AmirKabir University of Technology
(Tehran Polytechnic)

AmirKabir Jounrnal of Science & Research
(Mechanical Engineering) (ASJR-ME)
Vol. 47, No. 2, Winter 2015, pp. 33-36

Comparison of Artificial Neural Network Methods in Modeling of Polymer Matrix Composite Turning

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(Received February 5, 2014, Accepted October 21, 2015)

ABSTRACT

Surface roughness is an important parameter in machining process. The machining of composite materials is different from conventional materials due to inhomogeneous structure. In this research, polymer matrix composite filled with aluminum particles is synthesized. Bisphenol Epoxy resin is selected as a matrix of composite. The mean particle size of the aluminum is 32 micrometer. The composites are machined by CNC turning with different machining condition namely: cutting speed, weight fraction of particle, depth of cut and feed. Then, the surface roughness of the composites is measured. Physical interpretation of the effect of machining parameters on surface roughness for composites is presented. For modeling, two artificial neural networks models Multi-Layer Perceptron (MLP) and Radial Basis Function (RBF) are developed to estimate effects of four turning parameters on surface roughness. Correlation between training data and experimental data are shown that MLP network is better than RBF as a compatible network (correlations were 0.835 for MLP network and 0.542 for RBF network). Because of higher correlation for MLP network, this network is proposed as a model for investigation the effects of turning parameters on surface roughness.

KEYWORDS:

Turning, Polymer Matrix Composite, Surface Roughness, MLP Neural Network, RBF Neural Network

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1- Introduction

Machining of composite materials may take place for creation of special geometrical shapes, dimensional precession and desired surface roughness [1]. Polymer-reinforced with particulates have proven to be flexible and adaptable engineering materials for many applications [2]. Among various parameters that determine the quality of machined surface, surface roughness is a vital importance [3]. The surface quality is affected by the machining process. There are many applications of artificial neural networks in modeling of machining operation conditions [4]. In this study, polymer matrix composite reinforced with aluminum particles are produced and then machined by turning operation. Independently controllable predominant machining parameters are cutting speed, weight fraction of particle, depth of cut and feed rate. Then, the surface roughness is measured and two artificial neural networks (ANN's) models the Multi-Layer Perceptron (MLP) and the Radial Basis Function (RBF) are developed to estimate effects of four turning parameters on the surface roughness of samples. Results shows that the MLP network is better than the RBF network for estimation of the surface roughness.

2- Materials And Methods

Polymer matrix composites have been prepared by mixing of Bisphenol Epoxy resin and Amine hardener. Aluminum particles has been chosen as reinforcement of the composites. The composites were machined by turning CNC machine. The surface roughness tests were conducted using a Mitutoyo Sj-301.

3- Artificial Neural Network (Ann) Modeling

In the ANN modeling for the present work, the cutting speed, weight fraction of particle, depth of cut and feed rate are considered as the prime processing variables. Many ANN architectures have been proposed for process modeling. The most commonly used models are the feedforward neural networks such as MLP and RBF. Two proposed ANN model such as MLP and RBF networks are developed to estimate effects of four turning parameters on surface roughness. The data is obtained from the experimental study. To examine the effects of the various machining parameters on the surface roughness, the experimental data are grouped into training data, testing data and validation data. They are normalized in order to equalize the importance of variables. Inputs and outputs are normalized using their minimum and maximum values. Fig. 1 shows the architectures of the MLP and RBF neural networks. Table 1 shows the specification of the trained and selected networks.

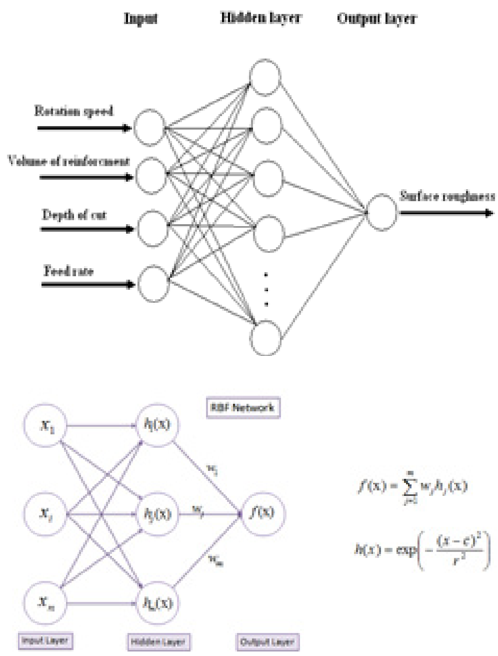

Figure 1. The architectures of the MLP and RBF neural networks

4- Results And Discussion

In order to assess the validity of the networks and their accuracy, regression analysis between the network response and the corresponding are performed. Fig. 2 shows the regression analysis for the RBF and MLP networks for the all data sets.

Table 1. The specification of the trained and selected networks

Network Specifications	Type of network	
	RBF	MLP
Number of inputs	4	4
Number of outputs	1	1
Number of neurons in hidden layer	50	28
Number of neurons in output layer	1	1
Hidden layer activation function	Gaussian	Log-sigmoid
Output layer activation function	Linear	Tan-sigmoid

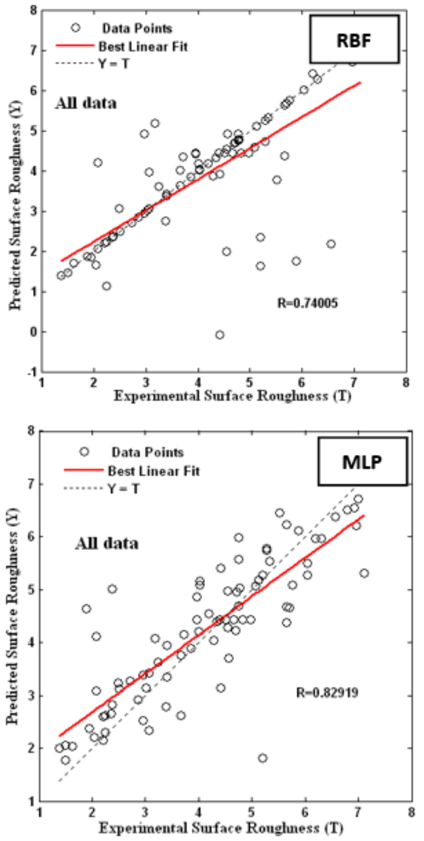

Figure 2. The regression analysis for the RBF and MLP networks for the all data sets

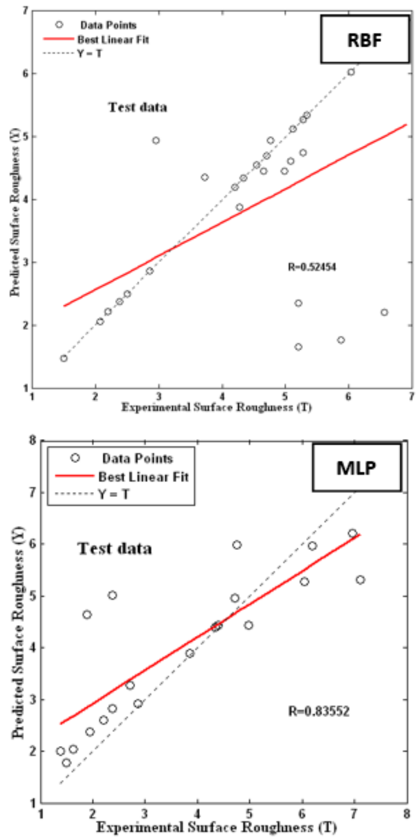

Figure 3. The regression analysis for the RBF and MLP networks for the testing data sets

Also, Fig. 3 shows the results of the same analysis which is only performed on the testing data set. Table 2 shows the correlation coefficients of the surface roughness. Correlation coefficients between target and predicted response of the MLP network show a better conformity as compared with the RBF network (0.829 and 0.835 in MLP network against 0.524 and 0.740 in RBF). Because of the high correlation coefficients for MLP network, the ability of this network in modeling of the machining process polymer matrix composites.

Table 2. the correlation coefficients for two networks

Network output	Testing data		All data	
	RBF	MLP	RBF	MLP
.Correlation cof	0.524	0.835	0.740	0.829

5- Conclusion

Two artificial neural networks, i.e. RBF and MLP was developed for modeling of machining process of polymer matrix composites. The RBF network consists of two layers with a radial basis function in the hidden layer and a linear function in the output layer as a transfer function. The MLP network was a three layer feed-forward neural. The effect of machining parameters including cutting speed, weight fraction of particle, depth of cut and feed on the surface roughness of polymer matrix composites was studied. Because MLP network has high correlation coefficients and low estimation error, it was found that this network provides better response compared to the RBF network. The suitable transfer function for layers of MLP network was found to be log-sigmoid for hidden layer and tan-sigmoid for output layer. The results were also confirmed by regression analysis. The result of the developed ANN model was found to be agreed with experimental data. Hence, the trained MLP artificial neural network can be used for prediction the surface roughness of polymer matrix composite.

6- Refrences

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