

MODELING OF MACHINING PROCESS BY NEURAL NETWORK

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Abstract

Machining is one of the most important manufacturing processes. Machining is very complex process. In recent years, modeling techniques using neural network have attracted attention of practitioners and researchers. The learning ability of nonlinear relationship in a cutting operation without going deep into the mathematical complexity makes neural network an attractive alternative choice for many researchers to model cutting processes. This technique offers a cost effective alternative in modeling of machining process. This paper discusses the basic idea and gives the concept of neural network modeling of machining process.

Keywords: modeling, machining, neural networks.

INTRODUCTION

Modeling of machining process aimed at better understanding of machining process has attracted many researchers. As a result of modeling of machining process has been examined from different points of view and using different techniques. Great number of parameters, partially understood relations between parameters, complex, multidimensional, non-linear and stochastic nature of machining make modeling of machining process a considerable task.

In past 20 years a number of researchers successfully applied neural network based modeling of various machining processes. Neural network possesses many characteristics which makes them suitable for addressing such tasks. Despite many advantages that neural networks offer, modeling using neural networks is a quite complicated task, more precisely developing optimal neural network model. Despite the fact that neural networks have been widely implemented in many areas during the past years, there are still certain issues regarding the development of an optimal model. The most typical method followed is a repetitive trial-and-error process, during which, a large number of different architectures is examined and compared to one another.

MODELING OF MACHINING PROCESS

A model can be defined as an abstract system which is equivalent to the real system with respect to key properties and characteristics, and is used for investigations, calculations, explanations of demonstrations purposes, which would otherwise be expensive or not possible [1]. Modeling can be stated as a scientific way to study the process behaviors. Machining process models represent the relationship between two parameters which are decision variables (input parameters) and responses (output parameters).

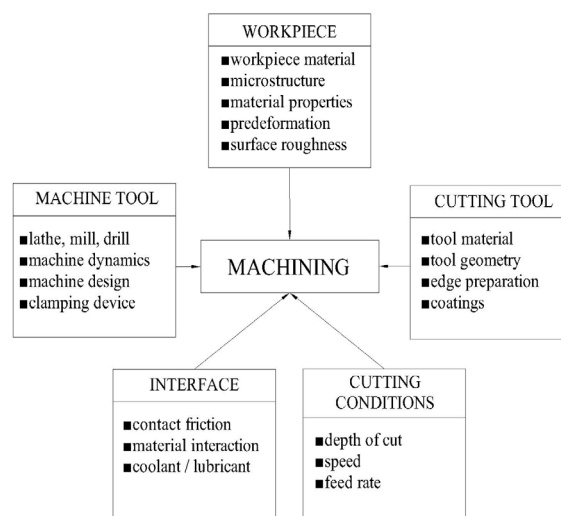


Fig.1. Parameters affected to machining process

Development of models to predict the values of decision variables and responses are important to have a better understanding of the machining processes.

In the field of machining very complex and highly nonlinear processes are involved. Machining processes are dependable on various known but also unknown parameters as well as on their interactions. The machining process is performed in the specific tribo-mechanical system consisting of five basic groups with associated elements (Fig. 1).

In machining process practically any parameter can be varied in a wide range. Nevertheless, in many cases, the true relationship between these parameters and the machining process is not fully understood. Because of the complicated relationships between the phenomena incorporated into the cutting model, the machining process is hard to be decomposed [2]. In Fig. 2 are shown performances of machining process.

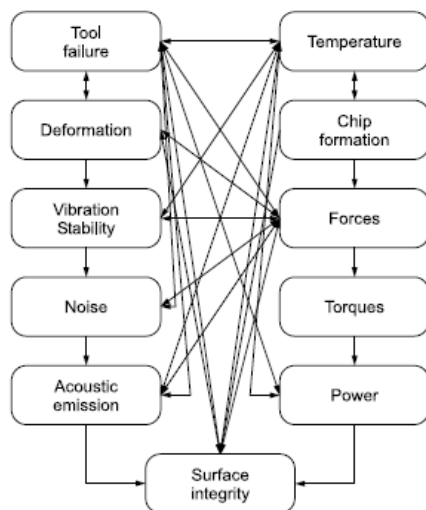


Fig. 2. Performances of machining process

For the past 50 years metal cutting researchers have developed many modeling techniques including analytical techniques, slip-line solutions, empirical approaches, finite element techniques etc.

Van Luttervelt et al. [3] have given the present state-of-the-art of the complex field of modelling and simulation of metal cutting processes and operations based on various types of sources with critical review on industrial applications of models. There are many different machining operations and for each of them different aspects can be modelled and

different techniques for modelling can be used. Consequently, there exist a wide variety of models dealing in one way or another with machining operations. According to [3] models are classified according to: type of operation, main purpose, predicted quantity, time of application and modeling technique. Taking into account the main purpose the models can be classified as: descriptive, predictive and learning. Taking into account the modelling technique the models can be classified as: empirical, semi-empirical and physical.

Machining process does not permit pure analytical physical modeling. Recently, semi-empirical models, developed using neural network (NN), have become the preferred trend which is applied by most researchers. Predictive models, which are capable of predicting quantitatively the influence of the magnitude of input parameters on the magnitude of output parameters, are of special importance in the machining area. Predictive modelling of machining process for practical applications would consist of two phases:

1. The development of models for machining parameters,
2. The development of models for machining performance.

Fundamental and applied modeling are shown in Fig. 3.

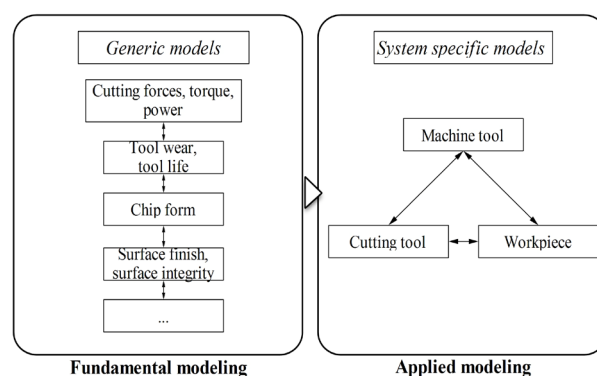


Fig. 3. Fundamental and applied modeling

The key parameters that the metal cutting practitioner finds valuable are [4]:

1. Prediction of tool life.
2. Prediction of the accuracy of the component being machined.
3. Prediction of surface finish of the component being machined.
4. Prediction of chip control.

MODELING OF MACHINING PROCESS USING NEURAL NETWORKS

In recent years, modeling techniques using neural networks have attracted attention of practitioners and researchers. These techniques offer a cost effective alternative in modeling of machining process. The learning ability of nonlinear relationship in a cutting operation without going deep into the mathematical complexity, or prior assumptions on the functional form of the relationship between inputs, in-process parameters and outputs makes neural network an attractive alternative choice for many researchers to model cutting processes [5].

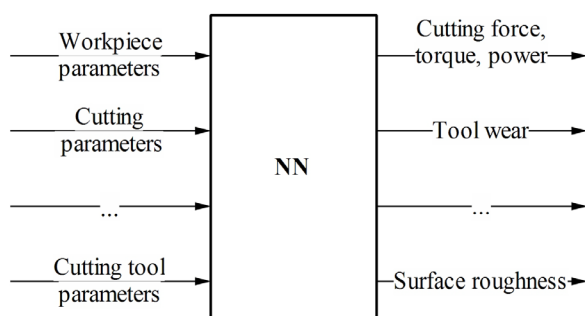


Fig. 4. Direct modeling by neural network

Generally, any parameter from the Fig. 1 can be regarded as machining process input parameter, while any of the parameters from the Fig. 2 can be selected as a machining process output parameter.

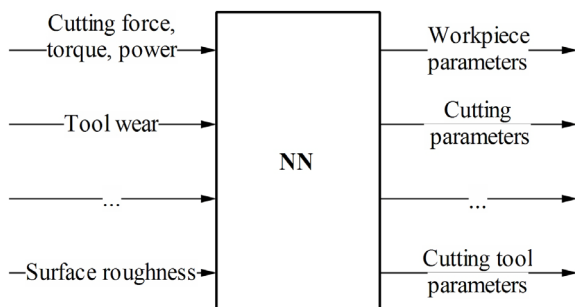


Fig. 5. Inverse modeling by neural network

In such a way, we have the situation where neural networks, as mapping tools, can be used for prediction of the performance parameters of machining as shown in Fig. 4. This type of modeling is often called direct modeling. Neural network can be used also in inverse modeling where input parameters are identified based on a given limitations for performance parameters (Fig. 5).

The practical application of neural network based machining models requires two stages as shown in Fig. 6. In the first stage (model developing stage), data are used by the neural network in order to develop a model. In the second stage, selected optimal model can be used for the prediction purposes.

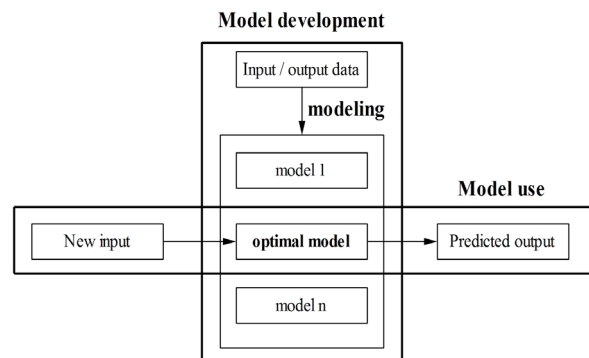


Fig. 6. Using neural network for modeling machining process

In order to speed up the process of searching for optimal or near optimal neural network parameters, one can use statistical techniques like Taguchi method, evolutionary strategies such as genetic algorithms as well as hybrid methods.

The prediction ability of neural network modeling could be further improved by integrating neural networks with genetic algorithms and fuzzy logic and thus creating hybrid models.

Reviewing the literature it could be seen that most used neural networks for modeling of machining process are: multilayer perceptrons (MLP) also known as multilayer feed forward networks, adaptive resonance theory models (ART), self-organizing maps (SOM), radial basis function network (RBFN), etc.

The most popular neural network for modeling machining processes is multilayer perceptrons (MLP) with back propagation (BP) learning algorithm. MLP with BP is adopted by most researches since MLP models are general-purpose models and have good generalization capabilities.

Nowadays, many papers have been published about modeling the machining process using neural network approach. The most of the models are for surface finish, dimensional deviation, tool life, tool wear and cutting forces, although there are some for other specific purposes. A review papers concerned with neural networks modeling of machining processes are [7], [8].

Table 1 shows some of the recent works related to neural networks modeling of three most applied conventional machining processes turning, milling and drilling.

Table 1. Recent application of neural networks in modeling of machining processes

Machining process	Modeling purpose	Neural network	Author (year)
Turning	Surface roughness	BP	Nalbant et al. (2009)
	Cutting force	BP	A.M.A. Al-Ahmari, (2007)
	Tool wear	MLP BP	Quiza R, Figueira L, Davim JP (2008)
Milling	Surface roughness	BP	Erzurumlu and Oktem (2007)
	Cutting force	BP	U. Zuperl et al. (2006)
	Tool wear	BP	P.Palasamy et al. (2008)
Drilling	Surface roughness	BP	Sanjay and Jyothi (2006)
	Drilling force	abductive NN	Lee BY, Liu HS, Tarng YS (1998)
	Tool wear	BP	Patra K, Pal SK, Bhattacharyya K (2007)

CONCLUSION

Basic ideas and concept of applying neural networks for modeling of machining process have been given. Numerous successful applications of neural networks based modeling in machining, showed a great potential of neural networks. However, modeling with neural networks is not a trivial task, since that there are no formal theories for determining, a priori, the optimal network model.

Methodology of neural network modeling comprised of two integral parts: model building phase and selection of neural network parameters. This is of crucial importance for developing neural network based prediction models. In order to speed up the process of searching for optimal or near optimal neural network parameters, one can use statistical techniques like Taguchi method, evolutionary strategies such as genetic algorithms as well as hybrid methods. The pre-

diction ability of neural network modeling could be further improved by integrating neural networks with genetic algorithms and fuzzy logic and thus creating hybrid models.

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