SOFTWARE FAILURES FORECASTING USING RADIAL-BASIS FUNCTIONS OF NEURAL NETWORK

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Reliability, as a science that studies patterns of failures of technical systems arise in the mid-twentieth century with the advent of complex electronic and information systems, automated control systems for transport, energy, technological processes, military systems, performing extremely complex and vital functions. Development of methods for reliability modeling is driven by increased requirements for reliability of estimate of reliability parameters of complex systems.

The most common traditional approaches to software reliability modeling and estimation use models that process the results of software testing while software is considered to be a black box. These models contain priori assumptions about the distribution of random variables such as time between failures or defects quantity. However, in addition to traditional approaches there are approaches that use non-parametric models, which do not require a priori knowledge of the functional dependence of the software reliability growth over time. One such approach is the use of artificial neural networks, since the last decade, it has been proved that neural networks can be a universal approximator for any nonlinear continuous function with arbitrary precision.

Neural network based on radial-basis function (RBF) is a new class of neural networks that have a high-speed training and has been successfully used for approximation problems of unknown functions. RBF network contains no recursion and is characterized by the following features: a single hidden neurons layer, only hidden layer neurons have a nonlinear activation function, synaptic weights of the hidden layer neurons are equal to unity.

This article investigates the impact of neural network activation functions on forecasting effectiveness of revealed software errors presented in the time series form. Because the task of forecasting is a case of regression task the radial-basis neural network (RBF) was selected for this study, and the four most common activation functions were used: Gaussian, Multiquadric, Inverse Multiquadric and Mexican Hat. The software implementation of RBF neural network was used for the experiments, which allows us to change the basic network settings like activation function, the number of neurons in the input and hidden layers and the number of learning epochs. Software implementation of RBF neural network module has been developed using the Encog library. As input data for training the neural network and forecasting the results of open source Chromium browser testing were used. Public reports on 870 days of testing were used, during which about 1000 errors were revealed. For network training the time intervals, for which there are failures data, should be equally distributed, so the studied input data were normalized. There were two series of experiments, each of which included one experiment with each activation function. In the first series the neural network with 10 neurons in the input layer and 30 neurons in the hidden layer was constructed. In the second series of experiments a neural network containing 30 neurons in the input layer and 10 in the hidden one was used. Training a neural network was carried out to achieve error of 0.005 or up to 5,000 training epochs, depending on what occurred before. To assess the effectiveness of forecasting the following parameters used: the number of learning epochs that characterized the rate of neural network training was used; squared Pearson's correlation coefficient and standard deviation between predicted and experimental data. It is shown that the optimal activation function is Inverse Multiquadric with 10 neurons in the input layer and 30 neurons in the hidden one (square of Pearson correlation coefficient is 0.997 and mean deviation is 14.4).

Keywords – software reliability, time series, RBF neural network, activation function.