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APPLICATION OF NEURAL NETWORK FOR CONSTRUCTIONAL FORMS CLASSIFICATION

Summary. The paper presents an application of Kohonen net for constructional forms classification. Rotationally symmetric shapes were used as classification objects. Two methods of description the constructional form were analyzed. The first one based on application of classification codes. In the second one the shape data are converted into a 16x16 data image. Four different part families were classified, from which every consisted of five elements. This elements were described using data image method. Results prove that neural network can classify elements according to their constructional forms and shows possibilities of the elements description as data image.

1. Introduction

Classification is widely applied in the area of design and manufacturing. The application of the classification let to decrease the labor demand of elaboration the new conceptions by enabling the utilization of ready solutions or partial ones. Secondly, the classification and subsequent optimization of variety of construction let to decrease the construction set and to create series of types and even to build module systems [1]. Module systems enable to extend the series of manufactured products and due to this to decrease their costs.

The classification problem has also acquired the significance in manufacturing prosesses after implementation of group technology methods. The basis for applying group technology is coding and classification of parts. Grouping similar parts, from manufacturing point of view, it is possible to save time and effort. Additionally, it causes the increase of cell duty, optimization of number of cells and number of machine tools in each cell.

According to the definition, classification is the process of categorizing parts into groups on the basis of the proper set of rules and principles. Lot of classification methods has been elaborated. Coding and processing of coded information about classified elements are the main principles of functioning of this methods. Different methods of classification use different types of algorithms. The most often used algorithms are among others: hierarchical, iterative and fuzzy ones [3]. Quality of the classification process depends on the precision of information about classified elements. Any inaccuracy can cause great differences in final results.

Nowadays, because of the development of computer science, the need for computer integration of whole creation process has appeared. The classification problem is the part of that process. Computer aided classification is closely connected with CAD. In CAD systems, which are the part of the integrated manufacturing system, one have to deal with the computer record of information about elements. This caused the occurence of the problem connected with data transformation from graphic system to classification one. This paper presents a possibility of such transformation. A neural network were used as a classifier. More precisely speaking the Kohonen network. One of the important feature of neural networks is the fact that they do not need precise information to process correctly. Besides, they can adapt their work algorithms themselves during the training phase.

2. The Kohonen Algorithm

The simplest way to describe the Kohonen network is to present it as a vector of input nodes connected to a [nxn] matrix of output nodes. Data, as a vector, are presented sequentially (one data image by one). Next the output value from each node is computed. Then the node with the maximum value is chosen from the matrix of output nodes. In the second step the updating of connection weights is performed. The Kohonen algorithm uses the "Mexican Hat" function to realize the lateral influences. The lateral connections do not exist but the weights updating rule has been elaborated to take the neighbourhood relations into account. This is why the neighbour nodes can respond to similar input signals (the image of classified elements). Due to it, it is possible to determine the level of similarity using the topological measure (the closer two nodes will be placed on the output matrix the more similar will be classified elements corresponding to those nodes). The particular algorithms of Kohonen network are presented in [2, 5].

3. Preparation of Input Patterns

One of the most difficult problems connected with application of neural networks for classification of constructional forms is the description method of classified elements. Till now the fixed classification code has been established to describe elements. The position in this code responds to determine feature of the classified element. It could be a suitably orderly set of dimensions of investigated elements, assuming the fixed constructional form. In examined case the rotationally symmetric parts were the classified elements. This parts differ each other with their shape and dimensions. So they are elements of different constructions. Figure 1 presents four representatives of investigated families.

The choice of rotationally symmetric parts was caused for aspiration to simplify the description method and at the same time for wish to test the results on not too complicated set of elements. This elements can be described appling the classification code. The codes for each family will be different so there is no way to compare codes for those families. This codes consist of the set of ten or nine numbers according to the equation (1). But the same position

$$K = W1.W2.W3.W4.W5.W6.W7.W8.W9.W10 \tag{1}$$

in each code will be respond to other feature of the classified element. Figure 1 shows the representatives of investigated families.

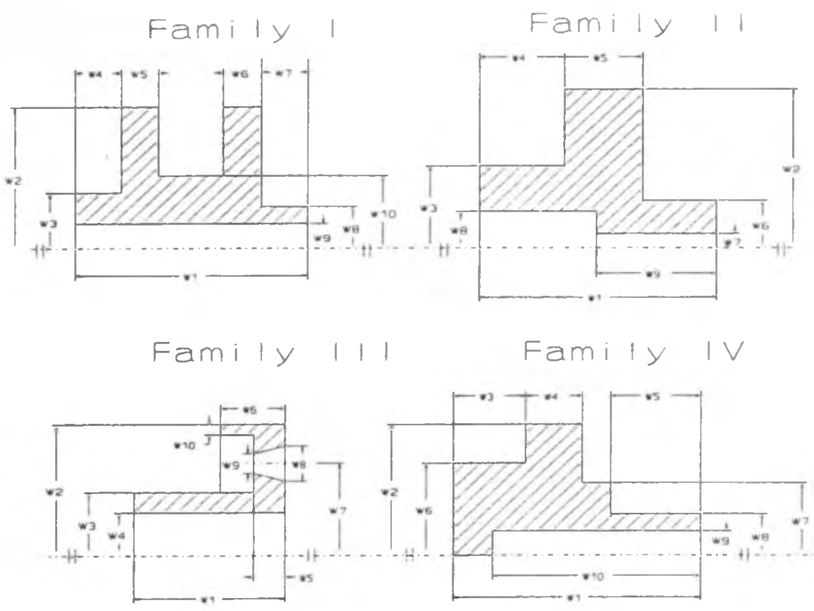

Figure 1. Representatives of classified families

According to equation (1) one can describe every representative as follows:

Table 1.

Family I	200.150.60.50.20.20.50.50.40.80
Family II	200.150.80.50.30.60.20.30.50
Family III	200.150.80.60.20.40.120.10.6.5
Family IV	200.150.50.30.100.100.80.60.40.150

When the Kohonen net is applied the above description can be replaced with the data image of given elements. It is another way of description which bases on transformation of graphic image into an alphanumeric one. It describes the shape and attributes of elements. The method of creation of such image data bases on work of K. Osakada and G. Yang [4]. The table 2 presents the method of converting the shape of primitives into alphanumeric symbols.

Table 2.

Primitive geometries	cylinder	trunc. cone	cone	barrel	semi-sphere	trunc. semi-sphere	none
inner	5	4	3	-	10	8	0
outer	11	9	6	2	1	7	

Using the above symbols one can obtain the description of given element in the form of data image as it is shown on the fig.2. This method let to avoid to use the classification codes which limit the group of investigated elements. On the other hand it enables to compare elements of different families what was not possible using the traditional method.

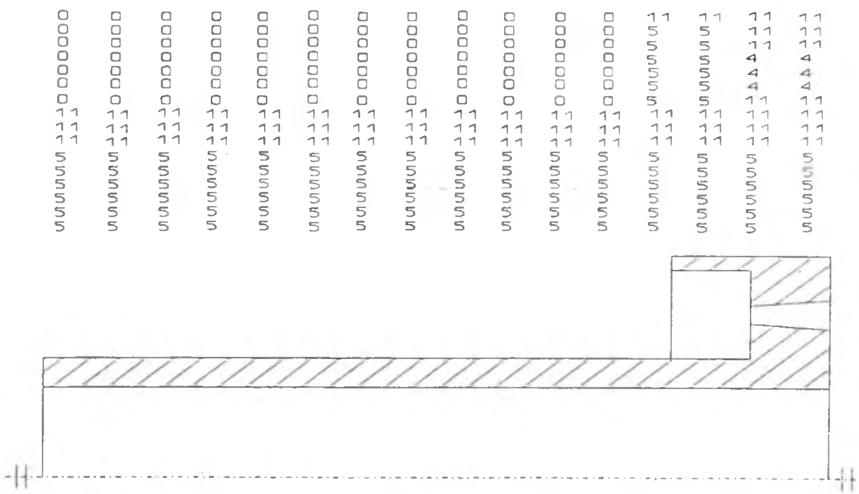

Figure 2. Example of conversion of the data shape into the data image

4. The Process of Investigation

The Kohonen network, shown on the Fig.3 was chosen for experiment. This net consists of the vector of input nodes (256 for image matrix 16x16) and matrix of output nodes (8x8) which has 64 nodes. The net classified the patterns in 3000 iterations. The experiments for elements which belong to the first and second families have been carried out. First, patterns of elements from the first family were presented an then patterns of elements from the second one. Next, the set of ten elements from both families were presented. The last step was verification of the work of such neural classifier in the case of four families each of other constructional form.

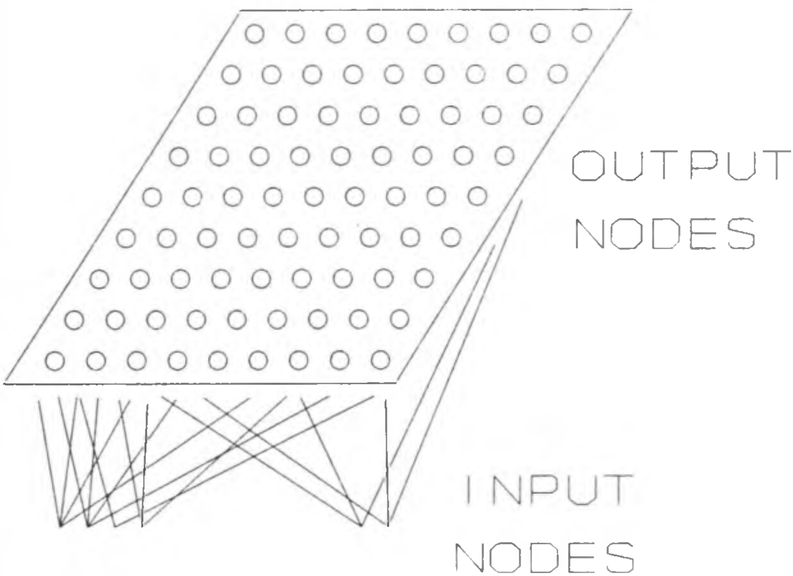

Figure 3. Scheme of the Kohonen net

The algorithm of Kohonen net takes particular patterns sequentially. As it was mentioned above each pattern consists of 256 numbers which describe the shape of the element. The training rate is equal to 0.25 and changes according to equation (2).

$$\eta = \eta_0 \left(1 - \frac{t}{T}\right) \quad (2)$$

where: T- assumed number of iterations. The learning method base on competitive learning algorithm.

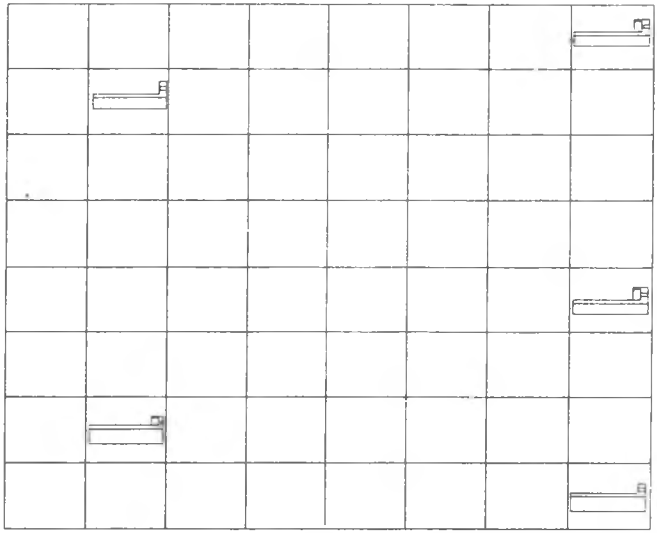

Figure 4. Result of the classification within the first family

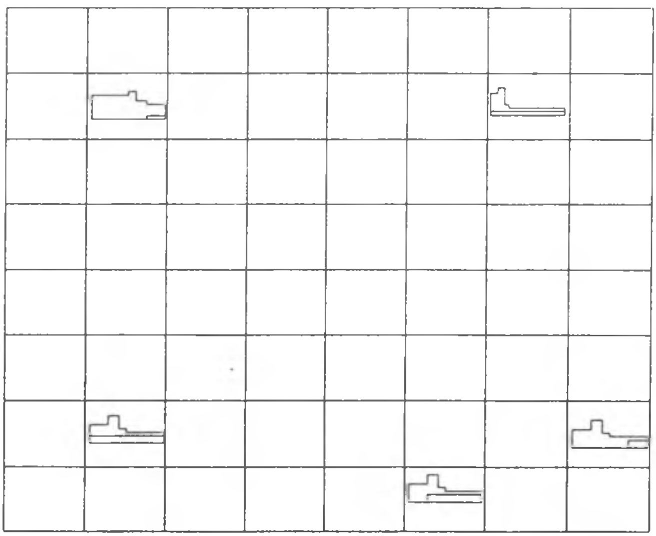

Figure 5. Result of the classification within the second family

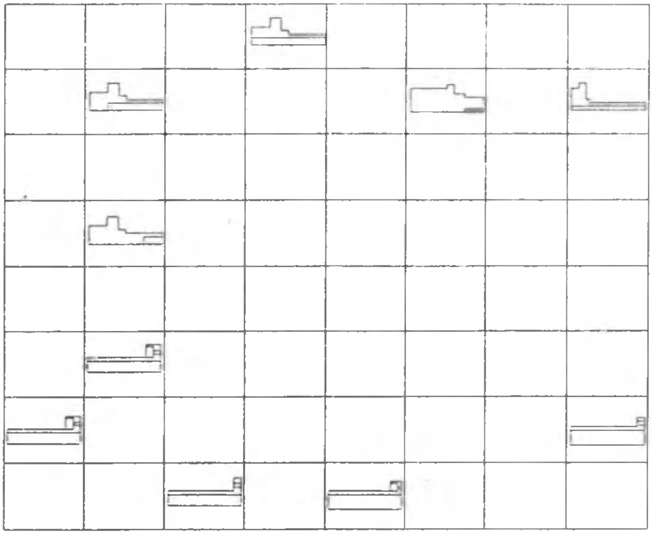

Figure 6. Result of the classification of objects from the first and second families

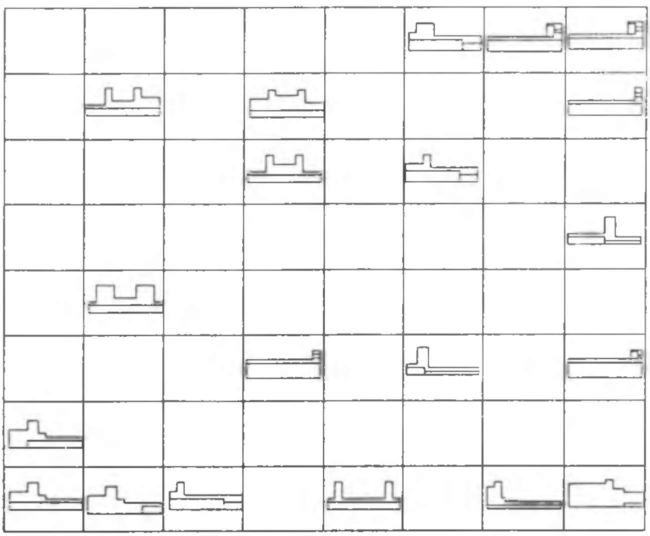

Figure 7. Result of classification of objects from four families

5. Results

Experiments results are presented on the Figures 4 - 7. Each figure shows the output matrix and elements corresponding to the particular nodes. The similarity measure is the distance between nodes. Comparing the diagrams it is possible to state that results could be applied to classify the objects. Moreover neural network allows to compare the different families of elements what was not possible using fixed classification codes. On the Fig.6 the example of classification elements from two families is shown. The last diagram presents an example of classification of elements which belong to four different constructional forms. Results of classification agree with the partition on construction families. Since the classification system deals with a great number of data, it is expected that the efficiency of the system will be improved significantly by integrating other learning algorithms, nodes functions, also fuzzy sets in the future to the classification system.

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