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Analysis of Labour Resources of Enterprises by Self-Organizing Maps of Features

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Abstract: In the article possibility of application of maps of Kohonen is examined for the analysis of professional development of machine-operators of machine-building enterprises. It will allow to perfect the traditional going near the estimation of qualification of workers, and also to promote the motivational effect of evaluation procedures.

Keywords: Neuron, Professional Development, Cluster, Neural Network, Self-Organizing Maps

1. Introduction

The presence of a highly skilled workforce is one of the most important factors in improving productivity and providing production of competitive products [1]. This leads increasing of requirements to general education and vocational level of training machine worker. Machine operator must know perfectly design of maintained equipment, all its components and mechanisms (mechanical, electrical, hydraulic, electronic); be able to design processing technology of details, to choose cutting modes; adjust the control programs; to carry out professionally adjustment of the machine in the shortest possible time[2]. In fact, the work of machine operator becomes the same as work of technicians and engineers and therefore machine worker must constantly increase their professional level. Thus, improving the system of professional development of machine operators is one of the priorities of personnel management of the enterprise [3].

An important step is the introduction of an objective evaluation system, which will form the machine operators to have the motivation to raise their level of professionalism. Many Ukrainian and foreign scientists noted the imperfection of evaluation procedures and the lack of scientific validity of many of the recommendations, despite numerous studies in the field of personnel evaluation [4].

2. Problem Formulation

The aim is to study the feasibility of using neural networks, of Kohonen maps to enhance the accuracy, objectivity and scientific validity of assessment procedures. Also there is an approach to assessing the level of individual professional development of machine operators as to the problem of recognition of professional images, which are integrated in the set of characteristics that are formed in the process of training and employment and which characterize the amount of savings and the practical use of knowledge and determine the level of professional development of machine operator.

3. Main Results

The number of neurons in Kohonen maps should be sufficient to master the training sets with satisfactory accuracy. Euclidean distance of each data point to the nearest map's node is used in practice to assess the accuracy of approximation of the training set examples. Usually the value of 0.05 is adopted as sufficient. You can take the number of estimated machine operators as an initial number of neurons card. A further increase in the number of neurons increases the accuracy of the classification. Distribution of neurons to sides of the card should be such that the card was close to square. This form of map allows you to set to neurons possible the number of neurons neighbors.

The Kohonen map was built to study the proposed machine operators. The map consists of 240 neurons. Gauss function was used as a function of the neighborhood at training. The map was divided into four clusters – levels of

professional development (denoted by Roman numerals). The results of clusterization is shown in Fig. 1 [4,5].

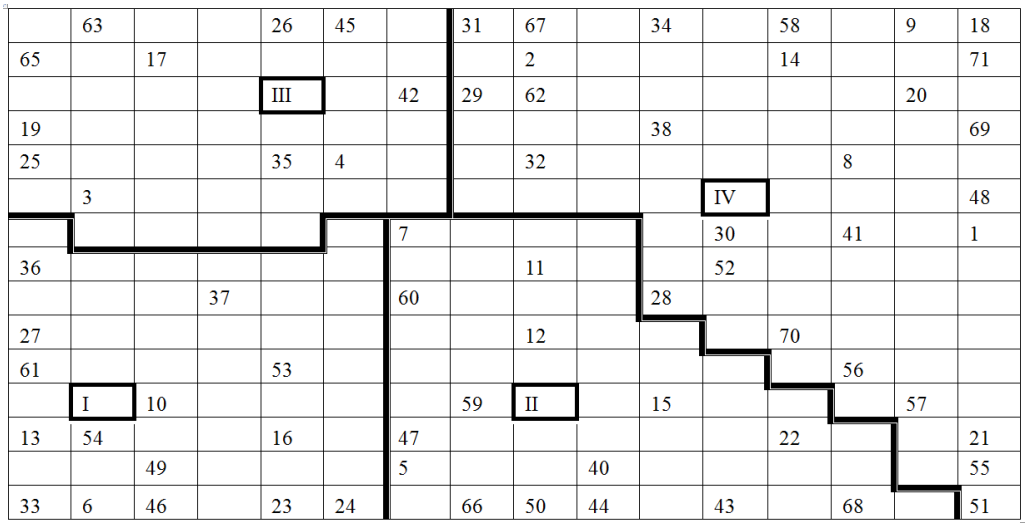

Fig. 1. *Splitting of Kohonen map into four clusters.*

Distribution of labels allows to study the distribution of machine operators on neurons of map. Neurons which are excited when filing characteristics of machine operators from Table.1, are marked in fig. 2 [6, 7].

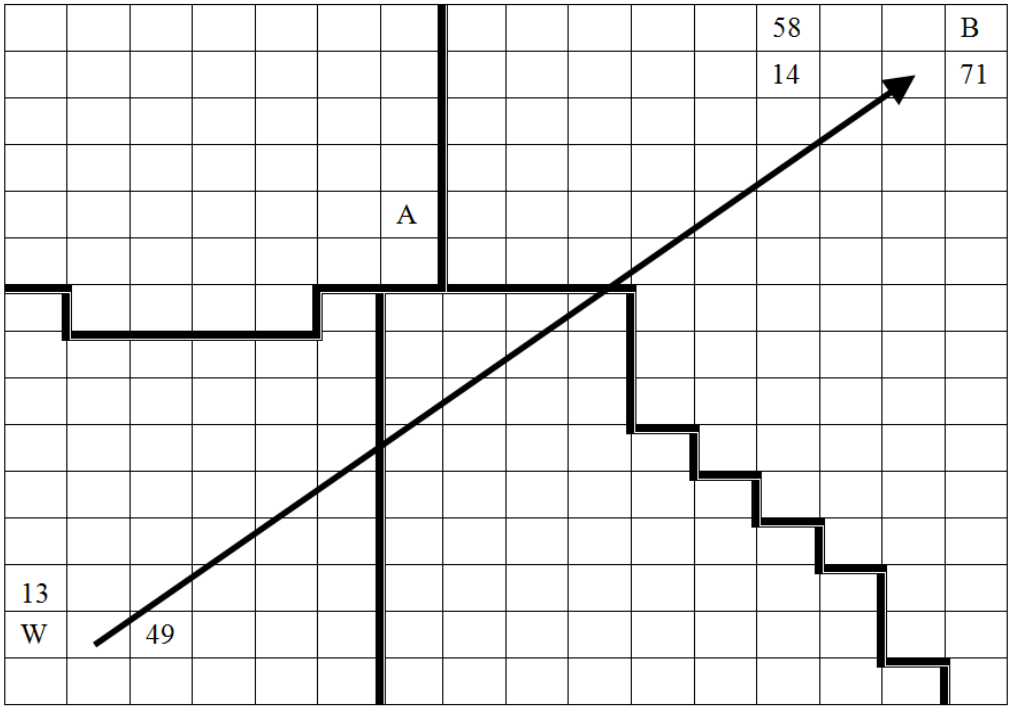

Fig. 2. *The positions of the test on the Kohonen map.*

Table 1. *Marks for Kohonen network testing.*

Mark	Evaluation criteria										
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
The best	6	5	1	3	2	45	2	4,5	0	2520	1774
The worst	1	2	0	0	0	2	0	2,1	2	305	275
Average	1,93	3,23	0,25	0,38	0,38	20,04	0,46	3,10	0,18	1242	1183

Neurons, which are located in the top right corner of the map in the fourth cluster, gets excited at the input of map machine operators with high levels as can be seen from fig. 2, and, conversely, the neurons that respond to «weak» machine

operators are concentrated in the lower left corner in the first cluster. Machine operator with the average index is posted in the center of the map in the third cluster (as in the one-dimensional Kohonen network).

Thus, the level of professional development of machine operators increases as you move through the map on the diagonal from lower left to upper right, as well as from the bottom up and from left to right.

The most important way to analyze the results of the Kohonen maps is a «coloration» of its values of individual input characters and subsequent study of colorings.

There is an example of such coloration by marking of map's neurons by discharges of machine operators, on which these neurons are excited. An example is given in fig. 3

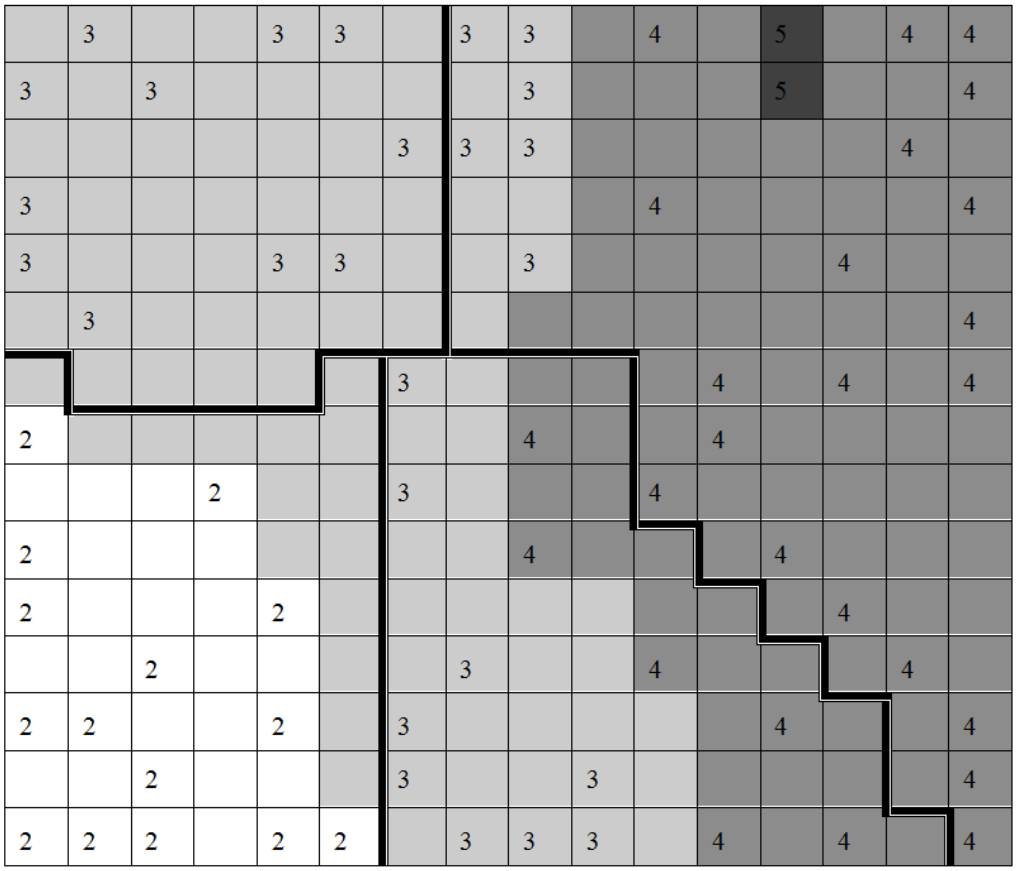

Fig. 3. *Coloration of Kohonen maps by discharges of machine operators.*

Location of machine operators on the map allows you to distinguish clearly between the four regions corresponding to categories of machine operators, it can be seen from the figure. Category of machine operators increases diagonally of map from the lower left corner to the upper right, that is, has the same direction as the level of professional development (see. Fig. 2).

When we put previously obtained structure of cluster on bitwise partition, you can see that in the first cluster machine operators are focused on the second category. Field of the third rank is divided into two clusters (second and third). The third cluster exclusively consists of machine operators of third rank.

Splitting the third category into two levels specifies the initial assessment of qualification machine operators, making it more detailed. The fourth cluster is composed mainly of machine operators fourth and fifth level, but also includes a small amount of a third category of machine operators. Thus, the partition of map on the discharges of machine operators and their professional development shows a similar ranking of machine operators in the evaluation of their professionalism.

At the same time, cluster boundaries and the boundaries of category do not match. It is caused by the fact that when clusterization, in addition to category of machine operators, consider additional evaluation criteria. So, we can conclude that the proposed method of assessing the level of professional development of machine operators confirms the validity of existing that machine operators have, but it makes its own specifications in assessment their professionalism.

If it is necessary you can use the resulting map together with the evaluation system of qualification, which is used in the enterprise and based on the categories of machine operators [8,9]. For this you can take as the basis of discharge system and carry out through a network of Kohonen the partition machine operators to subclass within existing categories. The machine operators of each of the categories were divided with using three-neural dimensional Kohonen network on three subclasses. The decomposition was carried out for the second, third and fourth categories.

Machine operators fifth level is not broken due to their small number.

The results of the partition categories applied to existing map of Kohonen (fig. 4).

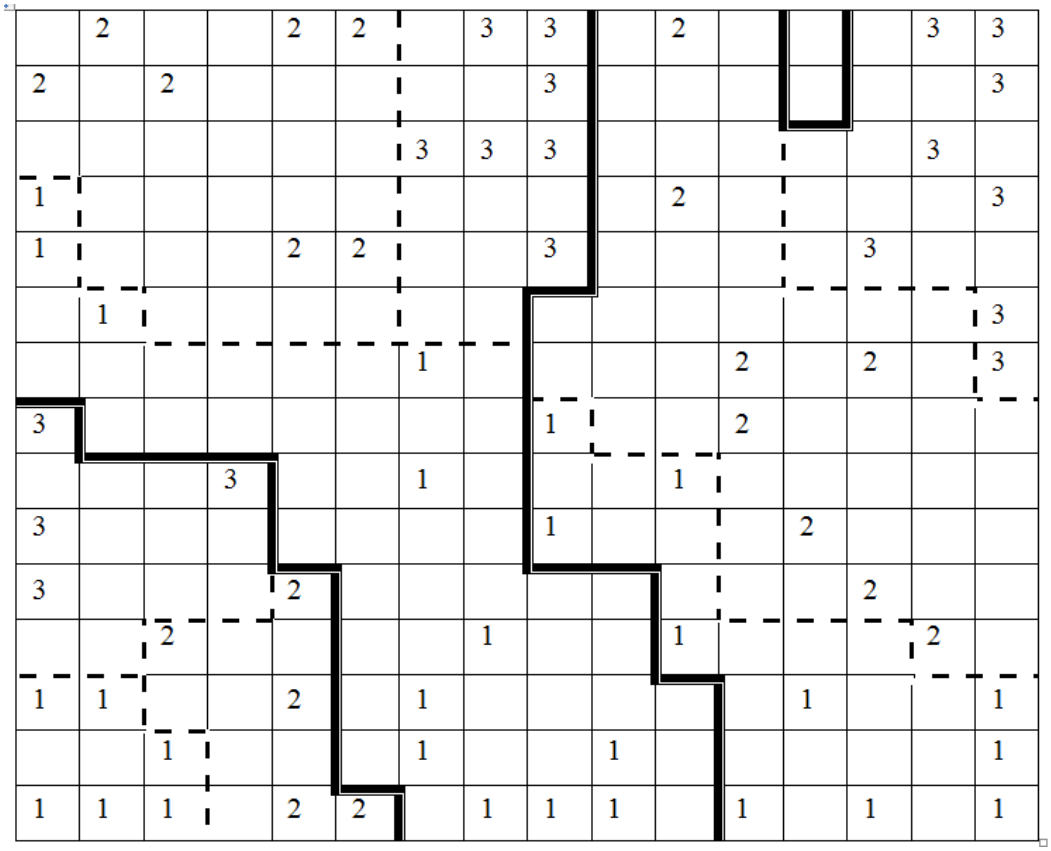

Fig. 4. *The results of the categories partition on subclasses.*

Borders of categories are marked on the map thick black line. Boundaries of subclasses are marked by the dashed line.

Breaking of categories on subclasses contains the main features of machine operators partition into clusters.

Location of subclasses from the third category close in shape to the partition this area of map on the second and third cluster: second and third subclass constitute the third cluster, and the first subclass – the second. And the third subclass demonstrates the attraction of group machine operators of third category to the fourth.

The second category is divided into the first subclass which is contained in machine operators with the lowest rates, a second subclass, which tends to the second cluster (or the first subclass of the third level) and a third subclass contains machine operators, which gravitate to the third cluster.

Breaking of the fourth subclass corresponds to the location of machine operators in the fourth cluster.

It was observed when analyzing the characteristics of the clusters, that the level of individual professional development of machine operators increases as you move from bottom to top of the map. Therefore, the first subclass of four category comprises machine operators with the lowest rates among the machine operators of the fourth category. Then the third subclass comprises the most "powerful" machine operators.

You can check the ratio of subclass in the ranks by setting markers on the map (Table. 2) [10].

Table 2. *Marks for identification subclasses.*

Category	Mark's name	Characteristic of mark	Neuron-winner
2	B	the maximal characteristics	213
	A	the averaged characteristics	178
	W	The minimum characteristics	209
	13	The worst in vector's length	193
	24	The best in vector's length	230
	36	The best by the number of maximums	113
3	2	The best by the number of maximums	25
	5	The worst by the number of minimums	215
	17	The best in vector's length	19
4	B	the maximal characteristics	16
	A	the averaged characteristics	158
	W	The minimum characteristics	220
	43	The worst in vector's length	236
	48	The best in vector's length	96
	71	The best by the number of maximums	32

There are tags that correspond to the real machine operators of department (name of marks – the number of machine operators) and to hypothetical machine operator.

The placement of tags inside the categories is shown in fig.

5. You can see from the figure that the distribution of tags on the map corresponds to the assumption of the relationship between subclass.

At the same time machine operators 24 and 36 deserve attention, their location indicates a high potential of their move respectively to the second and third cluster.

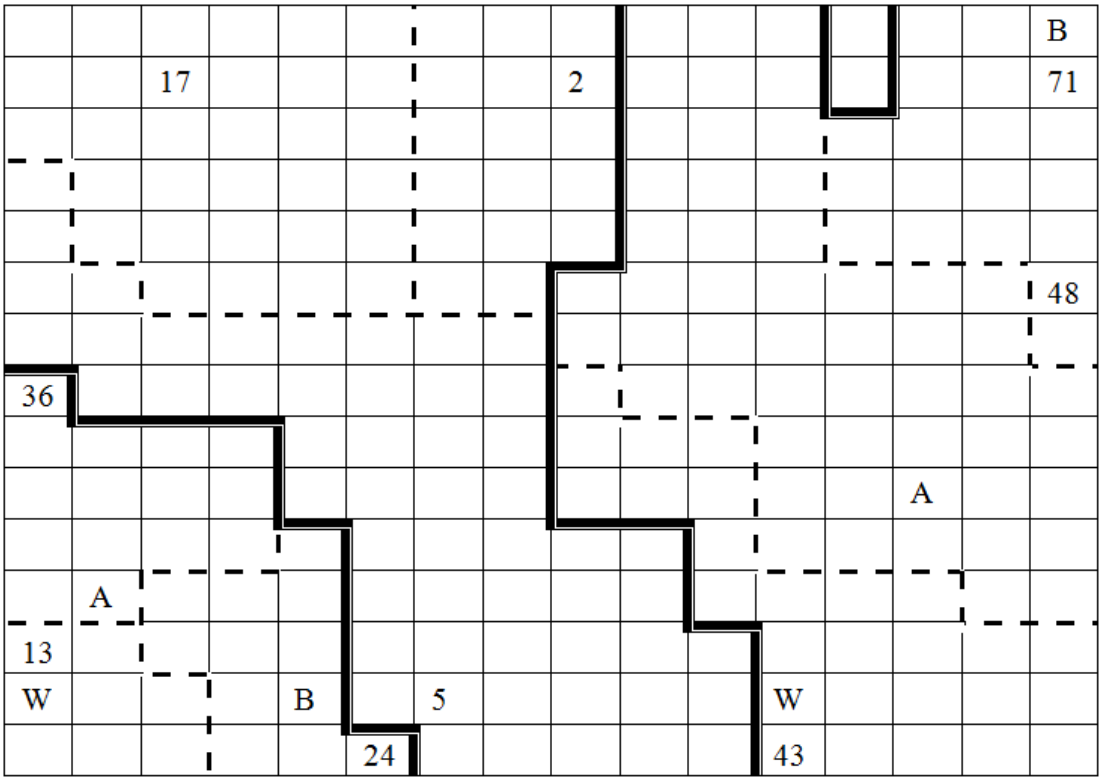

Fig. 5. *Placement of tags inside categories.*

So, Kohonen maps can be used to classify the initial set of machine operators in an arbitrary number of qualification levels, which determine the degree of workers professional development.

4. Conclusions

The proposed approach to the evaluation of the professionalism of machine operators, who use Kohonen maps allows:

- to analyze level of professional development of each machine operator in the complex;
- to establish a system of subclass within each skill category, which allows to expand significantly career opportunities for machine operators;
- to provide the validity of decisions management on issues, the need for education, training, career development, material incentives machine operators of different levels of professional development;
- to increase motivational effect of assessment procedures.

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