value 90

In the illustration of figure 3.1, the background is brighter than the black object. In the simplest case, the threshold value of the binarization results from the mean value of the darkest and brightest gray value in the image. Segmentation is often the precursor of a classification.

3.3.2. Edge-oriented methods

In these methods, the image is searched for edges or object transitions. Many algorithms do not provide closed edge trims; they need to be merged with other methods to include objects. Actually, edges always lie between the pixel regions of an image. The results of an algorithm can be polygons (or lines, or, in some cases, curves), but some operations also provide the edges as different-color pixels. In the OpenCV software, each segmented object is described by an enclosing traverse. Segmentation can also be used to divide an image into a foreground plane and a background plane [21].

With procedures like the Sobel operator and the Laplace operator, as well as a gradient search, pixels belonging to an edge can be found. However, these are usually initially still loose and must be completed with edge tracking algorithms. A popular method for producing a contiguous object silhouette or at least edge pulls from the edge pixels is the live wire method of E. Mortensen, W.A. Barrett and J.K. Udupa. The idea can be vividly compared with a navigation system that determines an optimal path from the start to the destination. Optimal means in the context of the segmentation that the path between start and finish always leads over the strongest edge pixels. The optimal choice of options is then a standard problem of computer science and can, for example, be solved with a wide search [20, 21].

3.3.3. Regions-oriented procedures

The region-oriented methods consider point sets as a whole and try to find related objects. Frequent use finds procedures such as region growing, region splitting, pyramid linking and split and merge.

Mathematically more sophisticated, the image cannot be understood as a matrix of pixels, but as a continuous function, which, for example, maps the unit square into the color space $u_0 : [0;1]^2 \to \mathbb{R}$ For a gray scale image.

Energy methods assign a real energy value to any possible segmentation of the image and seek a minimum of this energy function. A segment of u is understood to mean an image with areas of uniform (often constant) color intensity. A variety of C. separates between the regions [22]. Different energies can be used depending on the application field. Usually:

The difference between segmentation and original image, eg. $\int (u - u_0)^2$

A measure of the length of edges C between individual segmentation regions, for example $\mathcal{H}^2(C)$, the two-dimensional Hausdorff measure as the length of the segmentation edge.

If the segmentation regions do not have to have a constant intensity: a measure of intensity differences such as for example $\int_{[0;1]^2 \setminus C} |\nabla u|$

Possible solutions are:

Graph-cut methods, which proceed from the continuous model, nevertheless yield a discrete algorithm, Variational methods which achieve a descent of the energy function as a solution of a partial differential equation.

The former are currently available for smaller images in real-time (30 fps), but offer maximum pixel accuracy. The variation approach also allows sub pixel accuracy. This is particularly useful in the case of diagonal edges, which in discrete processes always produce stair effects. At present, methods are being explored to solve the variation approaches on the processors of graphics cards (GPUs). Speed advantages are predicted from a factor of 5 to 40, which would make the variance approaches considerably faster.

Continuous methods have only been explored with apparent success since about 2002 and are therefore not yet available in end-user software.

3.3.4. Model-based procedures

A model of the searched objects is used as the basis. This may, for example, concern the form. So you use knowledge about the image. A known method is the Hough transformation, by means of which points can be combined into lines or circles by mapping them into a parameter space. Furthermore, statistical models and segmentation are used by templates (template matching). In the latter method, the image is searched for given templates.

3.3.5. Texture-oriented methods

Some image objects do not have a uniform color, but a uniform texture. For example, an object may have grooves which then appear in the photograph as alternating strips of dark and light color. So that these objects are not decomposed into many small objects on the basis of the texture, one uses approaches, with which one tries to counter this problem. These methods are partly at the border of classification or permit simultaneous segmentation and classification [20, 23].

- Co-occurrence Matrices (Haralik Matrices)
- Texture Energy Measurements (Texture Energy Measure)
- Run-length matrix (run-length matrix)
- Fractal dimensions and dimensions

- Markow random fields and Gibbs potentials
- structural approaches
- Signal theoretical concepts

Tze Weng Ng [9] uses Haar wavelets in his methods. This system has two main modules. The first is the feature extraction and the other is the mapping module. A histogram equalization is performed on the standardized iris image. Histogram equalized iris image Haar wavelet transform is applied. As a result, 348 coefficients are produced. These coefficients are converted into binary iris code. Matching operation is performed with Hamming distance.

In next chapter we will discuss about the proposed method and we will investigate the filters which we used in our method. The median filter, Gaussian filter and also wiener filter we used for detection of the iris. For finding the area of the pupil we used the thresholding technique. Also we used the adaptive histogram equalization for enhancing the image and find the best histogram of the image

4. PROPOSED ALGORITHM

In this thesis for evaluation of our result we tested on the CASIA-Iris database. This database include 3 separate database: CASIA-Iris-Interval, CASIA-Iris-Lamp and CASIA-Iris-Twins. The CASIA-Iris-Interval include 249 person, CASIA-Iris-Lamp include 411 and CASIA-Iris-Twins include 100 person.

4.1. Wiener Filter

The wiener filter is a filter for signal processing developed independently by Norbert Wiener and Andrei Nikolaevich Kolmogorow in the 1940s [24] and published by Norbert Wiener in 1949. [25] It performs an optimal noise reduction.

4.2.1 Characteristics

The Wiener filter is described by the following properties: [26]

1. Prerequisite: The signal and the additive noise are equal to stochastic processes with known spectral distribution or known autocorrelation and cross-correlation
2. Error criterion: Minimum square deviation

Features

As an input signal of the Wiener filter, a signal $s(t)$ is interfered with by an additive noise $n(t)$.

$$y(t) = s(t) + n(t)$$

The output signal $x(t)$ results from the convolution of the input signal with the filter function $g(\tau)$:

$$x(t) = g(\tau) * y(t) = g(\tau) * (s(t) + n(t))$$

Error

$$e(t) = s(t + d) - x(t)$$

and quadratic error

$$e^2(t) = s^2(t+d) - 2s(t+d)x(t) + x^2(t)$$

result from the deviation of the output signal from the time-shifted input signal $s(t+d)$. Depending on the value d of the time offset, different problems can be considered.

The degraded image, i_D(x,y), along with the Power Spectral Density of the blur function and the noise variance are passed to the restoration filter. With knowledge of the noise, the restoration filter estimates the original input image, i(x,y).

It is possible to in an optimal solution using the method described above to arrive. In general, the statistical estimator looking to minimize the number of criteria such as mean square error. Another common estimator is least squares, which seeks to minimize $\| Q\hat{i} \|$, Q being a transformation matrix and i hat being an estimate of the original image. The optimal i hat is found by using Lagrange multipliers (Gonzales, 1992):

$F(\hat{i}) = \| Q\hat{i} \| + \alpha(\| i_D - H\hat{i} \|^2 - \| n \|^2)$ where i sub D is the degraded image and α is a Lagrange multiplier. The required minimization is achieved where the derivative is zero:

$$\frac{\partial F(\hat{i})}{\partial \hat{i}} = 2Q^T Q\hat{i} - 2\alpha H^T(i_D - H\hat{i}) = 0 \Rightarrow \hat{i} = (H^T H + \frac{1}{\alpha} Q^T Q)^{-1} H^T i_D$$

When α=1 the MSE $E\{[i(x,y) - \hat{i}(x,y)]^2\}$ is minimized and the Wiener solution can be obtained (Gonzales, 1992).

Typically, autocorrelation will signal a statistical characteristic of some of the employee's signal, which will be a guest ICT predictor of the ICT Develop an end result and estimate. Wiener filter so begins:

$R_i = E\{ii^T\}$ and $R_n = E\{nn^T\}$ are the autocorrelation matrices for the image and noise, respectively.

Since the real image noise, correlation matrices are symmetric. This allows for the correlation matrix approximation as it circulates blocks and we can develop high conversion actions:

$R_i = WAW^{-1}$ and $R_n = WBW^{-1}$

As developed above, A and B show DFTs. Because radon-ray and correlation matrix, A and B are the image and noise power spectrum, is respectively. To obtain a Wiener filter, as we choose a high conversion matrix (Gonzalez, 1992) is defined as: $Q^T Q = R_i^{-1} R_n$ and then use the minimal i hat solution:

$\hat{i} = (H^T H + \frac{1}{\alpha} R_i^{-1} R_n)^{-1} H^T i_D$, we now use $H = WDW^{-1}$, $R_i = WAW^{-1}$ and $R_n = WBW^{-1}$

$$\hat{i} = (WD^* W^{-1} WDW^{-1} + \frac{1}{\alpha} WA^{-1} W^{-1} WBW)^{-1} WD^* W^{-1} i_D = (WD^* DW^{-1} + \frac{1}{\alpha} WA^{-1} BW)^{-1} WD^* W^{-1} i_D$$

Note that the transpose operator on H causes D to be conjugated since it contains complex exponentials and reciprocating is equivalent to conjugating.

$$W^{-1}\hat{i} = (D^* D + \frac{1}{\alpha} A^{-1} B)^{-1} D^* W^{-1} i_D$$

In this form we see the W operator obtaining the DFT of the restoration estimate i hat and the degraded image. We know D, A and B are already DFTs. We also know α=1 for the Wiener filter solution. Therefore, this equation is a frequency domain representation of the filter solution:

$$\hat{I}(u,v) = \frac{H^*(u,v) I_D(u,v)}{H^*(u,v)H(u,v) + \frac{N(u,v)}{I(u,v)}} = \frac{H^*(u,v) I_D(u,v)}{|H(u,v)|^2 + \frac{N(u,v)}{I(u,v)}}$$

Of course, in practice, it is not necessary to estimate the degraded image i hat when i itself is known. Therefore, the ratio of the noise and image power spectra are usually estimated by a constant, K. This gives the final form of the Wiener filter in the frequency domain:

$$\hat{I}(u,v) = \frac{H^*(u,v) I_D(u,v)}{H^*(u,v)H(u,v) + K}$$

In our experimentation, we followed the suggestion of Gonzales and Woods to take $K=2\sigma^2$ where σ^2 is the variance of the noise. This generally yielded good results.

4.3. Median Filter

The rank order filters belong to the class of non-linear filters in digital image processing. These are filters which can not be described by a convolution.

In the rank order filters, the gray values of the pixels are collected in a defined environment of a pixel, sorted according to the size and placed in a ranking order. A gray value is then selected from this sorted list, which replaces the gray value of the current pixel.

The selection of the position determines the type of the rank order filter. With an ascending sorting one gets the

Minimum filter, for the minimum gray value, first position of the list

Median filter, for the gray value, which is in the middle of the list
Maximum filter, for the maximum gray value, last position of the list.

4.3.1. Minimum filter

In the minimum filter, the gray values of the pixels are collected in a defined environment of a pixel and sorted by size. Now the smallest gray value of this sorted list is selected, which replaces the gray value of the current pixel.

4.3.2. Principle

The main idea of the median filter is to replace each input by the median value of its neighborhood.

For example, if we consider these nine pixels, of which an aberrant value (here 111):

5	6	7
6	111	8
7	8	9

The median filter will consider the values of the neighborhood by increasing values:

5	6	6	7	**7**	8	8	9	111

And take the median value, here the value 7. The output of the filter will therefore give:

5	6	7
6	**7**	8

7	8	9

Which made it possible to replace the aberrant value by a "consensus" value between the neighboring values.

4.3.3. Characteristics

The median filter makes it possible to eliminate the aberrant values without being limited to making an average calculation which will tend to contaminate the neighboring values with this aberrant value and blur the image.

The median filter respects the contrast of the image (if one multiplies all the values by a positive constant, the scheduling of the values is unchanged) and the brightness of the image (adding a constant does not modify the scheduling either).

In areas where the intensity is monotonous (only increasing or decreasing only) the filter leaves the image unchanged. It respects contours, and eliminates extreme values.

On the other hand, the composition of several median filters does not correspond to a median filter.

The pseudo code for median filter is shown in figure 4.1

```
allocate outputPixelValue[image width][image height]
allocate window[window width * window height]
edgex := (window width / 2) rounded down
edgey := (window height / 2) rounded down
for x from edgex to image width - edgex
    for y from edgey to image height – edgey
        i = 0
        for fx from 0 to window width
            for fy from 0 to window height
```

```
                window[i] := inputPixelValue[x + fx - edgex][y + fy - edgey]
                i := i + 1
        sort entries in window[]
        outputPixelValue[x][y] := window[window width * window height / 2]
```

Figure 4. 1.Pseudo code for median filter.

In figure 4.2 the result is shown for the 8 type of the median filter. As shown in these result when the filter size is increasing then the image is blurring high. For these 8 type of the filters we used 3x3, 5x5, 7x7, 9x9, 11x11, 13x13, 15x15 and 17x17.

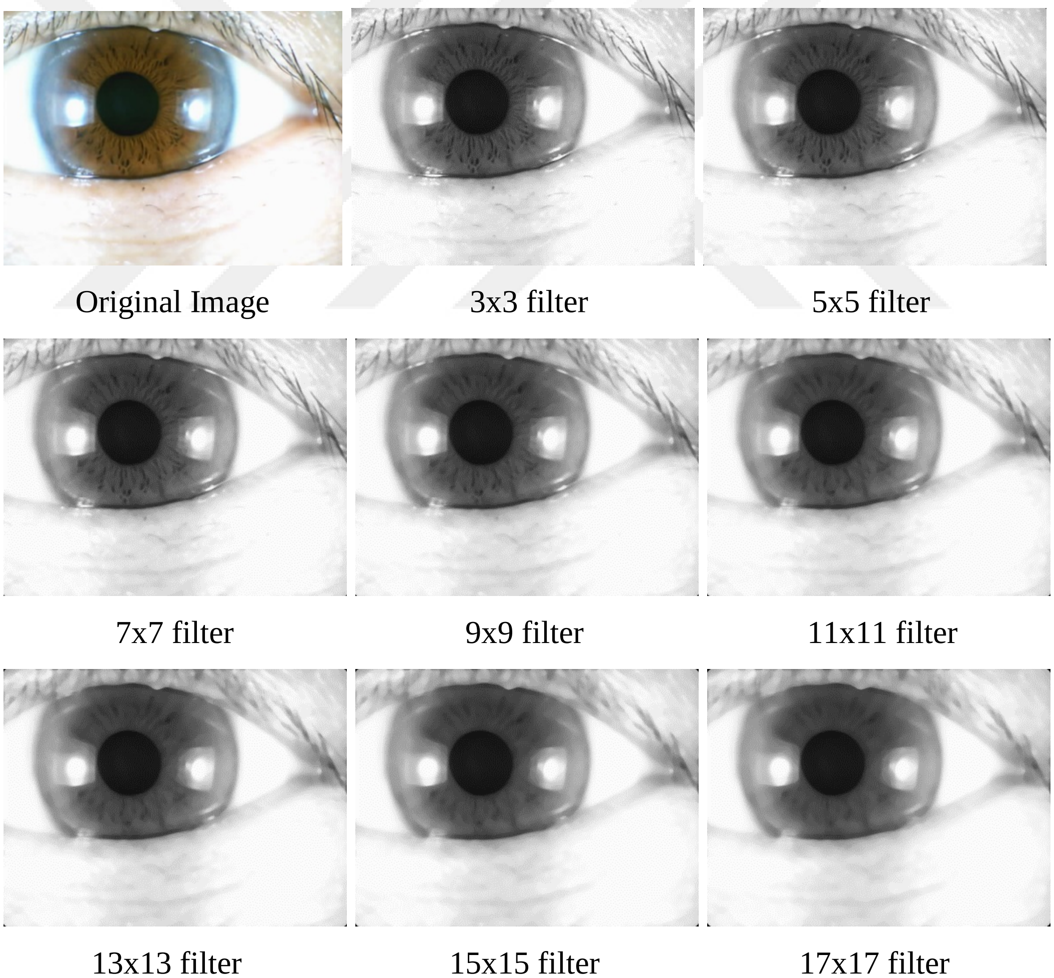


Figure 4. 2.Result for 8 type of the median filter

4.4. Gaussian Filter

Gauss filters are frequency filters which have no overshoot at the step response and at the same time have a maximum edge steepness in the transition region. A special feature of this filter is the transmission function as well as the impulse response, the curve of a Gaussian bell curve, as shown in the figures to the right, which also derives the name of this filter type.

Areas of application for this filter are digital modulation methods and image processing.

4.4.1. Transfer function

The amount of the transfer function $H(j\omega)$ is given by Gaussian filters

$$|H(j\omega)| = e^{-\left(\frac{\omega}{2\alpha}\right)^2}$$

With the constants α

$$\alpha = \frac{\pi}{\sqrt{\ln(\sqrt{2})}}$$

The impulse response of a Gauss filter is

$$h(t) = \frac{\alpha}{\sqrt{\pi}} e^{-(\alpha t)^2}$$

From this it can be seen that the Gaussian filter is an idealization because it is non-causal: half the impulse response (curve at t <0) has already appeared at the output of the filter when the triggering signal, the pulse, Occurs at t = 0.

The summary of proposed method is shown in figure 4.3.

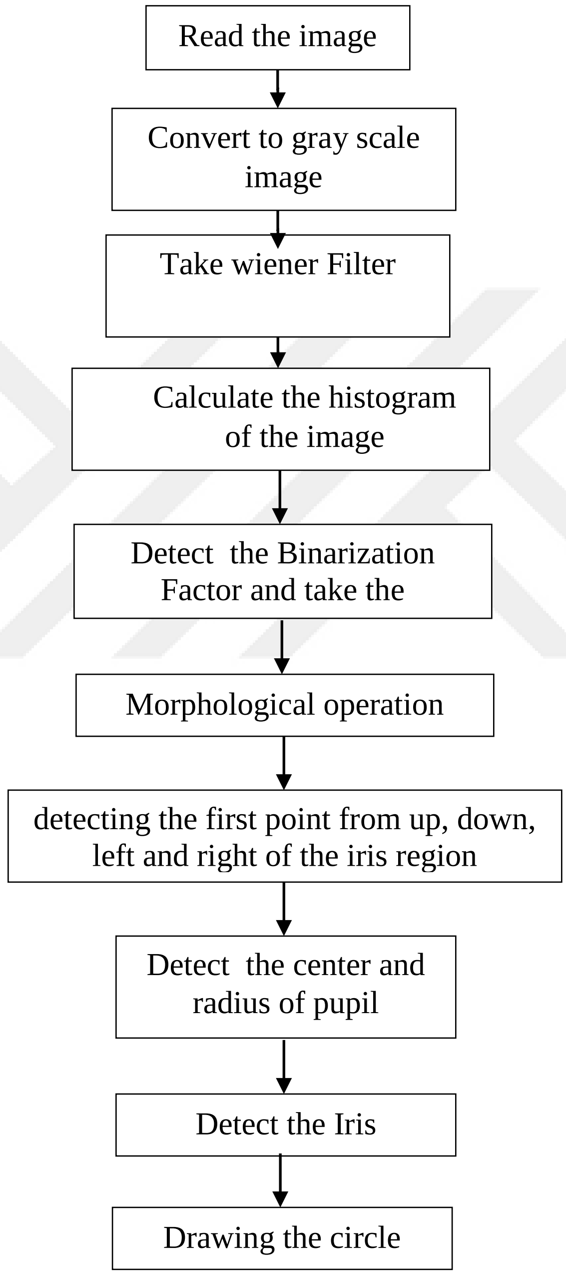


Figure 4. 3.Summary of proposed method for iris detection

In first step we read the image. Figure 4.4 shows the original image which we read and show in matlab program.

Figure 4. 4.Original image

Then we convert the original image to gray scale. This result is shown in figure 4.5. The original image here is colored. Also for our application we used CASIA database and all image of this database is grayscale image and not need for converting to gray scale. But for real time application our method will use and we read the image from camera signal in first step we can convert to gray scale and then the process will be implement.

Figure 4. 5.Gray scale image

In next step we calculate the histogram of the gray scaled image. The histogram of the image is shown in figure 4.6. As shown in this figure the range of the pixel is from 0 up to 255. This range is shown in x coordinate. The number of pixels are shown in y axis.

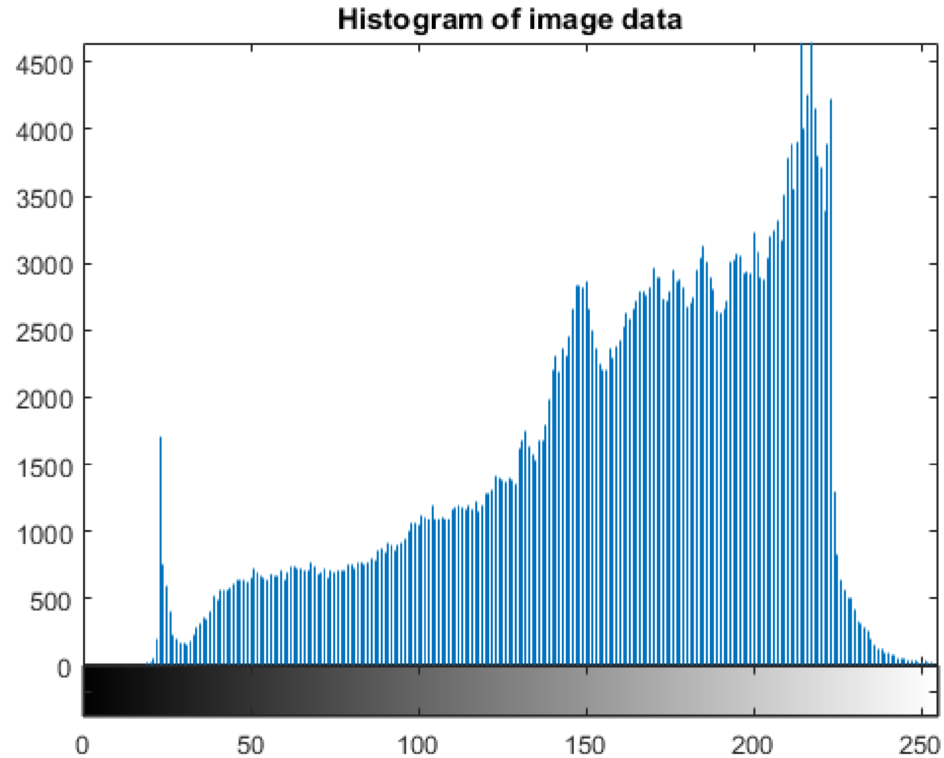
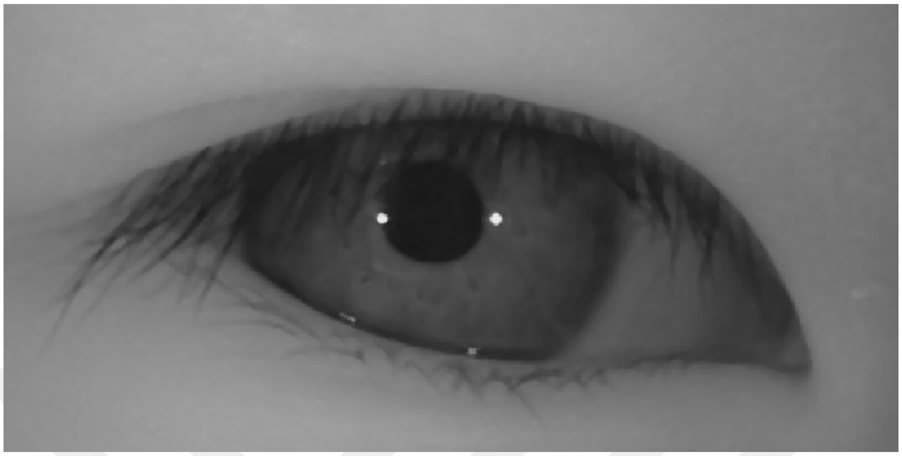
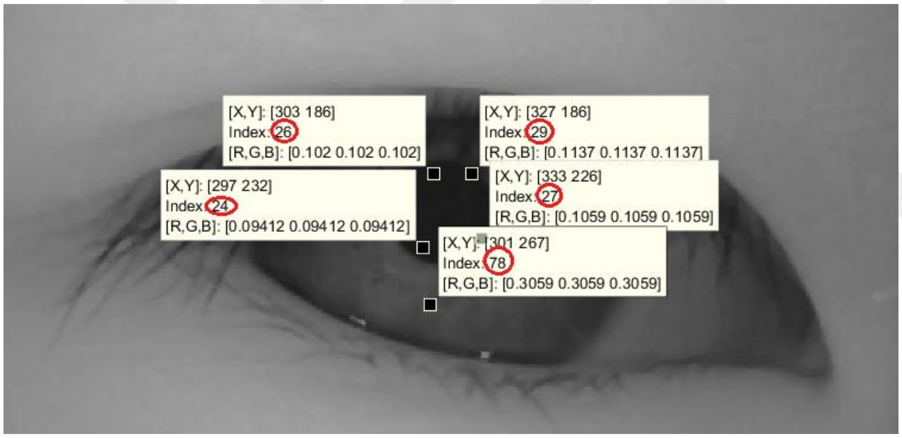


Figure 4. 6. Histogram of the gray scale image

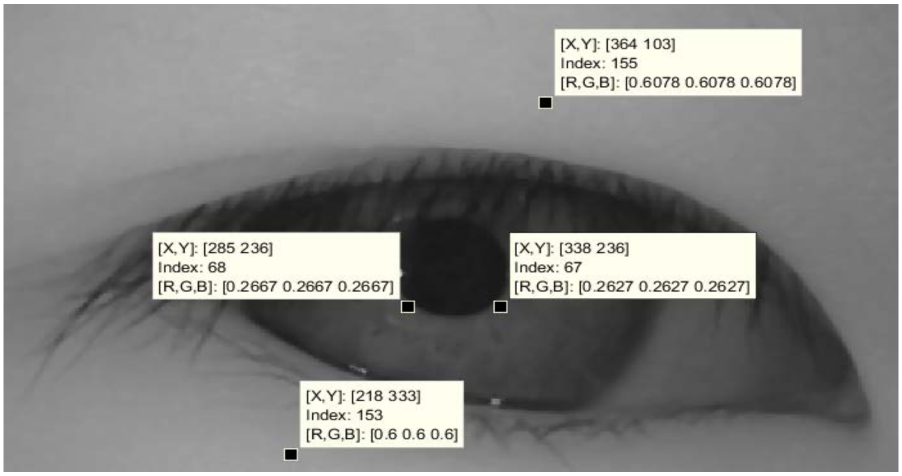
After finding the histogram we must find the binarization factor. This binarization factor will use for thresholding of the image. This factorization value will help us to find the threshold value for pupil part. For finding of this factor we start from 1 up to 50. These values are taken by testing and looking on the pixel values. For example this state is shown in figure 4.7.



(a)


[X,Y]: [303 186]
Index: 26
[R,G,B]: [0.102 0.102 0.102]
[X,Y]: [327 186]
Index: 29
[R,G,B]: [0.1137 0.1137 0.1137]
[X,Y]: [297 232]
Index: 24
[R,G,B]: [0.09412 0.09412 0.09412]
[X,Y]: [333 226]
Index: 27
[R,G,B]: [0.1059 0.1059 0.1059]
[X,Y]: [301 267]
Index: 78
[R,G,B]: [0.3059 0.3059 0.3059]

(b)


[X,Y]: [364 103]
Index: 155
[R,G,B]: [0.6078 0.6078 0.6078]
[X,Y]: [285 236]
Index: 68
[R,G,B]: [0.2667 0.2667 0.2667]
[X,Y]: [338 236]
Index: 67
[R,G,B]: [0.2627 0.2627 0.2627]
[X,Y]: [218 333]
Index: 153
[R,G,B]: [0.6 0.6 0.6]

(c)

Figure 4. 7. Find the value of the pupil which is in range of the 1 up to 50 range, a) original image, b) the range of the pixels, c) other range of the near pupil and far from pupil.

As shown in this figure the close pixel to pupil has range between 50 up to 70, and far pixels has range more than the 70.

This threshold value is 50 up to 70. This value is got from testing this area. In most images the pixel value of pupil part is change from 1 up to 50. As seen in this figure the out of the pupil is start from 50 to more than the 70. But in the near of the pupil the value is around the 70. For this reason we select the 70.

As seen in this figure the some pixels which we tested this value is in the range of the 50~70. After applying this thresholding value to image we get the binary image result and this result is shown in figure 4.8.

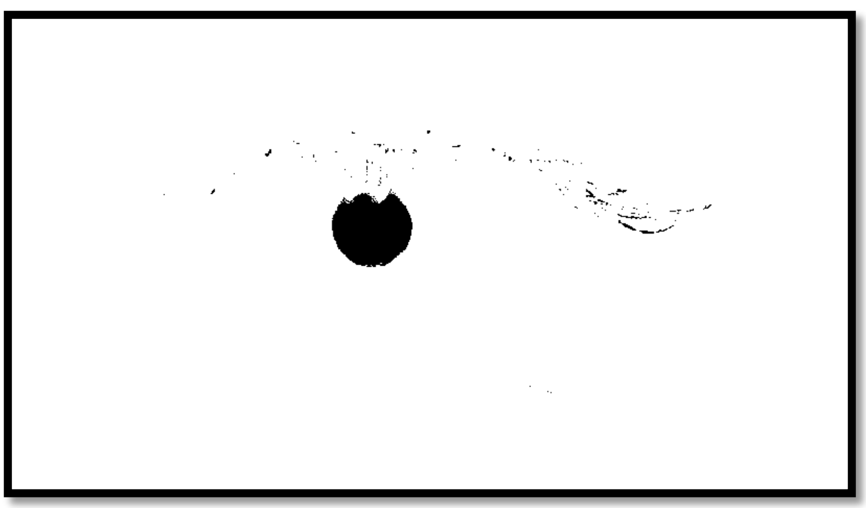


Figure 4. 8. Binerization of the image

After getting the result for binarization we get the same spot points and this points are the noise. We used morphological method for removing of this noise. For morphological operation we used dilation. Dilation method dilates the grayscale, binary, or packed binary image, and then return the dilated image. The argument of structural element (SE) is a structuring element object, or array of structuring element objects. If image is logical, the structuring element must be flat and image dilating performs binary dilation. Otherwise, image dilating method performs grayscale dilation. If structural element is an array of structuring element objects, image dilating method performs multiple dilations of the input image, using each structuring element in succession.

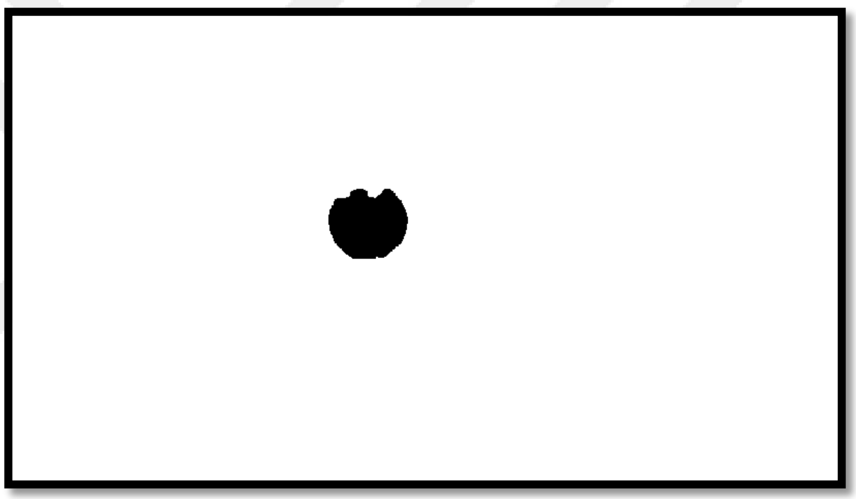


Figure 4. 9. After removing the spot noise

As shown in this figure all noise are removed from image. After this step the pupil is segment.

The segmented area of pupil is detected and this result is shown the 4.10.

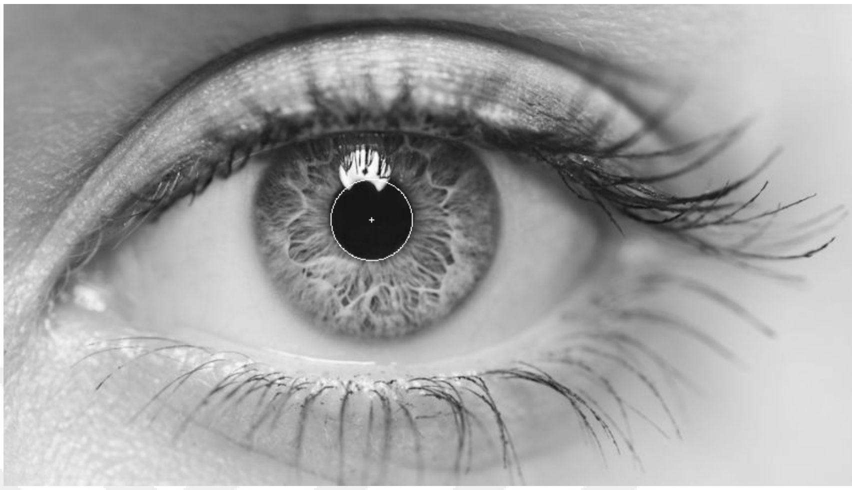
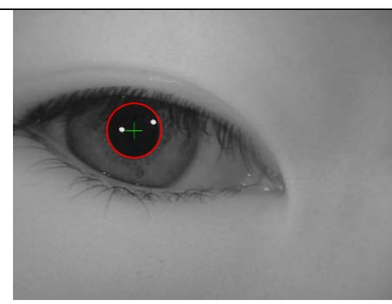
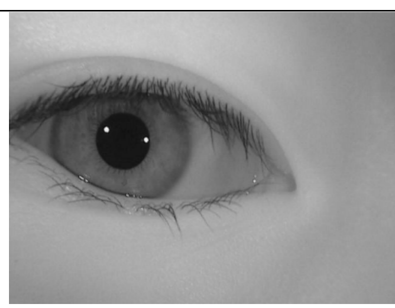
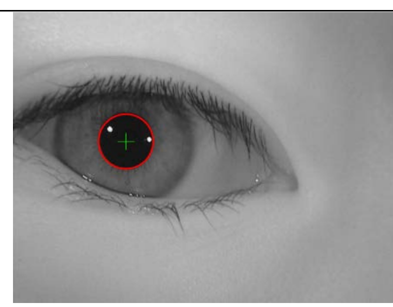


Figure 4. 10. The iris is detected

Some result for segmentation of pupil is shown in figure 4.11. As mentioned before, for detection of the iris we need to segment the pupil and then the iris will be detect.

Image number	Original Image	Iris detected
1		
2		

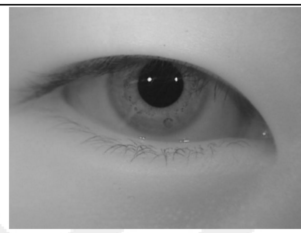
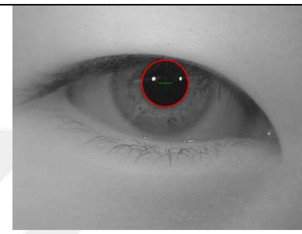
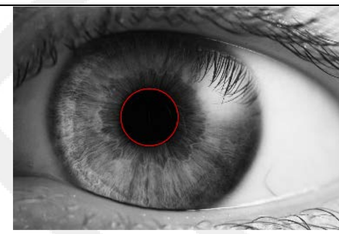
3		
4		
5		

Figure 4. 11. Result for some sample images.

Finally we select the 60 value (i.e. pixel value) for adding this value to radius of the pupil. This value is got from the experimental result as we will explain in the discussion part. We tested all images and this value is fixed for all images.

5. RESULT AND DISCUSSION

In this chapter we show the simulation results and we discuss about the results which we implemented on MATLAB 2016a version.

5.1. Simulation result

The result of proposed method is shown in figure 5.1. Also this figure shows the comparison between the other methods.

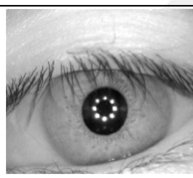
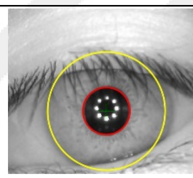
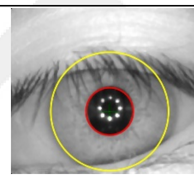
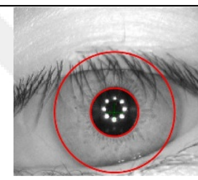
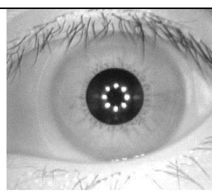
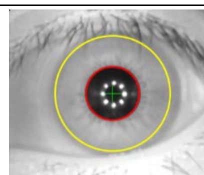
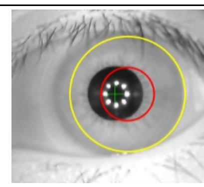
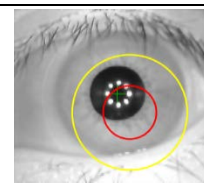
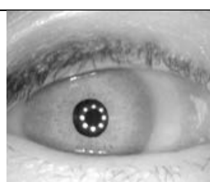
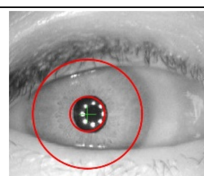
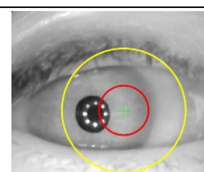
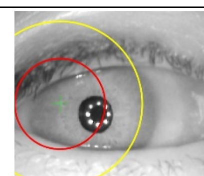
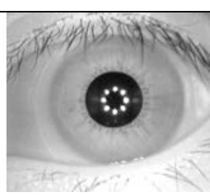
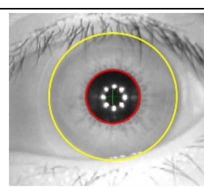
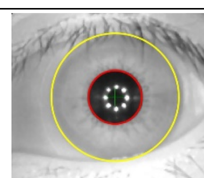
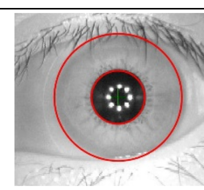
Original Image	**Wiener filter**	**Median filter**	**Gaussian Filter**
			
			
			
			

Figure 5. 1. Comparison between the three methods

In this figure the proposed method is compared with 2 others method. Proposed method is shown in second column and two other methods are shown in other two columns..

The result for all group from database is shown in figure 5.2.

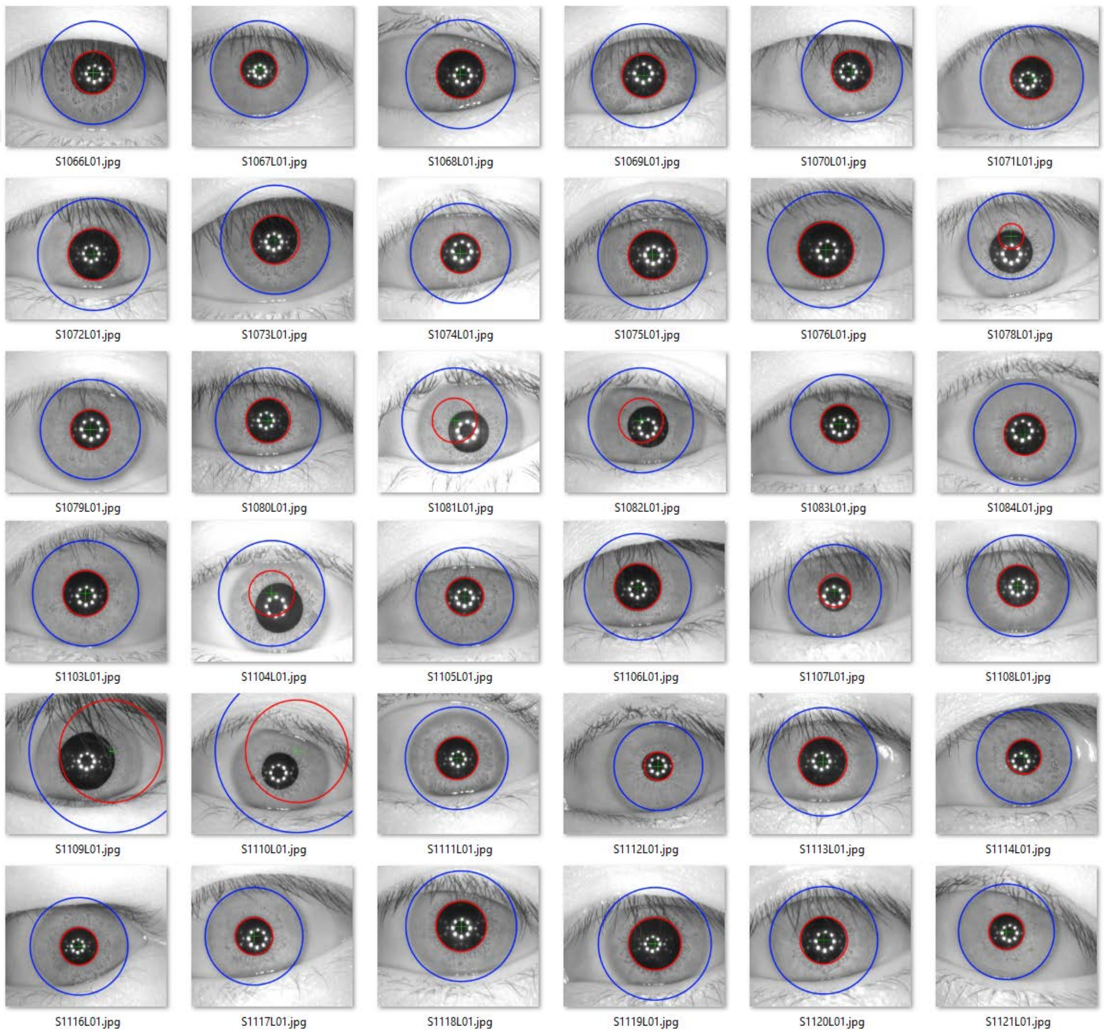


Figure 5. 2. Result for all group

As shown in figure 5.2 some images are correctly found the pupil but is some of them is not found correctly. The reason is dependent on the images. Some images has not good contrast and the resolution is low.

5.2. `Comparison based on the radius

We tested image for different value like 50, 60 and 70. The unit of these values are pixel. But the best value was 60. This statement is shown in figure 5.3.

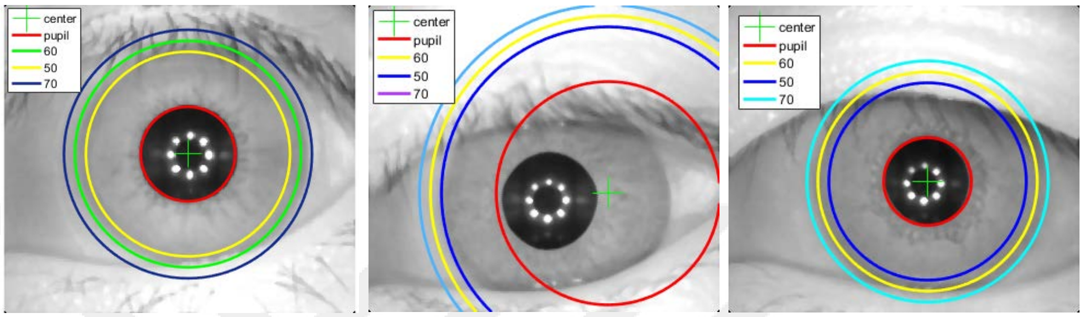


Figure 5. 3. The comparison for different value of radius.

As shown in this figure the best result is get for 60. In this value the Iris is detected. In value of 70 the area of iris is detected mistake and the circle is outside of the iris, also in 50 the circle is inside of the iris and this is mistake. But the best result is 60 and in this value the circle is fix to iris.

For finding of the iris value from radius of the pupil we tested on 5 values. These values are 50, 55, 60, 65 and 70. After testing we found that the most iris has the 60 pixel distance from radius of the pupil. For this reason we selected the 60 pixel value. The comparison between the different radiuses for iris include 50, 55, 60, 65 and 70 is illustrated in figure 5.4.

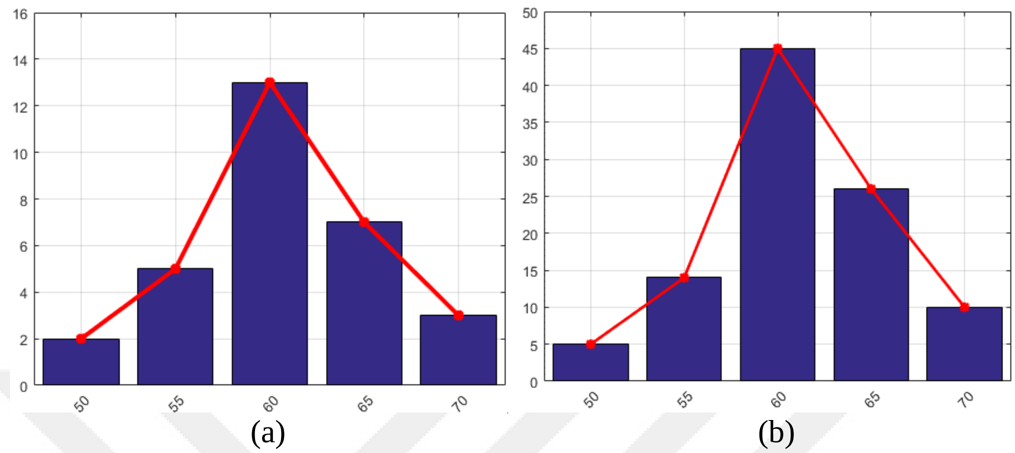


Figure 5. 4. Comparison between the different radiuses for iris include 50, 55, 60, 65 and 70 in a) for all database, b) for Twins database.

As shown in this curve the best value is 60 for selecting of the iris. In figure 5.4-a we implemented on the all database but we select the 30 images from all database. In figure 5.4-b we implemented and show about the Twins database and we selected 100 sample images.

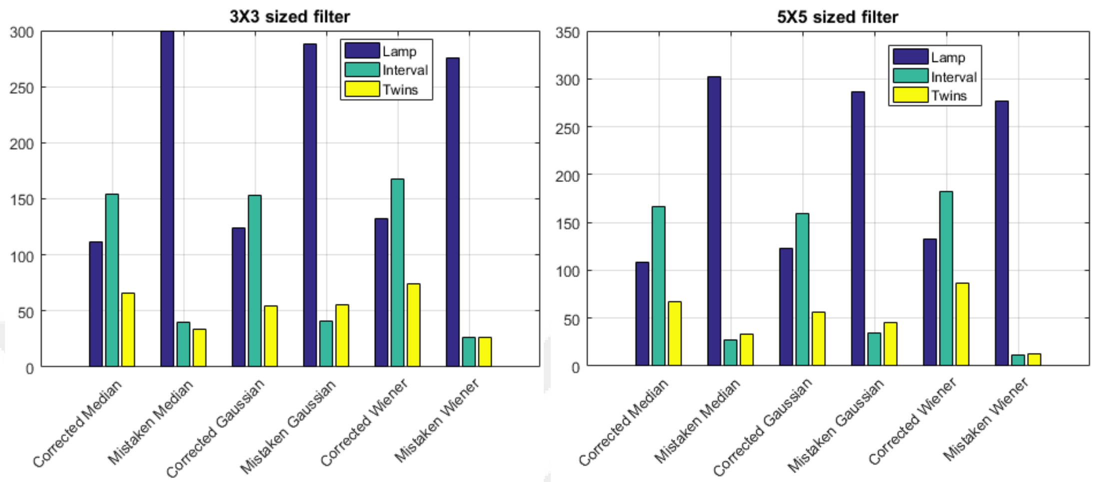


Figure 5. 5. The result for 3x3 and 5x5

In 3*3 lamp database for median filter the correctly iris detection is 112 and for mistaken number is 299. For Gaussian filter the corrected iris detection is 124 and mistaken detection is 288. Also for Wiener filter the corrected detection is 132 and mistaken detection is 276.

In Interval database for median filter the correctly iris detection is 154 and for mistaken number is 40. For Gaussian filter the corrected iris detection is 153 and mistaken detection is 41. Also for Wiener filter the corrected detection is 168 and mistaken detection is 26.

In Twins database for median filter the correctly iris detection is 66 and for mistaken number is 34. For Gaussian filter the corrected iris detection is 54 and mistaken detection is 56. Also for Wiener filter the corrected detection is 74 and mistaken detection is 26.

As well as the same results for 5*5

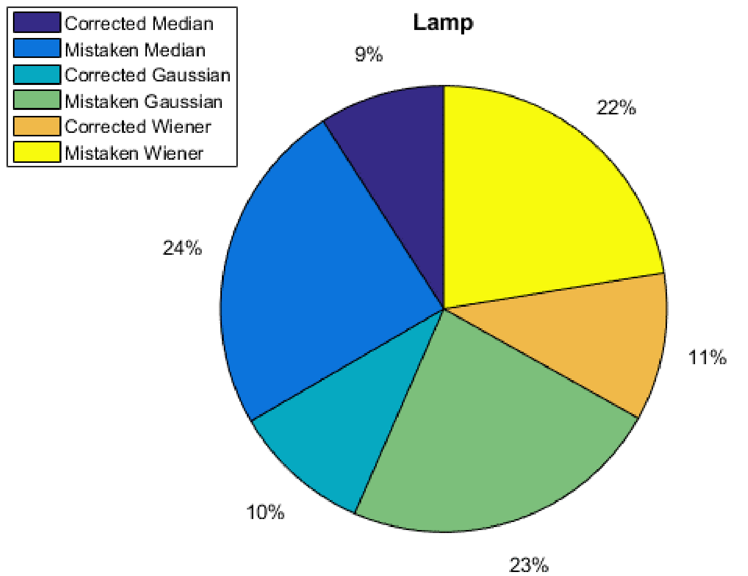


Figure 5.7. The result for Lamp 3x3

As shown in this figure the highest percentage is 24% for all images of Lamp database. And this value is dependent on the mistaken Median filter result. The lowest value is got for corrected Gaussian filter. The 11% is corrected for proposed method and also the mistaken percent is got 22%.

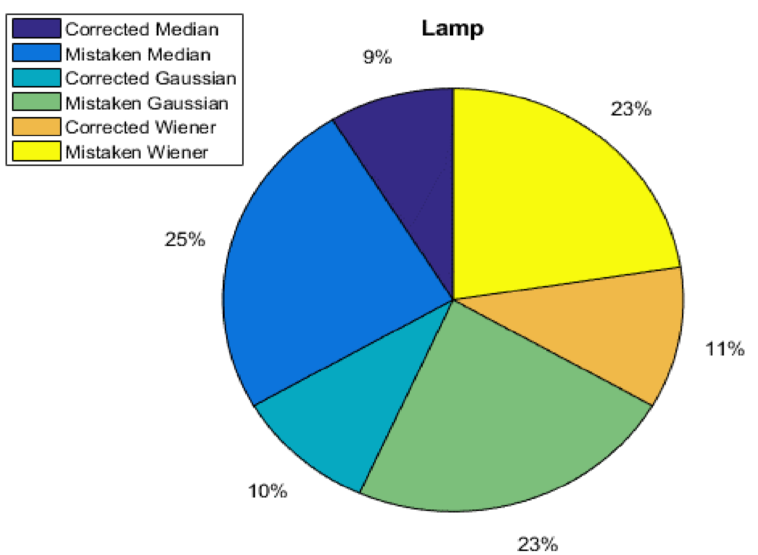


Figure 5.8. The result for Lamp 5x5

As well as the best result been made by Wiener filter for lamp 5*5

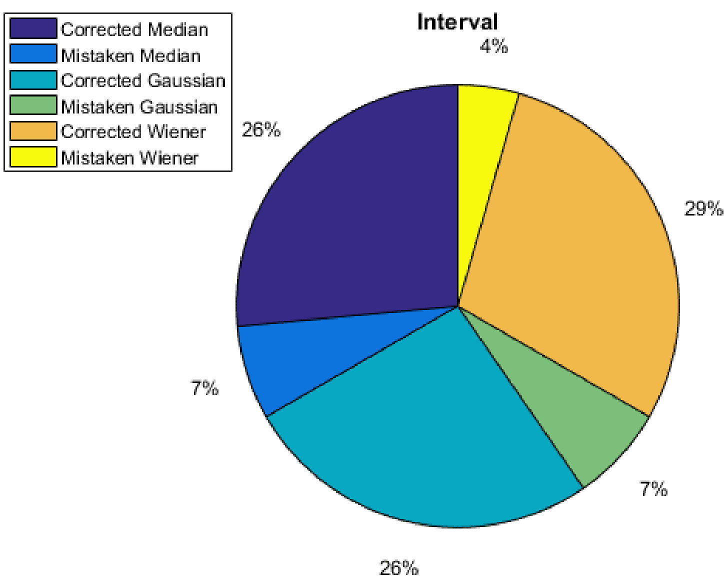


Figure 5.9. The result for Interval 3x3

The figure 5.9 shows the percentages of the 3x3 windowing size for Interval database. In this figure the highest percentage is 29% for all images of Interval database. This value is dependent on the corrected found for iris in eye images. This percentage also is got for proposed method. The lowest value is got for mistaken of proposed method and this value is 4%.

As well as the best result been made where the proportion is correct to31% As it is shown in the next form

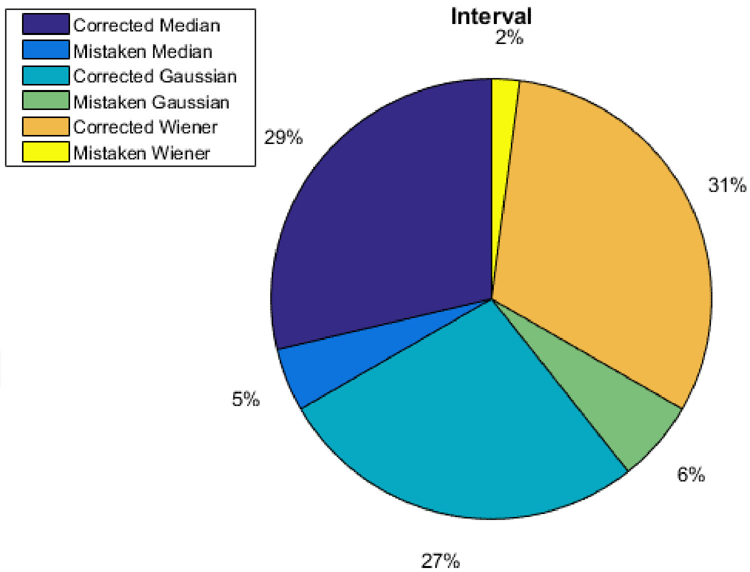


Figure 5.10. Result of a interval database

The figure 5.10 shows the percentages of the 5x5 windowing size for Interval database. In this figure the highest percentage is 31% for all images of Interval database

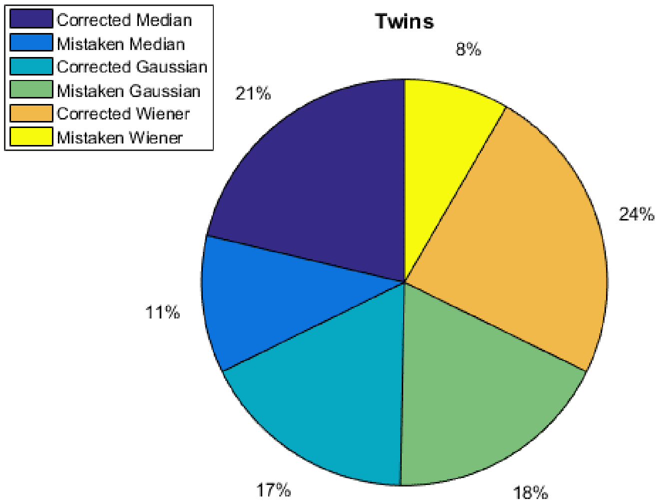


Figure 5.11. The result for Twins 3x3

The final result for the Twins database is shown in figure 5.11. This figure show the result for 3x3 windowing size. In this figure the highest percentage is 24% for all images of Twins database. The highest percentage is dependent on the proposed method. The lowest value is got for mistaken of proposed method and this value is 8%.

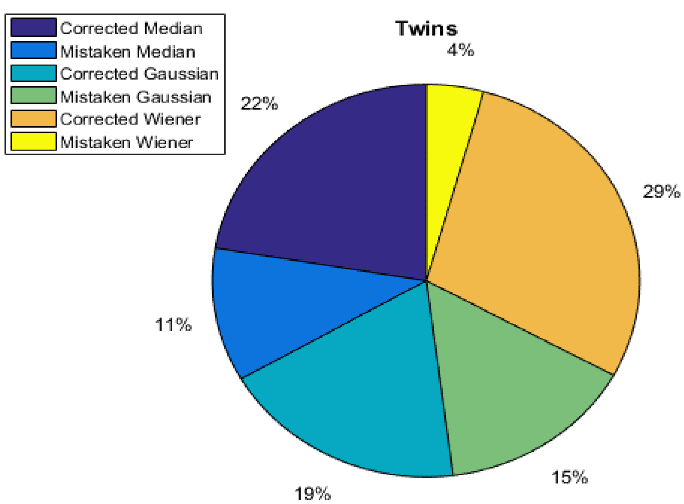


Figure 5.12. The result for Twins 5x5

The final result for 5x5 windowing size for the Twins database is shown in figure 5.12. In this figure the highest percentage is 29% for all images of Twins database. Also this percentage is got from our method.

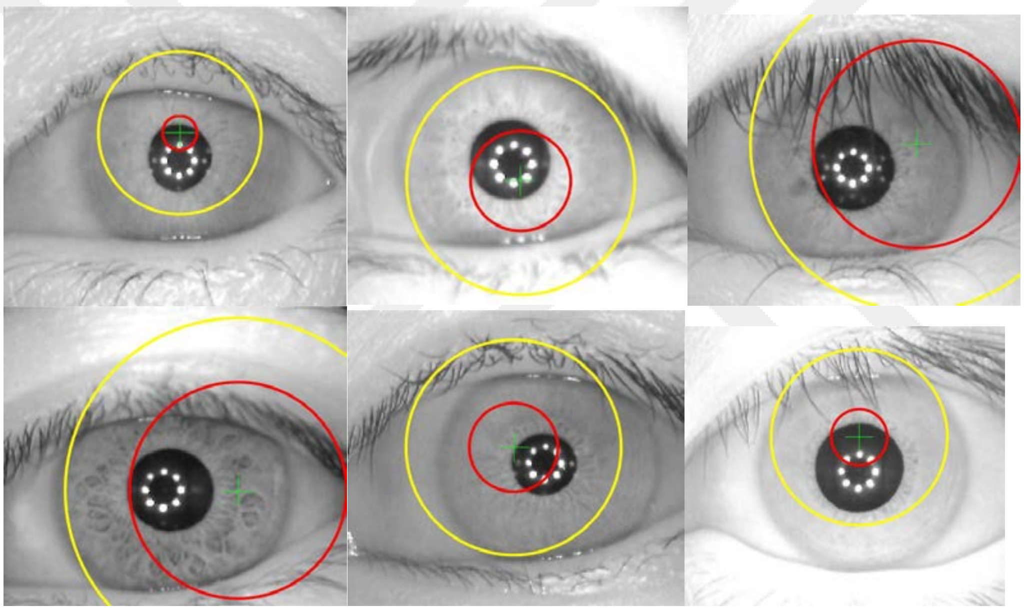


Figure 5.13. The uncorrected result for proposed method

As shown in the figure 5.13 the contrast between pixels of pupil and iris has less different, for this reason when the algorithm search about the thresholding value it get the mistakes value.

6. CONCLUSION

The development of an automatic system could provide great convenience for doctors and practitioners in the field. The image processing techniques proposed in this study can contribute to more effective analysis and more accurate regardless of the individual levels of experience of the users or particular situations and conditions such as fatigue or image quality. Obtaining eye images is extremely important in the diagnosis of eye disorders that progress to blindness if not detected early. In this thesis, we presented a robust method for eye iris segmentation and some automatic algorithms for analyzing the iris segmentation. In this thesis some classical methods implemented then with winner filter which we segmented the iris segmentation. Finally compared our result with other methods and we illustrated that our result has good performance than the other methods. In this thesis study, some filtering methods have been developed for all stages that necessary for recognition of iris. Moreover, the developed methods were run on PC with 6GH RAM hardware and a system which can be used for iris recognition and the success of the methods was evaluated through this system. Algorithms have been developed in the MATLAB environment, as the development phase can be faster. During the algorithm development phase, the images from the existing database are utilized as well as the iris databases available in the literature.

In Lamp database for median filter the correctly iris detection is 112 and for mistaken number is 299. For Gaussian filter the corrected iris detection is 124 and mistaken detection is 288. Also for Wiener filter the corrected detection is 132 and mistaken detection is 276. In Interval database for median filter the correctly iris detection is 154 and for mistaken number is 40. For Gaussian filter the corrected iris detection is 153 and mistaken detection is 41. Also for Wiener filter the corrected detection is 168 and mistaken detection is 26. In Twins database for median filter the correctly iris detection is 66 and for mistaken number is 34. For Gaussian filter the corrected iris detection is 54 and mistaken detection is 56. Also for Wiener filter the corrected detection is 74 and mistaken detection is 26.

Future works

In future we can use in the embedded system for real time applications. This method is fast and there is not used the complex mathematics. For this reason we can use in the real time application for finding the iris in the human face images.

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