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RESTORATION of IMAGE with APPLICATION of NEURAL NETWORKS

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Abstract **- The field of researches is connected with problems of restoration of images on the incomplete information of objects, which are represented in the digital image form. Questions of application of artificial intelligence systems for image restoration are considered.**

Key words **- restoration of images, neural networks, perceptron.**

I. Introduction

Let the continuous image be discretised on **N** levels, and intensity of every pixel is quantumed on one of **K** values. By reduction of **N** on unit on each step of discretization, on a place of four pixels appears the one and image becomes of a chess structure, that leads to changing of geometrical form of object. The problem consists in restoration of initial image on base of available discretized one.

The carried out experiments and researches of image restoration algorithms developed on basis of topological method [1, 2], have shown, that only partial restoration of image is possible. For simple objects the partial image which is not appropriate completely real, allows to identify objects, but for complex and real stages the identification is essentially complicated or is impossible. The reason of this phenomenon first of all consists in problems of restoration of images which refer to a class of intellectual one and can not be solved effectively enough by determination or probability methods. Therefore application of analytical technologies, particular neural networks is justified.

II. Restoration of the images with the help of neural networks.

Neural networks, been the model of human brain structure, are capable to find the effective decision in cases, when it is based on intuition or experience, but not on the strict mathematical description. To such tasks concerns recognition of the familiar faces in crowd or steady control of body motion. In robotics this is tasks of adaptation to continuously varied external conditions, effective control, recognition of objects and restoration of image. For networks functioning in conditions of incomplete information about object is also a characteristic fact. For neural network first of all architecture is selected, and then synoptical weights of neuron are set in. The most simple in structure

is three layer perceptron. Submitting on inputs of perceptron vectors x_1, x_2, ..., x_n on output turns out the value of some function $y = f(w_1x_1 + w_2x_2 + \ldots + w_nx_n)$.. The answer of a network depends as on input signal, as on values of its internal parameters – weights of neurons w_1, w_2 ,…, w_n and form of transmission activation function of every neuron, included in a network. The transmission functions of all neurons in network are fixed, but weights are variable parameters of network and can be changed. Initially weights are set on randomly, or with the help of simple dependence. As an activation one can be used sygmoidal function

$$f(x) = \frac{1}{1 + e^{-ax}},$$

as well as threshold function, such, that if $w_1x_1 + w_2x_2 + \ldots + w_nx_n > T$, then y=1, otherwise y=0, and radial-symmetric function, for example Gaussian function

$$h(x) = \exp\left(- \frac{(x - c)^2}{r^2} \right).$$

and others. For problems of restoration of image most preferable is sygmoidal function, which is close to the nonlinear transmission characteristic of biological neuron.

According to the Kolmogorov's theorem and its new interpretation offered by Hornik, Kibenko and Funahashy practically any problem, including the restoration of image, can be reduced to one solved by neural network. Let $f(x_1\ x_2, \ldots, x_n)$ – be a continuous function determined on limited set, and $e > 0$- is as much as small number, that means accuracy of approximation.

The theorem. There exist such number **L**, set of numbers w_{ij}, and v_i, that function

$$f(x_1, x_2, ..., x_n) = \sum_{i=1}^{L} v_i \cdot (w_{i1}x_1 + w_{i2}x_2 + \ldots + w_{in}x_n),$$

approaches the given function $F(x_1\ x_2, \ldots, x_n)$ with an error not much than e on all range of definition.

This expression completely coincides with expression for function, realized by perceptron. Then, in the terms of neural network the theorem is formulated as follow: any continuous function of several variables can be realized with any accuracy with the help of usual three layers perceptron with enough amount of neurons in the latent layer.

The increase of efficiency of image restoration is possible by using multilayer neural networks; however, it is required to supply nonlinearity activation function between layers. The absence of feedback guarantees stability of networks, however, such networks have limited opportunities in comparison with networks with feedbacks. The calculated out put vector, being transmitted in feedback network, modifies input. After that the output vector is calculated and the process of updatings and calculations is repeated. For steady networks the consecutive iterations leads to lesser changes of output vector, until output does not become constant. For unstable networks the process never ends. The network with feedbacks is steady, if matrix consisting from level-by-level neuron weights is symmetric $W_{ij} = W_{ji}$, and contains zero on the main diagonal $W_{ii} = 0$. The networks with feedbacks on their nature are dynamic and have properties similar to short time human memory, capable by separate fragments of images, causing certain associations, restore missing elements, intellectually design possible variants and select most probable.

As it is known, principle of functioning of computer memory of Fon-Neiman architecture and man are essentially differed from each other. The computer for searching of information uses the address, showing which, it takes the information stored at it. The man uses associations, by means of which information can derivate the connected with it field. For example, the musical fragment can cause sensual memoirs, landscapes, sounds, smells. Therefore, if it is known where to search information, the computer will find it quickly, but if it is not known, it is necessary to sort all memory. Just for a task of restoration of image missing elements of image apriori are unknown values and can be associatively offered by available fragments of image. The principle limitation of computers can be bypassed through systems of associative memory, for example, Hemming networks. The algorithm of network functioning is based on definition of Hemming distance - quantity of distinguished positions in binary vectors. The result of network functioning is determining of image with least distance. Hemming networks can be used in problems of indistinct search, optical character recognition and restoration of the deformed signal, by which discretised image of object can be submitted. To solve a problem first of all an encoder system of visual information into a vector is needed, for example, for everyone pixel is set its bit mask which appropriates to pixel address on a plane of image and to level of its intensity , that is brightness function, for example, first three categories of a code reflect a level of intensity, and second three categories- the address: $k(x_i, y_i)$ – 000001, $(k+1)\cdot(x_{i+1}, y_i)$ – 001010, $(k+2)\cdot(x_i, y_{i+1})$ – 011011… . Then received vectors move on an input of neural network. The Hemming networks assume deviation of initial image that allows to carry out group of experiments on the same image. However by significant deviations from initial image Hemming distance can appear to be too large. To eliminate these shortcomings on input it is necessary to submit the initial image and the same one, changing on in turn a small quantity of pixels.

Other possible structure realizing associative memory in restoration of image can be a network with Hopfield feedbacks. Similarly to human memory, by some part of the required information all one is taken from memory. For this purpose, weights should be chosen so that to form power minima in the necessary tops of unit hypercube. Latch of Hopfield networks is their tendency to be stabilized in local, instead of global minimum of function of energy. For this reason it is difficult enough to find optimum variant of the restored image.

Training of a network is made by selection of values of weights and is reduced to searching of such weights, at which the input information will correctly be displayed in to result. The correctness is provided by the initial set of certain number of obviously correct examples. For this purpose out discretisation of image of object ***A*** with **N** levels is carried, and the received image with **N**-1 levels of discretisation as a vector is submitted as a training example on input of a network. By selection sinaptical weights of network on output of a network is obtained a vector appropriate to the image with **N**-1 levels of discretisation. Such procedure is repeated for other objects ***B***, ***C***… . During training weights of network gradually become such, that each input vector developed a required output one. For much network architecture the special algorithms of training are developed which allow to adjust weights of a network definitely. Most popular among these algorithms is a method of inverse propagation of an error. At the result everyone neuron will define its contribution to an error and proportionally to it will change its weight. In other words training of neuron network consists in informing it what is needed from it. Training with the teacher assumes, that for each input vector there exist an aim vector representing required output value. At presentation to a

network of input vector, on its output appears some value, which is compared with appropriate aim vector and their difference is calculated - vector of forming. Use of algorithm of inverse propagation of error allows by vector of error to calculate the required amendments of a network weights. For each consistently showed vector of training set the errors are calculated and the weights are arranged until error on all training file will not reach zero or acceptable low level. The repeated presentation of the same training pair represents recurrence of training, or training of a network. Weights are stabilized, and network gives the correct answers on almost all input vectors from database. It means, that network is teaches and is trained. The weights of trained network store a lot of information about structures of showed images, therefore it is possible to expect the correct answer and for new variant of image.

Training without teacher is more plausible model of training, both in biological system, and when solving a problem of restoration of unknown image, because the aim vector, as a rule, is absent. The training set consists only of input vectors. The training algorithm arranges weights of network so that closed enough input vectors give identical output values. Thus, during training vectors are grouped in classes. The input vector from given class will give the certain output vector, which value before training was unknown. Hence, the output vectors should be transformed to some understandable form caused by training process.

III. Conclusion

The experiments on restoration of image were carried out on basis of multilayer neural and RBF networks Neural Analyzer, included in package Deductor. This network allows to use for definition of dependences and laws in difficultly formalizable problems not a set of rules, but examples. Neural network on a lot of examples is capable to be trained independently. After that the found laws are applied for unknown on the moment of training images.

Application of analytical technologies for restoration of images for the large group of objects especially for well structured standard geometrical objects, allows with high accuracy to receive an initial image of objects.

The restoration of real objects and stages significally depends on performance of visual information in a vector form. Often this process becomes very labor-consuming.

Other vital problem consists in interpretation of output information submitted in a vector form.

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