Application of artificial neural network for determination of standard time in machining

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Abstract The purpose of this article is to present the application of neural network for time per unit determination in small lot production in machining. A set of features considered as input vector and time consumption in manufacturing process was presented and treated as output of the neural net. A neural network was used as a machining model. Sensitivity analysis was made and proper topology of neural network was determined.

Keywords Neural network · Standard time · Machining · Sensitivity analysis

Introduction

One of the main problems in the activity of enterprises is determination of time and cost consumption of a production order of a new or modernized product. A manager should know the time consumption of a new product processing exactly before acceptance. Analytical time consumption methods require time and information about machining parameters; therefore it’s necessary to develop a new fast method used in the first steps of offer preparation. It seems useful to use a modern method of data analysis such as a neural network in this area of enterprise activity. An engineer samples time consumption of machining based on his experience, as well as the output data which is also related with his experience. A disadvantage of this method is connected with the reappraisalment of output data and overstated cost calculation, and finally lost or unprofitable contract.

Analysis of the existing methods of work measurement

There are a number of different techniques for work measurement, which can be either direct, where actual observations are made by workers (time study, activity sampling) or indirect comprising synthetic timing, analytical estimating and predetermined motion time systems (Muhlemann et al. 1993).

The most widely used of those is time study, which is a structured process of directly observing and measuring, using a timing device, human work in order to establish the time required for completion of the work by a qualified worker when working at a defined level of performance.

The next method of work measurement is activity sampling. This method was defined by British Standard as a technique in which a number of successive observations are made over a period time of one or a group of machines, processes or workers. Each observation records what is happening at that instant, and the percentage of time during which that activity or delay occurs.

It is not possible to use direct methods of work measurement for standard time setting of a new product processing before offering acceptance. These methods are applicable after the start up of new product processing.

Work content can be obtained before the task is actually carried out using indirect methods of work measurement.

In the synthetic timing the appropriate elements are identified and the time for the new work is established by adding the previously assessed times. Many organizations will build up books of tables of these times, entering new elements as they are discovered.

In the analytical estimating method the time required for the task is built up of synthetic data where possible, but supplemented where such data is not available for particular elements by estimations based on the best available knowledge and experience.
A predetermined motion time system breaks the work down into sets of basic human motions and, by combin-
ing those, any task can be synthesized (Muhlemann et al.
1993).

Those methods are not sufficient. Results of analytical estimating method application depend on human knowledge and experience, so different people obtain different results of time estimation. Synthetic timing method needs a lot of work to build up books of times. It is not easy to update those books. Predetermined motion time systems are labor consumption methods, so it is not often used in pre-production especially in small lot production.

It is necessary to develop a new method, which provides determination of time standards in a fast, easy to update and reasonable way. Production conditions are still changing. Many enterprises are trying to implement lean management, business process reengineering, etc., so it is necessary to develop a new, easy-to-use method of time calculation.

The application of modern data processing methods known as neural networks is promising in this area.

Nowadays, a process engineer may define the time needed for realization of a given technological operation even before order acceptance, making use of experience in comparing the new details with the previously made parts. Relating the results directly to the experience of the person defining specific labor demand is the basic drawback of this technique. It carries the risk of both under- and/or overestimation of duration of particular operation in the manufacturing process. As a consequence, the calculated costs may be overestimated and company’s offer risks to be rejected as unattractive. On the other hand, cost underestimation may be conducive to company’s losses while performing on unprofitable a con-
tract.

Neural network for data providing in manufacturing process organization

The neural networks have been used by number of research-
ers in the manufacturing area. Many manufacturing applica-

The time per unit for manufacturing operations is key data in manufacturing organization. The data is necessary for scheduling, productivity analysis, and cost calculation. Some authors (e.g. Jung 2002) use time standard as input on their research but this data was calculated by analytical methods. This paper presents a new approach to time stan-
dard setting by the use of neural networks. Until now there have been no methods which would provide time standard setting, in the same time for more than one machining opera-
tion in a production process. New approach presented in the paper gives such possibility. It is especially important in small lot production method.

Artificial neural network method for determination of time consumption in machining

This section attempts to provide guidelines for the training of NN to determine time consumption in machining. The three main issues, which will be addressed, are:

• Choice of the network type
• Determination of the input feature representation of the modeled process and determination of the training and verification set (sensitivity analysis)
• Evaluation of neural network prediction—regression anal-
ysis of neural network output

Choosing the network type

Artificial neural networks are electrical analogues of the biological neuron system. Two modules mathematically re-
present a typical artificial neuron: a linear activation and non-
linearity that limits the signal levels within a finite band. Neurons in an artificial neural net are connected in different topological configuration. The two most common types of configurations are feed-forward and feedback topology. Usually, a feed-forward network contains a number of layers, each layer consisting of a number of neurons. Signal propagation in such networks usually takes place in the for-
dward direction only, i.e. signals from the I-th layer can be propagated to any layer following the—Ith layer, for i ≥ 1. In the recurrent neural network, there exists feedback from one or more neurons to the other.

Informally, “encoding” or “learning” refers to adaptation of weights in a neural net. Thus, until the weights converge to a steady state value, the process of encoding is continued. Adaptation of weights can be accomplished in a neural net by different ways:

• supervised learning—employs a trainer, who provides the input–output training instances of the given neural net.
• unsupervised learning—unlike supervised learning, unsu-
ervised learning requires no teacher. Consequently, there are no target outputs. During the training phase, the neural net categorizes the received input patterns into different classes.
• competitive learning—competitive learning processes are usually represented as artificial neural systems with self-
existing recurrent connections.