Chapter 13

An Integrated Design for a CNC Machine

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ABSTRACT

Computer Numerical Control (CNC) is a technology that converts coded instructions and numerical data into sequential actions that describe the motion of machine axes or the behavior of an end effector. Nowadays, CNC technology has been introduced to different stages of production, such as rapid prototyping, machining and finishing processes, testing, packaging, and warehousing. The main objective of this chapter is to introduce a methodology for design and implementation of a simple and low-cost educational CNC prototype. The machine consists of three independent axes driven by stepper motors through an open-loop control system. Output pulses from the parallel port of Personal Computer (PC) are used to drive the stepper motors after processing by an interface card. A flexible, responsive, and real-time Visual C# program is developed to control the motion of the machine axes. The integrated design proposed in this chapter can provide engineers and students in academic institutions with a simple foundation to efficiently build a CNC machine based on the available resources. Moreover, the proposed prototype can be used for educational purposes, demonstrations, and future research.

INTRODUCTION

Over the last 50 years, computer numerical control (CNC) technology has been one of the major developments in manufacturing (Nanfara et al., 1995). This led to a conspicuous impact in manufacturing processes. The implementation of numerical control (NC) has been developed from simple automatic positioning machines controlled by instruction on punched tape or floppy disk to computerized numerical control in which a microcomputer is used to perform all the numerical control tasks (Tseng et al., 1989). The rapid advancement in NC machine technology has been accelerated by dramatic increases in machine programming and computational control (Kolluri & Tseng, 1989). These advances have provided the manufacturing industry with a new
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and greater degree of freedom in designing and manufacturing different industrial products.

Xie et al. (2012) reviewed the concept, development status and trend of the NC machining simulation technology. Moreover, Xie et al. (2012) emphatically introduced the key technologies of the NC machining simulation technology including the geometric modeling technology, NC code translation, entity collision detection and the material removal process simulation.

Due to this new freedom, along with other related enhancements, significant changes in manufacturing methodologies have been adopted such as the use of computer aided manufacturing and flexible manufacturing systems. The part program for a product manufactured by CNC machines is a very important stage in the manufacturing process. Therefore, many techniques have been developed to generate CNC part programs, for example using developed software and computer aided design/manufacturing (CAD/CAM) systems (Mansour, 2002; Choy & Chan, 2003). Wang et al. (2011) reported the implementation and preliminary evaluation of an intelligent CNC lathe based on the assessment of existing strategy of intelligent machine tool design. Cui et al. (2012) investigated a framework of an error compensation software system. This software system is able to realize software error compensation via NC programs reconstructing. Computer vision has been recently used in many applications in the field of production engineering. These applications include laser cutting, defect analysis, sheet metal cutting, reverse engineering (Huang & Motavalli, 1994), tool wear assessment (Kurada & Bradley, 1997), feature recognition (Tuttle et al., 1998) and stress homogeneity (Chen et al., 2013). Satishkumar and Asokan (2008) outlined the development of an optimization strategy to determine the optimum cutting parameters for CNC multitool drilling system. Chen and Lee (2011) used the grey relational analysis to find the optimal values of parameters of the servo drives and the controller of a five-axis CNC tool grinder in order to improve precision of grinding and accuracy of end mills. Wang (2011) proposed a new CNC system for ultrasonic vibration drilling based on the in-depth study of embedded systems technology and characteristics of the ultrasonic vibration drilling process. Naithani and Chauhan (2012) reviewed the literature regarding ‘machining parameter optimization’ for turning operation in CNC machines.

Due to the development of machine design and drive technology, modern CNC machines can be described to an increasingly extent as a characteristic example of complex mechatronic systems. A distinguishing feature of a mechatronic system is the achievement of system functionality through intensive integration of electrical and information (software) sub-functions on a mechanical carrier (Reinhart & Weissenberger, 1999). El Ouafi et al. (2000) presented a new approach to improve the accuracy of multi-axis CNC machines through software compensation of geometric, thermal and dynamic errors. Larson and Cheng (2000) developed a Web-based interactive cam design package which initially developed as a teaching and learning tool for educational use in an undergraduate Computer-Aided Mechanism Design course. Balic et al. (2006) proposed a computer-aided, intelligent and genetic algorithm (GA) based programming system for CNC cutting tools selection, tool sequences planning and optimization of cutting conditions. Álvares et al. (2008) described the implementation of an integrated web-based CAD/CAPP/CAM system for the remote design and manufacture of feature-based cylindrical parts and provided some examples illustrating the remote design, process planning, and manufacture of parts in a CNC turning center. Mokhtar et al. (2009) discussed the machining precedence of interactive and non-interactive STEP-NC features. Ülker et al. (2009) introduced a ‘system software’ based on a new artificial intelligence (AI) tool, called artificial immune systems (AIS). It is implemented using C programming language on a PC and can be used as an integrated module of a CNC machine
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