Expert System to Real Time Control of Machining Processes*

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Abstract. Industrial machining processes use automated milling machines. These machines are connected to a control device that provides the basic instructions used to obtain a piece. However, these processes depend on the human decision to diagnose and correct in real time the inaccuracies that can occur. In this work we present an expert system to real time control of machining processes using the information provided by sensors located on the machine. This system has been implemented as a prototype in a Kondia 600 milling machine with a FAGOR 8025-MG control device.

1 Introduction

Industrial machining processes use automated milling machines. These machines are connected to a control device that provides the basic instructions used to obtain a piece. However, these controls are not capable of checking and correcting in real time the imprecisions that happen in the process; for its usual operation, the milling machines still depend on the human decision for the production and modification of its processes. This dependence implies a high consumption of technical resources, affects the quality of manufactured products and the manufacturing and fine tuning process time. All these circumstances motivate that the current work on optimization of industrial machining processes remains a partially solved problem. To deal with this limitation, it has been proposed as a solution the use of artificial intelligence techniques.

According to Kyung [6], Artificial Intelligence applications to machining processes can be grouped into the following categories: knowledge-based expert systems, neural networks, probabilistic inference methods and fuzzy logic and genetic

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algorithms. The difference between these approaches is the way how to represent the knowledge base in the system and its inference engine.

Early work on rule-based expert systems to control the machining process come from the late eighties, as in the case of Bohez [2], who developed the first prototype of an expert system based on 500 rules. Today they are also successfully implemented rule-based expert systems with the genetic algorithms approach [5].

Unlike expert systems where knowledge is made explicit, systems based on neural networks generate their own knowledge from case studies of network training. This means that such systems build the knowledge base through learning, and do not require additional processes of acquiring knowledge [3].

The probabilistic approach uses an influence diagram model with a probabilistic reasoning engine. The influence diagram is developed for the representation of complex problems where the decision is based on incomplete information belonging to several sources [8].

Another line of research are the adaptive controls. The aim of these devices is to control the process input variables using another ones that show the state of the process and must be monitored at all times. However, this architecture can not act in general on external parameters of the machine.

In this work we present an expert system based on production rules to control machining processes. This system is integrated into an interface from which information is collected from the machining process control device itself and sensors on the machine. The system diagnoses the state of the machining process and decides corrective actions to keep it within optimal parameters. The system performs a separate treatment of each datum provided, this allows both deactivation, such as adding new data sources. The system design minimizes the number of changes between successive runs, thereby reducing its response time.

2 Pilot Implementation

The system showed here was implemented on a Kondia 600 milling machine. This machine has a table that can move horizontally in both directions of the XY plane, with a swing jaw to fix the block to be processed, and a spindle that moves vertically, where the cutting tool is placed. It is equipped with a control unit 8025-MG FAGOR from which the cutting instructions needed to process a piece are provided. The machining process instructions are provided through a machining program that is stored in the control unit. While the machining program can not be modified during processing, the behavior of the machine can be altered modifying the machining table motion (also known as feed) and the spindle speed, indicating a reduction over the values provided by the machining program, or ultimately stopping the machine.

To capture real-time information about the process, the machining center has been equipped with several sensors: an infrared temperature sensor providing the cutting tool temperature; two vibration sensors that provide information about the spindle vibration in X direction and the milling table vibration in Y and Z directions; and a strength sensor located under the swing jaw, that provides information about the vertical strength exerted by the cutting tool on the block.