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PhD. THESIS

SUMMARY

CONTRIBUTIONS TO IRIS IMAGE ANALYSIS FOR MEDICAL APPLICATIONS

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Key words

Iris localization, iridology, color analysis, segmentation, parameters for a clinical diagnosis.

Introduction and overview of the thesis

The iris, colored part of the eye, impresses, since ancient times, through its fascinating combination between it's random texture variations and vibrant color. Since the twentieth century, the iris became the subject of research with two directions more or less contradictory. Iris became one of the most important biometrics. The high performances of the iris recognition technology are due to iris's texture, which is considered unique. Formed during embryonic stage, iris texture remains unchanged throughout one's person life.

Likewise, the iris, only tissue in the body whose structure can be viewed and examined externally, can offer information regarding certain changes in the human body, by practice of iridology. In iridology are measured shapes, iris tissue's fiber changes and color variations which are then associated with the imbalances of certain tissues and organs, getting information about health status and degree of vitality of the body. The practice of iridology requires detailed view of the iris surface using iridology charts, process that is carried out through systems that allow manual processing of iris's digital images. Compared to these systems, this thesis proposes an automatic system which ensures processing and analysis of digital images of iris, according with the requirements of iridology.

Objectives

The main purpose of this study is to present all the contributions to the implementation of, a complex but efficient, automated analysis and processing digital images iris system, according with the requirements of iridology. Thus the stated objectives of this thesis coincides with functional stages of the implemented analysis system, whose general diagram can be observed in the first chapter of the thesis.

A first objective is to locate and extract the iris from the digital eye images, recorded for medical purpose. To this are presented some practical methods available in the literature. Compared with those is described a proposed optimized method, which is based on Circular Hough Transform (THC). Based on the experimental results, which claim the performance of the presented methods, the most appropriate is chosen to extract iris from analyzed images.

The actual analysis of digital images of the iris involves identifying items of interest on the surface and transforming them into useful information in the form of parameters for a clinical diagnosis. This is done to analyze the color of the iris. This direction is treated as a second objective of the thesis. The primary objective for color analysis was to integrate a method to estimate the predominant color of the iris, by calculating the average values of pixels in the image, performed on each color channel separately. Further concerns introduced two other secondary objectives. We followed the prevailing color estimation with information about the color pigments on the surface of the iris. Finally made a classification of iris color depending on the purpose of identifying specific topologies defined in iridology.

As a final objective of this thesis,is aimed processing information obtained through image analysis and conversion into details of medical interest. Conversion requires sectoral measurements and confronting certain regions of interest from the image with iridology charts which are screenings of some organ or systems within the human body. The data obtained are presented in a suggestive way for the user (iridology specialist) in order to ensure a clinical diagnosis.

Structure of the thesis

The structure of the thesis follows gradually the presentation stages of an compact and automatic analysis system for digital images of human eye iris, using specific digital image processing algorithms, techniques and methods.

In the second chapter are presented general information regarding the human eye iris and general directions of iridology. The role of this chapter is to provide the reader with background information on the study of the iris and familiarize him the concepts, techniques and methods by which one can obtain information about the health of the body through iridology. The last part of this chapter holds the detailed description of the images databases used in this study.

The third chapter focuses on describing the first major objective of this thesis, the localization and retrieval of iris surface from digital images of human eye. Some of the most popular techniques used to locate the iris surface are presented here: Daugman's integro-differential operator (DIO), circular Hough transform (CHT), edge detection by radial suppression. Compared with these methods an method (own solution) optimized for medical purposes recorded images is presented. End of the chapter is reserved to present experimental results. Based on the performances of the presented methods, the optimal iris localization and extraction technique is chosen.

The forth chapters provides descriptions of image processing techniques and methods used in iris color analysis. Will be presented four methods to identify the color of the iris surface and the classification of iris according to it's. Based on the experimental results presented in the final chapter the most appropriate method for determining the predominant iris colors with shades and color pigmentations is selected.

After applying the proposed procedures to identify dominant color and pigmentation regions, the results obtained are converted into details of medical interest. They are presented in Chapter 5. Based on descriptions from literature, sectoral measurements are performed and the resulted region of interests from the images are confronted with iridology charts which describe screenings of some organs and systems within the human body.

Chapter 6 provides some general conclusions to the work by highlighting the major findings and contributions, along with a discussion of possible future research direction which arise from the research work undertaken in this thesis. This process aims to simplifying the correlation between the image regions of interest and iridology charts, as well as eliminating the errors introduced by human factor.

Author's contributions

The main personal contributions together with the most important experimental results were published in respectable journals and international conferences from the field:

- In [12] a solution for localization of iris in the eye digital images is proposed. The method estimates the inner and outer iris boundary regions by circles whose parameters are determined using descriptive (CHT). The method provides satisfactory results even if it is an semi-automatic one, the computational parameters being specified by the user. The method was integrated into a preliminary version of the iris digital image analysis system implementation.

- An improved version of the first iris localization method is presented in [5]. It is proposed a completely automatic iris localization method from medical eye images based on an optimized version (CHT). The main improvements of this method are: automatic parameters estimation directly from the analyzed data and reduction of the time needed to locate the iris. Due to it's improved performance, the method is integrated into the final version of the automated system presented.

- A method for estimating the predominant iris colors is shown in [2]. This allows identification of the predominant colors and shades pigmentation on the iris surface by a intra-palette color merging technique. Experimental results claims the efficiency of the method, even though it presents a disadvantage: the mixing the color degree between colors from the palette is provided by the user.

- The improved version of the method described above is presented in [1]. This method provides the estimation of mixing colors degree directly from the original data set, based on histogram computation from Euclidean distances between all colors in the palette. Experimental results show a significant improvement in computing time required to determine the predominant colors from the surface of the iris. For iris color classification this method is associated with Martin-Schultz scale, for describing iris color.

- Another method for iris color classification is presented in [3]. The method combines the well known performance of Mean Shift algorithm with elements of iris color description used in iridology. Using the color specifications from iridology, presented in Demea et al., the results proved an efficient iris color classification.

- A first version of iris digital image analysis system for medical purposes implementation is presented in [8]. In this semi-automatic version, the user actively contributes on the stages of the system: iris localization, estimation of the predominant colors, pigment regions finding and correlation establishment in between such regions and iridology charts. User involvement is ensured by a friendly graphical interface that provides tools for measurement and control operations designed to ensure accuracy. Final results are presented graphically and can be exported to different formats.

- An improved version of iris digital image analysis system implementation is presented in [7]. In this version provides an automatic iris localization possibility. Also the iris's surface dominant colors estimation and correlation between regions of interest identified through the specification of iridology, are made with no user input. The integration of these methods significantly reduce the processing time and provides improved performance to the analysis process. Statistical information and results are then easily and meaningful accessible through tables and graphics.

List of Publications

[1] **A. Lodin**, "Automatic Human Iris Color Classification", in *Signal Processing and Applied Mathematics for Electronics and Communications-SPAMEC 2011*, Cluj-Napoca, Romania, August 26-28 2011, pp. 116–120.

[2] **A. Lodin** and C. Rusu, "Retrieval of Iris Dominant Color using Intra-Palette Color Merging", in *Proceedings of International Symposium on Signals, Circuits & Systems -ISSCS 2011*, Iaşi, Romania, June 30 - July 1 2011, pp. 89–93, iSBN: 978-1-4244-3785-6.

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