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IRIS LOCALIZATION IN BIOMTRIC PERSONAL IDENTIFICATION SYSTEMS DEVELOPED FOR MOBILE DEVICES

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Biometric personal identification based on iris recognition is considered as one of the most accurate, reliable and stable identification systems. The purpose of the research is solving the problem of iris localization for developing biometric identification system for mobile devices. The system also cares about protection of biometric data and templates, which is a crucial requirement when designing a biometric based authentication system. The Hough transform algorithm was used to address this problem. The algorithm runs in 3 separate steps: image binarization, creating accumulator array and threshold segmentation. The Hough transform algorithm was implemented using Android SDK and high level programming language Java.

Keywords: Hough transform, localization, Hough space, segmentation, iris recognition

Introduction

One of the most important tasks of software engineering is information security. Passwords are a common means of verifying a user's identity before access is given to information. Despite of easy to use and implement, the password security has its disadvantages, as it is highly dependent on human factors such as choosing a secure password. It is something that many people find difficult.

The increasing battle with cyber security has led to the birth of biometric security systems. Biometrics refers to unique physiological human characteristics that help in identifying an individual. Iris recognition security systems are one of the most accurate methods of biometric identification.

By virtue of these advantages, the next-generation operating system - Windows 10 will feature brand new biometric authentication system - Windows Hello. Windows Hello will support iris authentication. Alongside Windows Hello, Microsoft is also divulgence Passport, a new complement that apps and websites can use for biometric authentication.

Despite advantages, there are several open issues involved with these biometric identification systems. Biometric systems based on iris are vulnerable to direct attacks consisting on the presentation of a fake iris. Resourceful hackers can covertly acquire the biometric characteristics of a genuine user, use fake-eye or contact lenses to implement attacks on iris templates.

A group of researchers from Spain and the United states successfully demonstrated at Black hat conference how extremely easy is to implement attacks using fake biometric characteristics. Genetic algorithms were used to design images, which produced a near identical iris code as the original iris image when scanned. According to scientists, even the most reliable and modern iris scanners can be easily fooled by obtained results.

Everything mentioned above manifest that developers pay too little attention this the problem.

Almost all leading companies, telecommunication equipment and product manufacturers are working on the implementation or already have offered complete system solutions for human identification based on iris recognition.

In addition, despite the possibility of downloading already proposed systems on mobile devices for free, the implementation details are left in strict confidentiality, thereby limiting researchers and developers to expand the ready-made solutions.

Therefore, the iris recognition system must be implemented before solving the problem of biometric identification system implementation running on mobile devices with the protection against forgery biometric features.

Purpose of study and problem formulation

The overall aim is to implement biometric personal identification system based on iris analysis with protection against forgery of biometric features for mobile devices.

The first stage of this biometric method is localization, i.e determining the center of pupil and edges of iris in the digital image of human eye. To solve the problem of localization the Hough transform algorithm can be used.

The aim of this work is to solve the problem of localization of iris in human eye for implementing biometric identification system with feature template protection for mobile platforms.

Main section

The Hough transform is one of the most effective methods for detecting analytic curves in a digital image. In the Hough transform, a main idea is to consider the characteristics of the curve not as image points, but instead, in terms of its parameters [1]. The Hough transform algorithm builds Hough space for detecting curves, the size of the space is determined by the number of parameters of the curve. The primary step in Hough method is mapping a digital image into Hough space followed by the procedure of analysis.

The Hough method consists of the following steps: binarization; creating accummulator array; threshold segmentation.

Let us dig into each of these in more detail.

Binarization

The first step of the algorithm is the binarization of a digital image. The Canny edge detection algorithm can be used for finding contours [2]. The results of this step define the efficiency of Hough transform. Fig.1 shows the binary image edges $\tilde{K} = \left[\tilde{k}_{ij}\right]_{i=1,j=1}^{n,m}$ obtained after Canny edge detection algorithm using double thresholding where $T_L = 0.1$, $T_H = 0.32$.

a **b**

Fig. 1. Canny edge detection results: a – input image; b – binary representation of the edges

Creation of an accumulator array

The next step of the Hough transform algorithm is to map digital image to Hough space. Let $\widetilde{k}_{ij}$ be the value of the binary matrix of edges of the digital image $\widetilde{K} = \left[\widetilde{k}_{ij}\right]_{i=1,j=1}^{n,m}$ where i raw and j column intersect. The coordinate system used for all examples in this document has the origin in the upper left, with the x axis extending to the right and y axis extending downwards.

A single point in the coordinate system of a digital image can be represented by a set of circles. If this point has coordinates (i,j), than each circle that passes this point corresponds to the following equation:

$$(i-a)^2 + (j-b)^2 = R^2 \tag{1}$$

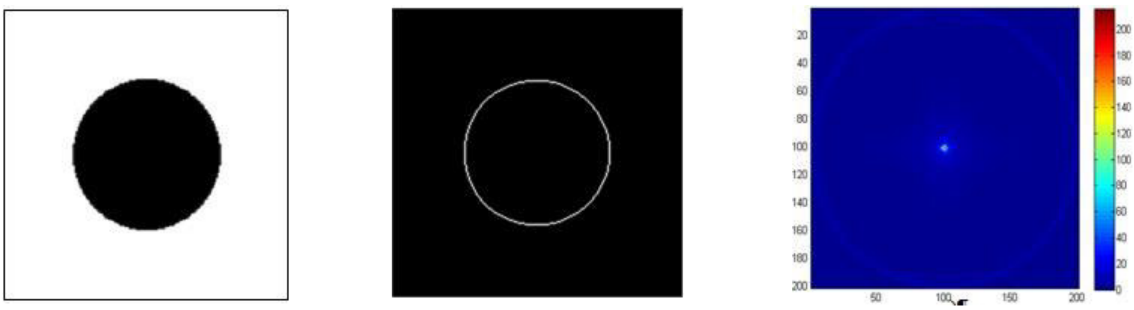
where (a,b) is a center, R – radius.

The set of parameter values $a \in [1,n], b \in [1,m], R \in [1, \max(n,m)]$ forms phase space or Hough space X, each point of which corresponds to some circle. Hough space X with set of points (a,b,R) represents three-dimensional space, which is transformed to two-dimensional space (a,b,R_0) if radius is known. The set of centers of circles with radius equal to R_0, which pass through the point (i,j) define circles in Hough space with radius R_0.

For each point (a,b,R_0) of the space X can be defined a corresponding indicator, which represents the number of points (i,j) of the circle with center (a,b) and radius R_0. Matrix $Z_{R_0} = \left[z_{abR_0}\right]_{a=1,b=1}^{n,m}$, each element of which is defined using above described method – is an accumulator array in Hough space:

$$Z_{abR_0} = \sum_{(a-i)^2+(b-j)^2=R^2} \widetilde{k}_{ij} \tag{2}$$

Figure 2, 3 shows a the synthetic digital image of the circle, the image contour is obtained using Canny edge detector algorithm (fig. 2, b). Due to known radius $R_0 = 50$ Hough space is two-dimensional. The equation (2) is used for building accumulator array Z_{R_0}. For more clarity accumulator array is represented in two-dimensional (fig. 2, c) and three-dimensional spaces (fig. 3).



a **b** **c**

Fig. 2. Building accumulator array for synthetic image: a – original digital image; b – binary representation of digital image contours; c – two-dimensional representation of accumulator array

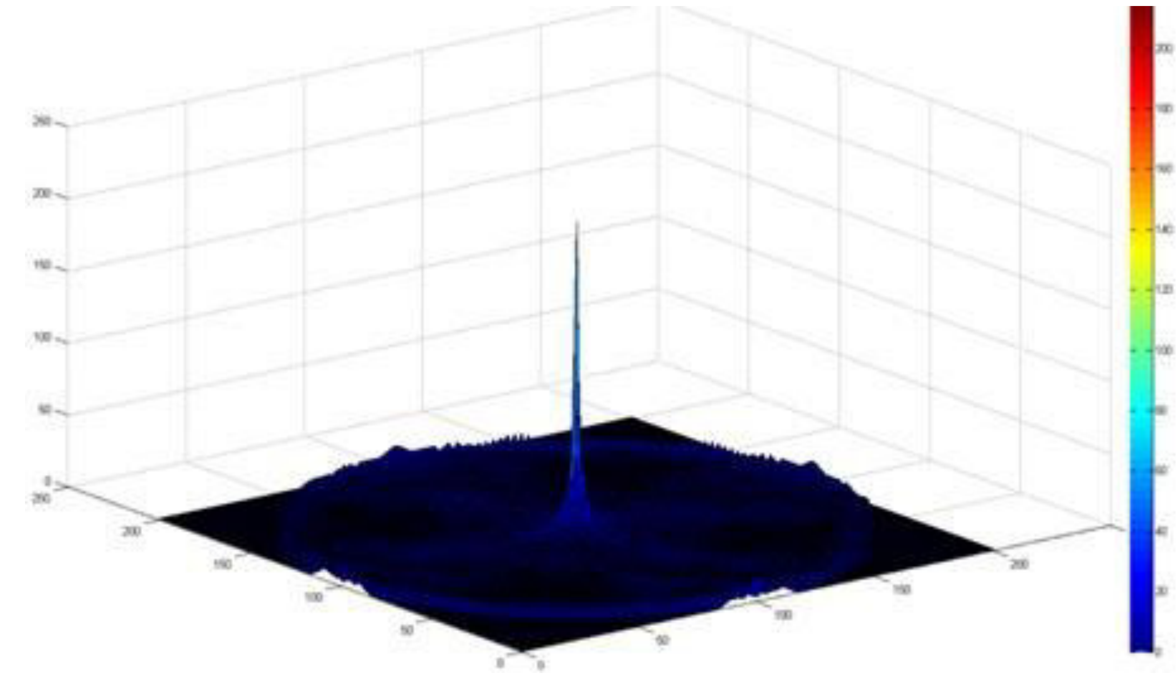
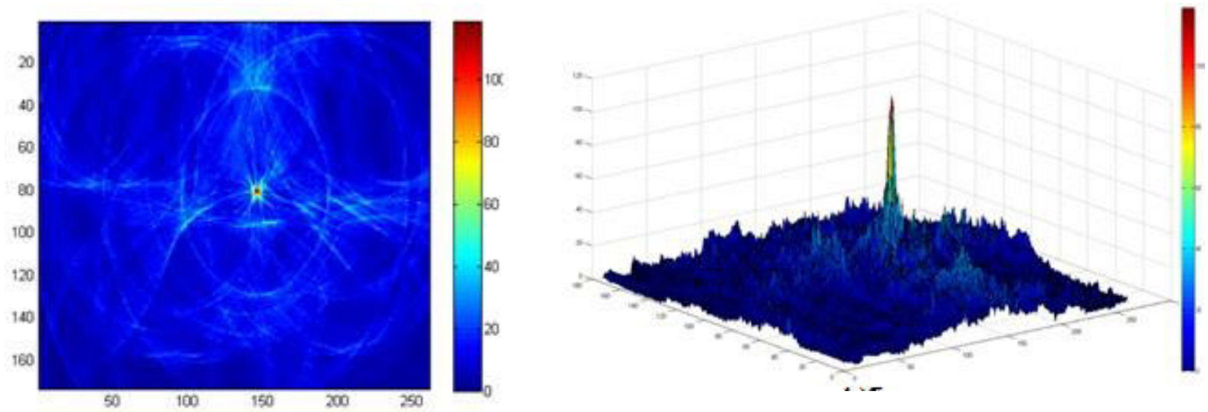


Fig. 3. Building accumulator array for synthetic image: three-dimensional representation of accumulator array

Figure 4 shows two-dimensional and three-dimensional representation of accumulator array for realistic digital image of pupil and iris of human eye (fig. 1). Accumulator array is built to find center of circle with radius $R_0 = 75$.



a **b**

Fig. 4. Building an accumulator array for realistic image: a – two-dimensional representation of accumulative array; b – three-dimensional representation of accumulative array

Threshold segmentation

The final step is to analyze accumulator array for determining the parameters of analytical curve in digital image.

After mapping digital image to Hough space, using equation (2), accumulator array is obtained, each element of which Z_{abR_0} equals to the number of non-zero values $\tilde{k}_{ij}$, belonging to potential circle with center (a,b) and radius R_0.

Therefore, for each element Z_{abR_0} of matrix Z_{R_0} the following is true:

$$z_{abR_0} \le [2\pi R_0] \tag{3}$$

Synthetic digital image (fig. 2) contains a circle, hence the indices of extremums of accumulator array $z_{100,100}$, correspond to center coordinates of circle $(100, 100)$ with the radius $R_0 = 50$ in digital image.

For realistic digital image a variety of methods for Hough space analyses can be used, for instance, searching fixed local maxima, threshold segmentation of accumulator array or searching global maxima of accumulator array with gradual exclusion.

While determining the circle parameters, which is the model of iris, threshold segmentation of accumulator array was applied to a realistic digital image or frame sequence of digital video [3], as the result $\tilde{Z}_{R_0} = [\tilde{z}_{abR_0}]_{a=1,b=1}^{n,m}$ is obtained

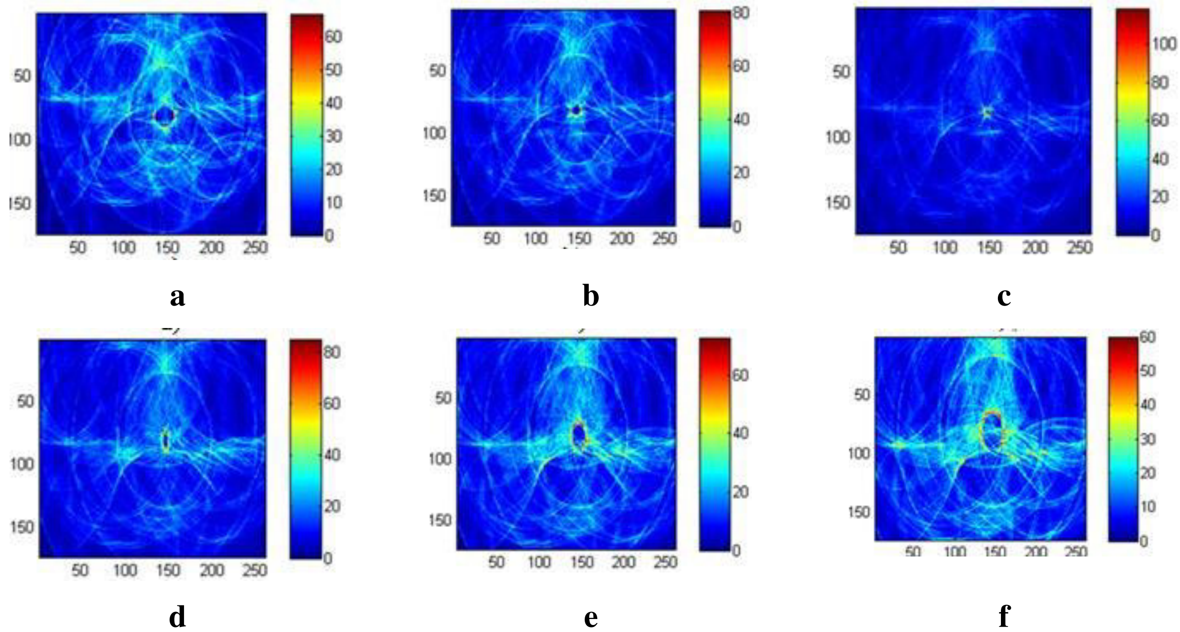
$$\tilde{Z}_{abR_0} = \begin{cases} z_{abR_0}, & if \;\; z_{abR_0} \ge 0.9(2\pi R_0) \\ 0, & if \;\; z_{abR_0} < 0.9(2\pi R_0) \end{cases} \tag{4}$$

To obtain the image of iris with a diameter of 100 pixels, which is considered as low-quality standard [4] on the camera with resolution of $1000x800$ pixels the user eye must enter the area of $9x7$ centimeters. Therefore, for further analysis of the iris to solve the problem of person identification for mobile device the radius from $R_0 \in [60;90]$ is selected. With specified radius range the procedure of threshold segmentation is applied to each accumulator array. The sequence of arrays $\tilde{Z}_{R_0} = [\tilde{z}_{abR_0}]_{a=1,b=1,R_0=60}^{n,m,90}$ contains non-zero values, indices of which correspond to parameters of the circles. To choose parameters of the single circle let us consider the relative value $\hat{Z}_{R_0} = \left[\frac{\tilde{z}_{abR_0}}{2\pi R_0}\right]_{a=1,b=1,R_0=60}^{n,m,90}$ and select the maximum value

$$[\hat{a}, \hat{b}, \hat{R}_0] = \underset{a=1,b=1,R_0=60}{\overset{n,m,90}{Max}} \left(\frac{\tilde{z}_{abR_0}}{2\pi R_0} \right), \tag{5}$$

where the function $\max(x)$ returns the coordinates of the center $(\hat{a}, \hat{b})$ and the radius $\hat{R}_0$ of the circle.

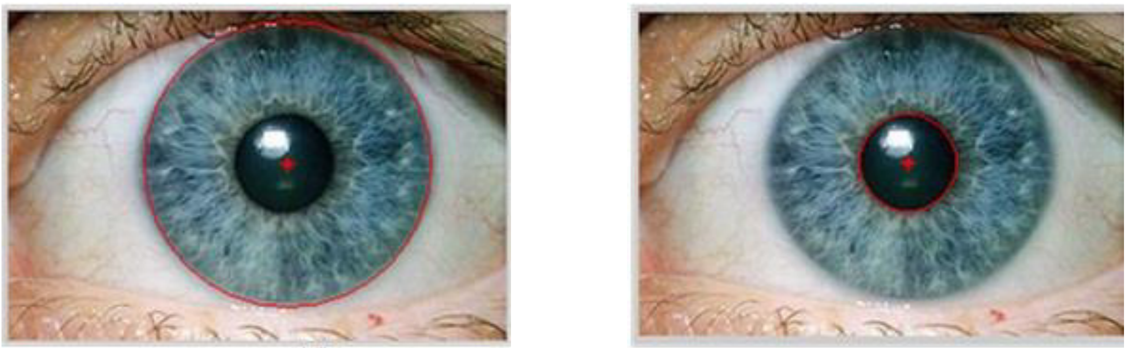
Figure 5 shows the sequence of accumulator arrays for $R_0 = 65$, $R_0 = 70$, $R_0 = 75$, $R_0 = 80$, $R_0 = 85$, $R_0 = 90$ for determining parameters of the circle corresponding to the iris of human eye (fig. 1). After applying threshold segmentation (4) to each accumulator array only threshold accumulator array $\tilde{Z}_{75}$ (fig. 5, c)) for $R_0 = 75$ contains non-zero values. Equation (5) outputs the center of the circle $(147,81)$.



a b c d e f

Fig. 5. Analysis of an accumulator array: a – $R_0 = 65$; b – $R_0 = 70$; c – $R_0 = 75$; d – $R_0 = 80$; e – $R_0 = 85$; f – $R_0 = 90$

Figure 6 shows the result of the Hough algorithm.



a b

Fig. 6. The Hough algorithm usage: a – determining the parameters of iris; b – determining the parameters of pupil

Conclusion.

As a result of this work, the Hough transform algorithm was implemented for the iris localization, which is the first step in the implementation process of the biometric identification system with feature template protection for mobile devices.

The resulting application was developed for android platform using high-level programming language – Java. The further work aims implementing fully functioning biometric person identification system for mobile devices.

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ЛОКАЛІЗАЦІЯ РАЙДУЖНОЇ ОБОЛОНКИ ОКА ДЛЯ МОБІЛЬНОЇ СИСТЕМИ БІОМЕТРИЧНОЇ ІДЕНТИФІКАЦІЇ ЛЮДИНИ

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Метод біометричної ідентифікації людини за райдужною оболонкою ока вважається одним з найбільш точних і надійний способів ідентифікації. Метою дослідження є вирішення задачі локалізації райдужної оболонки ока людини для можливості реалізації біометричної системи ідентифікації людини засобами мобільного пристрою. Для досягнення поставленої мети в роботі розглянуто алгоритм методу Хафа, який складається з наступних кроків: бінаризація, побудова акумулятивної матриці, порогова сегментація акумулятивної матриці. Проведена програмна реалізація алгоритму Хафа для мобільної платформи Android з використанням засобів мови програмування високого рівня Java.

Ключові слова: метод Хафа, локалізація, простір Хафа, порогова сегментація, райдужна оболонка ока

ЛОКАЛИЗАЦИЯ РАДУЖНОЙ ОБОЛОЧКИ ГЛАЗА ДЛЯ МОБИЛЬНОЙ СИСТЕМЫ БИОМЕТРИЧЕСКОЙ ИНДЕТИФИКАЦИИ ЧЕЛОВЕКА

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Метод биометрической идентификации человека по радужной оболочке глаза считается одним из самых точных и надежных способов идентификации. Целью исследования является решение задачи локализации радужной оболочки глаза человека для возможности реализации биометрической системы идентификации человека средствами мобильного устройства. Для достижения поставленной цели в работе рассмотрен алгоритм метода Хафа, который состоит из следующих шагов: бинаризация, построение аккумулятивной матрицы, пороговая сегментация аккумулятивной матрицы. Проведена программная реализация алгоритма Хафа для мобильной платформы Android с использованием средств языка программирования высокого уровня Java.

Ключевые слова: метод Хафа, локализация, пространство Хафа пороговая сегментация, радужная оболочка глаза