Intellectual measuring converters based on neural network technologies

V.N. Loktiukhin, S.V. Chelebaev

The Ryazan state radioengineering university (RSRTU)
59/1, Gagarin str., Ryazan, 390005, Russia
Tel.: +7[4912]991763  E-mail: sergey_chel_r@rambler.ru

Abstract

Intellectual neural network representation form of information converters synthesis and implementation questions are considered in article. Neural network frequency and voltage converters structures in to a digital code are offered.

Keywords: A neural network, the converter, frequency, a time interval, a code

1. Introduction

In modern intellectual measurement and the control systems wide distribution have received the gauges which are giving out result in the analogue sizes form. Known transformation methods "analogue → a code" are focused basically on construction of microelectronic analogue-digital converters (ADC) on the basis of schemes with an integration average level. Thus they do not consider possibilities modern analogue and digital circuit on their operative program reorganisation at change transformation operation that is rather essential to devices creation with reconfigured structure [1].

One of converters efficiency increase directions, presented in the time-and-frequency parameters signals form (frequency, the period and a time interval) or signals amplitudes (a voltage, a current), is development of their intellectual possibilities.

Until recently intellectual ADC development (in narrow sense of this word) was conducted basically by the way of joint realisation in one microprocessor computer environment as actually transformation functions, and nonlinear mathematical processing of pulse-analogue signals, for example their functional transformation. However practically there are no researches on working out of intellectual ADC, in a broad sense this word when their architecture creation is based on achievements results of the modern artificial neural networks theory and practice, the indistinct logic and others, united under the name "soft calculations".

The most important factor in such devices creation is intensive chips development with programmed structure, including Field Programmable Gate Arrays (FPGA), characterised by a high integration degree and their possibility on operative program modification on performance of a new conversion function. However their application, taking into account this specificity, leads to necessity of information form converters synthesis formalising, starting from task setting on the concrete development to the device on its microelectronic implementation.

2. Artificial neural network converters synthesis

Converters synthesis based on of the device artificial neural networks consists of following stages [2].

1. Converter representation as artificial neural network structures, construction neurons mathematics models.
2. Converter neural structure logic signals representation and its knots by means of matrixes.
3. Neural network operations representation in logic or other basis, structural synthesis of digital automatic machines for their realisation.

Thus the first stage breaks into following components: a choice and a substantiation initial neural network, definition the converter structure base configuration as networks, network adjustment.

Each of spent stages on offered the neural network converter structure synthesis technique is accompanied by the analysis of its characteristics linked to its possible physical implementation, and also revealing of structure and a collection of certain approaches, receptions and the models derivating as a whole methodological converters new constructions development support of analogue signals parameters on the neural network technologies basis.

3. Neural network converters adjustment

One of the major and most labour-consuming stages at neural network converter synthesis is network adjustment for the decision of a transformation task, because standard neural networks training algorithms are calculated as a rule for the digital representation form entrance, internal and target information. However they do not consider the hybrid information representation form in ADC neural network, because this representation form imposes certain restrictions on factors values and for ways of their realisation.

Therefore a neural networks adjustment procedures updating and working out problem, focused on training of information representation form transformation new function, is arised.

Adjustment the neural network converter is understood as set of the special procedures consistently providing based on generated initial converter structure model support of carrying out of operations, necessary for its further designing.

Adjustment neural network ADC is necessary for reducing to following operations [3]:

1. Weight coefficients and the neurons thresholds algorithms development of correction taken as a converter initial network training result by means of training standard algorithms. It is carried out on purpose:
   - weight coefficients and neurons thresholds values revealing, uneffective for the subsequent implementation at the set form of an analogue variable representation;
   - reduction of hardware expenses by implementation sinaptis links. It is carried out at the weight coefficients correction expense to the sort accepting digital sinaptis links and neurons implementation in the digital logic circuits form.


3. Neural network converters decomposition on more simple systems for the purpose of increase in their training stability on the basis of standard algorithms.

4. Hardware and hardware-software procedures implementation of operative modification neural network converters.

According to the specified development cycles neural network ADC are constructed. This ADC based on one- and multilayered perceptron networks, recurrent, radially-basic networks, and also based on neural networks multicascade connection. As a result neural network converters components library is developed in the equipment description language VHDL.

Neurons weight factors and thresholds correction algorithms are developed for training some conversion networks.

Weight coefficients and neurons thresholds correction algorithms are developed for two-layer perceptron training on the conversion task solution of frequency and a time interval in a digital code with conversion result classification coding way [4]. The distributive (zero) such converter network layer consists two neurons on which the value and the conversion measurement standard. The neural network neurons quantity an output (second) layer is taken equal to bits number of an output code. The neurons number in a hidden (first) layer is
defined at a grade level of a network proceeding from demanded accuracy and sort conversion dependences [5]. After the converter neural network training on the basis of error back-propagation algorithm [6] weight coefficients and neurons thresholds values are unsuitable to hardware implementation are taken. Neural network weight coefficients correction values and neurons threshold values is carried out stage by stage. In the beginning weight coefficients and neurons threshold values are corrected for the first neural network layer of the converter. Then – the second layer of a network is carried out.

At first the first layer neurons threshold indemnification is carried out at the expense of the weight factors change, the setting weight sinapsis communications. These factors are a part of analogue sinapsis communications with reference value of analogue size.

On the second layer weight coefficients and neurons thresholds values the limitations similar to limitations, superimposed on the first layer coefficients and thresholds are not superimposed. Because the first layer output signals are digital binary signals. The second layer neuron, trained on the error back-propagation algorithm of, can be hardware realise on the basis of digital multipliers, the summator and the comparator. Therefore the second layer weight and neurons thresholds digital values are led by coefficient to the sort accessible to implementation on logical units. Finally the second layer neuron can be realised on the programmed logical unit, capable to realise logical functions "and", "or" with demanded quantity of direct and inverse inputs that essentially simplifies its hardware implementation.

The received results allows essentially simplify neural networks converters synthesis procedures, and consequently also their hardware realisation.

4. Conclusion

Intellectual converters "analog – a code" on the basis of perceptron networks, a perceptron networks tandem connection, recurrence networks, radially-basis networks are constructed [7, 8]. The neural networks converters components library on the hardware description language VHDL on programmed logical chips is developed for their implementation on the basis of these neural networks.

Weight coefficients and thresholds correction neural networks algorithms are developed for one- and two-layer perceptrons training on solution of the frequency and a time interval in a digital code conversion task with conversion result classification coding way [7].

The received results show that development neural network analogue-digital conversions is the actual task, and its solution allows to simplify essentially procedures of synthesis of converters, and consequently also their hardware implementation. The received results show that neural networks analogue-digital conversions development is the actual task, and its solution allows to simplify essentially procedures of converters synthesis, and consequently also their hardware implementation.

5. Acknowledgements

Authors would like to thank Prof. Yuri Chugui for valuable contribution and helpful discussions.

References


