PREDICTION OF ENERGY EFFICIENCY OF A SOLAR AIR COLLECTOR USING ARTIFICIAL NEURAL NETWORK TECHNIQUE

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Solar air collector (SAC) is a most commonly used solar energy system. It absorbs incident solar radiation, converts it into thermal energy, and releases this energy into circulating air. SACs are main components in many engineering applications, such as space heating and crop drying [1]. Various researchers have conducted experimental and analytical studies to improve the thermal performance of SAC [2]. These studies require a lot of time and are comparatively expensive. Therefore, soft computing techniques can be used to avoid these problems. Artificial neural network (ANN) technique is used to predict and optimize the performance of SAC[3]. İn recent years, ANN has becom increasingly popular in numerous engineering applications and has been used by many researchers in many fields [4]. The structure and behavior of this technique resemble the human nervous system. In general, the structure of ANN cosists of three layers, namely an input layer, a hidden layer, and an output layer. This network structure is the most common model and is called multi-layer perceptron (MLP). Each layer has a certain number of small, individual, and highly interconnected processing elements called neurons. ANN operates like a black box model and can predict the desired output of the system with limited training data. There are numerous algorithms for learning neural network models. Out of these algorithms, LM is the most popular due to its fast computing and minimum error rate [5].
The aim of this research is to predict the energy efficiency of a V- corrugated solar air collector using the actual weather data of Miskolc city, Hungary with the help of ANN. Six input parameters such as date, time, solar intensity, ambient temperature, mean plate temperature and air outlet temperature are used in the input layer. Energy efficiency is used as output parameter in the output layer. A total of 112 data samples are used for prediction, of which, 70% are used for training, 15% for validation, and the remaining 15% for testing the model. The number of neurons in the hidden layer is determined by trial and error. However, 2 to 14 neurons were examined. The lowest mean square error (MSE) value and the highest correlation coefficient (R) value indicate the optimal neuron model. From the statistical analysis, the lowest value of MSE for training, validation, and testing is 1.23E-04, 1.518E-04, and 6.33E-04, respectively, and the highest value of R for training, validation, and testing were 0.99917, 0.99936, and 0.99468, respectively. These values were found for a number of 3 neurons compared with the values of other neurons. Thus, the 6-3-1 structure is the optimal neuron model. The regression plot for this structure is shown in Figure 1.

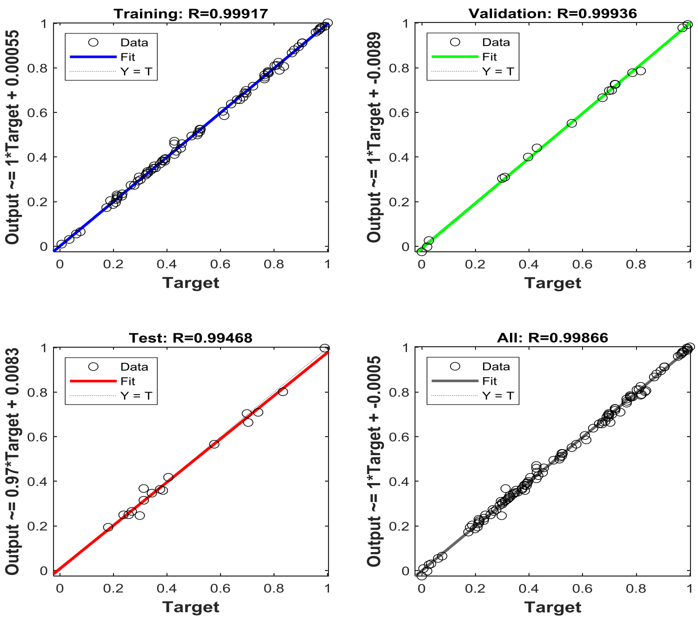

Figure 1 Regression plot of 6-3-1structure

The best validation performance occurred in epoch 87, where the MSE during validation was 0.0001518. in addtion, the training process was terminated in epoch 93 because the minimum gradient error was reached.
The prediction accuracy of ANN is also observed from the histogram error graph (see Fig. 2). It can be observed that most of the errors are near the 0 point error line. Therefore, it can be concluded that the neural structure 6-3-1 with LM learning algorithm is the optimal model for accurately predicting the efficiency of SAC.

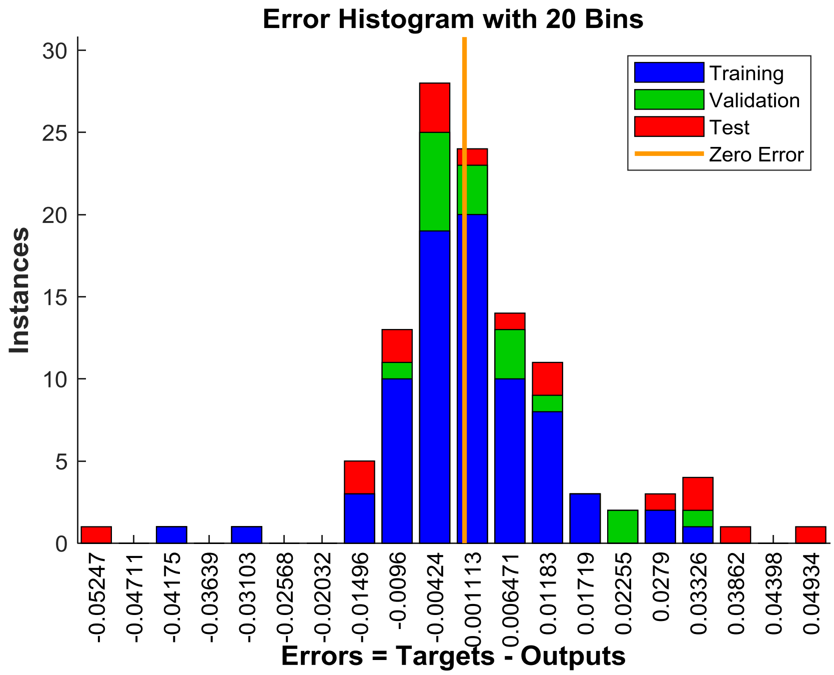

Figure 2 Error distribution graph

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