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APPLICATIONS OF ARTIFICIAL INTTELEGENCE APPPROCH IN MACHINIG OPERATIONS

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Abstract: The increasingly advanced functions, high performance and high degree of accuracy, in machining process demands complex functional solution. Traditional ways are insufficient to meet these challenges. Nowadays, in the era of high end automation, manufacturing industries looking intelligent system to meet these challenges. Most of economical solutions advances with the development of electronic controllers, PLC, and microprocessor based programming. In this article attempt has been made to review various problems associated in marching of nonlinear responses and its intelligence scope towards solutions.

Keywords: AI methods, Machining, Manufacturing.

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1. INTRODUCTION

Process modeling and optimization are the two important issues in manufacturing products. The selection of optimal cutting parameters, like depth of cut, feed and speed, is a very important issue for every machining process. In workshop practice, cutting parameters are selected from machining databases or specialized handbooks, but the range given in these sources are actually starting values, and are not the optimal values [1]. Optimization of machining parameters not only increases the utility for machining economics, but also the product quality to a great extent. These challenges in machining operations can by artificial intelligence approach.

2. Various AI methods

The various methods developed to solve complex, nonlinear and heuristic nature of machining problems. Different techniques widely used as simulated annealing based optimization of machining process, particle swarm based machining process optimization, genetic algorithm based optimization of machining process, neural network and fuzzy based approach [1]. AI solutions are problem solving techniques of optimization for decision making.

2.1 Simulated annealing based optimization of machining process

In simulated annealing (SA) is a method, an exponential cooling schedule on the basis of Newtonian cooling process for the number of iterations (m) at each step. SA approaches the global maximization problem similar to using a bouncing ball that can bounce over mountains from valley to valley. It begins at a high "temperature" which enables the ball to make very high bounces, which helps it to bounce over any mountain to access any valley, given enough bounces. As the temperature declines the ball cannot bounce so high and it can also settle to become trapped in relatively small ranges of valleys. A generating distribution generates possible valleys or states to be explored. An acceptance distribution is also defined, which depends on the difference between the function value of the present generated valley to be explored and the last saved lowest valley [1]. The general SA algorithm involves the following three steps. First, the objective function corresponding to the energy function must be identified. Second, one must select a proper annealing scheme consisting of decreasing temperature with increasing of iterations. Third, a method of generating a neighbor near the current search position is needed.

Simulated annealing presents an optimization technique as (a) process cost functions possessing quite arbitrary degrees of nonlinearities, discontinuities, and stochasticity; (b) process quite arbitrary boundary conditions and constraints imposed on these cost functions; (c) be implemented quite easily with the degree of coding quite minimal relative to other nonlinear optimization algorithms; (d) statistically guarantee finding an optimal solution.

Simulated annealing combines a downhill search with a random search. In order not to be trapped in a locally optimum region, this procedure sometimes accepts movements in directions other than steepest ascend or descend. The acceptance of an uphill rather that a downhill direction is controlled by a sequence of random variables with a controlled probability. Simulated annealing (SA) is a powerful stochastic search method applicable to a wide range of problems for which little prior knowledge is available. It can produce high-quality solutions for hard combinatorial optimization [1]. A major advantage of SA is its flexibility and robustness as a global search method and good performance will be obtained when the size of problem is small. It can deal with highly nonlinear problems and non-differentiable functions as well as functions with multiple local optima.

2.2 Particle swarm based machining process optimization

Eberhart and Kennedy [2] suggested a particle swarm optimization (PSO) based on the analogy of swarm of bird and school of fish. The PSO mimics the behavior of individuals in a swarm to maximize the survival of the species. In PSO, each individual makes his decision using his own experience together with other individuals' experiences. The algorithm, which is based on a metaphor of social interaction, searches a space by adjusting the trajectories of moving points in a multidimensional space. The individual particles are drawn stochastically toward the position of present velocity of each individual, their own previous best performance, and the best previous performance of their neighbors. The main advantages of the PSO algorithm are summarized as: simple concept, easy implementation, robustness to control parameters, and computational efficiency when compared with mathematical algorithm and other heuristic optimization techniques Particle Swarm Intelligent technique combines social psychology principles in socio-cognition human agents and evolutionary computations. PSO has been motivated by the behavior of organisms, such as fish schooling and bird flocking. Generally, PSO is characterized as a simple concept, easy to implement, and computationally efficient. Unlike the other heuristic techniques, PSO has a flexible and well-balanced mechanism to enhance the global and local exploration abilities. Thus, a PSO algorithm can be employed to solve an optimization problem [1]. The basic PSO algorithm consists of three steps, namely, generating particles' positions and velocities, velocity update, and finally, position update and a particle refers to a point in the design space. The Swarm Intelligent is designed for optimization of four inputs, the feed (F), speed (V) depth of cut (D) and tool nose radius (R) and surface roughness (Ra) as output gives good relational agreement.

2.3 Genetic algorithm based optimization of machining process

GA is a search algorithm based on the hypothesis of natural selections and natural genetics also the GA is a parallel and global search technique that emulates natural genetic operations [3]. GA can find a global solution after sufficient iterations; GA-based approaches for optimization of machining parameters have several advantages. Naturally, they can treat the discrete variables and overcome the dimensionality problem. They have the capability to search for the quasi optimums within a reasonable computation time. To enhance GA‘s efficiency, an improved evolutionary direction operator (IEDO) modified from [4] and a migration operator [5] are embedded in GA to form the IGA. On the contrary, studies on evolutionary algorithms have shown that these methods can be efficiently used to eliminate most of the above-mentioned difficulties of classical methods [6]. The selection of optimal cutting parameters, like depth of cut, feed and speed, is a very important issue for every machining process. In workshop practice, cutting parameters are selected from machining databases or specialized handbooks, but the range given in these sources are actually starting values, and are not the optimal values [7]. In any optimization procedure, it is a crucial aspect to identify the output of chief importance, the so-called optimization objective or optimization criterion.

Three most important aspects of using GA are:

- Definition of objective function
- Definition and implementation of genetic representation
- Definition and implementation of genetic operators.

The GA has been used for optimization of surface roughness for the machining process. The basic operators in the GA include reproduction, crossover, and mutation. The input gains and output gain are taken as individuals in GA, and are represented by a binary string of length 200 with 50 bit for each individual.

Steps in Genetic Algorithm

- Create the initial population.
- Evaluate the fitness of each individual.
- Select the best individuals and perform recombination.
- Mutate the new generation.

Step1. If termination condition is not reached, go back to

Step2. The calculation can be terminated for example when a certain fitness level is reached or after a certain number of iterations are performed.

Step3. If it seems that the solutions will not get any better for a long time, it can be deduced that it is best to stop the calculation.

2.4 Neural network

Neural networks are non-linear mapping systems that consist of simple processors, which are called neurons, linked by weighted connections. Each neuron has inputs and generates an output that can be seen as the reflection of local information that is stored in connections. The output signal of a neuron is fed to other neurons as input signals via interconnections. Since the capability of a single neuron is limited, complex functions can be realized by connecting many neurons. It is widely reported that structure of neural network, representation of data, normalization of inputs– outputs and appropriate selection of activation functions have strong influence on the effectiveness and performance of the trained neural network [10]. Large number of researchers reported application of neural network models in tool condition monitoring and predictions of tool wear and tool life.

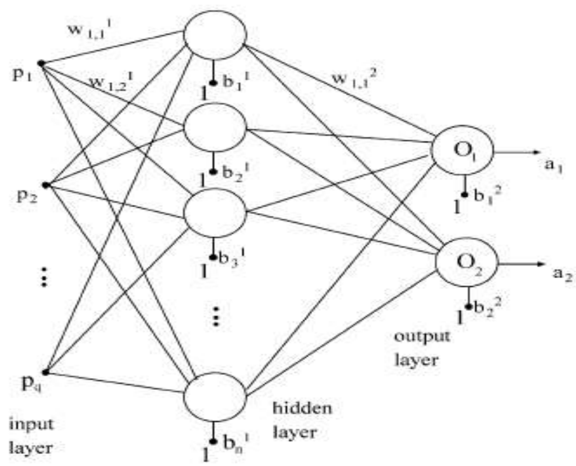

Figure: 1 Structure of a neural network.

Neural network models with cutting force inputs and a single output yielded better results than neural networks with two outputs, which predict surface roughness and tool wear together. Elanayar and Shin [11] proposed a model, which approximates flank and crater, wear propagation and their effects on cutting force by using radial basis function neural networks Liu and Altintas [12] derived an expression to calculate flank wear in terms of cutting force ratio and other machining parameters. The calculated flank wear, force ratio, feed rate and cutting speed are used as an input to a neural network to predict the flank wear in the next step. Azouzi and Guillot [13] examined the feasibility of neural network based sensor fusion technique to estimate the surface roughness and dimensional deviations during machining. This study concludes that depth of cut, feed rate, radial and z-axis cutting forces are the required information that should be fed into neural network models to predict the surface roughness successfully O¨ zel and Karpat [14] presented preliminary results for predicting surface roughness and tool wear using both regression analysis and neural network models in finish hard turning.

2.5 Fuzzy based approach

Fuzzy logic (FL) as an AI technique is mostly use for modeling of machining processes s to predict the surface roughness and various machining processes. FL considered for prediction, selection, monitoring, control and optimization of machining process. Maximum literature showed that milling contributed the highest number of machining operation that was modeled using FL. In terms of machining performance, surface roughness was mostly studied with FL model. In terms of fuzzy components, center of gravity method was mostly used to perform defuzzification, and triangular was mostly considered to perform membership function. The reviews extend the analysis on the abilities, limitations and effectual modifications of FL. The analysis leads to conclude that FL is the most popular AI techniques used in modeling of machining process. Fuzzy logic is flexible that makes easy to select suitable parameters. With any given system, it is easy to layer on more functionality without starting again from scratch. Fuzzy logic is tolerant of imprecise data that covers non addressed influencing factors of machining. Fuzzy reasoning builds this understanding into the process instead tacking it onto the end. It is possible to create a fuzzy system to match any set of input-output data.

The nine fuzzy control rules with linguistic grades for each attribute are constructed under the following considerations

RULE 1: If medium speed and low feed rate, then the surface roughness is excellent.

RULE 2: If low machining speed and medium feed rate, then the surface roughness is good.

RULE 3: If low machining speed and high feed rate, then the surface roughness is fair.

RULE 4: If medium speed and medium feed rate, then the surface roughness is fair.

RULE 5: If medium machining speed and high feed rate, then the surface roughness is poor.

RULE 6: If medium machining speed and low feed rate, then the surface roughness is good.

RULE 7: If high machining speed and high feed rate, then the surface roughness is worst.

RULE 8: If high machining speed and low feed rate, then the surface roughness is fair.

RULE 9: If high machining speed and medium feed rate, then the surface roughness is worst.

This process is made particularly easy by adaptive techniques like Adaptive Neuro-Fuzzy Inference Systems (ANFIS). The fuzzy rule combinations for various relational membership function as shown in figure 2. The triangular membership can be vary by sliding red line. Last column shows predictive of machining responses.

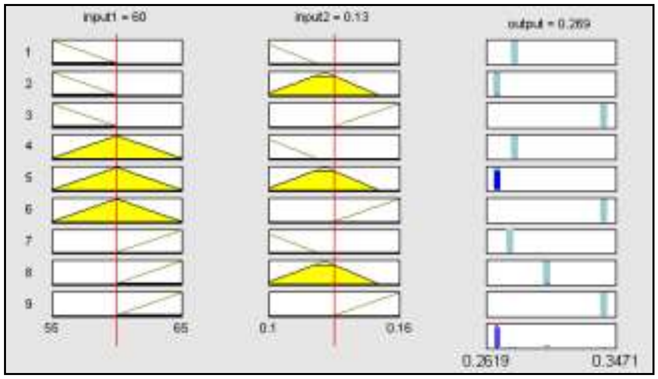

Figure 2: Rule viewer

3. AI scope in machining

The SA, PSO and GA mostly use to develop using MATLAB. For each evolutionary algorithmic method, optimum cutting conditions are provided to achieve better surface finish, metrical removal rate and to assess cutting force conditions. The computational results using SA gives solution procedure is quite capable in solving such complicated problems effectively and efficiently. Particle Swarm Optimization (PSO) is a relatively recent heuristic search method whose mechanics are inspired by the swarming or collaborative behavior of biological populations. From the results it has been observed that PSO provides better results and also more computationally efficient. Based on the results obtained using GA for the optimization of machining process, the proposed GA provides better results than the conventional GA [1]. The improved genetic algorithm incorporating a stochastic crossover technique and an artificial initial population scheme is developed to provide a faster search mechanism. The predictive model of ANFIS shows best agreement with response outcome of turning, milling and various machining process.

4. Conclusion

Besides, increasing demands for more efficient milling processes, qualified surface finishing, and odeling techniques have propelled the development of more effective modeling methods and approaches The PSO algorithm searches in parallel using a group of individuals similar to other AI-based heuristic optimization techniques. PSO gives better result than SA. The Fuzzy logic is conceptually easy to develop predictive model. The mathematical concepts behind fuzzy reasoning are very useful for costly machining process.

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