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## METHODS OF CHOOSING THRESHOLD VALUES FOR PERSON IDENTIFICATION BASED ON THE IRIS IMAGE

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**Abstract.** *The study is devoted for statistical methods of threshold values selection for decision making in the case of iris identification, and the problem of determining threshold values according to Hamming distance based on Bayesian, Neumann-Pearson and minimax criteria is studied in the article. Depending on the situation, the use of these criteria in the iris recognition systems is recommended.*

**Keywords:** *biometric technology, iris, identification, Hamming distance, Bayesian criteria, Neumann-Pearson criteria, Minimax criteria.*

### I. INTRODUCTION

Today, the issue of information protection is one of the urgent problems in the world community. The use of systems of identification, such as cards and hidden codes, which are used in practice and are more popular, could not fully meet all the requirements for ensuring the security of information. For example, a password must have a complex structure to ensure a sufficient level of security. The complexity of the password is provided by the combination of letters, numbers and symbols. At the same time, it is required to create its own secret code for each information resource. In some cases, the user may forget his secret code or it may be stolen by other persons, and the cards may be lost [1,2,3]. Such situations have a sharp negative impact on ensuring the level of information security. That's why in recent years biometric methods are being used in the process of recognizing a person, which are free of the above shortcomings and store the person directly. Today, biometric technologies are actively used in the following areas: protection of personal data in machine-readable travel documents and visas;

registration of immigrants and foreign workers using biometric identifiers, even without identity documents; identification of victims (unknown bodies) and protection of children from abduction; protection of facilities from unauthorized persons; in the voting system; launch and enter the operating systems of computers, smartphones and laptops; protection of information stored on external carriers from persons who do not have permission to access it; making payment for the purchase; in the system of accounting for working hours in enterprises and organizations; organization of distribution of social assistance and medical services to the population, etc. Currently, unique characteristics of a person such as face image, fingerprint, color membrane of the eye and retina image, voice signal are used for identification [4,5,6,7]. Among these biometric identification systems, retinal biometric identification is one of the most promising areas today, and it is used in various fields, such as government, military, judicial, law enforcement, secret and service in financial institutions. It is used in controlling access to buildings, restricting access to local and complex

systems, implementing automated border control, etc. [3].

The main reason for this is the following specific characteristics of the colored membrane of the eye [8]:

- uniqueness. A retinal image has a high degree of randomness, the higher the degree of randomness, the greater the probability that the exact image is unique. Randomness is mathematically characterized by degrees of freedom. Studies have shown that the texture of the retina has 250 degrees of freedom, which is much higher than the degrees of freedom of a fingerprint (35) and the degrees of freedom of a face image (20) [8, 9];

- genetic independence. The uniqueness of the colored membrane of the eye is consistent with its lack of genetic connection, which differs even in twins [8, 10];

- high level of informativeness. The colored membrane of the eye has a complex image consisting of small details and contains a large set of characters;

- the recognition result does not depend on age. The color of the retina can change, but the pattern (pattern lines) remains constant [8];

- non-contact, that is, the absence of physical contact when registering a person with optical devices and the possibility of remote recognition (from 10 cm to 1.3 meters).

The aforementioned shows that in high-reliability biometric systems for personal recognition, the retina can be used as a stable, well-defined and highly informative biometric object that distinguishes a person from another person.

## II. MAIN PART

A person's identification based on retinal image can be considered a

formalized recognition problem, and this person's identification system includes the following three main steps: initial image processing; extraction of image classification symbols; Comparison of macular markers with macular markers from database. The process of initial image processing is divided into the following three stages: localization of the iris area, normalization of the iris image, and image quality improvement. Localization of the area of the colored membrane of the eye made it possible to determine its inner and outer borders. The inner and outer boundaries are usually considered as circles. However, these circles are not concentric circles [11]. That's why correct determination of their position is the first important step in the processing of the image of the colored membrane of the eye. The final step in the process of recognizing a person based on the image of the retina is to determine which class the image belongs to by comparing the image submitted for processing with the images recorded in the database. There are two methods for evaluating the similarity of images, one of which is to calculate the distance between images in a multidimensional character space, and the other is to determine the correlation between images.

When calculating the distance, if the distance between the compared images is small, two images belong to the same class, otherwise they do not. If the correlation of the compared images is high, they are considered similar, otherwise they are not similar.

We use the Hamming distance (HD) to determine the similarity between the retinal codes of two eyes:

$$HD = \frac{1}{N - M} \sum_{i=1}^N (X_i \oplus Y_i) \wedge X_{ni} \wedge Y_{ni}, \quad (1)$$

Here  $M = \sum_{k=1}^N (X_{nk} \vee Y_{nk})$ ,  $X_i$  and  $Y_i$  are the values of the binary symbols characterizing the images of the colored membrane of the eye being compared,  $X_{ni}$  and  $Y_{ni}$  are the binary values of noise affecting the area of the colored membrane of the eye in the compared images,  $N$  - is the number of binary symbols characterizing the image of the colored membrane of the eye.

Hamming distance value is 0 if all the binary symbols characterizing the images of the colored retina of the compared eye overlap, and Hamming distance is equal to 1 if no symbol overlaps. Therefore, the value of the Hamming distance is in the cross section [4, 12].

There are four cases when deciding on the overlap between recorded and unrecorded retinal pigment values in the database, two of which are correct and the other two are incorrect. It will be dull. The relationship between these solutions is presented in Figure 1. As you can see from this figure, there is an intersection of the probability distributions for overlapping and non-overlapping binary symbols.

The fields presented in Figure 1 present the following cases: 1 persons registered and recognized in the database; 2 persons not registered in the database, but recognized by the system; 3 persons registered in the database, but not recognized by the system; 4 persons not registered in the database and not recognized by the system. Each of these areas represents the averaged data based on the results of the experiment, of which area 2 reflects the first type of error, and area 3 reflects the second type of error.

It should be noted that in existing systems of biometric recognition of a person, the threshold value  $TH_k$  does not change when checking the compatibility

of all retinal images. If the condition  $HD < TH_k$  is met, the binary symbols characterizing the image of the colored retina of the eye will match, otherwise they will not match [12].

The probability of making a wrong decision  $P_{AE}$  is the sum of the following two probabilities:

$$P_{AE} = P_{SE} + P_{DE},$$

$$P_{SE} = \int_{TH}^1 P_{sam}(x) dx, \quad (2)$$

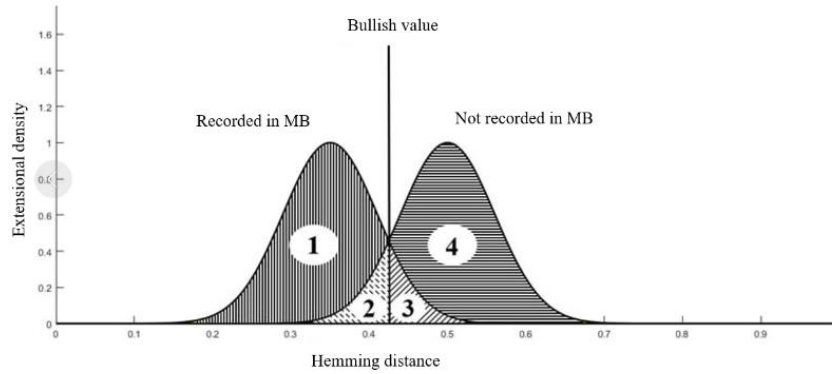
$$P_{DE} = \int_1^{TH} P_{diff}(x) dx,$$

where  $P_{SE}$  - the probability of considering a person recorded in the database as not recorded,  $P_{DE}$  - the probability of considering an unrecorded person as recorded,  $P_{sam}$  - the conditional probability density of the Hamming distance of those recorded in the database,  $P_{diff}$  - the conditional probability of the Hamming distance of those not recorded in the database density.

The quality of the decision to be made is determined by the amount of probability distribution in the cross section. An increase in the quality of recognition of a person based on the image of the retina of the eye is determined by increasing the distance between the average value of the Hamming distances of those recorded in the database and the average value of the Hamming distances of those not recorded, or by reducing the value of dispersion.

The separability criterion  $d'$  can be used to quantitatively describe the separation of two classes [13]:

$$d' = \frac{|\mu_s - \mu_d|}{\sqrt{\sigma_s^2 + \sigma_d^2}} \quad (3)$$



**Fig.1.** Conditional probability distribution of Hamming distance values

where  $\mu_s$  -the mathematical expectation of the first and  $\mu_d$  -second classes,  $\sigma_s$  and  $\sigma_d$  are the mean squared deviation of the first and second classes. This criterion can be used to evaluate the quality of characterizing signs. The larger the value of  $d'$ , the better the character resolution ability. In order to make a decision about the quality of the symbols, the value of  $d'$  found by formula (3) is compared with the threshold value  $TH_k$ .

We use the Bayesian, Neyman-Pearson, and minimax criteria to find the threshold value.

The Bayesian criterion ensures the minimum of average risk in decision-making. It is advisable to use it in the multiple realization of the system of recognition of a person based on the image of the colored retina in the space of invariant characters.

If the following condition is met

$$c_{DQ} \cdot P_{DE} \cdot P_{diff}(HD(X,Y)) > c_{SQ} \cdot P_{SE} \cdot P_{same}(HD(X,Y)) \quad (4)$$

a decision is made about the similarity of two classes of binary characters characterizing the image of the color membrane of the compared eye. Here:  $P_{diff}(HD(X,Y))$  is the conditional probability density of the Hamming distance between the binary characters characterizing the retinal image belonging

to different classes;  $P_{same}(HD(X,Y))$  is the conditional probability density of the Hamming distance between the binary characters characterizing the retinal image belonging to one class;  $c_{DQ}$  is the estimate (value) of the loss that occurs as a result of considering those recorded in the database as not recorded;  $c_{SQ}$  is the estimate (value) of the loss arising as a result of considering those not recorded in the database as recorded;  $P_{SE}$  -is the possibility of considering the binary characters characterizing the image of the colored membrane of the eye recorded in the database as not recorded;  $P_{DE}$  -is the possibility of considering the binary characters characterizing the image of the colored membrane of the eye, which are not recorded in the database, as recorded.

In order to apply the Neyman-Pearson criterion, it is necessary to determine the maximum probability of the permission,  $P_{DEmax}$ , given only through the recognition system for a person who is not recorded in the database. Using the Neumann-Pearson test, the threshold value  $TH_k$  is found from the following equation:

$$\int_0^{TH_k} P_{diff}(X) d(x) = P_{DEmax} \cdot \quad (5)$$

If it is not possible to estimate the a priori probability of the events that allow

to determine whether the images of the colored membrane of the compared eye are similar and not similar in the comparison, then it is appropriate to use the minimax criterion. The minimax criterion ensures the minimum of the maximum loss. Using the minimax criterion, the Hamming distance threshold value is found from the following equation:

$$c_{DQ} \int_{TH_k}^1 P_{diff}(x) dx = c_{SQ} \int_0^{TH_k} P_{same}(x) dx. \quad (6)$$

The mentioned criteria are recommended to be used in the systems of recognition of a person based on the image of the colored retina, depending on the situation.

The following indicators are used to determine the performance of biometric recognition systems.

FRR (False rejection rate) is the probability of falsely denying a user's access recorded in the system or the first type of error [14]. The value of this indicator is calculated using the formula (7) below.

$$FRR = \frac{\int_{TH_k}^1 P_{same}(x) dx}{\int_0^1 P_{same}(x) dx}. \quad (7)$$

FAR (False Acceptance Rate) is the probability of missing a user that is not recorded in the system or the second type of error [14]. The value of this indicator is calculated using the formula (8) below.

$$FAR = \frac{\int_0^{TH_k} P_{diff}(x) dx}{\int_0^1 P_{diff}(x) dx}. \quad (8)$$

EER (Equal Error Rate) is a measure of the error of the recognition system. Since

the value of FAR and FRR are equal to each other, the value of EER is equal to the value of FRR. The smaller the value of EER, the higher the accuracy of the recognition system [14].

Identification based on the use of a variety of physical or behavioral characteristics of a person is one of the promising areas for the development of biometric technologies. The main advantage of the integration of several parameters is the increase in the reliability and quality of recognition, as well as the acceleration of the identification process, which can significantly increase the performance of the biometric system.

### III. CONCLUSION

Identification based on the use of a variety of physical or behavioral characteristics of a person is one of the promising areas for the development of biometric technologies. The main advantage of the integration of several parameters is the increase in the reliability and quality of recognition, as well as the acceleration of the identification process, which can significantly increase the performance of the biometric system.

When entering an identifiable iris image, distortions inevitably occur due to changes in lighting conditions (changes in brightness and contrast), head rotation, which is accompanied by rotation of the resulting image and its deformation along the coordinate axes, and a change in the distance to the camera. Decision-making algorithms must be resistant to these distortions, of course, within certain limits. By choosing a feature system and normalizing the iris image, it was possible to compensate for possible distortions, except for rotational distortions. The existing algorithms for comparing information about the structure of the iris with the standard are sensitive to the

lateral inclination of the head during the shooting.

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## МЕТОДЫ ВЫБОРА ПОРОГОВЫХ ЗНАЧЕНИЙ ДЛЯ ИДЕНТИФИКАЦИИ ЛИЧНОСТИ ПО ИЗОБРАЖЕНИЮ РАДУЖНОЙ ОБОЛОЧКИ ГЛАЗ

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**Аннотация.** Статья посвящена исследованию статистических методов выбора критериев пороговых значений для принятия решений в задачах идентификации личности, а также изучению проблемы определения пороговых значений на основе расстояния Хэмминга основанного критериев Байеса, Неймана-Пирсона и минимаксного критерия. Приведены условия применения этих критериев в системах распознавания личности по изображению радужного оболочки глаза.

**Ключевые слова:** биометрическая технология, радужка, идентификация, расстояние Хэмминга, байесовский критерий, критерий Неймана-Пирсона, минимаксный критерий.

## KO'ZNING RANGDOR PARDASI TASVIRI BO'YICHA SHAXSNI IDENTIFIKATSIYALASHDA BO'SAG'AVIY QIYMATLARNI TANLASH USULLARI

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**Annotatsiya.** Maqola shaxsni identifikatsiyalash masalida qaror qabul qilish uchun bo'sag'aviy qiymatlarni tanlash mezonlarining statistik usullarini tadqiq etishga bag'ishlangan bo'lib, Bayes, Neyman-Pirson va minimaks mezonlari asoslangan Xemming masofasi asosida bo'sag'aviy qiymatlarni aniqlashga qaratilgan masala o'rganilgan. Ushbu mezonlardan vaziyatga bog'liq holda shaxsni ko'zning rangdor pardasi tasviri bo'yicha tanib olish tizimlarida foydalanish bo'yicha tavsiyalar berilgan.

**Kalit so'zlar:** biometrik texnologiya, ko'zning rangdor pardasi, identifikatsiya, Xemming masofasi, Bayes mezoni, Neyman-Pirson mezoni, Minimaks mezoni.