A Review paper on Artificial Neural Network: A Prediction Technique

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Abstract *:* This paper presents a brief review of prediction technique- Artificial Neural Network (ANN). It is used to improve prediction accuracy of the model with less dependancy on experimental data. The basic steps used in MATLAB are reported along with different ANN trainings. The purpose of the training is to minimize mean square error. ANN model can be used easily for prediction of output parameters which helps in optimum selection of machining parameters for the purpose of process planning and optimisation of machining parameters.

Key words : Artificial Neural Network, LM Training algorithm

INTRODUCTION

ANN is an interconnected group of nodes, a kin to the vast network of neurons in a brain. ANN are computational models inspired by animal's central nervous systems (in particular the brain) that are capable of machine learning and pattern recognition. They are usually presented as systems of interconnected "neurons" that can compute values from inputs by feeding information through the network. An ANN is configured for a specific application, such as pattern recognition or data classification, through a learning process. Learning in biological systems involves adjustments to the synaptic connections that exist between the neurons. There are certain advantages of ANN in general**,** a neural network can perform tasks that a linear output cannot.

When an element of the neural network fails, it can continue without any problem by their parallel nature. It can be implemented in any application. A neural network learns and does not need to be reprogrammed. So ANN is becoming popular for prediction of results about certain parameters. In machining processes ANN can be applied for prediction of response parameters from process parameters, once trained properly. Proper care must be taken while applying the ANN to these processes and needs training to operate. The architecture of a NN is different from the architecture of microprocessors therefore needs to be emulated. It requires high processing time for large neural networks [1].

LITERATURE SURVEY

Pradhan and Bhattacharya [2] demonstrated the use of RSM and ANN with back-propagation-algorithm-based mathematical modelling. They carried out the optimization of the machining characteristics of micro-EDM during the microhole machining operation on Ti–6Al–4V. The input parameters were utilized for developing the ANN predicting model. The performance measures for optimization were MRR, TWR, and overcut. They developed an ANN model with back-propagation neural network algorithm, which was trained with response values obtained from the experimental results. The Levenberg–Marquardt training algorithm has been used for a multilayer feed-forward network. From the analysis of ANN-predicted responses and experimentally obtained responses for multi-objective optimal input process variables settings, they found that the percentage of error is very small and is in an acceptable range. The developed ANN model for the micro-EDM process can be utilized to determine the combination of optimal process parameter settings for obtaining the best micromachining efficiency. Fig 1 shows the comparison of experimented and predicted values of MRR.
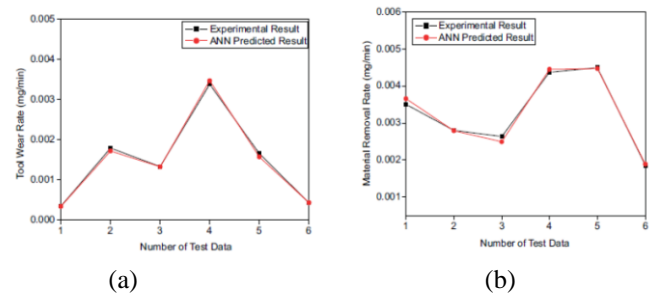

Fig. 1 (a) Comparison of experimental and ANN predicted results of MRR (b) Comparison of experimental and ANN predicted results of TWR [2]

Rao et al. [3] applied the hybrid model and performed optimization of surface SR in EDM using ANNs and genetic algorithm (GA). They conducted the experiments by varying the peak current and voltage and the corresponding values of SR were measured. Multi-perceptron neural network models were developed using Neuro Solutions software. GA concept is used to optimize the weighing factors of the network. There is considerable reduction in mean square error when the network is optimized with GA.

Atefi et al.[4] studied the influence of different EDM parameters such as pulse current, pulse voltage, pulse on-time, pulse off-time in finishing stage on MRR as a result of application copper electrode to hot work steel DIN1.2344. Full factorial experiments were chosen and statistical analysis has been carried out on MRR data gathered from the test. Appropriate ANN has been designed for the prediction MRR in finishing stage of hot work steel DIN1.2344. Finally for reducing the error in ANN, a hybrid model i.e. a combination of statistical analysis and ANN model has been designed.

Gao et al. [5] reported combination of ANN and GA to establish the parameter optimization model. They set up an ANN model with Levenberg-Marquardt algorithm represent the relationship between MRR and input parameters, and GA was used to optimize parameters, so that optimization results are obtained. The model is shown to be effective, and MRR is improved using optimized machining parameters. They concluded that the net has better generalization performance, and convergence speed is faster. GA was used to optimize parameters. MRR was improved by using optimized parameters. Fig. 2 shows regression analysis between train MRR and prediction.
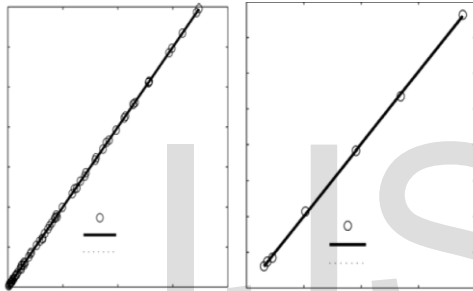

Fig. 2 (a) Regression analysis between train MRR and prediction (b) Regression analysis between check MRR and prediction [5]

Wang et al. [6] have employed a hybrid artificial neural network and Genetic Algorithm methodology for modelling and optimization of two responses i.e. MRR and SR of electro-discharge machining. To perform the ANN modelling and multi-objective optimization they have implemented a two-phase hybridization process. In the first phase, they have used GA as learning algorithm in multilayer feed-forward neural network architecture. In the second phase, they used the model equations obtained from ANN modelling as the fitness functions for the GA-based optimization. The optimization was implemented using Gene-Hunter. The ANN model optimized error for MRR and SR were found to be 5.60% and 4.98% which laid a conclusion for these two responses to accept the model. Fig. 3 gives the structure of the hybrid system at optimized phase.
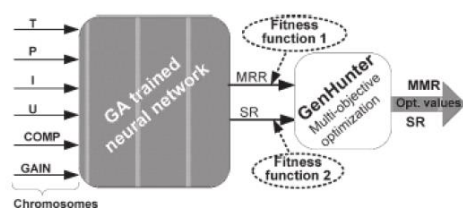

Fig. 3 Structure of hybrid system at optimized phase [6]

Mathew et al. [7] reported on the development of modelling and optimization for micro EDM process. ANN was used for analysing MRR to establish the parameter optimization model. A feed forward neural network with back propagation algorithm was trained to optimize the number of neurons and number of hidden layers to predict a better MRR. They concluded that low value of RMSE results in increasing model accuracy. Choice of important factors within the manufacturing process is very important because these factors determine performance. The results indicated that ANN model can be successfully applied to predict the machining response.
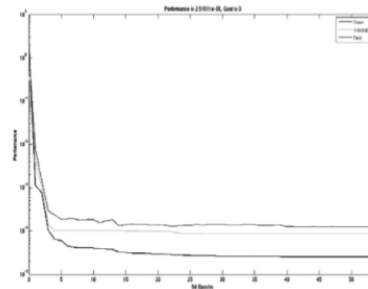

Fig. 2.15 Results of neural network training [22]

Fig. 4 Results of neural network training [7]

Steps of ANN in MATLAB

Following are the basic steps of ANN used in MATLAB [8]

a. Collection of input-output dataset
b. Pre-processing of input-output dataset
c. Neural network design and training
d. Performance evaluation of the neural network.

a. Collection of input and output data set: Output values in response to the different experimental combinations of input parameters obtained from the experiments are chosen. The capability of ANN model to generalize data depends on several factors such as appropriate selection of input-output parameters of the system, the distribution of the input-output dataset and the format of the presentation of the input-output dataset to the neural network.

b. Pre-processing of input-output dataset :Feed forward back propagation, 'newff', is the network structure with a Levenberg-Marquardt backpropagation training function, 'trainlm', and a backpropagation weight and bias learning function, 'learngdm'. A two-layer feed forward network is used as it can approximate any function with a finite number of discontinuities given sufficient neurons in the hidden layer. Samples obtained at the experimental stage were randomly divided into three groups to train (60% of the samples), validate (20% of the samples) and test (20% of the samples) the neural networks with a 'dividerand' data division function. Levenberg-Marquardt backpropagation algorithm automatically stops training when generalization ceases to improve, as an increase in the mean square error (MSE) of the validation samples indicates. Input processing functions used were 'fixunknowns', 'removeconstantrows' and 'mapminmax'. Tansig/purelinis the transfer function of the *i*th layer:

'tansig' for the hidden layer and 'purelin' for the output layer. The output processing functions used were'removeconstantrows' and 'mapminmax'. The learning rate and ratio to increase learning rate used here are 0.215 and 1.215 respectively.

c. Neural network design and training

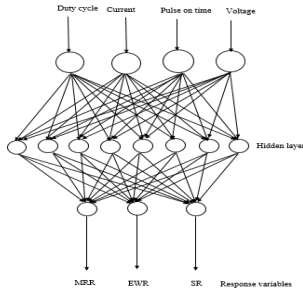The network architecture is an important factor, which affects prediction.

Fig. 5 Neural network Architecture

d. Performance evaluation of the neural network

Training performance of the optimum network architecture can be evaluated by the following measures. Equation 1 shows the formula for R^2.

$$R^2 = 1 - \left[\frac{\Sigma_j(t_j - O_j)^2}{\Sigma_j(O_j)^2} \right] \dots \text{Eqn (1)}$$

where,

t_j = Target value
O_j = Output value
$R2$ = Coefficient of determination
j = processing elements

ANN - Training

An ANN has to be designed and implemented in a way that the set of input data results into a desired output (either direct or by using a relaxation process). Several methods to quantify the strengths of the connections can be applied. In otherwords, the weights can be set explicitly (utilizing a priori knowledge) or the net can be trained by feeding learning patterns into the solution, and by letting the net change/adjust the weights according to some learning rule. Learning based solutions can be categorized as:

Supervised or associative learning.

Where the net is trained by quantifying input, as well as matching output patterns. These input/output pairs are either provided by an external teaching component, or by the net itself also known as self-supervised approach.

Unsupervised learning (self-organizing paradigm)

Where the net (output) unit is trained to respond to clusters of pattern within the input framework. In this paradigm, the system is supposed to discover statistically salient features of the input population. Compared to the supervised learning method, there is no a priori set of categories into which the patterns are to be classified, rather the system has to develop its own representation of the input stimuli.

Reinforcement Learning

In this method, the learning machine executes some action on the environment, and as a result, receives some feedback/response. The learning component grades its action (as either good or bad) based on the environmental response, and adjusts its parameters accordingly. Generally speaking, the parameter adjustment process is continued until an equilibrium state surfaces where no further adjustments are necessary.

An ANN reflects/represents a system of simple processing elements (neurons) that can exhibit complex, global behavior that is determined by the connections among the processing elements and the element parameters, respectively. Neural networks offer a number of advantages, including the ability to implicitly detect complex, nonlinear relationships among dependent and independent variables, the ability to detect all possible interactions between predictor variables, or the availability of multiple training algorithms. ANN based solutions have provided excellent results/insides into very complex problems in forecasting, data-mining, task scheduling, or optimized resource allocation problems.

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