Research Article
Algorithm for Recognition of Movement of Objects in a Video Surveillance System Using a Neural Network

S. Harish,1 C. Anil Kumar,1 Lakshmi Shrinivasan,2 S. Rohith,3 and Belete Tessema Asfaw4

1Department of Electronics and Communication Engineering, R. L. Jalappa Institute of Technology, Kodigehalli, Dodaballapur, Karnataka 561203, India
2Department of Electronics and Communication Engineering, Ramaiah Institute of Technology, Bengaluru, Karnataka 560054, India
3Department of Electronics and Communication Engineering, Nagarjuna College of Engineering and Technology, Bengaluru, Karnataka 562164, India
4Department of Chemical Engineering, Haramaya Institute of Technology, Haramaya University, Haramaya, Ethiopia

Correspondence should be addressed to Belete Tessema Asfaw; belete.tessema@haramaya.edu.et

Received 28 June 2022; Revised 22 July 2022; Accepted 26 July 2022; Published 12 August 2022

1. Introduction

In today’s world, the slogan is becoming more and more relevant. This applies to all spheres of activity and human life. Security of the object being protected is one of its components, and video surveillance is one of the ways to maintain security at the appropriate level [1]. The surveillance system is a set of hardware and software designed to monitor the territory, activities, and situation. Traditional video surveillance systems are widespread in today’s security agencies and show a high level of protection but have their own shortcomings: as a result, the large amount of recorded video material requires a high amount of memory and time to analyze and view. Our research is focused on improving the efficiency of video surveillance systems [2]. The video surveillance information system is based on modern cybernetic methods and technologies, namely, machine learning [1], computer vision theory [2], and the theory of image recognition [3].

The work of F. Rosenblatt must be noted among foreign scientists; he proposed in 1957 a perfect machine for the recognition of images. It was the simplest model of human brain activity. A significant contribution to the further development of the theory of image recognition was made by W. Gardner. The identification of object movements is an extremely complex task, but all of them rely on neural measurements, which allows for more accurate results in a short period of time. This is confirmed by the practical experience of the authors. The aim of this research is to develop and create an algorithm for recognition of objects’ movements by means of a neural network for video surveillance systems [3]. Artificial neural networks are
composed of nodes or units that resemble the neurons in a biological brain. A signal can be transmitted from one artificial neuron to another through each connection, just as it would be in a biological brain.

1.1. Theoretical Foundations of Research. Pattern recognition theory is a branch of cybernetics devoted to creating theoretical foundations for the classification and identification of objects. The processes of classification and identification are called recognition, and objects are called things. Based on the research of the authors, we shall identify the main definitions and give a short description of each method of the theory of image recognition. A pattern is a model that reproduces the properties of the object being recognized. An image is characterized by a multiplicity of recognition features, which create a structured vector-image realization. Often the image is replaced with a recognition class. The feature of recognition is a characteristic of a certain property of the object being analyzed. Vector realization of an image is a structured, i.e., ordered, sequence of recognition features, which will be presented in the form of a vector row or vector carrier. System image recognition—a complex electronic and computational method—is capable of modeling mental processes in humans during decision making with the aim of detecting analogies among the surveyed objects [4]. For image recognition, it is necessary to solve two main tasks: to divide the space of recognition signs into areas corresponding to a certain class of objects and to identify the relevance of the image being recognized to the corresponding class. The main approaches in image recognition theory are as follows: (1) algebraic, the main advantage of which is simple decisive rules; the main disadvantage of this approach is the unreliability of recognition, as it does not take into account uncontrolled factors that affect the recognition process; (2) geometric, which is characterized by its universality, simplicity, and ease of interpretation of the recognition algorithms; (3) statistical, which uses statistical characteristics of data analysis; (4) biological, which includes neural networks; (5) measurement; (6) the non-fuzzy one, which is created on the basis of algebraic approach, allows modeling the processes of recognition of images, which are naturally overlapping in the space of recognition signs, but it is not applied to optimization of parameters of the recognition system functioning; and (7) a game-theoretic approach, in which the decision-making rules are characterized by a high degree of complexity and a low degree of certainty of recognition. In practice, these approaches complement one another to improve the efficiency of image recognition. Image recognition methods can be roughly divided into two groups: intrinsic and extrinsic [5]. The study demonstrates the features of each group and the methods that belong to each group and identifies the quality characteristics of these methods and their disadvantages. There are several main tasks involved in image recognition, including the following: input data; a selection of informative features; object recognition and classification; automatic classification; dynamic recognition; dynamic classification; forecasting.

1.2. Research Results. As evidenced by the scientific sources on the problem of image recognition, the interest in solving more complex tasks of recognition of objects, due to automation, and the need for image communication processes in intelligent systems are growing every year. Therefore, improving the implementation of recognition of computer systems images is relevant. One of the promising directions of solving this problem is based on using piecewise neural networks and neurocomputers as the most progressive method in relation to the problems of image recognition classification [6]. At our time, a large number of neural network archetypes have been proposed for use in the recognition of objects. The analysis of the proposed solutions shows that none of the best-performing neuroscience solutions would be the best. The development of the theory of piecewise neural networks is associated with the names of neural networks which are useful for solving tasks in cases where a large amount of data has been accumulated, but there is no software to process and systematize it; the data available are spoiled, incomplete, or not systematized; and data are so different that it is difficult to see the links and patterns between them [1]. The artificial neural network (ANN) is a system of interconnected and mutually inter-connected neurons based on relatively simple processors. Each ANN processor periodically receives signals from one processor and periodically sends signals to the other processors. Together, these simple processors integrated into the measure are able to solve complex tasks [7]. Neurons are most often located in the network by rank. Neurons of the first level are usually input. They receive data from outside and after their processing transfer impulses through synapses of neurons to the next level. Neurons on the other level (called adjacent, as it is indirectly connected to neither the input nor the output of the ANN) process the received impulses and transmit them to the neurons on the output level. As the neurons are mutated, each input-level processor
is linked to several output-level processors, each of which in turn is linked to several output-level processors. This architecture is the simplest ANN, which is trainable and can find simple interconnections in the data. Figure 1 shows a schematic diagram of the complex image processing and analysis algorithm. This algorithm includes modules for controlling the calculation process. Thus, depending on the type of tasks solved, the structure of the complex algorithm can vary. When each stage of image processing and analysis is completed, the obtained information is fed to the control unit, which forms the plan for further procedures. Apart from the control unit, the database is stored in the processing system’s memory, which contains the required data and various information processing procedures in accordance with accepted regulations [8].

1.3. Image Recognition Algorithm. Information support of the project of the automated system of video surveillance by means of a mathematical model of recognition of object movements can be represented in the form of a structural algorithm of information flows, which is presented in Figure 2. As a result, the network is self-organized, i.e., after the method is defined, modules based on different criteria matrices are reconfigured in a cycle, making the scheme dynamic rather than static.

1.4. Findings and Prospects for Further Research. The development of video surveillance systems offers new possibilities not only for the detection of offenses but also, and more importantly, for their prevention. The capabilities of modern systems are also used for intelligent analysis of the video stream received. At present, there are a lot of different algorithms for image recognition. Each of them was created for a particular type of image, and for its subsequent use in the application of programming, we need to choose the most optimal method in terms of the specific task and improve it in specific realities. Our next task is to develop a software maintenance algorithm for video surveillance with the help of the runway recognition system.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

[1] G. V. Mygal and O. F. Protasenko, “Inzheneriya lyudskogo chinnika v suchasniy osviti Human factor engineering in modern education,” Scientific notes of Taurida National V.I. Vernadsky University. Series: Technical Sciences, vol. 6, no. 1, pp. 1–6, 2019.
[2] J. Dul, R. Bruder, P. Buckle et al., “A strategy for human factors/ergonomics: developing the discipline and profession,” Ergonomics, vol. 55, no. 4, pp. 377–395, 2012.
[3] J. R. Savard and N. A. Stanton, “Individual latent error detection: simply stop, look and listen,” Safety Science, vol. 101, pp. 305–312, 2018.
[4] J. R. Wilson, “Fundamentals of systems ergonomics/human factors,” Applied Ergonomics, vol. 45, no. 1, pp. 5–13, 2014.

[5] R. H. Stevens, T. L. Galloway, and A. Willemsen-Dunlap, “Neuroergonomics: quantitative modeling of individual, shared, and team neurodynamic information,” Human Factors: The Journal of the Human Factors and Ergonomics Society, vol. 60, no. 7, pp. 1022–1034, 2018.

[6] H. Hsiao, J. Chang, and P. Simeonov, “Preventing emergency vehicle crashes: status and challenges of human factors issues,” Human Factors: The Journal of the Human Factors and Ergonomics Society, vol. 60, no. 7, pp. 1048–1072, 2018.

[7] A. C. Marinescu, S. Sharples, A. C. Ritchie, T. Sánchez López, M. McDowell, and H. P. Morvan, “Physiological parameter response to variation of mental workload,” Human Factors: The Journal of the Human Factors and Ergonomics Society, vol. 60, no. 1, pp. 31–56, 2018.

[8] E. Kapkin and S. Joines, “An investigation into the relationship between product form and perceived meanings,” International Journal of Industrial Ergonomics, vol. 67, pp. 259–273, 2018.