Design of an Iris-Based Medical Diagnosis System

Adrian Lodin[1], Sorina Demea[2]
[1] Technical University of Cluj-Napoca, Basis of Electronics Department,
Str.Baritiu 26-28, 400027 Cluj-Napoca, Romania
adrian.lodin@bel.utcluj.ro
[2] Oftalmological Center of Investigation REVIEW, 400001 Cluj-Napoca, Romania

***Abstract*—The goal of this study is to present a system which use correlation between medical pathology and different sectors from the surface of the iris. A computerized iris texture and color analysis reveals texture regions which offer useful information. Locations of those regions upon a segmented iridology charts point out an interrelation between map sectors and the projection of the internal body system. The final automatically generated diagnosis needs user approval, thus making the system semi-automatic.**

I. INTRODUCTION

The iris of the eye impresses by its unique texture and color. Iris can reveal information about unbalances and health of human body internal organs. The analysis of one's iris from both eyes, offering information about the health of some internal organs can be a challenging and controversial problem in medicine. The alternative medicine technique which deals with diagnosis based on iris analysis is called iridology. Iridologists consider eyes, as state of health 'windows' in the body [1]. Patterns, colors and other iris parts, are identified and matched to iris charts. The iris charts, divide the iris surface into a finite number of segments, each segment being associate with an internal organ, apparatus or system. The latest improvements in the biometric field and the newest image acquisition and processing techniques can offer very useful solutions for the iridology. An automatic or semi-automatic biometric system for eye image processing, can be implemented. In comparison to the visual iris examination method, a computer based analysis system offers some advantages: precision in detecting the boundaries of the iris, correct color identification, exact chart matching, accurate specific iris regions localization. All this advantages increase the final diagnosis accuracy [1].

An important role in the system is the user's role. Based on this remark, the diagnosis system should be semi-automatic one, in the way that the final decision, the diagnosis, it should be approved by the user. The current paper presents the design and functionality of such a system.

The paper is organized as follows: an overall presentation of the methods and image processing techniques used in the implementation is illustrated in Section II. Section III contains the experimental results used with the system. The comments regarding the subject of this paper are delivered in the section IV.

II. IRIS RECOGNITION AND TEXTURE ANALYSIS SYSTEM

Iris analysis begins with eye images and their acquisition. The optical system used to obtain the images used for this approach, is described in [2], but its description and functionality is not the topic of the current paper. The iris images are stored in 'PNG' image format, without compression. The color space of the images is RGB, so the luminance of each pixel in the image is stored on three channels: red, green, blue. The solution proposed by the authors for the iris recognition and diagnosis is described as a block diagram in Fig 1.

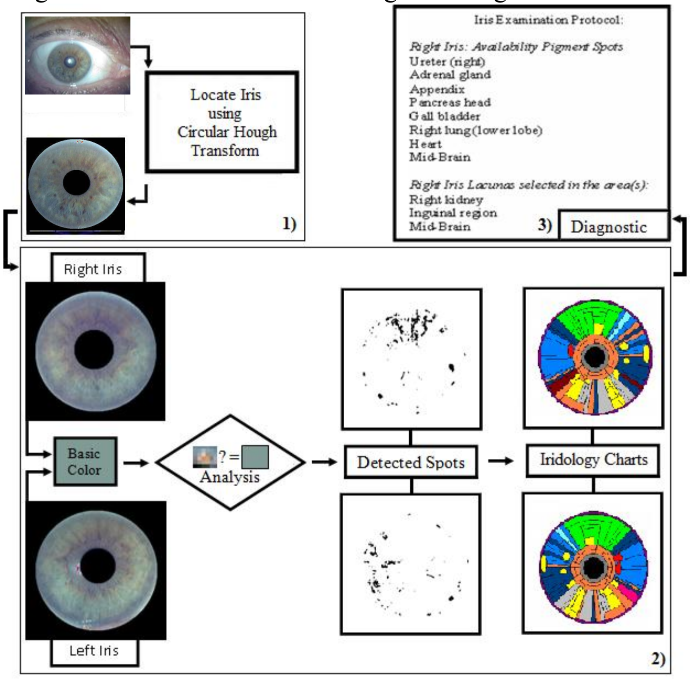

Figure 1. The General System Diagram: 1) Iris Recognition, 2) Iris Analysis 3) Diagnostic generation

Its functionality is simple, following three interdependent steps: iris recognition, analysis of the iris and final diagnosis generation. The eye is a pair organ, but each eye is different and so is the iris. Based on this assumption iris recognition and all the processing methods will be applied independently for each eye. Even the final diagnosis will be correctly generated based on both irises analysis.

A. *Iris recognition and Identification*

The first task, like in any other iris recognition system, is to locate the iris in the eye image. This means to demarcate the boundaries, the outer boundary between the iris and the sclera and the inner one, enclosing the pupil. Because the iris texture has a circular shape, the simple way to detect the boundary it's to approximate it by a circle. In order to approximate and detect, circular shapes inside images, there are a few established methods. First method, used to detect circular iris borders, was presented in 2002 by John Daugman [3] and it detects the iris

9781-4244-3786-3/09/$25.00 ©2009 IEEE

boundaries based on Gabor wavelet method. The integro-differential operators combination method, was introduced by C. Tisse, L. Martin [3]. Another useful method, which was used in our case, is the Circular Hough Transform (CHT). The CHT is a standard computer vision algorithm that can be used to determine the geometrical parameters for a simple circle, present in an image. The main advantage of the Hough transform technique is its tolerance for gaps in feature boundary descriptions and its robustness to noise. By Hough Transform we assume the transformation of a point in the (x, y) normal plane to the Hough parameter plane. The circle is characterized by two parameters: radius and the pair of center coordinate (1). Those parameters make representation on the Hough space very easy to achieve. The circle can be expressed using (1):

$$(x-a)^2 + (y-b)^2 = r^2 \tag{1}$$

where a, b are the center coordinates, r is the radius and x, y the directions; or using the parametric representation:

$$\begin{aligned} x &= a + r\cos(\theta) \\ x &= b + r\sin(\theta) \end{aligned} \tag{2}$$

with the polar coordinates, where r is the radius and θ is the angle. The idea of CHT is shown in Fig 2. The points in the normal plane situated on a circle, have in Hough plane a corresponding circle. All those corresponding circles have only one common intersection point. This point represents the center of the circle from the normal plane [4].

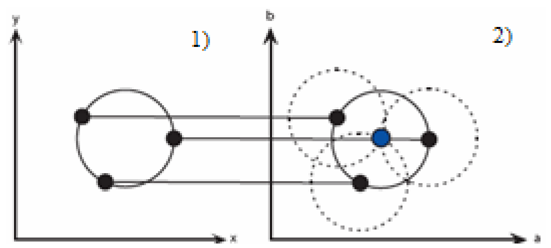

Figure 2. CHT representation: 1) Normal plane, 2) Hough plane

In order to identify correctly the center of the circle, it’s very important to know the radius value. Methods for radius estimations are presented in [5]. The circles in the Hough space having the same given radius, will point out correctly the circle center in the normal space.

The intersection points for all the circles having the same radius will be stored on an accumulation matrix and the maximum in this matrix will reveal the center of the circle in the normal space.

B. Iris Pattern Analysis

Once the boundaries of the iris are identified correctly and its surface is extracted, the analysis of the iris surface can be done. Following the steps described in the Fig. 1, iris pattern analysis is the second step. The iris pattern analysis assumes: identifying the basic iris color, locate the particularities on the surface of the iris, locate those regions on segmented iridology charts. Based on the work of iridologists and their research an automatic analysis can be implemented. In order to perform this type of analysis special techniques of image processing must be used.

Iris color is a polygenic trait and is determined primarily by the amount and type of pigments present in the eye's iris. Color variations among different irises are typically attributed to the melanin content within the iris stoma. The density of cells within the stoma affects how much light is absorbed by the underlying pigment epithelium [1]. Iris color can provide a large amount of information about an individual and a classification of various colors may be useful in documenting pathological changes or determining how a person may respond to various ocular pharmaceuticals. Iris color varies from dark shades of brown to the lightest shades of blue. There are three colors (brown, yellow and gray), which determine the outward appearance of the eye [1]. Those color combinations are responsible for all the iris color variations (see Fig 3).

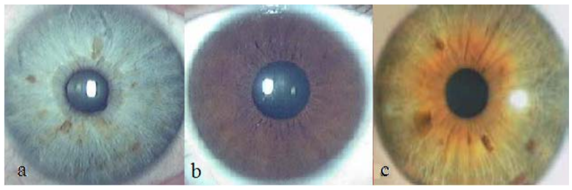

Figure 3. Iris color variations: a) blue iris, b) brown iris, c) green iris

The process of identifying the basic iris color is simple. All the dominant colored iris regions should be identified and their color extracted.

One useful method in identifying the basic color is the mean pixel luminance value computation. The mean for a data set represent the sum of all the observations divided by the number of observations. So in our case the mean will be the average value of the regions within the surface of the iris. On the surface of the iris there are darker or lighter regions, different than the basic color. When applying the mean upon the surface pixels, the pixel values from those regions will influence the result and the resulting color will be erroneous. In order to eliminate this aspect, instead of mean a more efficient is median pixel averaging. The median is in fact the middle of a given set of data. So the lower half values of the data set are below the median, meanwhile the high half values are above. The extremes values, also called outliers, are neglected, so the median is less sensitive to those values than the mean. This makes the median more suitable for skewed data sets. When applying the median upon the pixels data set, the pixels from the dark and light regions will be considered outliers and in this case their value will not influence the final value of the result, which is the resulted basic color.

Other useful method for iris recognition method should be region segmentation. This method is presented in [6]. Because the both irises are skewed, the basic color identification is done independently for each of them. The result will prove that the color is in the same color range, but the exact RGB values of the color are not the same but close. As mentioned before there are color discontinuities within the surface of the iris. Those discontinuities are region of interest, or texture spots.

Identifying the interest regions is the next step in the surface analysis process. The iris surface is impressive and unique from each person. At a close look the iris texture presents some regions of connective tissue generally extend in the radial direction, called radial furrows. The iridologist claim that on the surface of the iris during life some variation of texture can appear. Some texture variation can appear at the beginning of iris formation in the embryonary age. Depending on the shape and size those regions are grouped and recognized as: rings, radial folds, vaults. Others are seen as strong color variation and are classified in darker or lighter spots or regions. Sample of different texture variations are presented in Fig. 4.

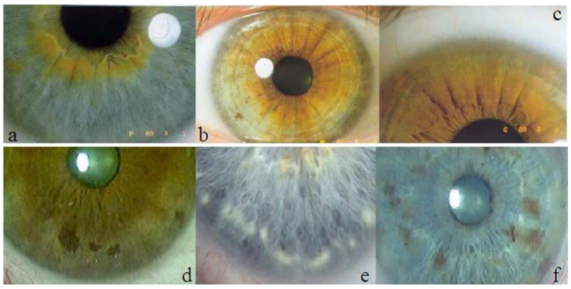

Figure 4. Spots on the iris: a) texture folds, b) texture rings, c) texture volts d) dark spots, e)light spots f) dark and light spots on the same texture

Identifying those regions it is the next purpose in the system implementation, as presented in the diagram from Fig. 1. In order to identify the dark and light regions from the texture first a standard value should be set. This standard value is the basic color. Knowing the basic color it is easier to express which regions are darker and which ones lighter. Together with the basic color a threshold value is also chosen, in order to establish two color intervals. If the pixels colors have values belonging in the interval defined for dark regions, then all those pixels are declared dark meanwhile all the pixels belonging to the light interval are light.

Based on their coordinates a map of interest dark/light regions can be obtained (see Fig. 1). The regions are interest regions for the iridologists, who assume that some color variations on the surface are due to health variation of some internal organs in the body. According to this theory, a person's state of health and disease can be diagnosed from the color, texture and location of various pigment flecks in the eye. Some also claim that the eye markings can reveal a complete history of past illnesses as well as previous treatment. One textbook, for example, states that a white triangle in the appropriate area indicates appendicitis, but a black speck indicates that the appendix had been removed by surgery. On their work and studies iridologist have managed to implement maps and charts which prove that illness an internal human body sufferance are recorded on the iris's surface [7].

An iridology chart is the representation of both left and right iris, using segments. Each segment has associated an internal body organ or apparatus projection [8]. Based on the texture variation on iris texture according to the chart a complete history of past illnesses for each internal organ or apparatus can be withdrawn. In Fig. 5 there is an example of an iridology chart drawn by G. Abramov [1], chart which is used in the system implementation.

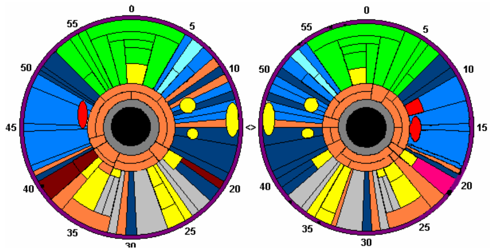

Figure 5. Right and left iris Map (according to G. Abramov), 10 colors segments representing all important internal body subsystems

In the iridology chart presented in Fig 1, the 10 important internal body systems are represented using distinct colors. Systems starting from the Cardiovascular System to Ophthalmology are represented in 10 color palette. At a closer look at both iris charts, one can easily see that all the subsystems are represented also on the left and right chart [1]. So in order to correct estimate and express the illness history for one subsystem all the time both irises must be analyzed. Using the chart the last task from the texture analysis can be performed. Localization of interest regions ensures obtaining the final diagnosis. The process assumes the association of detected dark/light regions to the corresponding colored segment from the iris chart. The already detected regions pixels have their (x, y) coordinates stored. On the iris chart the pixels having the declared coordinates, will retrieve the exact color of the segment to which the pixel belongs. Gathering the color information about all the pixels from iris chart will ensure that the interest region are correct localized.

C. Patient Final Diagnosis

As shown in Fig. 1, the final stage of the system is the final diagnosis generation. The diagnosis is obtained based on the previous dark/white texture regions localization, on the selected chart. The internal body systems, are represented with colored segments on the chart. Some of the systems have correspondence only on the left or right iris chart (ex. Dermatology) others on both charts (like Cardiovascular System or Respiratory System). For an optimum complete diagnosis generation both irises need to be analyzed, taking into consideration the exact only the location of the dark/light texture regions upon the segmented charts. Several constraints are imposed. The dimensions of the iris images and chart images must be the same. Located regions smaller than 5 to 10 pixels, are not considered interest region useful in the diagnosis process. The diagnosis must be approved by an iridologist or a doctor, because there are tricky regions which sometimes do not obey the imposed rules. The role of the user is important when giving the final diagnosis, thus making the system semi automated. For this reason the system include a friendly user interface.

III. EXPERIMENTAL RESULTS

The proposed system is a direct interdependent system. According to its functionality, described in Fig. 1, each image processing step is dependent on the previous one. The input for this system is a pair of images for both left and right eye. The result is presented as a final diagnosis diagram, pointing out the problems in the identified internal body subsystems.

The system was tested on a set of images for 40 patients and the illness patient state obtained from the eyes analysis was in the end compared to the patient medical records. In the followings the eye images for patient no 32, system results will be presented. Fig. 6 displays the extracted image obtained after CHT identification method. On the left side both patient eye images are loaded into the system. CHT method is applied twice for detecting the circles representing the inner and outer iris boundaries. CHT returns the coordinates of the two circles and based on those coordinates, the regions outside the boundaries of the iris are eliminated. The result is stored as an uncompressed "PNG" format image file.

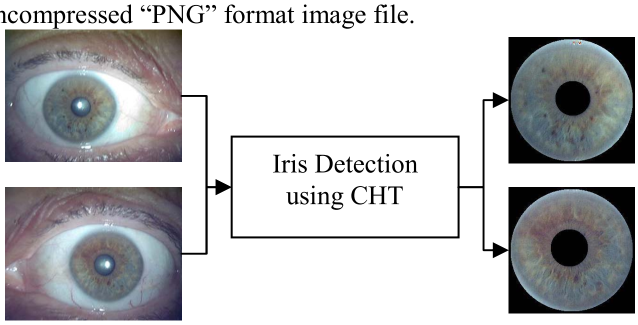

Figure 6. Detecting Iris using CHT Method

The next stage inside the system is the iris texture analysis. Texture analyses process is realized in four steps. First one is basic iris color identification. As proved before, because the left and right irises are not identical, the basic color checking is done for each iris image independently. The method used for color identification is the pixels median within the texture. For a better precision the iris texture is divided in three concentrically segments. Only the segment in the middle is used, for color detection, because it is considered that on this region the accumulation of the pigment is optimum. In order to obtain the right basic color values, the median is computed independently for the pixels inside the segment separately for each RGB channels. Fig. 7 illustrates the result of basic color identification for patient's both iris images.

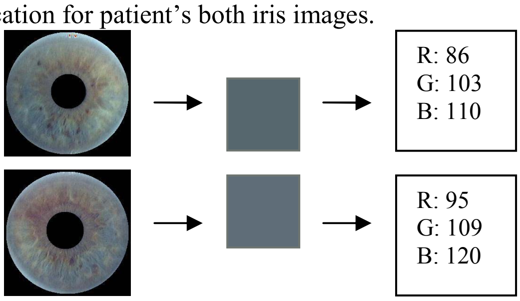

Figure 7. Basic iris colors calculation method

Second step in texture analysis is the dark/light texture region identification. The algorithm for this method is simple. Test if the pixels from the iris textures belong to the interval [basic color, threshold] and mark those pixels as dark and light. On the next step the iridology map drawn by G. Abramov [1] is generated and properly adjusted to for the next step. For a proper region localization the iridology chart must have the same dimensions as the tested image. As shown in the Fig.8 each dark/white region is located on the segmented map.

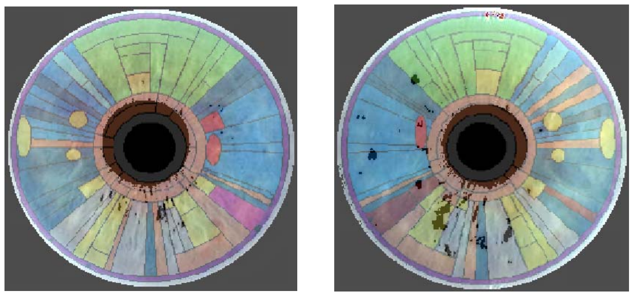

Figure 8. Identified dark/white regions on iris surface

The final stage of the system is diagnosis generation. The diagnosis is presented as a table in which is stated which internal subsystem has encountered an illness issue. The table contains: on the first row the internal body system or apparatus; on second and third row the identified regions on left and right iris and on the last row the patient state of health records. If a dark/white region is located on the segment corresponding to the apparatus or system then on the corresponding left or right iris table field this will be marked by "1" otherwise by "0". The values of patient health records will have "1" values if the patient is known to suffer with that system or apparatus or else "0" values.

IV. Conclusions

The main purpose was to create a system which process eye images and based on the iris texture analysis care provide useful information about the patient state of health. Based on tissue information an iridologist can establish a correct diagnosis for the patient. The system functionality is presented on three stages: iris recognition and extraction, dark/white region localization and generation of a diagnosis based on iridology charts. Using advanced image processing methods and computational techniques the system offers the possibility to locate and extract parts from the eye images and gather useful information.

Acknowledgment

This research was supported by CNCSIS Grant ID_162/2008.

References

[1] S. Demea, "Correlations between iris aspects and endocrine pathology", (original romanian title: "Corelatii intre aspectul irisului si patologia generala").PhD Thesis, Medical Domain, Cluj-Napoca 2005.

[2] A. Discant, S. Demea, C. Rus, "Extraction of Relevant Information for Iris Clasification," 18th International EURASIP BIOSIGNAL 2006

[3] Daugman J "Gabor wavelets and statistical pattern recognition." The Handbook of Brain Theory and Neural Networks, 2nd ed., MIT Press (M. Arbib, editor), 2002.

[4] S. J. K. Pedersen, "Circular Hough Transform", Aalborg University, Vision, Graphics and Interactive Systems, November 2007

[5] Mohamed Rizon, 2Haniza Yazid, "Object Detection using Circular Hough Transform" American Journal of Applied Sciences 2 (12): 1606-1609, 2005

[6] S. Fan, C. R. Dayer and L. Hubbard, "Quantification and Correction of Iris Color", Technical Report 1495, Department of Computer Science, University of Wisconsin-Madison 2003.

[7] Bernard Jensen, D C The "Science and Practice of Iridology" Volume one Hardcover 2005

[8] Ernst E. "Iridology: not useful and potentially harmful" Arch Ophthalmol. 2000