An Educational Scheme for a CNC Drilling Machine

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ABSTRACT

Computer numerical control (CNC) involves machines controlled by electronic systems designed to accept numerical data and other instructions, usually in a coded form. CNC machines are more productive than conventional equipment and consequently produce parts at less cost and higher accuracy even when the higher investment is considered. This article proposes an educational scheme for designing a CNC machine for drilling printed circuit boards (PCB) holes with small diameters. The machine consists of three-independently move-fully controlled tables. Output pulses from the personal computer (PC) parallel port are used to control the machine after processing by an interface card. A flexible, responsive and real-time visual C# program is developed to control the motion of the stepper motors. The educational scheme proposed in this article can provide engineers and students in academic institutions with a simple foundation to efficiently build a CNC machine based on the available resources.

Keywords: Computer Numerical Control, Interface, Parallel Port, Stepper Motor, Visual C#

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 and greater degree of freedom in designing and manufacturing different industrial products. 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. Computer vision has been recently used in many applications in the field of production engineering. These applications include lace cutting, defect analysis, sheet metal cutting, reverse engineering (Huang & Mota-valli, 1994), tool wear assessment (Kurada & Bradley, 1997), and feature recognition (Tuttle et al., 1998). Satishkumar and Asokan (2008) outlined the development of an optimization strategy to determine the optimum cutting parameters for CNC multi-tool 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.

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 tool. Bi et al. (2011) proposed some useful geometric modeling techniques in the CNC simulation field. Afzeri et al. (2011) introduced the methodology of machining technology for direct remote operation of networked milling machine.

Along with the dramatic advancement in technology and aggressive marketing competition, CNC technology has attracted much research and scientific work because of its widespread applications in different manufacturing processes. The academic institutes play a vital role in providing students and engineers with a solid foundation of CNC technology research and knowledge. Due to the restrictions on some resources such as the budget, space, and operating cost, the capital-invest system such as CNC machines are infeasible or hardly available for many academic institutes. One possible alternative for the lack of hands-on system is the development of educational schemes for building CNC machines based on the available resources. Such schemes can serve as an effective and convenient tool for both research and instructions. Moreover, these educational schemes stand as a flexible integrated system for studying design strategies, manufacturing techniques, interface systems and programming development (Tseng et al., 1989).
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