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AN INTELLECTUAL COMPONENT RECOGNITION FOR SECURITY SUBSYSTEM

Виявлено та обґрунтовано загальну структуру алгоритмів, які застосовуються у сфері розпізнавання. На основі проведеного дослідження пропонується створити математичне та алгоритмічне забезпечення задачі розпізнавання образів, яке буде забезпечувати швидкодію та високу ймовірність розпізнавань. Проведено порівняльний аналіз методі та підходів до вирішення задачі знаходження та ідентифікацію обличчя людини на зображенні. Запропоновано модифікований алгоритм масштабування та кластеризації зображення.
Ключові слова: розпізнавання обличь, кластеризації, ідентифікація, інформативні ознаки, згортальна нейронна мережа.

Выявлено и обосновано общую структуру алгоритмов, применяемых в сфере распознавания. На основе проведенного исследования предлагается создать математическое и алгоритмическое обеспечение задачи распознавания образов, которое будет обеспечивать быстродействие и высокую вероятность распознавания. Проведен сравнительный анализ методов и подходов к решению задачи нахождения и идентификации лица человека на изображении. Предложен модифицированный алгоритм масштабирования и кластеризации изображения.
Ключевые слова: распознавания лиц, кластеризации, идентификация, информативные признаки, свёрточная нейронная сеть.

Discovered and proved the overall structure of the algorithms used in pattern recognition. A comparative analysis of methods and approaches to solving the problem of finding and identifying human face on the image. A modified algorithm for image scaling and clustering, which reduces the number of informative tracts candidates for the location of the research object (human face) is proposed. It is established that the use of neural networks coagulation makes a small number of errors in a large number of coagulation and other layers. It is established that the network has a large invariance to position the face in the picture. In consequence of that generalization ability higher than the multilayer perceptron. Evaluating the effectiveness of probabilistic systems showed that the use of the proposed approaches and algorithms enables a high probability likely face recognition (93%). Results of the study can be used in the development of automated systems for access: a personal computer, a bank account, application to access data on the image of a human face in miniature devices where there is no possibility to embed common hardware identification.
Keywords: recognition system, optimization, machine learning, image, information criterion, functional efficiency.

Introduction. With the development of computer technology it became possible to solve a number of problems arising in the process of vital activity, to facilitate, accelerate, improve the quality of the result. For example, the work of various life support systems, human-computer interaction, the emergence of robotic systems.

Recognition systems become an integral and very important part of automated control systems for the shop, plant, industry, since in order to manage the optimal way, it is necessary to have information about the phenomena and processes in the system, is formed, in particular, as a result of the functioning of the corresponding recognition systems.

Human face recognition systems are now being increasingly used in those applications where access to information is differentiated, as well as in security systems. A major problem facing computer vision systems is the large variability of visual images associated with changes in illumination, scales, viewing angles. In addition, people have a habit of walking around the streets and in the premises dressed, which leads to significant variability in the images of the same person.

The results of the research can be used in the development of automated access systems: a personal computer, a bank account. The use of access to data on the image of a person's face in miniature devices, where it is not possible to embed conventional technical means of identification.

Description of the research object. Person identification subsystems for face recognition are widely used in automated security systems (large enterprises, large airports, metro) for the purpose of identifying individuals. This recognition technology, unlike the use of biometric features (fingerprints, the shell of the eye), does not require physical contact with the device and is the most suitable for mass use.

The search and identification of a person is made only in the event of the availability of data about it (name, date of birth, gender). An effective search option can be the method of identifying a person by her photo.

Correctly described features of the investigated object (human face) provide an efficient and fast operation of the application.

One of the effective methods for describing the characteristics of a person is the method of geometric characteristics, which was originally used in forensic science. The essence of the method is as follows. It is necessary to isolate the key points of the research object, and then the feature sets. Each feature is the ratio of the distances between the key points or simply the distance between them.

The authors identified the most significant informative features. This is illustrated by Figure 1.

Figure 1 –Characteristics of the research object

The description of the features is given in Table 1.

Table 1 – The most informative signs

Plot of land	Units	Description
BC	мм	Distance from the beginning of hair growth to the eyebrow
CE	мм	From the eyebrow to the tip of the nose
EF	мм	From the tip of the nose to the chin
AD	мм	From the highest point of the head to the eye line
DF	мм	From the line of the eyes to the chin
KL	мм	Distance between the inner corners of the eye
PK	мм	Length of the eye
OR	мм	Nose width
BF	мм	Height of the face
AF	мм	Head height

An important point to be noted is the aging of the organism, characteristic of the human nature, the growth of hair and the variability of facial expressions, as well as scars and other artificial changes. This all prevents recognition, therefore, selected features of the object that are minimally dependent on these factors [1].

The distinguished features are qualitative, stationary, not stochastic.

Also, the attributes are dependent, for example, the KL region should be smaller than the DF portion by about three times.

Purpose and objectives of the study. Statement of the research task. Safety is an important component of human life. A person faces the task of protecting a room (production, office or home).

To date, CCTV cameras have been installed in all large credit institutions, diverse trading enterprises and public entities.

Personality, information and material values are the main objects of protection of the security system.

One of the effective security systems is the pattern recognition system.

The formulation of the problem was formulated as follows. There are 50 photos (10 photos for 5 different people). All photos have a size of 600 × 600 pixels. When a particular person appears in front of the webcam, the system must determine if there is a face image in the field of view. Next, determine whether the image is the face of a particular person from those that are stored in the database. And after that, carry out identification and make a decision.

Materials and methods for solving the research problem. The authors analyzed the main methods of identifying a human face, identified the advantages and disadvantages of each of them. During the analysis, the overall structure of the recognition process was identified. It was found that the algorithms analyzed differ only in how the features are found and compared. At the initial stage, the object is detected and localized on the image. At the recognition stage, the image is aligned, then the characteristics are calculated and the found characteristics are compared with the standards set in the database.

As a result of the analysis of methods and approaches to the solution of the problem, the authors selected the most effective for solving the research problem. Namely, one of the approaches, based on neural networks, is the convolutional neural networks.

In order for the neural network to be trained, it is necessary to form a set of learning examples. Key features are extracted by themselves, during training. Further, the importance of the found features is established and the mutual dependence of their individual characteristics is found. When the network is already trained, it is assumed that it can apply the experience obtained to previously unknown images due to generalizing abilities [2].

The convoluted neural network has a peculiar peculiarity, it consists in the following. The limited two-dimensional connectivity of neurons is provided by local receptor fields, and common weights guarantee the detection of certain traits anywhere in the image.

As can be seen from Figure 2, the architecture of a convolutional neural network consists of a number of layers that are periodically repeated. Select the convolution and sub-sampling layers.

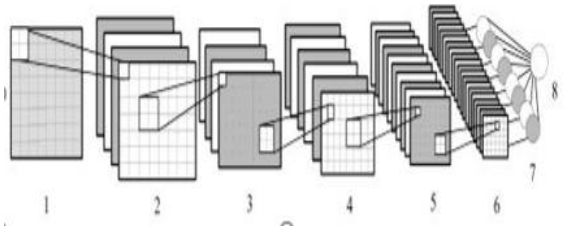

Figure 2 – Neural network architecture:1 – entrance; 2, 4, 6 – convolutional layers; 3, 5 – select layers; 7 – layer of ordinary neurons; 8 – exit

Each layer has a set of planes, neurons of the same plane have equilibrium coefficients of the synapse weights that lead to all local sections of the previous layer. The local receptor field gives inputs to each layer neuron, that is, the input image of the previous layer is scanned as a small window and passed through a set of synaptic coefficients, and the result is mapped to the corresponding neuron of the current layer. A set of planes is a map of characteristics, and each plane finds "its" parts of the image anywhere in the previous layer [3].

The scale of the planes is reduced by the sub-sample layer, that is, the values of the neurons at the output are averaged. More general characteristics are extracted by the following layers.

Scaling and clustering an image. When the system finds an object (person's face) on the image, then the searched area is marked with a rectangle. The main difficulty is the fact that in one image several informative candidate plots can be found for the location of the object. An illustrative example of such recognition is shown in Figure 3.

In order to minimize such errors, as well as increase the probability that the investigated object will be highlighted in the image, it is suggested to use scaling and clustering.

Figure 3 – Example of highlighting informative candidates in the image

The scaling process is that the original image is methodically scaled with a factor of 1.2 to 0.8. In consequence of this process, we obtain five images with different scales [4].

Due to the scaling process, the same image takes different sizes, that is, the structure of some of the image elements is partially changed. Proceeding from this, each of the scaled images has its own distinct candidate areas, not all of which can coincide on some of the five scaled images.

After the above process, the resulting images are scanned by the neural network. She finds and allocates candidates in each image. All these areas can be characterized by a set of parameters: the coordinates of the center of the site, the width and height, the recall of the neural network for the area found. After scaling relative to the original image, the candidates are compared. They are superimposed on each other and overlapping candidate areas are clustered together. Candidate plots that are not included in the clusters are considered false and are not accepted.

Image recognition. After the system has determined the location of the object, it must be recognized.

At the input of the convolutional neural network, there is a photograph of the person, on which recognition is carried out.

After that, the incoming image is viewed by a local receptive field, the information of each receptive field is transformed by the function and written to each neuron of the next layer. The above process is repeated in each of the neural network layers. After the neural network has extended the characteristics of the image, the process of establishing the output of the network corresponds to one of the classes of images stored in the database. This process is called teaching with the teacher [5].

Estimation of the effectiveness of probabilistic recognition systems. This algorithm is used for the developed system to work with objects that can be used to evaluate the effectiveness of probabilistic recognition systems based on mathematical modeling. To conduct such tests, a mathematical model of the functioning of the recognition system can serve.

To conduct each test with the help of a random number generator, an object model is formed, the belonging of which to a certain class is known in advance. Formation of the model of the object is carried out by setting a set of numerical values of the characteristics $x_1, x_2, \ldots, x_n$, which for objects from the class Ω_i are generated as realizations of a multidimensional random variable with a given distribution law $f(x_1, x_2, \ldots, x_n)$ by one of the known algorithms.

Before entering the input of the recognition algorithm, the numerical values of the parameters $x_1, x_2, \ldots, x_n$, which represent an object that is recognized, are subject to random distortions, which simulates the result of the impact of various obstacles in the process of determining the characteristics $x_1, x_2, \ldots, x_n$ with the use of appropriate technical means with certain characteristics of accuracy. Distorted value $x_1, x_2, \ldots, x_n$, which represent the object observed in the form in which it is perceived by the system, arrive at the input of the recognition unit, which determines the belonging of the object to one of the classes $Q_1, Q_2, \ldots, Q_m$. Matches the number of the class to which the object belongs with the recognition unit, with the "true" number, that is, with the one set at the first stage of object formation, determines the correctness of object recognition and systematizes the relevant information to calculate the probability estimates of the correct and erroneous solutions. When recognizing objects from a class Q_i probability evaluation w_i the correct answer is the ratio of the number of correct answers N_{pr}^i to the total number of tests N^i over objects of a class Q_i:

$$w_i \approx \frac{N_{\text{pr}}^i}{N^i}, \qquad (1)$$

Number of tests N^i is determined by the confidence probability given in the formulation of the research task. The considered statistical model allows to find the dependence of the system efficiency index W from the type and number of attracted for recognition indications $x_1, x_2, \ldots, x_n$ and accuracy of technical means $k_1, k_2, \ldots, k_s$, which are equipped with the recognition system:

$$W = W(x_1, x_2, \ldots, x_n; k_1, k_2, \ldots, k_s) \qquad (2)$$

The information contained in (2) – output for tasks on determining the composition of technical means of observing the recognition system, the necessary accuracy of their work.

Conclusions. A comparative analysis of approaches and methods to solving the problem of detecting and identifying a person's face on an image is conducted, their advantages and disadvantages are considered. As the most effective approach is chosen using convolutional neural networks. A method for selecting a face in an image by its features is proposed. A modified algorithm for scaling and image clustering is proposed, which is used to prepare the image for recognition. The mathematical and algorithmic

support of the procedure for solving the research problem is developed.

Bibliography

1. *Edwards G. J.* Face Recognition Using Active Appearance Models / *G. J. Edwards, T. F. Cootes, C. J. Taylor* // ECCV'98. Proceedings of the 5th European Conference on Computer Vision. Freiburg, Germany, June 2–6 1998. – Vol. II. – Heidelberg : Springer, 1998. – P. 581–595.
2. *Головко В. А.* Нейроинтеллект: Теория и применения. Книга 1. Организация и обучение нейронных сетей с прямыми и обратными связями / *В. А. Головко*. – Брест: БПИ, 1999. – 260 с.
3. *Гультяева Т. А.* Распознавание лиц с использованием скрытых марковских моделей / *Т. А. Гультяева, А. А. Попов* // Наука. Технологии. Инновации. НТИ-2004: Материалы всероссийской науч. конф. мол. ученых. - Ч. I. - Новосибирск: НГТУ, 2004. – с. 159–160.
4. *Haddadnia J.* Human face Recognition Using Radial Basis Function Neural Network / *J. Haddadnia, K. Faez* // Proc. of 3rd Int. Conf. on Human and Computer. Aizu, Japan, 6–9 Sept. 2000. – P. 137–142.
5. *Резник А. М.* Система проектирования модульных нейронных сетей САПР МНС / *А. М. Резник, М. Э. Куссуль, А. С. Сычев, Е. Г. Садовая, Е. А. Калина* // Математичиские машины и системы. – 2002. – № 3. – С. 28 – 37.

References (transliterated)

1. Edwards G. J., Cootes T. F., Taylor C. J. Face Recognition Using Active Appearance Models. *ECCV'98. Proceedings of the 5th European Conference on Computer Vision. Freiburg, Germany, June 2–6 1998. Vol. II.* Heidelberg, Springer Publ., 1998, pp. 581–595.
2. Golovko V. A. Nejrointellekt: *Teorija i primenenija. Kniga 1. Organizacija i obuchenie nejronnyh setej s prjamymi i obratnymi svjazjami* [Neurointelligence: Theory and Applications. Book 1. The Organization and Training of Neural Networks with Direct and Reverse Links]. Brest, BPI Publ., 1999. 260 p.
3. Gultyaeva T. A., Popov A. A. Raspoznavanie lic s ispol'zovaniem skrytyh markovskih modelej [Face Recognition Using Hidden Markov Models]. *Nauka. Tehnologii. Innovacii. NTI-2004: Materialy vserossijskoj nauch. konf. mol. uchenyh. Ch. I* [Science. Technologies. Innovation. STI-2004: Proceedings of the All-Russian Scientific Conference. Conf. Young scientists. Part I.]. Novosibirsk, Novosibirsk State Technical University Publ., 2004. pp. 159–160.
4. Haddadnia J., Faez K. Human face Recognition Using Radial Basis Function Neural Network. *Proc. of 3rd International Conf. on Hu man and Computer. Aizu, Japan, 6–9 Sept. 2000*, pp. 137–142.
5. Reznik A. M., Kussul' M. Je., Sychev A. S., Sadovaja E. G., Kalina E. A. Sistema proektirovanija modul'nyh nejronnyh setej SAPR MNS [The system design of modular neural networks of the CAD MNS]. *Matematichiskie mashiny i sistemy*. 2002, no. 3, pp. 28–37.

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