THE ADEQUATE TYPE OF FUNCTION FOR MODELING TOOL LIFE SELECTION
BY THE USE OF GENETIC ALGORITHMS

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Abstract: In this paper comparison between three types of functions for predicting tool life modeling is presented. Genetic algorithms as a means for optimizing those functions are used. Most accurate results obtained were when power function was used. Although it was most time consuming, it still is justified because obtained results are far more precise.

Key words: tool life, genetic algorithms, power function


Ključne reči: postojanost alata, genetski algoritmi, stepena funkcija

1. INTRODUCTION

Industry is making huge leaps forward on daily basis. Increasing demands putted are on precision, productivity and economy of process. Competition on market is unforgiving and sometimes not fair. Not only competition is putting pressure on producing companies but also so are buyers. To an average buyer, everything counts design, functionality, accuracy, time of delivery and most of all prices. If a company wants to meet all this requirements, it has to rationalize on every step during technological process. Extra expenses cannot be tolerated because it could turn out to be devastating regarding companies business. Cutting corners is present almost in every company on every step. Some of these made in right direction, for example learning to think on long runs or decreasing production times, but unfortunately, some of them made in wrong direction. Few of these examples could be: employing under qualified staff, buying materials that does not meet standards or basing working environment on non-human conditions. This article presents one use of artificial intelligence for cutting tool life prediction. Comparison of results presented for three types of modeling tool life. By being able to predict precisely tool life one can optimize cutting parameters and in that way increase efficiency of production, which will consequently lead to more competitive final product.

2. PREVIOUS WORK


3. MODELING FUNCTION

In the paper genetic algorithms used to, as a means for modeling tool life. Genetic algorithms present a powerful tool for space search. They are well known for theirs ability to find a global minimum for functions that otherwise would be impossible. They belong to a group of evolutionary algorithms. All these have one thing in common and that is that all they inspired by nature. Because of that, most expressions and terms were taken from biology as a science.

3.1 Genetic algorithms

Genetic algorithms were widely spread after popularization by a scientist John Holland in seventies, last century. Since they inspired by nature, way of finding minimum for given function is very simple; take two individuals with high fitness, mate them and most probably that you will produce an offspring with same or higher fitness. Almost like every principle found in nature, is simple yet surprisingly effective. This is the reason why this type of artificial intelligence selected. For purpose reviewed in this article, it doesn’t require much computational power nor time. It could easily were implemented in production sphere where it could save considerable amount of resources.
3.2 Tool life

For modeling of tool life, three different four factorial functions used:

\[ T = C \cdot e^{x_1 \cdot v + x_2 \cdot f + x_3 \cdot a + x_4 \cdot VB} \quad \cdots \cdots \cdots (1) \]

\[ T = C + x_1 \cdot v + x_2 \cdot f + x_3 \cdot a + x_4 \cdot VB \cdot \cdots \cdots \cdots (2) \]

and

\[ T = C \cdot v^{x_1} \cdot f^{x_2} \cdot a^{x_3} \cdot VB^{x_4} \quad \cdots \cdots \cdots (3) \]

In further text, function (1) is known as exponential, function (2) as linear and function (3) as power function.

Process of tool life modeling consist of finding coefficients C, x1, x2, x3, and x4 for which modeled tool life will be as close as possible to experimentally obtained values. In other words, every individual will consist of these five, real numbered values.

3.3. Fitness function

In order to be able to simulate “survival of the fittest” one must have a quantitative measure of every individual’s success rate. This quantitative measure provided by fitness function. In this case, it was defined as a sum of absolute deviations for modeled values and experimentally measured values of tool life.

Mathematical presentation of fitness function is:

\[ \Delta(j) = \sum_{i=1}^{25} \left| \frac{M(i,j) - P(i)}{P(i)} \right| \times 100\% \quad \cdots \cdots \cdots \cdots (4) \]

where M(i,j) is modeled value of tool life for i-th parameters combination and j-th individual, and P(i) is experimentally measured tool life for same parameters combination.

Table 1. Experimentally gathered data

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5. PRACTICAL REALIZATION

For practical realization of problem, software Matlab was used.

In first generation 50 individuals, with their values between 0 and 1, were randomly created. Afterwards they were ranked from highest to lowest by fitness value, and with roulette wheel method selected in the mating pool. Two of highest ranked individuals were automatically moved to next generation. This act is called elitism and it enables preservation of best genetic material. By crossover of two parents in the mating pool, 43 off springs are created. Heuristic crossover with rate of 1.6 was used because it was the only method which would yield successful results. Remaining 5 individuals, were created by mutating same amount of theirs predecessors. Uniform mutation was selected with slightly high rate of 0.2. This means that chances of mutating specific gene are 20 %. After 200 generations results were gathered in form of best individual which had these attributes:
Implementing these into exponential type of function, average absolute deviation for all 25 experiments was $E = 43.30\%$. Graphical comparison between simulated and experimentally gathered results is shown in Fig. 1.

Using the same settings linear function (2) was analyzed. Results were as follows:

$$
C = 13.9865 \\
x_1 = -3.5294 \\
x_2 = -28.6429 \\
x_3 = 0.2226 \\
x_4 = 73.0316
$$

Mentioned coefficients will produce an average absolute deviation of $E = 27.56\%$ which is a noticeable improvement compared to exponential type of function. Graphical presentation of these results can be found in Fig. 2.

At the end power function was analyzed (3). Same settings used with only difference that number of generation had to be increased to 500. Following coefficients generated:

$$
C = 701.407 \\
x_1 = -2.2661 \\
x_2 = -0.8211 \\
x_3 = 0.0865 \\
x_4 = 1.8512
$$

and graphical comparison between experimental and simulated data can be seen in Fig. 3.
6. CONCLUSION

As it can be seen form Fig. 1, Fig. 2 and Fig. 3, power function is most precise in tool life modeling. Although it takes 300 generations more to yield the best solution, this amount of time, measured in seconds, can be overlooked because result are far more better than the other types of functions. So if one would use genetic algorithms for predicting tool life, it is advisable to use power function.

Further research in this area would be to implement more real life factors that have influence on tool life duration. For example various cooling fluids and theirs effect could be observed and alternatively implement theirs effect in modeling function in form of coefficients.

7. REFERENCES


Authors: M.Sc. Vladimir Pucovsky, Prof. Dr. Pavel Kovac, Prof. Dr. Marian Tolnay1, M.Sc Borislav Savkovic, M.Sc Dragan Rodic, University of Novi Sad, Faculty of Technical Sciences, Institute for Production Engineering, Trg Dositeja Obradovica 6, 21000 Novi Sad, Serbia, Phone: +381 21 485-2324 E-mail: pucovsky@uns.ac.rs

povace@uns.ac.rs
savkovic@uns.ac.rs
rodicdr@uns.ac.rs

1 Slovak University of Technology in Bratislava, Faculty of Mechanical Engineering, Institute of manufacturing systems, environmental technology and quality management, Namestie slobody 17, 812 31 Bratislava, Slovakia

E-mail: marian.tolnay@stuba.sk

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