OBJECTS OF HIGH ORDERS IN RESTORATION OF IMAGES

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Abstract – This paper deals with the process of transformation of groups of defective objects in order to restore their true images. The processors created on basis of objects of higher order in comparison to restored ones, appear to be naturally adapted to restored objects and allow to use wide arsenal of mathematical and technical tools among which the most effective are the neural networks.

Key words - restoration of images, the order of objects, networks, the control operator.

I. INTRODUCTION

All objects of environment are divided into orders. The 1-st order object $\boldsymbol{x}_{\mathrm{n}}^{1}$ represents some heterogeneity therefore it is allocated on general homogeneous background. The 1-st order object can be presented as set of two and more 1-st order objects. And true is the converse: the 1-st order object can be a part of other, larger 1-st order object. Thus, any subject or group of subjects can be the 1-st order object. The 2-nd order object $\boldsymbol{x}_{\mathrm{n}}^{2}$ is a result of transformation of 1-st order objects. When there are some defects in 1-st order object, then 2-nd order object is capable to transform the defective image, thus to restore it. The structure formed by association of two 2-nd order objects of the 1-st and the 2-nd types $\boldsymbol{x}_{\mathrm{n}}^{2.1}$ and $\boldsymbol{x}_{\mathrm{n}}^{2.2}$, represents 3-rd order object of the 1-st type $\boldsymbol{x}_{\mathrm{n}}^{3.1}$ and allows to carry out more complex transformations of 1-st order objects.

II. THE 2-ND ORDER OBJECTS IN RESTORATION OF IMAGES

The 2-nd order object $\boldsymbol{x}_n^2$ is a result of transformation of 1-st order objects. It is known two versions of 2-nd order object: of the 1-st type - object $\boldsymbol{x}_n^{2.1}$ (fig. 1.1) and of the 2-nd type - object $\boldsymbol{x}_n^{2.2}$ (fig. 1.2):

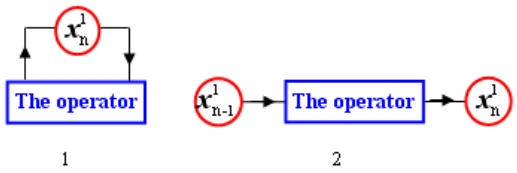

Fig. 1.The 2-nd order objects: 1 – of the 1-st type $\boldsymbol{x}_n^{2.1}$; 2 – of the 2-nd type $\boldsymbol{x}_n^{2.2}$.

Control operator $\boldsymbol{I}$ of the 2-nd order object changes output 1-st order object on the basis of information received from input 1-st order object. This operator $\boldsymbol{I}$ is used for solving of various problems, among which is the problem of restoration of image. The 2-nd order object of the 1-st type $\boldsymbol{x}_n^{2.1}$, is considered as:

$$\boldsymbol{x}_n^1 = \boldsymbol{I}(\boldsymbol{x}_n^1). \qquad (1)$$

The decision of expression (1) is the set of certain states of object $\boldsymbol{x}_n^1$: $\boldsymbol{x}_{n1}^1, \boldsymbol{x}_{n2}^1, ..., \boldsymbol{x}_{nq}^1$, where $q=|\boldsymbol{x}_n^1|$ – complexity of object $\boldsymbol{x}_n^1=(x_1, x_2, ..., x_K)$, determined as $|\boldsymbol{x}_n^1|=|x_1|\cdot|x_2|\cdot \ ... \ \cdot|x_K|$, where $|x_k|$ – number of states (power) of parameter x_k. Then, the set of certain states of object $\boldsymbol{x}_n^{2.1}$, among which there are many defective images $\tilde{\boldsymbol{x}}_1^{2.1}, \tilde{\boldsymbol{x}}_2^{2.1}, ...$ and the single true one $\boldsymbol{x}_{nE}^{2.1}$, is the decision of expression (1). Thus, the object $\boldsymbol{x}_n^{2.1}$ is capable to correct its own defects by means of control operator $\boldsymbol{I}$.

The 2-nd order object of the 2-nd type $\boldsymbol{x}_n^{2.2}$ is presented as two 1-st order objects $\boldsymbol{x}_{n-1}^1$ and $\boldsymbol{x}_n^1$, and, state of object $\boldsymbol{x}_n^1$ is in some dependence on state of object $\boldsymbol{x}_{n-1}^1$. The object $\boldsymbol{x}_n^{2.2}$ is considered as a function of a kind:

$$\boldsymbol{x}_n^1 = \boldsymbol{I}(\boldsymbol{x}_{n-1}^1). \qquad (2)$$

Then, object consisting of object $\boldsymbol{x}_{n-1}^1$ and object $\boldsymbol{x}_n^1$, controlled by means of operator $\boldsymbol{F}$, can be considered as 2-nd order object of the 2-nd type $\boldsymbol{x}_n^{2.2}=\{\boldsymbol{x}_{n-1}^1, \boldsymbol{x}_n^1\}$, in which the object $\boldsymbol{x}_n^1$ is transformed:

$$\boldsymbol{x}_{n-1}^1 = \boldsymbol{F}(\boldsymbol{x}_n^1). \qquad (3)$$

Similarly to the 1-st order objects, the 2-nd order objects also can be divided into smaller 2-nd order objects and be a part of larger 2-nd order objects. So the object $\boldsymbol{x}_{n}^{1}$ in object $\boldsymbol{x}_{n}^{2.1}$ can be divided into two objects $\boldsymbol{x}_{n1}^{1}$ and $\boldsymbol{x}_{n2}^{1}$ which values of parameters will be in some dependence, given by operator $\boldsymbol{I}$: $\boldsymbol{x}_{n1}^{1} = \boldsymbol{I}(\boldsymbol{x}_{n1}^{1})\ \boldsymbol{x}_{n2}^{1} = \boldsymbol{I}(\boldsymbol{x}_{n2}^{1})$. And converse statement is: objects $\boldsymbol{x}_{n-1}^{1}$ and $\boldsymbol{x}_{n}^{1}$ are considered as a single object $\boldsymbol{x}_{n+1}^{1}$ which values of parameters form the subsets with the same dependence, as in initial object.

According to (3) object $\boldsymbol{x}_{n-1}^{1}$ is capable to correct defects of object $\boldsymbol{x}_{n}^{1}$, but according to (1) object $\boldsymbol{x}_{n-1}^{1}$ is capable to correct its own defects. It is obvious, that for object $\boldsymbol{x}_{n-1}^{1}$ to correct its own defects as well as defects of object $\boldsymbol{x}_{n}^{1}$ it is needed the united structure consisting of objects $\boldsymbol{x}_{n-1}^{2.1}$ and $\boldsymbol{x}_{n}^{2.2}$. Such structure represents the 3-rd order object of the 1-st type $\boldsymbol{x}_{n}^{3.1}$ (fig. 2.1). Equivalent representation of given structure is shown on fig. 2.2.

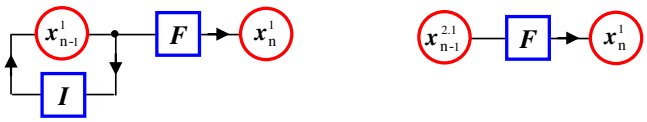

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Fig. 2. The object $\boldsymbol{x}_{n}^{3.1}$ formed by objects $\boldsymbol{x}_{n-1}^{2.1}$ and $\boldsymbol{x}_{n}^{1}$.

III. EXPERIMENTAL

The control operator $\boldsymbol{F}$ is defined by training of Hecht-Nelson neural networks of counter distribution or of multilayered neural networks of direct distribution. In order to determine the control operator $\boldsymbol{I}$ other multilayered neural networks of direct distribution are trained. In this process is used $\boldsymbol{h}$ training pairs: $(\tilde{\boldsymbol{x}}_{n-11}^{1} - \boldsymbol{x}_{n-1E}^{1}), (\tilde{\boldsymbol{x}}_{n-12}^{1} - \boldsymbol{x}_{n-1E}^{1}), ..., (\tilde{\boldsymbol{x}}_{n-1h}^{1} - \boldsymbol{x}_{n-1E}^{1})$, where $\boldsymbol{x}_{n-1E}^{1}$ – is standard value of object $\boldsymbol{x}_{n-1}^{1}$; $(\tilde{\boldsymbol{x}}_{n-11}^{1}, \tilde{\boldsymbol{x}}_{n-12}^{1}, ..., \tilde{\boldsymbol{x}}_{n-1h}^{1}$ – are the variations of defects of object $\boldsymbol{x}_{n-1}^{2.1}$. Generalizing ability of trained network results in output appearance of true value of object $\boldsymbol{x}_{n-1}^{1}$ for vectors $\tilde{\boldsymbol{x}}_{n-1h+1}^{1}, \tilde{\boldsymbol{x}}_{n-1h+2}^{1}, ..., \tilde{\boldsymbol{x}}_{n-1h+g}^{1}$, not participating in training. Founded control operators $\boldsymbol{I}$ and $\boldsymbol{F}$ allow to change in appropriate way parameters of the main and of the subordinate objects for correction of defects of their images.

IV. CONCLUSION

Division of objects into orders confirms, that any object is capable to operate only a certain kinds of other objects. If objects $\boldsymbol{x}_n$ and $\boldsymbol{x}_{n+1}$ have no opportunity to control each other, then they are objects of the same order, but different modifications. The object of higher order $\boldsymbol{x}_n^2$ includes all parameters of object of lower order $\boldsymbol{x}_{n-1}^1$.

The process of restoration of images is reduced to transformation of the 1-st order objects by the 2-nd order objects. The 2-nd order object initially has the ability of restoration of defective images. But influence on objects is assigned to trained neural network.

Restoration of defective images of objects means a finding of missing information about objects that is reception of new knowledge about objects and their interaction. Hence, the 2-nd order objects, which install connection between objects $\boldsymbol{x}_{n-1}^1$ and $\boldsymbol{x}_n^1$ inherently represents the knowledge.

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