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ANALYSIS OF THE IDENTIFICATION ERRORS AND WAYS OF ACCURACY IMPROVEMENT OF THE SYSTEMS OF BIOMETRICAL IDENTIFICATION

Identification and authentication provides safe protection of the personal data ,realizes reliable access to the objects or confidential information, results of scientific research, etc. Especially important becomes the combination of the passwords with the biometrical characteristics of a person, as a result , the reliability of the access system increases thousandfold. The paper considers basic properties and principles of the biometric identification systems, errors of the main methods of biometric identification have been analyzed and classified: Static methods (fingerprint identification, iris identification, face or hand geometry, venous picture of the hand ,eye retina) and dynamic(voice identification, fingertrip identification, signature identification). Principle of hand vein pattern obtaining, which consists in IR absorption by blood hemoglobin has been substantiated, according to which the necessary vein picture is determined by the degree of the emission reflection and the level of the blood stream visualization. The comparative analysis of several methods of identification by the veinprints has been performed and the method with the best characteristics has been selected. The analysis of the control points of the vascular pattern (minutia) has been performed. For optimal data taking new technique of hand scanning, using blocking device is introduced, the given technique enables to reduce to minimum the veinprint shift of the investigated person and makes its comparison with the sample easier. The choice of the commercial sample of the vein reader – scanner, which can be quickly and qualitatively adapted in the general structure of the identification system is substantiated. For the skeletonization of the binary image the method of patterns is selected, this method enables to process the data rapidly and obtain the data matrix – coordinates of the minutia and their type. For the improvement of the functional model of the person identification process by the hand vein pattern the identification protocol was introduced to the structure of the identification process, the realization of this protocol stipulates adequate taking a decision "identified / unidentified".

Key words: *biometrical identification, biometric profiles, recognition, vein print, biometric system, scanner, identification accuracy, biometrics.*

Introduction

Conventional methods and means of authentication require from the user different levels of the proficiency, financial expenses, security and other measures aimed at provision of the accurate and valid person identification. The following measures are most widely used nowadays: fingerprint scanning (used by 57% of the companies); face recognition (14%); hand geometry (5%); iris identification (3%); voice recognition and palmprint scanning (by 2%) [1]. According to Biometrics Research Group, the volume of the world market in 2020 exceeded 50 billion US dollars [1].

Unfortunately, all modern methods of person identification are not free from the drawbacks, this stipulates the necessity of searching the solutions, aimed at provision of high accuracy of the personalized biometric identification.

Analysis of the literature content

Methods of biometric identification have a number of drawbacks: from the possibility to avoid the algorithm of identification to the complete impossibility of authentication in case of changing the corresponding parts of human body. The most advanced scanner of the human face may not distinguish the twins and may not identify the person after the replacement of the eye crystal or prosthetics of eye cornea, that is why, eye retina or iris identification is used [1]. Annually in the world the companies produce approximately 75 mil. tools of biometric identification, accuracy of these tools are only 80% [1].

Main tasks of the unambiguous identification is the minimization of the erroneous irregularities and correspondences. In the first case the reading of the person`s data should be performed in accordance with the list of the corresponding requirements (correct position of the finger in case of fingerprinting, face of the person in case of identification by the face geometry, position of the eye during scanning of the iris, etc.). In the second case, certain person has close or similar parameters, with the person, whose data are already stored in the data base, in this case, the system will operate

incorrectly, recognizing this person as a true. We may correct this error, studying another biometrical characteristics of this person [2].

As the primary device, intended for taking the information for person identification is a scanner, then the quality of its operation influences greatly further data processing. This stipulates the necessity to equip the systems of biometric identification with more accurate scanning devices and, first of all, with high distribution power.

In semiconductor scanners the image of the finger surface or hand vein pattern is obtained by means of using the semiconductor properties, that change in the places of the papillary picture ridges contact (for the dactyloscopy) or hemoglobin in the blood flow (veinprint) with the scanner surface [3].

The operation of the capacity scanners is based on the change of the capacity of p-n junction of the semiconductor during the touch of the papillary picture ridge with the element of the semiconductor matrix. Scanners are not expensive and reliable, although they are not efficient against simulants.

Radiofrequency scanners operate using tiny antennas. On the surface of the hand, being scanned, low intensity signal is directed and the signal, reflected from the surface, is received by the sensitive antenna. However, the operation of the scanner is not stable that stipulates high probability of the error in the process of identification.

Sensitive to the contact with the skin, scanners use the matrix of piezoelectric elements, sensitive to the degree of pressing. The drawbacks of the method is low sensitivity, inefficient protection against simulants, possibility of damage in case of the excessive applied efforts.

Thermal scanners are built on the pyroelectric elements which allow to fix the temperature difference. During scanning the temperature map is built, the map is formed by the levels on the ridges and valleys of the papillary picture. The system is resistant to the electrostatic discharge, efficiently protected against the simulants but the main drawback is rapid vanishing of the fingerprint image.

Ultrasonic method is based on the fixation of the distance between the source of waves and the valleys of the papillary picture. Image of the object is of high quality, the protection against the simulants is high, at the same time the information about human pulse can be obtained. Main drawback – high price of the equipment [3].

As it was already mentioned, for the veinprint scanning the semiconductor scanner, operating in IR band, is used. This contributed to the obtaining of the sharp image, protected against simulants. The only requirement to the identified person is that the person must position the palm correctly in the window of the scanner.

Generalized analysis of the considered methods and means of biometric identification enabled to determine their advantages and drawbacks, group them and present in the form of the Table 1.

Data of the Table 1 give an idea about the available common advantages and disadvantages as well as advantages and drawbacks unique for the specific method or means, underlining the actuality and importance of the existing problem and motivating the specialists to search efficient and adequate ways of its solution.

The problem is the complexity and ambiguity of the selection of the high accurate method or means for the personified identification of the person.

The aim of the paper – determine the reasons of the insufficient level of the faultless identification and determine the ways of their elimination.

Main part of the paper

One of the ways of increasing the accuracy of biometric identification system is the integration of various methods of person identification. Although this leads to the growth of the material expenses, the result becomes more reliable and for more close to the desired one.

Unlike the face geometry identification method the veinprint identification is more accurate and reliable and by the accuracy can be compared with the iris identification accuracy for one eye. The

stability of the obtained results is explained by the fact that the channels of the blood vessels do not change with the age and their form and location do not greatly depend on various diseases, for instance, varicosis or throbosis. This provides stable results of the identification during many years. The external conditions practically do not affect the results of veins scanning, that is why, the given method can be used for the identification at the production site.

At the same time for the statistically dependent biometric characteristics methods of the assessment of distribution densities, operating with multidimensional space of the comparison results, depending on the level of biometric technologies integration, can be used. Statistic dependences of the biometric tests on the level of the characteristics are explained by the fact that one biometrics includes other biometrics (form and facial thermogram, fingerprints and palm prints), or pair organ (veinpicture of the left and right palms, iris). If the dependence is on the level of the samples of biometric characteristic the quality of the recognition may be improved, increasing the number of samples, taken in the process of training, because in this case the impact of factors, distorting the results, is compensated.

Table 1

Advantages and drawbacks of the biometric methods of identification

Method	Advantage	Drawback
2D-recognition	1) in the process of 2D-recognition, unlike, the majority of biometric methods, the expensive equipment is not needed; 2) possibility of recognition at great distances from the camera.	1) the requirements, regarding the illumination (for instance, it is not possible to register the faces of people, entering from the street in a sunny day); 2) for many algorithms there exist unacceptability of certain external obstacles, for instance, glasses, beard, some elements of the hearcut; 3) obligatory frontal facial image, with minor deviations; 4) many algorithms do not take into considerations possible changes of facial expression, i. e., the expression must be neutral [4].
Finger prints	1) high validity (statistical indices of the method are higher than the indices of the methods of facial identification, voice, signature); 2) low cost of the devices, scanning the image of the finger print; 3) rather simple procedure of the prints scanning.	1) papillary picture of the finger print can be easily damaged by small scratches, cuts; 2) insufficient protection against the forgery of the finger print, caused by wide spread of the method [5; 6].
3D-recognition	1) lack of the necessity to contact with the device, performing the scanning; 2) low sensitivity to the external factors both on the person himself and in the surrounding (illumination, turn of the head; 3) high level of reliability, which can be compared with the method of finger print identification.	1) expensive equipment; 2) change of the facial expression and obstacles on the face, worsen the reliability of the method; 3) method has not been sufficiently developed, especially as compared with dactyloscopy, that hampers its wide application [6; 7].

Continuation of the Table 1

By iris	1) capture of the iris image may be performed at the distance from several centimeters to several meters, physical contact of the person with the devices does not take place; 2) iris is protected against the damage by the eye cornea; 3) durable counteraction to forgery.	1) cost of the system for capturing the iris is higher than the cost of the fingerprint scanner and the camera for capturing 2D facial image. [11]
By the eye retina	1) high level of statistic reliability; 2) due to the low spread of the systems low probability to develop the method of"misleading" the systems; 3) hands free method of data scanning.	1) system is difficult to operate, long time of processing; 2) high cost of the system; 3) lack of the wide market of the propositions, as a result, insufficient intensity of the method perfection [6].
By the vein pattern of the palm	1) unique character of the vein pattern of each person, the vein pattern does not change since the age of 2 years; , 2) lack of the necessity to contact with the device, performing the scanning, that is why, the problem of the hygiene is solved; 3) high degree of protection: characteristic can not be obtained from the person "in the street", in case of the hand simulant the vein pattern will not be taken by the IR camera; 4) possibility of wide application due to minimization of the impact of the external factors; 5) simplicity: user`s interface promotes maximal perception simplicity; 6) high probability: statistic indices of the method can be compared with the indices of iris scanning.	1) inadmissible lighting of the scanner by the solar rays and by the rays of the halogen lamps; 2) certain aging associated diseases, for instance, arthritis, worsen identification quality [4; 6].

For the construction of the palm vein pattern that takes into account the coordinates of the control points, their mutual location and angles, we will form *N*-set of biometric samples and *H*-finite set of the solutions, for which two variants of identification are possible

$$H = \{-1; +1\},$$

where $\{-1\}$ – biometric sample is defined as «foe», and $\{+1\}$ – as «friend». The result of identification is the reflection $h*: N - H$, obtained as a result of the system operation

$$h(n) = sign[f(n, w) - w_0],$$

where $h(n) \in H$ – solution regarding the identification of the system; $n \in N$ – input biometric sample; $f(n,w)$ – discriminant function; w –vector of parameters; w_0 – cut off threshold [8].

Each separate minutia of the vector picture, as a rule, is described by its coordinates, angles and directions

$$M_i = (x_i, y_i, \alpha_i, \theta_i),$$

where x_i, y_i – minutia coordinates; α – direction of the minutia; θ – type of minutia (field in bites): disjunction – «0», expiration – «-1», bend – «-2».

The model of the vein picture of the palm can be presented

$$M = \{(x_i, y_i, \alpha_i, \theta_i, \dots, (x_i, y_i, \alpha_i, \theta_i)\ \}, i=1,k.$$

More convenient form of the minutia description is the presentation of its coordinates, angles and types in the form of the matrix *M*, bythe analogy with [9]

$$M = \begin{vmatrix} x_1 & y_1 & \alpha_1 & \theta_1 \\ x_2 & y_2 & \alpha_2 & \theta_2 \\ \dots & \dots & \dots & \dots \\ x_k & y_k & \alpha_k & \theta_k \end{vmatrix},$$

where x_i, y_i – coordinates of the minutia relatively the start of the coordinates system – centroid of the silhouette image of the hand; α_i – direction of the probable elongation of the vessels to the point of «termination» and direction of «closure» – in the points of splitting ; θ_i – type of the control point.

In real conditions during reading out of the biometric sample (vein picture of the palm) to eliminate the possible ambiguity and mistakes, caused by the change or turn of the vein picture image in the registered template relatively the control one, the transformation procedure of the absolute values of the minutia parameters into the relative values by the following formulas is used [9]

$$\begin{cases} d_{ij} = \sqrt{\left(x_i - y_j\right)^2 + \left(y_i - y_j\right)^2} \\ \alpha - 1_{ij} = \alpha_{ij} - \alpha_i \\ \alpha - 2_{ij} = \alpha_j - \alpha_i \\ \alpha - 3_{ij} = \alpha_{ij} - \left(\alpha_i + \alpha_j\right) \end{cases},$$

where i, j – minutia; d_{ij} – distance between the points i and j ; $\alpha - 1_{ij}$ – angle between the direction of the point i and direction to the point j; $\alpha - 2_{ij}$ – splitting angle between the direction

of the point i and direction of the point j; $\alpha - 3_{ij}$ – angle of coincidence of the point direction i and point direction j into the arc;

Authors have developed the system, where the vein picture scanner BioSmart PV-WM with following parameters and functions is used: type of scanner – optical, IR; built-in reader of the RFID-marks; controller interface - Ethernet (IEEE 802.3, 100BASE-TX); maximal length of the Ethernet cable – 100m; support PoE - IEEE 802.3af class 3; supply – 12V, DC, 400mA; dimensions 185x160x134 mm; net weight 532 g.; cost – 18240 hrs.

Available analogs were chosen: 1) Biometrical network terminal of the fingerprints ZKTECO MA300 with the following basic parameters and functions: fingerprint memory – 1500; contactless cards memory – 1000; number of records – 5000; port Wiegand: input and output; interface – RS485, TCP/IP, USB – host: sensor – ZK optical; version of the algorithm ZK Finger v10.0; access control interfaces – electronic lock, reed switch, button «Exit», alarm; functions of the access control – 50 time zones, 5 access groups, 10 release combinations; supply 12V, DC, 500mA; dimensions 73x148x34,5mm; cost – 5145hrs (without the computer).

2. Biometric terminal for the access control with iris recognition ANVIZ ULtraMath S2000 having such basic parameters and functions: model Iris 2000 for two eyes; processor ARM cortex; operation system WinCE/Linux; scanning distance – 180-240cm; scanning time – 1sec.; number of users – 1000; number of events in the memory of the device – 100000; FAR<1/1 000 000 000 000; Security standards for the eye health - ISO/IEC 19794-6(2005&2011) / IEC62471: 22006-07; network interface – TCP/IP; supply 12V, DC, 2A; dimensions - 180 x 141 x 70; environmental requirements – do not let the direct sun light; cost – 61434hrs.

In the experiment 160 person (80 men and 80 women) took part, among them 152 persons with absolutely undamaged palms; 8 persons (5 men and 3 women) with palms, having changes, caused by the disease. In the process of the experiment the attempt to register the vein picture of the palm in case of sun outage, was modelled for 10 persons with the undamaged palms (5 men and 5 women), and in case of flash from the halogen lamps – for 12 persons, also with the undamaged palms.

Generalized diagram of the experiment is shown in Fig. 1: DB1 – data base of the control templates; DB2 – data base of the persons, denied the access; DB3 – data base of the registered (current) templates.

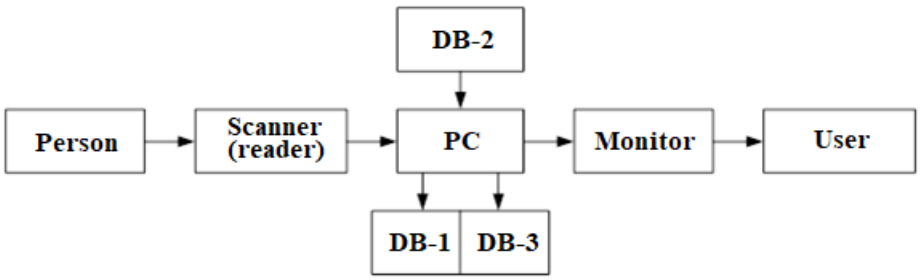

Fig. 1. Scheme of the experiment for the assessment of the quality of person identification

Experiment sequence.

1. Data bases of the control templates DB1-1, DB2-2, DB3-3 are formed for each of three available identifies.

2. Data bases DB2-1, DB2-2, DB2-3 of the persons who were denied the access permissions are formed for each of three available identifiers.

3. 30 days after p.p. 1 and 2, the identification procedure of 160 persons was performed separately for each of three available identifiers; 1 – reader BioSmart PV-WM – for the hand vein pattern; 2 – terminal ZKTECO MA300 – for fingerprints; 3 – terminal ANVIZ ULtraMath S2000 – for iris recognition. Hardware component of the system is identical for all three variants of the identification. In the given part of the experiment the developed biometric system for person identification is presented in the complete configuration, i.e., with the improved subsystem of data capture, the given subsystem includes thermographic IR camera HY-18 MLX90640, completed with IR temperature sensor; tremor sensor, based on Web-camera iSlim32IR (requires on the PC operation system(OS) Windows XP\Vista) and palm spot heater of own design.

4. The replacement of the improved subsystem of the data capture by the conventional, standard is performed, after that the indication procedure for 160 persons is carried out.

Data, obtained as a result of the experiment are systematized, if necessary, additionally processed and grouped in the corresponding Tables.

Table 2

Distribution of the identified persons by types of a scanner

Type of scanner (reader)	Number of persons prior the identification		Identified persons		Non identified persons
	Damage-free	With changes caused by the disease (in anamnesis)	Damage-free	With changes, caused by the disease	
BioSmart PV-WM (improved system)	152	8	152	4	4
ioSmart PV-WM (standard system)	152	8	151	2	7
KTECO MA300 (analog)	152	8	151	1	8
NVIZ ULtraMath S2000 (analog)	152	8	150	3	7

Table 3

Comparative table of biometric systems by the basic criteria

Empiric characteristics	Fraud resistance	Environmental stability	Utilization comfort	Operation speed	Stability of biometric indication in time	Cost-quality factor
Hand-vein pattern (improved)	12	10	10	9-10	10	10
Hand-vein pattern (standard)	10	10	9-10	8-9	10	9-10
Papillary pattern of the finger (analog)	6	9	8-9	9-10	9	9
Iris (analog)	10	9	7-8	8-9	10	9-10

The assessment was carried out by 1 – 10 scale.

The analysis, carried out, showed that the developed system of biomedical identification by the veined pattern of the palm has the indices, not lower, than the indices, given for the analogs and by certain indices, exceeds the existing analogs.

At the same time, analysis of the identification in Tables 2 and 3, detected and confirmed the problem of provision the authenticity of biometric identification of the person. It makes sense to refer to the information, published in [9] and presented word-for-word. “To begin with, the papillary picture of the fingers and palms skin is considered to be unique and unchanged during the whole life of a person, although the suggested hypothesis, in spite of its wide practical application, does not have scientific substantiation until now. Moreover, nobody and never has carried out serious assessment of the reliability of the person identification by the fingerprints and palms. By default, this hypothesis is taken for 100%, but there are reliable scientific data that actually it does not exceed 98%.”

One of the perspective directions, aimed at the decrease of the invalidity level and increase of the accuracy and reliability of the methods and means of biometric identification is SABI technology (system of the efficient biometric identification) [1].

The base of the technology is the effect, the essence of which is that the combined radiation in certain bands of SHF and HFB may deeply penetrate in the tissues of the organism. This enables to obtain by the results of the analysis of the signals, reflected from the object the unique electro-magnetic profile of the bio-object, containing the print of electric, physiological, cellular and molecular processes, occurring in certain tissues [1].

Conclusions

1. Thus, having analyzed the existing methods of biometric identification and the technology of their realization the following conclusions can be made.

The problem of identification and authentication of the person is one of the main problems, solution of which promotes qualitative storage of the personal data, provides the reliable access to the objects or confidential information, scientific developments, etc. Combination of the passwords

with the biometric characteristics of a person becomes really important as the reliability of the access system increases thousandfold.

2. Main properties and principles of biometric identification systems are considered, the errors of the basic methods of biometric identification are analyzed and classified: static methods (fingerprints identification, iris identification, facial geometry or hand geometry identification , vein pattern of the hand, eye retina identification) and dynamic (voice identification, keying, signature-based identification).

3. It is suggested to apply integration of biometric technologies on the principles of combining the information and SABi technology as the basic directions for solving the problem of the accuracy improvement of the personalized biometric identification of a person.

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Editorial office received the paper 04.03.2020.
The paper was reviewed 13.03.2020.

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