Annals of DAAAM for 2011 & Proceedings of the 22nd International DAAAM Symposium, Volume 22, No. 1, ISSN 1726-9679
ISBN 978-3-901509-83-4, Editor B. Katalinic, Published by DAAAM International, Vienna, Austria, EU, 2011
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Annals & Proceedings of DAAAM International 2011

OPTIMIZATION OF CUTTING TOOL PATH GENERATION USING GENETIC ALGORITHM

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Abstract: *Nowadays CAD /CAM systems have found wide application particularly in the field of metal cutting enableing control of tool path and generation of NC program.*
The aim of the present work is to optimize control of tool path generation by an approach using integrated Genetic Algorithm (GA) system. The main aim is to develop an intelligent CNC programming system for turning integrated in commercial CAD/CAM systems.
In this paper genetic algorithm (GA) for optimization of sequences of tool path generation by involving criteria to minimize processing time or production cost, is used.
Key words: *intelligent CNC programming, control of tool path, genetic algorithm*

1. INTRODUCTION

Recently, computer technologies are increasly and intensively used in modern manufacturing system. Intelligent CNC machines have been becoming a very popular tool to produce machine parts (Balic, 2006). The machine tools are operated by computer control device and the movements of cutting tool are directed operated by NC program. Optimization of tool path generation for linear interpolation and circular interpolation is realized by using a GA.

An NC program is ready to be incorporated on the CNC machine, when all logical and syntax errors in the program are corrected and final product also will be corrected in shape. In the Figure 1, is presented the abscise and ordinate which is used for linear interpolation ($x_0\, y_0$), … ,($x_n\, y_n$).

$$X_0 < X_1 < X_i, \dots , < X_{n-1} < X_n \qquad (1)$$

Where are:
X_0 – start point of X – axis,
X_n – end point of X – axis,
Y_0 – start point of Y – axis,
Y_n – end point of Y - axis.

When tool path realizes circular motion by code G02 – clockwise or G03 – opposite clockwise through known radius R, then should be required to define center of rotation (x_c, x_c). This case is defined by expressions:

$$(x_e - x_c)^2 + (y_e - y_c)^2 = R^2 \qquad (2)$$

$$(x_s - x_c)^2 + (y_s - y_c)^2 = R^2 \qquad (3)$$

In the Figure 2 is presented the tool path motion for circular interpolation or spline interpolation which is used to the complexity geometry of workpiece.

The main objective of tool path generation is to compute a sequence of cutter location points from the predicted surface. Various authors have given detail description and classification of various tool path generation methods.

Focus in the paper is on developing efficient methods of manufacturing data generation for NC turning and some of free form trajectories. A significant workpiece of the manufacturing data generation involves tool path generation. Specifically, a new technique for tool path generation that maximizes the material removal along the tool path and an integrated system for turning will be developed by using GA.

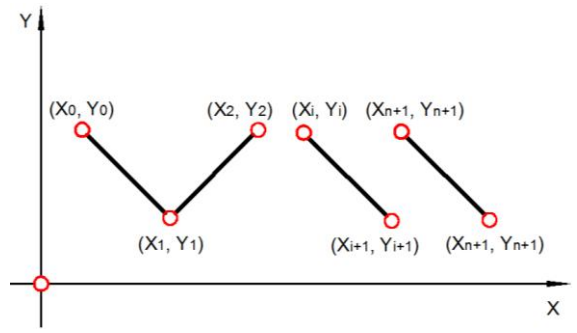

Fig.1. Tool path generation for linear interpolation

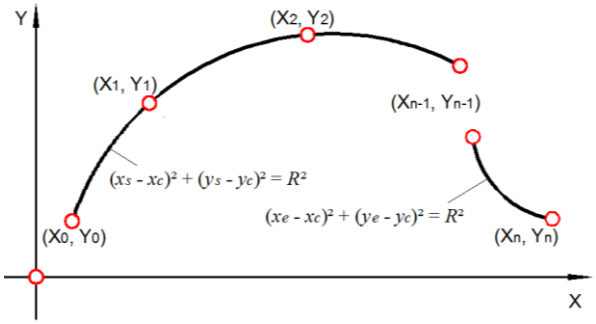

Fig. 2. Tool path generation for circular or spline interpolation

2. TOOL PATH OPTIMIZATION

The tool path generation, typically includes many line segments, each of them represents one linear movement of the cutter. For each linear movement, the start and end point will be accurately positioned. More line segments in the tool path will influence not only at many codes for NC machine but also will reflect in efficiency of production. Considering this, the method was developed to optimize the tool path by merging two successive line segments if they are nonlinear (Cus et al., 2003).

2.1 Development of algorithms

Development of an intelligent CNC programming by G - code and simulation of tool path is started by building some algorithms used for preparing the CNC programming. In the Figure 3 is presented the start process of turning operation with start and reference point.

The algorithm of tool path generation, concrete for turning and milling operation are presented below (Figure 4).

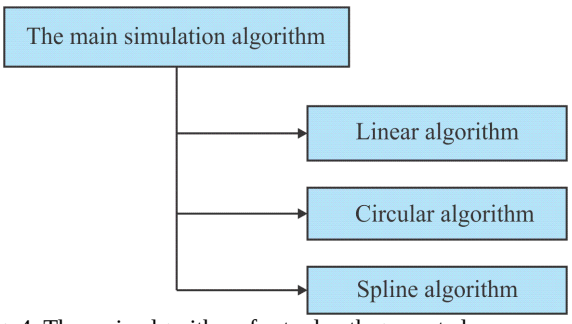

Fig. 4. The main algorithms for tool path generated

Tool path generated with G-code algorithm applies when G-code is detected. Circular tool path algorithm used when G02 or G03 are detected and the simulator determines which arc should be taken and drawn.

The circular tool path lines are generated based on idea an intelligent CNC programming model such as shown in the Figure 5 and with using of genetic algorithm it can be optimized the trajectory of tool path for each contour.

Programming of the same workpiece was done with newly developed Genetic Algorithm based system. Definition of raw workpiece, starting point and end point of tool movements are the same as in conventional CNC programming. After this definition the Genetic Algorithm process is started generating a set of CNC programs.

The main goal of Genetic Algorithm optimization is to generate the tool-path for machining of workpiece such as shown in figure. For its realisation it was needed: tool path for linear interpolation, tool path for circular interpolation and tool path generated for each spline interpolation. Each cut or tool path consists of several basic tool movements. The number of basic tool movements needed to produce the part that is a measure for efficiency of CNC programming system (Balic et al., 2006).

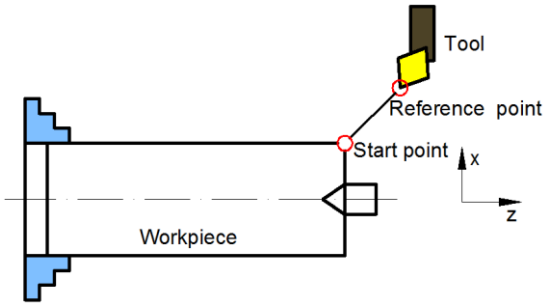

Fig. 3. Start process of turning operation

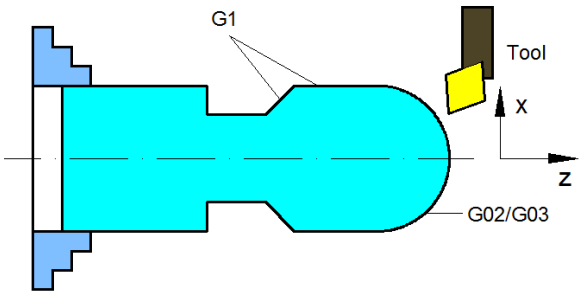

Fig. 5. Types of basic tool path generation

3. GENETIC ALGORITHM

Nowadays, the application of artificial intelligence such as the genetic algorithm for one NC program has been applied in the field of machining process. The Genetic Algorithm GA simulation adopts a repetitive process to find the tool path by following the natural selection rule of genetic evaluation. The repetitive process includes selection of mating couples, selection of hereditary individuals of the next generation, individuals crossover, individuals mutation and evolution.

In our Genetic Algorithm simulation, we will presented the individual expression in a two dimensional coordinates system X and Y axes (Ramli et al., 2009). In other words, by using the X and Y coordinates for a tool path generation (TPG), we express an individual P such as:

$$P_1 = (x_0 - y_0; x_1 - y_1 + \ldots + x_n - y_n) \quad (4)$$

$$P_2 = (x_s, x_c, R^2) \quad (5)$$

3.1 Fitness calculation

The fitness, F of each individual in the population is defined by the following:

$$F = CL_i, \quad (6)$$

Where CL is defined as the desired cutting length. Hence cutting length CL is calculated by the sum of an individual cutting length of each individual trajectory.

3.2.Crossever

Crossover operates on selected genes from parent chromo-somes A random number is generated between 1 and n. Figure 5 illustrates a parallel over where

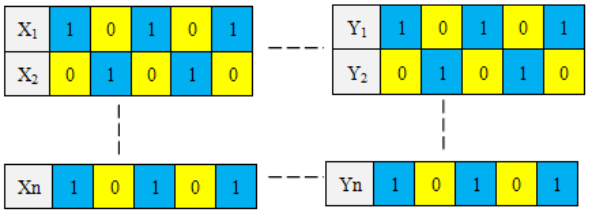

Fig. 6. Crossever

4. CONCLUSION

In this paper, the concept of optimization for tool path generation especially for turning process by ussing genetic algorithms is presented. Recently, from production process is required higher quality and accurate production. To achieve this request it is necessary to optimise tool path generation for being competitive in the market.

Hence, the development of the main algorithm consisted from: linear, circular and spline algorithm for solving problems with the application of genetic algorithm has contribute directly in optimise tool path generation in automatic and intelligent CNC programming systems.

5. REFERENCES

Balic J. (2006) *Intelligent CAD/CAM Systems for CNC Programming – An Overview*, Advances in Production Engineering & Management APEM Journal, 1, 13-22 ISSN 1854-6250

Balic J. Miha K. Bostjan V. (2006) Intelligent programming of CNC turning operations using genetic algorithm, Journal Intel. Manuf. 17:331–340 DOI 10.1007/s10845-005-0001-1

Cus F.; Balic J. (2003) *Optimization of Cutting processes by GA approach, Robotics* & Computer Integrated Manufacturing, 19, p9, ISSN: 0736-5845

Rizauddin. R.; Hidehiko Y.; Jaber A. Q. (2009) Tool path of lathe machine in flexible transfer lines by using genetic algorithms, Int. J. Production Economics 121 (2009) 72–80 ISSN**:** 0925-5273