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E. I. Chumachenko

DESIGN OF HYBRID NEURON NETWORKS

Technical Cybernetic Department National Technical University of Ukraine
"Kyiv polytechnic institute", Kyiv, Ukraine
E-mail: chumachenko@tk.kpi.ua

Abstract*—*It is developed the procedure of hybrid neuron networks design. It is considered the possibility of use input signals of different types.

Index Terms—Hybrid neuron networks; design; fuzzification; topology.

I. INTRODUCTION

Hybrid neural network formally by structure is identical to multilayer neural network with training, for example, the algorithm of back-propagation errors, but hidden layers in it correspond to the stages of fuzzy system operation:

– so, the 1st layer of neurons functions as the introduction of fuzzification based on the given membership functions of the inputs;

– 2nd layer displays a set of fuzzy rules;

– 3rd layer performs the function of defuzzification.

Each of these layers is characterized by a set of parameters (the parameters of membership functions, fuzzy decision rules, activation functions, the weights coefficients), that are tuned essentially the same, as for conventional neural networks.

Wide spreading of artificial neuron network (ANN) is explained by the following advantages:

– ability to generate solutions of the problem for which there are no corresponding theoretical models or heuristic rules, that determine the solution algorithm, by replacing the complex mathematical apparatus for necessary amount of information concentrated in the training sample, the corresponding learning algorithm and the structure of the ANN;

– ability to adapt to changes in operating conditions, including and not pre-specified situations;

– the versatility of decision receiving, based on the convergence of the learning algorithm (e.g., for multi-layer perceptron), which allows to solve problems of approximation of the objective functions by a finite set of values;

– possibility of realization of nonlinear mappings by an appropriate tuning of neurons activation functions in the hidden layers of the multilayer ANN;

– the possibility of submitting incomplete and fuzzy source data;

– high parallelism in data processing;

– ability to effectively handle high-dimensional and heterogeneous data, etc.

The experience of recent years has shown that the application of Informatics homogeneous methods, i.e. methods, corresponding to one scientific paradigm for solving complex problems and tasks may not always lead to success. In a hybrid architecture that combines multiple paradigms, the effectiveness of one approach can compensate for the weakness of another. Combining different approaches, it is possible to circumvent the disadvantages associated with each of them separately.

Therefore, one of the leading trends in modern computer science was the development of integrated , hybrid systems. Such systems are composed of different elements (components), that are combined in order to achieve the set goals. The integration and hybridization of different methods and technologies helps to solve complex problems, that cannot be solved on the basis of any specific methods or technologies.

Integration as a fundamental property of complex systems, that is closely connected with its integrity, implies not only the association, but also mutual adaptation and co-evolution of its components, that provides the appearance of new qualities not inherent in its separate components.

We define a hybrid system as a system, consisting of two or more integrated heterogeneous subsystems, united by a common purpose or joint actions (although these subsystems may have different nature and different description languages). In computer science we will call systems as hybrid ones that use two or more different computer technologies.

The main tasks that should solve the hybrid model are follows:

– optimization problem;

– classification and recognition;

– forecasting;

– multi-criteria selection;

– logical inference etc.

For each of the individual component of the hybrid model we should solve series of internal

problems, that are connected with their disadvantages, but their joint use in the solution of the general problem allows us to compensate for their disadvantages and to enhance their advantages, thereby creating a synergistic effect.

There are three series of morphological indications that you must consider when are creating hybrid models [1], [2]:

– the purpose of the system;

– search and analysis methods of alternative solutions;

– features of the realization.

To determine the ways of hybrid models realization it's necessary to pick out two types of architectures:

– complex architecture consisting of multiple interacting models, each of which performs its function;

– the architecture in which the models are aggregated at the level of methods at the individual stages of the realization of combine models basic algorithms.

To create hybrid models of the first type it is necessary to investigate the disadvantages of each technology and determine the ways of integration to eliminate these disadvantages moreover the internal structure of the model remains unchanged.

Creating the second type of models requires a more in-depth research of algorithms of each model functioning to determine the realization method of certain functions on the basis of more advanced technologies.

The creation of combined neural networks consisting of different types ANN, each of which is trained on a particular algorithm, in many cases can significantly improve the efficiency of the ANN functioning.

Study of ANN hybridization principles, fuzzy logic and genetic algorithms will allow you to create new types of models with a higher recognition accuracy while reducing the computational cost of training.

II. Synthesis of neural network for solving applied tasks

Synthesis of neural networks to solve specific problems is a complex procedure and is determined by such criteria as the accuracy of the solution, the number of recognition errors, training time, time, recognition, etc. In the synthesis process of the network, you must choose the type of network, architecture (topology), the learning algorithm and other above-mentioned parameters that affect the value of the criterion. As a result of synthesis it must be formed the ANN with the desired properties and allowing to solve the problem. The main problems of ANN synthesis are the following:

– the lack of formal methods for the selection of ANN type, adequate to solve the class of problems;

– poor research of problems, related to the automatic formation of ANN topology that in many cases does not allow to create ANN of minimum complexity;

– insufficient justification of optimization methods choice in the process of ANN training, which leads to large forecast errors.

As the result the generated ANN do not always meet the requirements.

III. Problems of formation ANN topology

The most important problem of ANN synthesis is the choice of the network topology, which determines the complexity of ANN. The complexity of ANN topology is determined by the total number of neurons in the network and the number of links between them. For multilayer perceptron (MLP), for example, the optimal topology is a topology that provides the smallest number of layers and the smallest number of neurons in each layer at a given generalization error. However, the ANN with a small number of neurons is not sufficient to restore the desired sought function $F : \mathbf{R} \to \mathbf{Y}$, where $\mathbf{R}$ is the input vector of ANN, $\mathbf{Y}$ is the output. The ANN with a large number of neurons is usually too accurately generalized examples of training samples (effect of re-training), which reduces its ability to predict.

The complexity of the neural network is a number equal to the total number of computational operations required to compute the output vector $\mathbf{Y}$ by the input vector $\mathbf{R}$, depending only on the topology of the network (number of neurons, hidden layers and the connections between them).

When forming the topology it is stated the task to select the network parameters so that the generalization error $E_{\text{gen.}}$ remained at an acceptable level with minimal complexity of the network. A comprehensive theoretical study carried out in where it is concluded that for the most frequently used in practice of multilayer neural networks objective topology optimization (minimization of the number of neurons and number of layers) can be supplied only or in terms of the elimination of redundancy in the number of neurons, or by setting limits on the number of neurons. Accordingly, in the literature on neural networks are widely considered two of the heuristic approach to the choice of topology: destructive (reduction of neurons in the network) and constructive (gradual increase of ANN, starting with a minimal topology), and explore statistical approaches.

When using hybrid ANN, there are several problems: how much information should be included in the used topology view, which genetic operators to apply for conversion ideas during the evolution, how to organize the scheme of hybrid ANN realization. The existing methods of forming the topology of the ANN using the hybrid ANN, use the following methods in the topology view:

– maximum admissible representation with detail to individual neurons or neuronal connections (direct encoding) [3];

– the only representation of some, the most significant parameters (parametric representation) [4], [5].

The most frequently used methods of encoding in the first case: the view of a bit matrix, in which each element $c(i, j) = 1$ if there is a connecting neuron i to neuron j. The disadvantages of this encoding consists in the possibility of occurrence of invalid architectures in the process of hybrid INN functioning and a rapid increase in the size of the description when the network is increasing [6], [7].

III. Conclusion

It is considered the procedure of hybrid ANN design. The necessity of hybrid ANN is shown. The use of hybrid ANN permits to increase the possibilities o ANN.

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Chumachenko Olena. Candidate of engineering. Associate Professor.
Technical Cybernetic Department, National Technical University of Ukraine "Kyiv Polytechnic Institute", Kyiv, Ukraine.
Education: Georgian Politechnic Institute, Tbilisi, Georgia (1980).
Research area: system analysis, artificial neuron nets.
Publications: 49.
E-mail: chumachenko@tk.kpi.ua

О. І. Чумаченко. Проектування гібридних нейронних мереж

Розглянуто процедуру проектування гібридних нейронних мереж. Запропоновано підхід для вирішення цього завдання.

Ключові слова: гібридні нейронні мережі; проектування; фаззіфікація; топологія.

Чумаченко Олена Іллівна. Кандидат технічних наук. Доцент.
Кафедра технічної кібернетики, Національний технічний університет України «Київський політехнічний інститут», Київ, Україна.
Освіта: Грузинський політехнічний інститут, Тбілісі, Грузія (1980).
Напрям наукової діяльності: системний аналіз, штучні нейронні мережі.
Кількість публікацій: 49.
E-mail: chumachenko@tk.kpi.ua

Е. И. Чумаченко. Проектирование гибридных нейронных сетей

Рассмотрена процедура проектирования гибридных нейронных сетей. Предложен подход для решения этой задачи.

Ключевые слова: гибридные нейронные сети; проектирование; фаззификация; топология.

Чумаченко Елена Ильинична. Кандидат технических наук. Доцент.
Кафедра технической кибернетики, Национальный технический университет Украины «Киевский политехнический институт», Киев, Украина.
Образование: Грузинский политехнический институт, Тбилиси, Грузия (1980).
Направление научной деятельности: системный анализ, искусственные нейронные сети.
Количество публикаций: 49.
E-mail: chumachenko@tk.kpi.ua