CONVOLUTION NETWORKS AS A METHOD OF REALISATION OF CUSTOMS RISK-MANAGEMENT

Boris Moroz, Sergii Konovalenko

Abstract: *The paper discusses the theoretical aspects of the mathematical model of convolutional neural networks as a means of classifying the information was not originally a graphic of origin. The description of this approach was illustrated by the information classification of customs control, which involves the transformation of a set of vectors multitype information graphics (pseudographic patterns).*

Keywords: *convolutional neural network, customs control, risk management*

ACM Classification Keywords: *I.5 PATTERN RECOGNITION – I.5.1 Models – Neural nets.*

Introduction

Application of the customs services of the European Union, modern information technology [WCO] allow to automate customs procedures. They use analytics and decision support have improved the efficiency of customs control and clearance. The use of the mechanism of risk management violations of customs legislation is a key part of their automated information processing systems E-customs [ASYCUDA]. Customs risk management allows for the selective control of the appropriate level of detail where it is needed. This approach allows for the acceleration of customs procedures and effective detection of violation of customs regulations.

In the Ukrainian Customs Service is also actively improving customs control at the expense of upgrading the Unified Automated Information System. The concept of e-Customs [Moroz, 2011] involves the active use of customs risk analysis system. Only the use of effective methods and tools for information processing of customs control will reliably identify potentially dangerous situations. This in turn increases the economic security of Ukraine.

Based on the foregoing, it is possible to select a current area of research as the development of methods and tools to identify risks violation of customs laws. Publications on the use of information processing methods of customs control are relatively few and, for the most part, they are conceptual in nature, highlighting the problems and the relevance of the topic. In the work [Moroz, 2011] it was shown that the use of mathematical models of neural networks such as multilayer perceptron can be pretty good to recognize the input data vector $x = [x_1, x_2, \cdots, x_i]^T$ risk {“Low”,“Moderate”,“High”}. In spite of this fully connected network has some drawbacks, which may reduce their effectiveness. This increase in the dimension of the input vector, which leads to an increase in adjustable parameters and the network as a result of more training time. Additionally, you must take into account the need for E-customs in the recognition of graphic data recorded by technical means of customs control (X-ray, video cameras, etc.). That is, information processing system should have such properties as a relatively small number of adjustable parameters, resistance to distortion, taking into account the topology of the input space and scale. These properties are convolutional neural networks. Convolutional neural network performed well in pattern recognition [Lawrence *et al.*, 1997], closed-circuit television [Fan *et al.*, 2010], scanning systems [Prokhorov, 2010], assessing the quality of digital video [Callet *et al.*, 2006].

This gives us the opportunity to consider the possibility of using convolutional neural networks for recognition of the risks violation of customs laws. In this paper we describe the theoretical aspects of this paradigm of Applications for the needs of the customs service. We ask authors to follow some simple guidelines.

Problem definition

The purpose of this paper is a theoretical consideration of the application of the mathematical apparatus of convolutional neural networks for risk analysis breach of customs legislation, in connection with which there is a need in the following tasks:

- To carry out the transformation of the input data vector to the pseudo-image;
- Form a network architecture of the convolution;
- Draw conclusions about the possibility of using this architecture in the customs risk management.

Customs risk management

Risk Management is a methodology that helps managers make best use of their available resources (Fig. 1). Risk assessment is a feature of many industries, such as insurance, banking, and environmental protection. Risk Management include:

- Good management practice;
- Process steps that enable improvement in decision making;
- A logical and systematic approach;
- Identifying opportunities;
- Avoiding or minimizing losses.

Risk assessment is a technique used to predict adverse outcomes and to contain risks within acceptable limits. Customs Risk Management (CRM) is the name given to a logical and systematic method of identifying, analysing, treating and monitoring the risks involved in any activity or process of customs control.

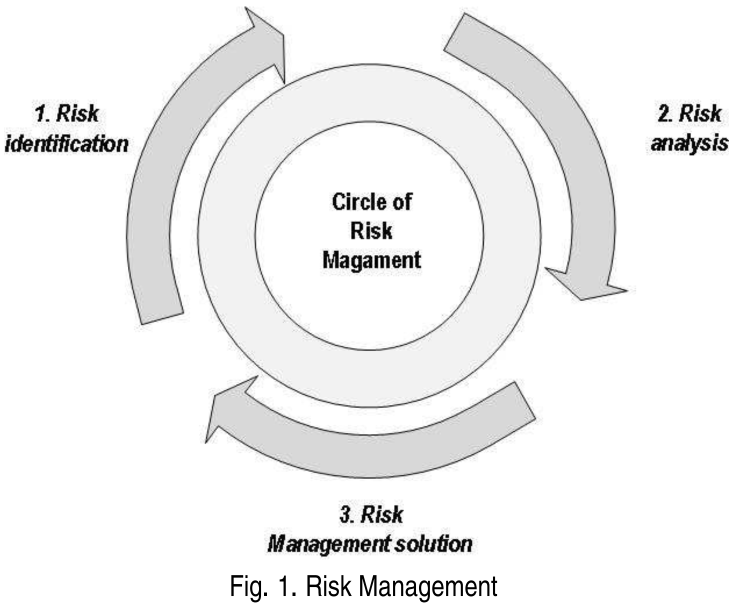

Fig. 1. Risk Management

Risk analysis breach of customs legislation is implemented by means of risk profiles (PR). PR applied at the time of customs control and customs clearance of goods i of vehicles crossing the customs border, and are on target to prevent the Inspector of the risks involved violations of the law at the time of a particular foreign operation. Next, the system gives the inspector recommendations for the use of certain forms of control. The ultimate goal of PR – Customs security software by making management decisions.

Development of PR involves the execution of such actions:

- The definition of an indicator of risk;
- an assessment of selectivity;
- assessment of the importance of PR for filling the state budget;
- determine the effect of negative PR stories, etc.

Using the system of risk analysis methods and tools of effective intellectual processing of information will improve the quality of risk identification of violations of customs rules and smuggling.

Convolutional neural networks and customs risks

Consider the problem of analyzing and identifying risks violation of the customs legislation as a problem of pattern recognition, which in turn is a complex and multidimensional (Fig. 2). It is proposed to use for this purpose the model of information processing based on neural network approach.

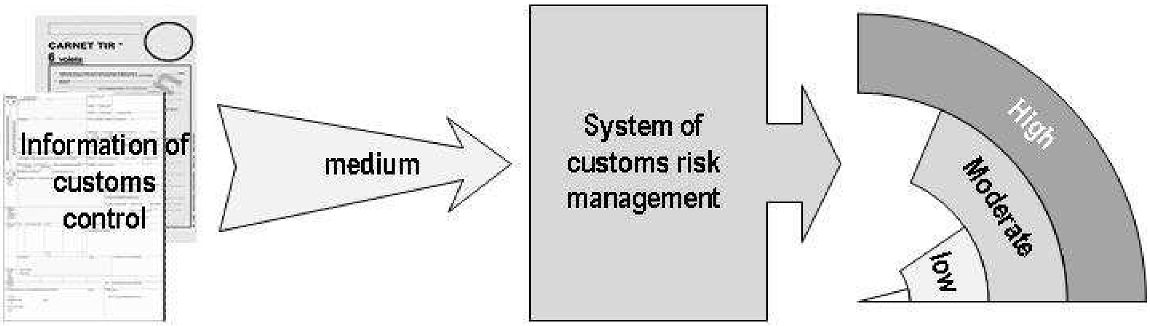

Fig. 2. Customs Risk Managament.

In [Moroz, 2011] were obtained quite good results on the multilayer perceptron Good results were obtained at the expense of low-dimensional input vector and undistorted (adequate) training and testing samples. But in our case it is necessary to ensure effective learning and recognition of the quality of the network by increasing the dimension or change the input vector. This can be achieved by using convolutional neural networks [LeCun and Bengio, 1995]. Convolution neural network is resistant to changes in scale displacements, rotations, changing angles, and other distortions in the input space [Bishop, 2006]. The basis of this paradigm are the following ideas [Haykin, 1998]:

- Invariance to shift with the help of maps of the convolution;
- Reducing the number of free parameters within the overall balance;
- Layers of sub-sample of implementing the local average.

Maps of the convolution implement local perception, i.e. on the input of one neuron is fed is not the whole image (or outputs of the previous layer), but only a portion (area). The use of shared common scale means that for a large number of connections used is very small set of weights (kernel). This kernel is the same for all layers of convolution. With the sub-sample resolution is achieved by reducing the signs of cards, which reduces sensitivity to deformation. Construction of convolutional neural networks lies in the alternation of convolutional layers (C-layers), subsampling layers (S-layers) and the presence of fully connected (F-layers) at the output layer (Fig. 3)

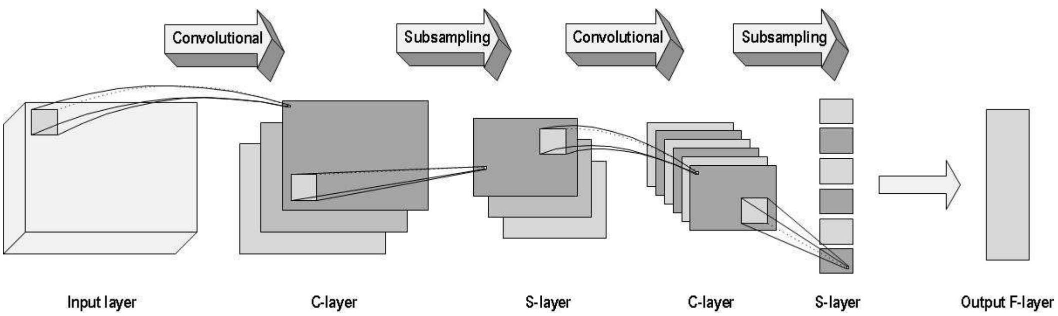

Fig. 3. Convolutional neural network.

The size of the convolution plane is determined in accordance with the following expression:

$$w_c = w_u - K + 1,$$
$$h_c = h_u - H + 1, \quad (1)$$

where w_c,h_c – width and height of the convolution plane, respectively; w_u, h_u – width and height of the plane of the previous layer; $K(H)$ – width (height) of window scanning.

The state of the convolutional neuron is given by the:

$$y^k_{i,j} = b^k + \sum_{s=1}^{K}\sum_{t=1}^{H} w^{k,s,t} x_{((i-1)+s),(j+t)}, \quad (2)$$

where $y^k_{i,j}$ – k-th neuron of the plane of the convolutional layer; b^k – neuronal bias the k-th plane; K – the size of the receptive field of the neuron; $w^{k,s,t}$ – element of the matrix of synaptic coefficients; x – output neurons of the previous layer.

The process of functioning of the neuron subsampling layer is given by the following relation:

$$y^k_{i,j} = b^k + \frac{1}{np} w^k \sum_{s=1}^{n}\sum_{t=1}^{p} x_{((i+s),(j+s)),(i,j))}. \quad (3)$$

For training the neural network described algorithm error backpropagation [LeCun *et al.*, 1998]. As the neuron activation function used the hyperbolic tangent $f(x) = \tanh(x)$. To assess the quality of recognition usually use the most common in the theory of neural networks is a function of mean-square error:

$$E_p = \frac{1}{2}(D^p - O(I^p, W^p))^2, \quad (1)$$

where E_p – this is an error detection for the p-th training pair, D^p – the desired network output, $O(I^p, W^p)$ – output of the network, depending on the p-th input and the weights W, which includes the convolution kernel, bias, weighting coefficients of S-and F-layers.

Thus, we describe the theoretical model of the recognition of risk breach of customs legislation with the help of the convolution of the neural network. At our disposal is the input vector $x = [x_1, x_2, \cdots, x_i]^T$, which has in its structure, heterogeneous data types in need of normalization and coding, so that our network could work with him [Moroz, 2011]. Because the network is working with two-dimensional convolution of images, the input data should lead to precisely this form. Consider a vector of seven elements and transform them into pseudo-dimension image of 7×7 (Fig. 4). Graphic matrix is horizontally symmetrical range of risk levels $(1; 0.7; 0.3; 0; 0.3; 0.7; 1)$, and vertically - the elements of our input vector $(1...7)$. Each value is the input vector is estimated in accordance with the profile and level of risk (the anomaly) from 0 to 1. And then stained with the cell at the intersection of the corresponding element of the vector and its significance level of risk. The symmetry of the level of risk necessary for a better perception of the network image. Examples are presented in Figure 4 forming the input vector to the pseudoimage, the first column corresponds to a high level of risk, the second and third – the moderate and low. Now, the input vector data suitable for processing by the convolution of the neural network. We project a convolution neural network (Fig. 5) The size of the input layer is equal to 7×7 neurons realizing only way to feed the input to the neural network. Next to the input layer is a convolutional layer C, consisting of a folded card features with its kernel (weight vector W). Each neuron in the map signs to get their inputs locally receptive field dimensions of 2×2. For our problem will be enough to select four maps attributes dimension of 6×6 (1). The next layer implements subsample S and the local average of the layer C. Each plane of S is associated with only one plane of the layer C. The size of each plane of the layer $S - 3 \times 3$ neurons, which is twice smaller than the size of the plane of the previous layer. Each plane of S has a single factor and neuronal synaptic bias. In our case, then alternate layers of convolution subsample does not make sense because of the small dimension of the input image. Layers $F1$ and $F2$ contain simple neurons. These layers provide the classification after the extraction of features implemented and a reduction in the dimension of the entrance. In the layer 4 neuron $F1$ is, each neuron is fully connected with each neuron only one layer plane S, it performs weighted summation of its nine entries, adds the offset neuron and passes the result through an activation function. Three of the $F2$ layer neuron is fully connected to all neurons in layer $F1$ and perform the final classification. Each neuron corresponds to one of three levels of risk {“Low”,“Moderate”,“High”}. Thus a network, where a total of 143 adjustable parameters $(C - 80, C - 8, F1 - 40, F2 - 15)$, which is several times smaller than similar fully connected networks. This effect is achieved through the principle of sharing of synaptic coefficients. This in turn will only improve the quality of recognition and stability of the network compared to the multilayer perceptron.

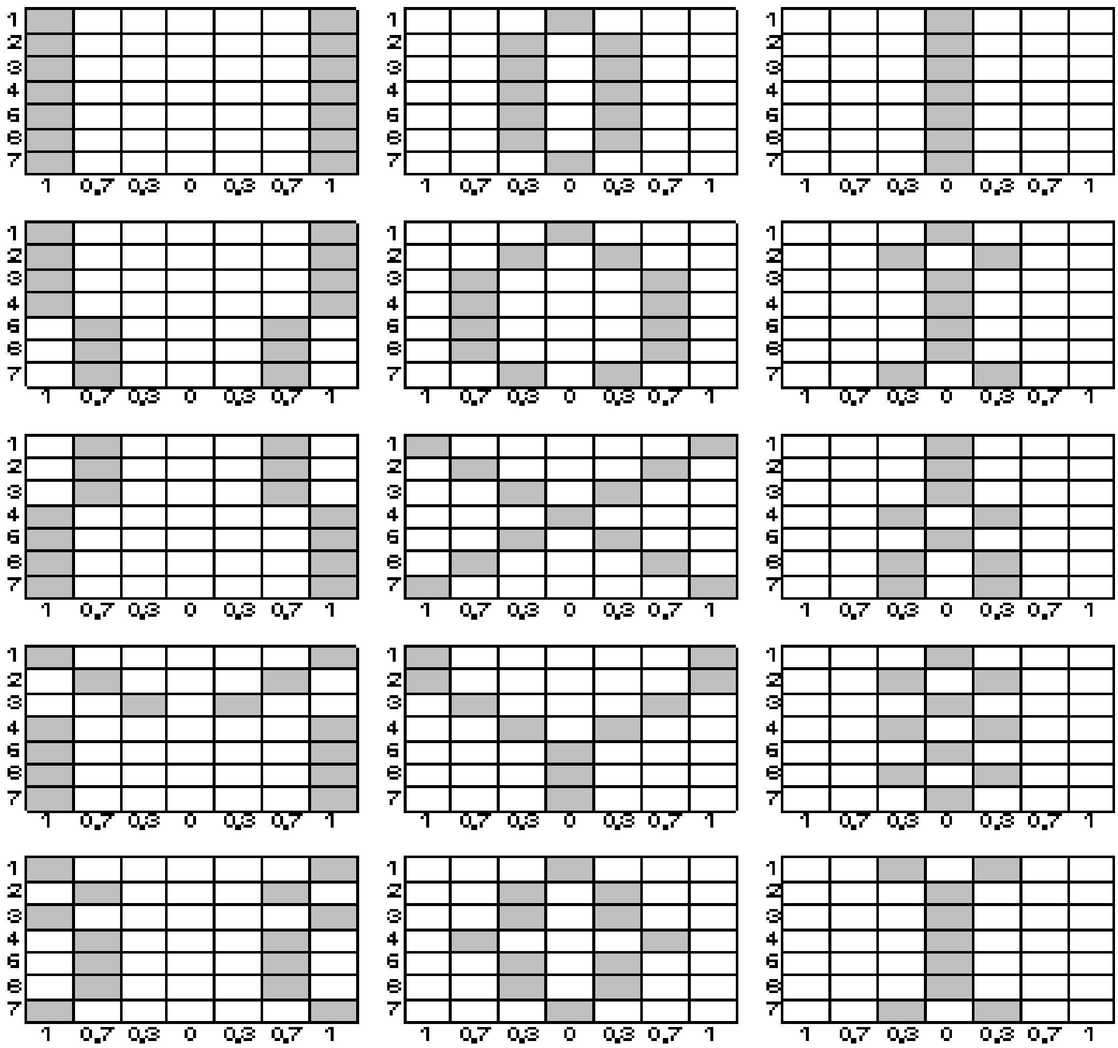

Fig. 4. Pseudographic patterns: {“High”,“Moderate”,“Low”}.

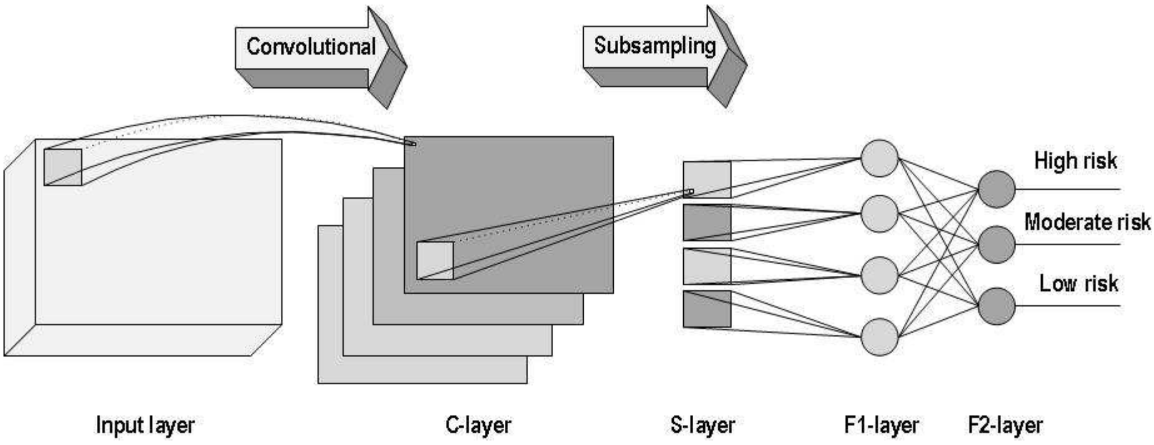

Fig. 5. Convolution model of the recognition of risks.

Conclusion

As a result of this work was theoretically developed models to identify risks breach of customs legislation, based on the convolution of the neural network. The paper shows the mechanism of transformation was not originally a graphic information in a graphical origin of the plane. On the basis of studying and research papers and publications can be argued that the proposed model has not bad processing input recognition quality images than the fully connected network. In addition, the convolution of the neural network model has fewer adjustable parameters than the earlier model by [Moroz, 2011]. The use of convolutional neural networks as a method of classification of information of customs control may be a useful tool in the management of customs risk management. Further research should be devoted to the study of the practical implementation of convolutional neural network models for classification of pseudo-information, and enable them to recognize the numbers of transport crossing the border.

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Bibliography

[WCO] World Customs Organization. WCO course on risk assessment, profiling and targeting [Online]. Available: http://www.wcoomd.org

[ASYCUDA] Automated SYstem for CUstoms DAta (ASYCUDA). Risk Management [Online]. Available: http://www.asycuda.org

[Moroz, 2011] B. Moroz, S. Konovalenko, "Aplication of neural networks within of the concept E-customs," (in Russian), in *Information Science and Computing*, book 22, *Applicable Information Models*, K. Markov, V. Velychko, Ed., 1st ed. Sofia, Bulgaria: ITHEA, 2011, pp. 104-110.

[Lawrence *et al.*, 1997] S. Lawrence *et al.*, "Face recognition: a convolutional neural-network approach," *IEEE Trans. Neural Netw.*, vol. 8, pp. 98-113, Jan. 1997.

[Fan *et al.*, 2010] Jialue Fan *et al.*, "Human Tracking Using Convolutional Neural Networks Neural Networks," *IEEE Trans. Neural Netw.*, vol. 21, pp. 1610-1623, Oct. 2010.

[Prokhorov, 2010] D. Prokhorov, “A Convolutional Learning System for Object Classification in 3-D Lidar Data,” *IEEE Trans. Neural Netw.*, vol. 21, pp. 858-863, Oct. 2010.

[Bishop, 2006] C. M. Bishop, *Pattern Recognition and Machine Learning* (Information Science and Statistics), 1st ed. New York: Springer-Verlag, 2006.

[Haykin, 1998] S. Haykin, *Neural Networks: A Comprehensive Foundation*, 2nd ed., Prentice Hall, 1998.

[Callet *et al.*, 2006] P. Le Callet *et al.*, “A Convolutional Neural Network Approach for Objective Video Quality Assessment,” *IEEE Trans. Neural Netw.*, vol. 17, pp. 1316-1327, Sept. 2006.

[LeCun and Bengio, 1995] Y. LeCun and Y. Bengio,“Convolutional Networks for Images, Speech, and Time-Series,” in *The Handbook of Brain Theory and Neural Networks*, MIT Press, 1995.

[LeCun *et al.*, 1998] Y. LeCun *et al.*, “Efficient BackProp”, in *Neural Networks: Tricks of the trade*, G. Orr and K. Muller, Eds., Springer, 1998.

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