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INVESTIGATION OF MACHINED SURFACES USING ARTIFICIAL INTELLIGENCE METHODS

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Abstract

Production and application of technical surfaces have a great importance in industry. Prediction of the surface quality or selection of the appropiate machining would be useful for both of the costumer and the producer. Two different methods are introduced in this paper for providing simple tools of the production of the required surface. Application of neural network and neuro-fuzzy methods can help to solve the aforementioned problem. The common result of the two parallel research is learning more about the surface production. These research were carried out with strong student assistance.

Keywords: Cutting processes, Surface roughness, Neural network, Fuzzy

Introduction

Realization of the required quality is the most important chalange faces the manufacturer. The new concept of quality control implies new methods not only inthe manufacturing but in the preparing of that, too. For machining the given surface quality it is necessary to select the cutting method, cutting parameters with considering the effects of the tool wear, vibration etc. Artificial intelligence methods have some special capabilities for handlin large amounts of information, out of which they build knowledge bases that are consulted during decision making. The experimental experiences are appiered as the structure orconstant multipliers of the mathematical realization of the method.

In particular, we are working with two methods which are capable to artificial intelligence. The first of these is Fuzzy Logic, which makes use of Fuzzy Sets and logical rules for processing and classifying data. The information is obtained then compared with some dynamic classes and inferences are made in accordance with this. The other method we are working on is based on parallel neural network architecture. This, in particular, is a network of processors, which are wired and adapted in such a way as to enhance their efficiency in solving the problem in question hand. [1]

The following two research were carried out in the Technical Universitz of Budapest, Department of Manufacturing Engineering with application Neuro-Fuzzy and ART neural network systems in order to solve the decision and selection problems using their learning ability.

1. Application of a neuro-fuzzy system for prediction of surface roughness

Fuzzy systems are considered to be a natural link between symbolic and subsymbolic approaches. On the one hand they can work in real-time circumstances and handle uncertainties as artificial neural networks, on the other hand they can manage both symbolic and numerical information. However, fuzzy systems usually do not incorporate automatic learning ability. It seems, best performance can prospectively be obtained by combining neural and fuzzy approaches, integratedtheir benefits. The resulting neuro-fuzzy system is a hybrid system, where the system architecture remains fuzzy, but using neural learning techniques, it can be trained automatically. [2]

1.1 The FuzzyTECH Development System

To solve the monitoring problem with the neuro-fuzzy approach we have chosen the WINDOWS version of the FuzzyTECH development system (INFORM GmbH, Aachen). This software fulfils the automatic feature selection, the ANN base learning and classification. Its main benefits are the following: [3]

- graphical development environment,
- arbitrary curved and linear membership functions,
- standard MAX-MIN/MAX-DOT and advanced FAM inference methods with compensatory operators,
- individual rule weighting,
- rule blocks,
- various defuzzification methods (Centre of Maximum, Centre of Minimum, Centre of Area, Mean of Maximum),
- off line simulation with graphic tools,
- real-time code generation, etc.

Through the Neuro-Fuzzy Module of the system degree of support (DoS) for rules and membership functions can be trained automatically using supervised learning technique with combines the idea of competitive learning and error back propagation. [4]

1.2 The investigated end mill cutters

We executed the test machining with four different end mill cutters:

1. FORCON normal cutter ϕ18 (The edge geometry is a simple straight line.)
2. Clarkson roughing cutter ϕ18 (The edge geometry is wavy, the waviness has radial direction.)
3. Clarkson finishing cutter ϕ18 (The straight edge line interrupted with grooves.)
4. Clarkson Crest Kut cutter ϕ20 (The edge geometry is also wavy, but the waviness direction is in the tangent plane.)

As the list shows the geometry of these cutters are different, and as the result of this difference the surface roughness would be also different, and the machining process itself has special characters in each case.

1.3 Experimental equipment

We used a VF22 vertical milling machine for the experiments. Our experimental setting up contains a KISTLER 9281B piezoelectric three-component force sensor, a KISTLER 9863A charge amplifier, a Brüel & Kjaer 4381 piezoelectric accelerometer and 2626 vibration preamplifier, a GOULD 1600 digital storage oscilloscope and a 386 type IBM PC with coprocessor. The workpiece material was structure steel (C45). We changed the cutting parameters, we used the all combination of the three different feed, revolution and depth of cut, separately.

1.4 The created fuzzy inference engine

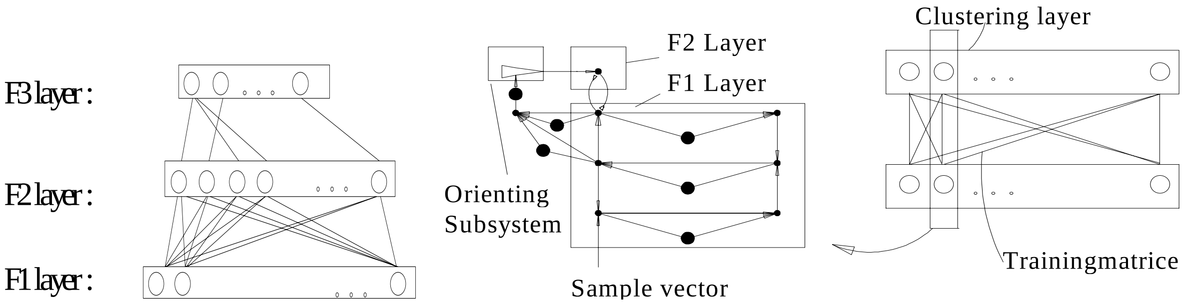
We gave in the neuro-fuzzy system the type of the tool, the measured cutting force perpendicular to the machining plane and vibration as inputs. As the result we expected the surface finish. The FuzzyTECH System created the all possible rules, and after giving the data gained from the test machining the neural learning module adjusted the membership functions and gave the best rules. We tried the rules and membership functions which we had got with some extra machining and the surface finish predicted the system was very close to the real one in any case [5]. Using this fuzzy inference engine we can monitor the machined finish without geometrical measuring during the cutting process, and we can avoid the waste products.

2. Application of ART neural network for recognition of the machining operation

The aim of this research was to try the applicability of the Adaptive Resonance Theory for recognition which machining operation produced the surface. If this application was successfuly finished the determination of the cutting parameters and other machining information could be possible, too. This is the final (long run) aim of the research.

2.1. Description of the ART neural network

In the research the modified version of the ART2 neural network was used [6,7], which is a type of the unsupervised neural network. It means that the network creates the clusters itself. In this application the characters of the machined surfaces were the inputs and the machining operations were the outputs of the network. Because of the given classes of the inputs and outputs the modification of the original method was necessary. There were two important changes in the method in order to solve the supervision of the training process. The first one was the handling of negative vector elements, the second one was the using of a new layer of neurons [8]. (see figure)



2.2. The surface roughness measurement method, and the characters

The investigated surfaces were machined metal surfaces. There are several different methods for measuring surface roughness, however the profil tracking method is used most frequently for measuring roughness of technical surfaces. The PERTH-O-GRAPH device was used which has a diamond point with 3μm nose radius. Unfortunately the measures of the surface roughness were in the same scale, the investigation would be more exact if more sensitive device was used. The measuring lenght was 10 mm in every case. the Perth-O-Graph gives five characteristic measures based on the DIN, these were R_p,R_v,R_a,R_s,R_t

In order to characterize the surface 3 different

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