COMPUTER SCIENCE

АВТОМАТИЗИРОВАННЫЙ АНАЛИЗ ДАННЫХ ОХРАННЫХ ТЕПЛОВИЗОРОВ НА ОСНОВЕ ГЛУБОКОГО ОБУЧЕНИЯ

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DEEP LEARNING AUTOMATED DATA ANALYSIS OF SECURITY INFRARED CAMERAS

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Аннотация

Рассмотрены перспективы применения тепловизионных систем в задачах контроля безопасности. Особенно актуальным является своевременное обнаружение запрещённых предметов, которые потенциальный злоумышленник может прятать под одеждой. С целью повышения эффективности тепловизионных охранных систем предлагается автоматизация процесса обработки термограмм с помощью средств глубокого обучения. В частности, одним из наиболее перспективных методов является использование свёрточных нейронных сетей для автоматического детектирования запрещённых объектов на инфракрасных снимках. Предложенная в статье архитектура сети позволяет обнаруживать у личности запрещённые предметы и распознавать класс этих предметов с долей правильных ответов на тестовом множестве до 97.92%.

Abstract

Prospects for the use of thermal imaging systems in safety control problems are considered. Particularly relevant is the timely detection of prohibited items, a potential attacker can hide under clothes. In order to increase the efficiency of thermal imaging security systems, automation thermograms processing using deep learning. In particular, one of the most promising methods is the use of convolutional neural networks for automatic detection of objects in infrared images. The network architecture proposed in article makes it possible to detect identity of prohibited items and to recognize these items with correct answers on the test set up to 97.92%.

Ключевые слова: тепловизоры, охранные системы, глубокое обучение, свёрточные нейронные сети, дополнение данных.

Keywords: thermal imagers, security systems, deep learning, convolutional neural networks, data augmentation.

Introduction

Today, humanity is in a phase of constant development of new technologies. The security of the population is one priority areas for development. The issue of recording and controlling unauthorized events is particularly important in the places with large concentrations of people. In particular, effective and timely identification of hazardous items and reliability of this information is a great challenge [1].

The usage of thermal imaging systems is very effective solution to this problem. A peculiarity of such thermal detectors is the requirement to obtain clear and high-quality images offender at the greatest possible distances maximum operating range of temperatures. The image has to be as clear as possible to reduce the probability of a false alarm. Reliable automatic object recognition on infrared images is a current task. It is necessary to improve the efficiency of data processing and reliability of security systems.

Review of previous works

Modern thermal imaging systems are at an early stage of development. Most of the latest developments in this field are carried out in a highly secret mode. That is why, the number of scientific publications in this field is limited. This scientific paper [2] considers promising fields of application thermal imaging systems. The analysis of existing developments has shown that the usage of thermal engineering equipment in security systems significantly improves safety. It is stated that improvements in production process of thermal imaging equipment and the consequent reduction cost in future will lead to the widespread adoption of this technique.

In article [3], the authors develop methods for analysing thermal images obtained from thermal imaging of a working object. The authors analyze obtained thermal images and suggest using neural networks for image processing and recognition. The proposed fault diagnosis methods have following stages: thermal imaging, preprocessing, feature extraction and classification. These diagnostic and analytical techniques make it possible to monitor an object.

The work [4] proposes an approach to intelligent three-dimensional video surveillance based on object programming tools. In contrast to the conventional 2D video surveillance, the methods of 3D vision provide reliable recognition of parts human body that makes possible a new statement of the problem and efficient practical application methods of people behavior analysis in the video surveillance systems. The logic-based approach intelligent video surveillance allows easy definition of people complex behavior in terms of simpler activities and postures. The goal of this work is to implement advantages of the logic programming approach in area of 3D intelligent video surveillance.

An approach to constructing security systems using a combination of infrared and terahertz images is well-known. It is possible with Actor Prolog [5]. The authors of the work have formed a huge database educational images which is freely accessible. The image data can be used to develop algorithms for automating the process video surveillance and security control. The created data set consists images actors in the visible, infrared and terahertz spectra of electromagnetic radiation. There are potentially dangerous objects hidden under the actors' clothing (there are knives under the men’s clothes in the example shown in Figure 1). The authors of this development see possibility of automating the processing images from the data set under consideration. Still, they do not propose concrete ways of solving this problem.

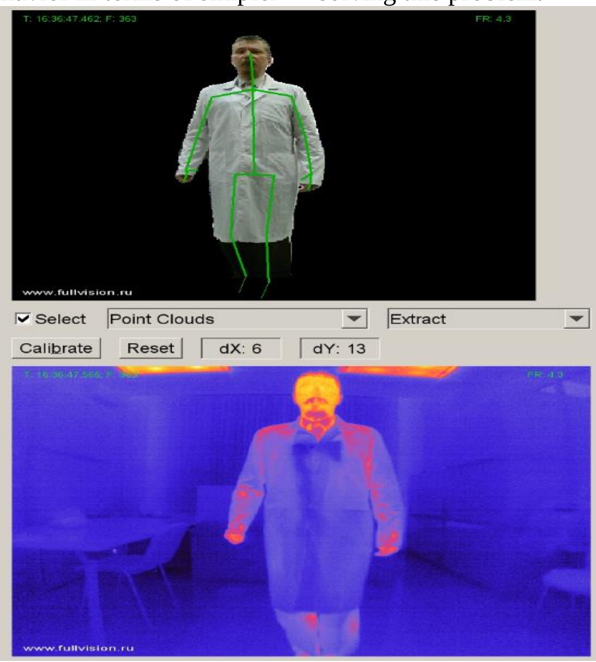

Figure 1. Sample images from the Actor Prolog training dataset

Several approaches to object recognition in infrared images are identified. These approaches can be divided into two classes: recognition of secondary image parameters by the programmer recognition system and automatic recognition of parameter data using a large number image samples, with the knowledge of a class [6]. The most promising is the second class recognition methods. It reduces the learning time of the classifier and reduces influence of subjective errors that operator can make. This is the basic approach for in-depth learning methods, which have recently taken a leading position in the field of pattern recognition.

However, there are a number of problems in constructing neural network classifiers. The most serious issue is completeness training sample during training of the classifier. Moreover, the right choice optimal classification algorithm is important. Such algorithm will make the most rational use of available computing power. We should avoid the effect of re-training classifier. Therefore, the classifier based on the comparison of convolution neural networks is the most promising in order to solve the problems object recognition [7]. At the same time, it is necessary to select empirically the neural network architecture as well as the size of the kernels and other external parameters for each specific problem.

Research results

The aim of the work is to construct an object classifier on infrared images using apparatus of convolutional neural networks (CNN). Its advantages have been described more specifically and in detail in the work [1]. Based on the experience authors of Actor Prolog, a convolutional neural network was developed to handle a set of experimental data. The input image from the results of the network automatically belonged to one of the seven classes type detection of dangerous objects, such as: automatic assault rifle, pistol, grenade, knife, bottle, metal plate or safe object (not dangerous).

Python - programming language - was used to achieve efficient and fast image processing. The advantages of this programming language are the existence of Python libraries. They have a variety of tools for solving AI and data analysis problems. Using this language, tasks of image analysis, text analysis and data visualization can be performed much more easily. The TensorFlow framework was chosen to develop neural network [8]. This library includes many different sets of tools that allow you to write code at the desired level abstraction.

The final experimental image base was divided into three groups: training (4,300 samples), validation (950 samples) and test (950 samples). The training sample is used to train network; the validation sample in the learning process serves to select hyperparameters network; the test sample is a set of images that are used to assess the performance network after graduation. The ReLU activation function was used in the development and is a good approximate. The optimizer adam and accuracy metric were also used.

The main problem that significantly affects construction time classifier is the necessity to select empirically architecture of the neural network. In this work experiments were carried out with the selection of the most efficient network structure. Possibilities for further automation of the operation security system were taken into account. The architectures with one, two and three convex layers with 3x3 pixel kernels were tested in the course of development. Table 1 shows the results of a neural network with different architectures.

Table 1.

Formatting numerical data in the form of a table

Augmentation data	Quantity convolutional layers	Proportion of right answers training sampling, %	Proportion of right answers validation sampling, %	Proportion of right answers test sampling,%
without augmentation	2	85.54	71.83	63.45
with an augmentation	1	97.64	96.47	95.32
	2	98.97	98.32	97.92
	3	98.2	97.4	96.87

As it can be seen from Table 1, a trained two-layered neural network provides up to 97.92% confidence in detection and classification of hazardous objects. However, an augmentation of data was used to improve the results training. It was due to the small number and homogeneous nature training images. The augmentation was provided by a built-in TensorFlow image generator. It randomly modified each educational image: reflected, turned to a certain angle, changed its size, contrast, brightness or changed nothing. This approach has resulted in an artificial increase in the representativeness data set for neural network training. Moreover, it increased the reliability of the classification [9]. The detailed architecture of the optimal network is presented in Figure 2.

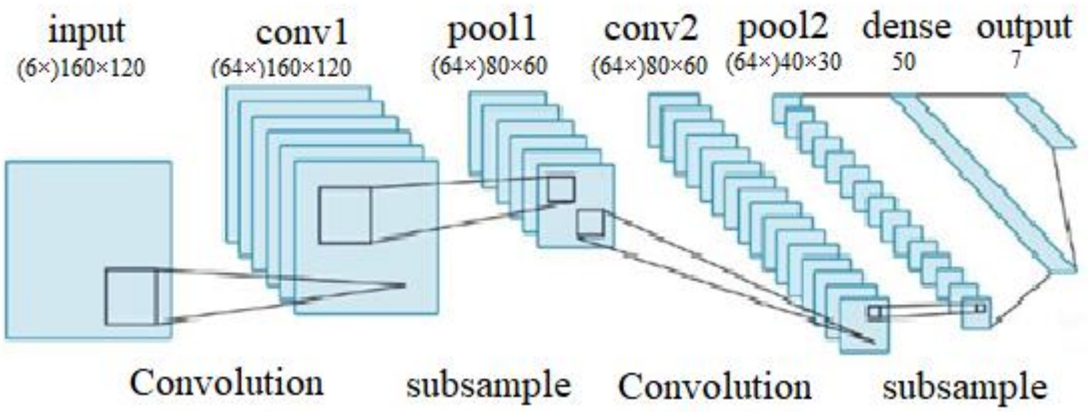

Figure 2. Architecture of a neural network for recognizing objects in infrared images

The neural network training graph is shown in Figure 3.

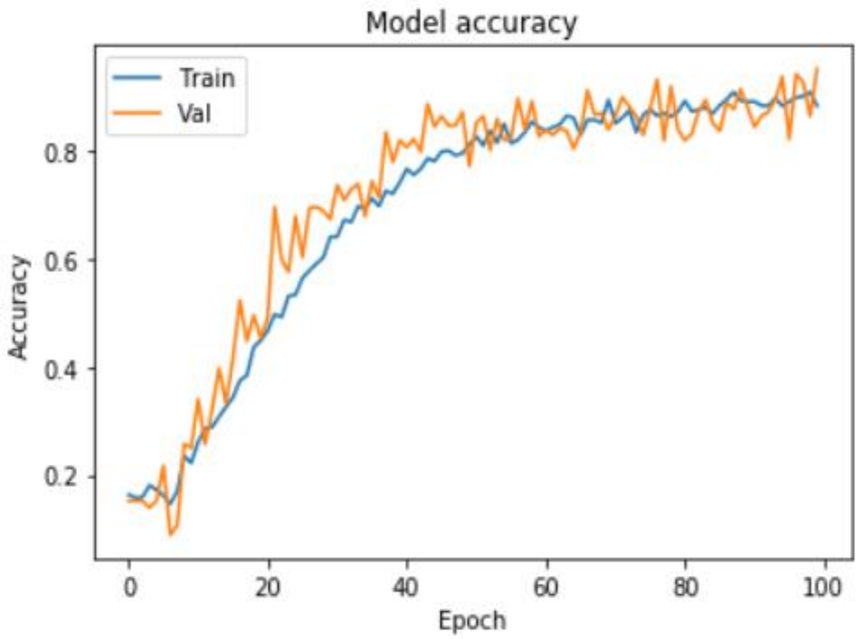

Figure 3. Graph of neural network training

In reality, the main drawback of this system is a serious dependence on the type of human clothing. The presence of oversized or warm clothing (such as a winter jacket) on a person makes it difficult to detect a dangerous item on thermograms.

To address this problem, it is proposed to analyze images not only in the infrared but also in terahertz range. At the same time, the usage of such an approach is currently hampered by both the high cost of security thermal imaging and the difficulty of obtaining terahertz images. Moreover, there is a problem of the limited radius of efficient usage terahertz radiation [10].

Conclusions

This work analyses ways of developing and increasing efficiency of thermal imaging systems in sphere of safety. Together with the improvement technical parameters of thermal engineering equipment, the future direction is the automation of the work security systems. A software was developed for the automated analysis of infrared images based on the big training base of Actor Prolog. Due to a number of advantages, the usage of convolutional neural networks (CNN) is proposed as a method of thermal image automation. In order to improve the development results, it was decided to increase the data artificially (the process of augmentation). This approach made it possible to detect automatically forbidden objects on infrared images and to recognize a class of these objects with a proportion correct answers to 97.92%.

The study suggested ways to improve thermal safety systems. The main task for further development is to expand image database. It is necessary to use not only infrared images, but also terahertz images. This approach will lead to a more efficient neural matching network and reduce false alarm.

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