NEURAL NETWORK IN OBJECT CLASSIFICATION USING MATLAB

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Abstract

Presented paper deals with images of nanotubes that provide a new way of a surface bioactivation of dental titanium implants. The evaluation of selected material parameters forms an important part of material quality assessment. The first step is an image segmentation and object detection. In the following step, object classification is a crucial point in separation object. Various methods could be used for classification implementation, neural network provides one of them. In the paper, an object classification method based on competitive neural network use is presented. In the first part, basic principles of neural network are described. In the next part, selected classification method is tested on a set of images.

1 Introduction

Nanostructure materials belong to important parts of new technologies, they find use in industrial applications, medicine, information technologies and many others. Nowadays, a development of new materials and processes based on nanostructures is a very topical issue [1]. At the same time, a necessity of a solution of problems connected with a system for validation and verification of achieved results appears. Nanomaterial properties assessment constitutes one of the essential issues in the process of material development. The evaluation of nanostructure quantities could be based on a processing of microscopic images of the nanomaterial that could be obtained with electron microscope.

Presented paper deals with images of nanotubes that provide a new way of a surface bioactivation of dental titanium implants [3]. The evaluation of selected material parameters, such as nanotube diameter, tube wall thickness and residual space determination, forms an important part of material quality assessment. The first step in an image analysis is its segmentation and object detection [4, 5]. In the following step, object classification is an essential and crucial point in separation object into two groups: tubes, and non-tube objects. Various methods could be used for classification implementation, neural network provides one of them [6, 7, 2, 8]. There are several possibilities of neural network design. For object classification, competitive neural networks are used in the paper. The algorithm is implemented in MATLAB system using its Image Processing and Neural Network Toolboxes [9].

2 Competitive Neural Networks

Neural networks perform a variety tasks, such as prediction and function approximation, pattern classification, they are also capable of complex data and signal classification task and many other using.

Kohonen competitive neural network (CNN) provides one method of classification of image segments into a given number of classes using segments features. This network belongs to feed-forward network types. It uses an unsupervised (competitive) learning algorithm. Unsupervised learning involves a network learning to response correctly on its own without involvement of

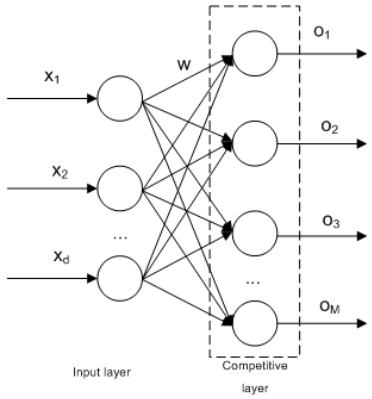

Figure 1: Competitive neural network architecture [11]

an external agent (external agent is used in supervised learning). In next step, by process of self-organization network configures outputs into spatial maps. The designed network is trained on data series and after that it analysis a given input in a form of a binary matrix. The accuracy of developed method depends on training set quality, number of training cycles and other factors [12, 10].

The network contains two layers of nodes - an input layer and a mapping (output) layer, see Fig. 1. Each image is represented by its features in separate columns of the pattern (input) matrix P. The weight matrix W is the connection matrix for the input layer to the output layer. The first step in simple network implementation is determination of number of output neurons. It is better to have a larger number of outputs than is the possible number of clusters because redundant outputs can be eliminated. After the number of inputs and output is set, weights must be initialized. They can be a set of small random values, or they can be randomly choose from the inputs and used as weights. The simplest way to describe competition is by using the concept of distance between and input and a weight vector. The network input can be describe as $||x||||w||cos\theta$ where θ is the angle between the input vector $\mathbf{x}$ and a weight vector $\mathbf{w}$. Then the Euclidean distance d_j between them is defined as

$$d_j = \mathbf{x} - \mathbf{w_j} = \sqrt{\sum(\mathbf{x}_i - \mathbf{w}_{ij})^2} \tag{1}$$

Also other methods such as correlation, direct cosines, and city block distance could be used to input-weight distance description.

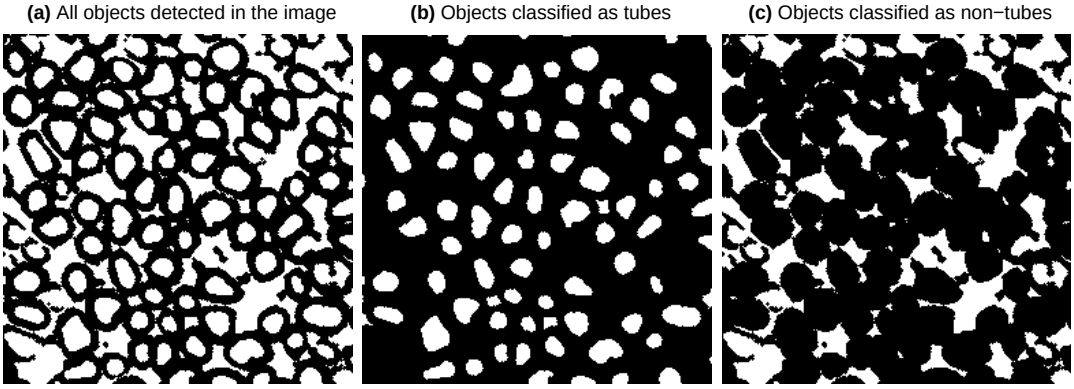

Figure 2: Example of object classification in a selected cut of an original image: (a) Object detection, (b) The first object group - tubes, (c) The second object group - nontubes.

3 Application of CNN on Nanostructure Images

The first step in nanostructure image analysis is its segmentation using basic methods of an image processing. In this step, number of objects is detected in the image, see Fig. 2(a). In the next step, accurate object classification is an essential point. In this paper, object classification based on using CNN is presented. Based on principles of CNN implementation, image features must be chosen. The classification could be based on selected object properties such as its convexity, size, shape and others. Objects are separated into defined number of classes, in this case into two groups: tubes, and non-tubes. In this primary study, classification is based on object convexity. Selected results are presented on Fig. 2b, 2c. For easier recognition, the same objects are presented placed on original image, see Fig. 3a, 3b. The algorithm is implemented in MATLAB system using its Image Processing and Neural Network Toolboxes [9].

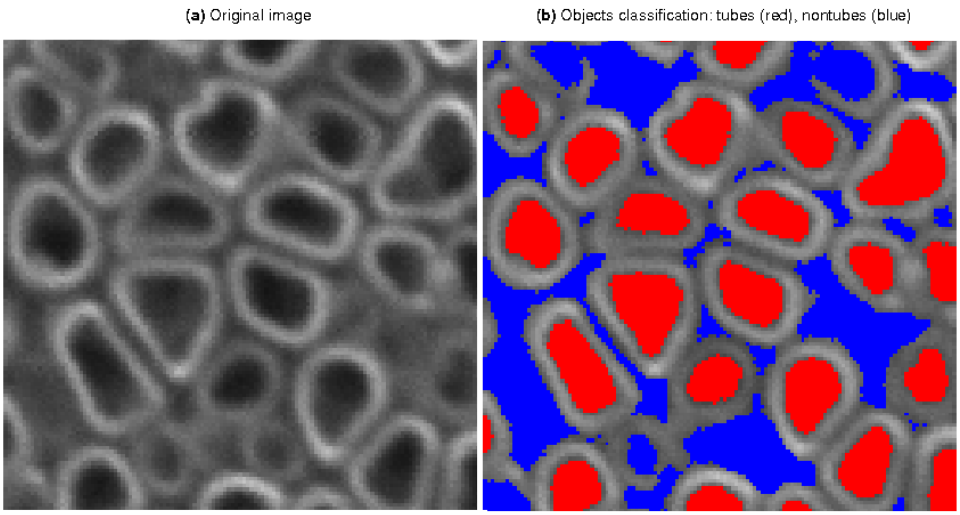

Figure 3: Example of object classification in a selected cut of an original image: (a) Original image, (b) Tubes (red) and nontubes (blue) objects placed on original image.

4 Conclusion

In this paper, primary study of object classification by using competitive neural networks is presented. Based on current results, this method seems to be a suitable tool for object classification in nanostructure images. In the next research step, varied image features will be tested as network inputs. Comparison of these results should help to choose the most useful image feature for this kind of classification.

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