EFFECT OF TRAINING DATA CHANGING STEP AND INPUT VECTOR EXCESSIVE DIMENSION OF A NEURAL NETWORK ON APPROXIMATION ACCURACY. LOAD CALCULATION OF A UNSTABLE COMMUNICATION LINE

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Machine learning and neural networks are increasingly use in various areas activities. Artificial neural networks, including on superconducting elements [1], have qualities that are absent in computers with the von Neumann architecture. Such qualities, in particular, are the capability to training and generalization, tolerance to errors, parallelism of work. The machine and especially deep learning do not have a powerful mathematical platform and are based almost exclusively on engineering solutions. It is a practical discipline in which ideas are often proven empirically rather than theoretically [2].

One of the applications of neural networks are the approximation or regression tasks. The calculation of a resistive sensor as the load of an unstable communication line is the example of this task. Used a feedforward neural network is trained by input and target data [2, 3]. Such data are calculated from a mathematical model of the communication line in the form of a resistive two-port with some type of change step of the load and line parameters. Usually or by default, the values of the changing parameters are set with some constant or regular step. According to the well-known practice of solving the overfitting problem, data are usually split into training, validation, and test sets. As the result of training, small mean squared error values for these sets are achieved. Subsequent simulations for an extended control data were to confirm the calculation accuracy of this trained network. But, as it turned out, there were large variations in relative error values for individual data.

The initial researches of two-port with stable parameters have shown that it is all about the input and target data generation [4]. On the one hand, a given step of changing parameters is present in the training, validation, and test sets and the neural network reveals this internal pattern. Therefore, the small mean squared errors are obtained. On the other hand, if the control data uses the same type of change step, small relative error values for the entire data set are also obtained. But, if the control data with a different type of step, relative errors immediately appear.

Therefore, for a two–port with one unstable parameter, the training data generation is carried out by combining data with both regular and irregular steps of changing parameters [5]. Hence, in these three sets, this internal pattern is excluded and the network shows the capability to generalization by presented numerical experiments.

The presented study considers the two–port circuit with all the unstable three elements as r0, r1, r10 in Fig.1. The equation $I0(RL)$ has the known fractionally linear view

$$I0(RL) = V0\frac{RL + r1 + r10}{RL(r0 + r10) + r0(r1 + r10) + r1r10} = \frac{a1RL + a2}{a3RL + 1}.$$

In turn, the load values are calculated from the measured input current by the inverse equation

$$RL(I0) = \frac{b1I0 + b2}{b3I0 + 1}$$

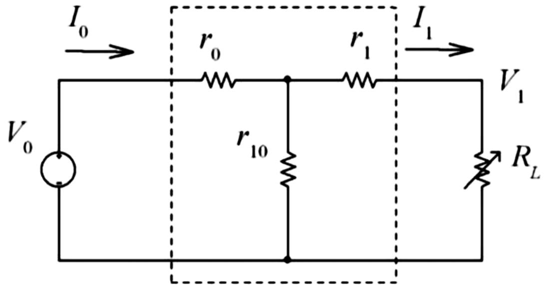

Fig. 1. Two-port with a load resistor RL

Parameters of this two–port are possible determined by known measurement methods [6]. In this case, three measurements are made with three values of the base load and the system of equations with three unknown *b*1, *b*2, *b*3 is solved. But for unstable elements, the redefine line parameters takes time and complicates this calculation method.

An attractive side of using a neural network is the ability to immediately put all the changes of circuit elements and loads into training data. The corresponding calculated set of input currents forms the input vector of four components, and the measuring load values are the target vector. Conducted numerical experiments with neural network training and verification on extended control data showed unsatisfactory results.

In turn, the use of already excessive four basic load values radically increase the capability to generalization of the network, provides the necessary accuracy on a much smaller size of training data. In this case, the input vector contains five elements.

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