DEVELOPMENT OF VIRTUAL COMPONENT TECHNOLOGY-BASED CNC SYSTEM FOR ISO 6983 DATA INTERFACE MODEL

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**A thesis submitted
in fulfillment of the requirements for the degree of
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DECLARATION

I declare that this Choose an item. entitled " Development of Visual Component Technology Based CNC System for ISO 6983 Data Interface Model" is the result of my own research except as cited in the references. The Choose an item. has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : HAMDAN SYAKIRIN BIN MD AMIR

Date : 18 JANUARY 2022

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Manufacturing Engineering Technology with Honours Engineering Technology (BMMW) with Honours.

Signature : ....

Supervisor Name : *TS. DR. KAMRAN LATIF*

Date : 28-01-2022

DEDICATION

This research paper is wholeheartedly dedicated to my dearest parents Norizah Binti Othman and Md Amir Bin Ahmad, who have extremely been willing to support me mentally and physically and have been my source of strength and inspiration for me to accomplish my report. Thank you for always being by my side. Next, to all my family members and friends, thank you for helping me, encouraging me and also supporting me to complete the research. Lack of support and help from them, I might not be able to accomplish my thesis on time. Lastly, my sincere appreciation to my supervisor and panels for guiding, helping as well as giving me the knowledge to complete this thesis throughout the project.

ABSTRACT

This paper reports development of a visual component technology-based CNC machine system for the ISO 6983 data interface model. This can do three-axis simultaneous interpolation. Today's fast-paced CNC machines are governed by the ISO 6983 data interface model, which was already deemed a poor script, and diverse CNC programs are generally viewed as owing to reliance on manufacturer requirements. Most of the existing systems are high cost and black box in nature. This is most likely because of these robots' remarkable capability. The goal of this project is to create a low-cost, portable machine using the characteristics of a conventional PC interface as well as an ATMEGA 328 microprocessor CNC system in an Arduino. This device also has an offline G-Code parser that is read via a USB and instead interpreted just on the microcontroller. The primary goal of this study is to create a three-axis soft CNC motion control system for a three-axis milling machine that incorporates virtual components to carry out ISO 6983. An interpreter is a software model that interprets input code according to the mechanical properties of a CNC machine. The method that is used in this project is LabView software where it can interpret the G-Code and run the machine to create the design. The result has been shown that the G-Code running smoothly and no error while machine doing the process. This project can improve the quality of the machine, the need to reduce human errors, reduce wastage and maintain high quality and precision are some intrinsic properties driving the potential volume for CNC milling machine.

ABSTRAK

Kertas ini membentangkankan perubahan sistem mesin CNC berasaskan teknologi visual untuk model antara muka data ISO 6983. Ia boleh dilakukan interpolasi tiga paksi serentak. Mesin pantas CNC hari ini dikawal oleh model yang mengawal data ISO 6983, yang sudah dianggap skrip yang lama, dan pelbagai program CNC umumnya dilihat sebagai bergantung kepada keperluan pengeluar. Kebanyakan sistem yang sedia ada adalah kos yang tinggi dan kotak hitam dalam alam semula jadi. Ini kemungkinan besar karena kemampuan luar biasa robot ini. Matlamat projek ini adalah untuk mewujudkan mesin CNC kos rendah dan mudah alih menggunakan ciri-ciri antara muka PC konvensional serta sistem CNC mikroprosesor ATMEGA 328 di Arduino. Peranti ini juga mempunyai penghuraian G-Kod luar talian yang dibaca melalui USB dan sebaliknya ditafsirkan hanya pada microcontroller. Matlamat utama kajian ini adalah untuk mewujudkan tiga paksi sistem kawalan pergerakan CNC sistem untuk tiga paksi mesin pengilang yang menggabungkan komponen visual untuk menjalankan ISO 6983. Penterjemahan model perisian adalah yang mentafsirkan kod input mengikut sifat-sifat mekanikal mesin CNC. Hasilnya telah menunjukkan bahawa G-Code berjalan lancar dan tiada ralat semasa mesin melakukan proses. Projek ini boleh meningkatkan kualiti mesin, keperluan untuk mengurangkan kesilapan manusia, mengurangkan pembaziran dan mengekalkan kualiti dan ketepatan yang tinggi serta beberapa sifat intrinsik yang mendorong potensi volum untuk mesin pengilangan CNC.

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LIST OF SYMBOLS AND ABBREVIATIONS

D,d	-	Diameter
ISO	-	International Standards Organization
CNC	-	Computer Numerical Control
CAD	-	Computer Aided Design
CAM	-	Computer Aided Manufacturing
NC	-	Numerical Control
	-	
	-	

CHAPTER 1

INTRODUCTION

1.0 Background

The Computer Numerical Control (CNC) machines are based on a method that employs minicomputers to create, interpret, and implement progressive control. These machines, which were first created in the 1970s, use computers to replace Numerical Control (NC) (Correa, Toro and Ferreira, 2018). The CNC computer's most important component is the controller, which is made up of two parts which are software and hardware. The interpreter is the controller's software component that converts the International Standards Organization (ISO) data interface model instructions to hardware instructions (Latif, Yusof, Latif, *et al.*, 2017)

Today's fast paced CNC machines are governed by the ISO 6983 data interface model, which was already deemed a poor script, and diverse CNC programs are generally viewed as owing to reliance on manufacturer requirements. Overall, the world's accelerated industrialization necessitates greater CNC versatility. In other, worldwide during the past CNC aims to make it more adaptable, open, interoperable, and informative (Iliyas Ahmad *et al.*, 2020). One of the most significant problems of vendor specification dependence was seen in modern commercial CNC systems are encountered in the race to develop next generation CNCs. The majority of new systems are costly and have a back-end nature. According to (Aktan *et al.*, 2016), CNC controllers are included in the majority of today's devices for CNC machine tools that are supplied as a black box by control suppliers, making it problematic for machine tool builders to rapidly create and execute new ideas or customized control functions.

Most of the CNC devices are configured using the ISO 6983 G and M code languages. The ISO 6983 data interface model is commonly used in numerical control apparatus manufacturing processes. CNC machines use the ISO 6983 data interface format, commonly referred to as G-code. As a consequence of these additions, component programmed cause problems with machine interchangeability. Following proposed instructions render more machine-specific G-code, but they are not included in ISO 6983. Since their development, these machine tools have progressed in a wide range of applications, including milling, spinning, grinding, tube welding, and cutting robots, using simple to cutting-edge CNC techniques (Magdum *et al.*, 2018).

CNC computers also have a wide range of capabilities, such as multi-axis control and using many processes production. CNC system has exhibited cost-effective mass, bunch, as well as several more solitary manufacturing scenarios. Fast production speed, product uniformity, lower component deprivation, reduced replacement parts costs, less operator interference, and ease of convoluted form machining are a few of the major factors that contribute to CNC technology's economic viability (Latif and Yusof, 2016).

Each vendor has its own set of specifications, compatibility between component programmed is due to the manufacturing shop floor programming must adhere to the ISO 6983 G&M code for, various development data, such as machining design elements, machining mechanism, and machining military hardware, cutting equipment, machining experience (Manu *et al.*, 2018). Besides, function information, can be left out of the component software or even lost. Adaptable manufacturing has grown in popularity in the 1970s and 1980s as part of the transition to more modern systems, to permit batch processing in small quantities of a diverse variety of components. Because of their ability to be reprogrammed to produce various components, CNC machines have become a vital manufacturing resource in order to achieve modular manufacturing (Manu *et al.*, 2018).

According to the IEEE concept (Covert, 2020), a framework that requires features that allow accurately deployed applications to run on a range of platforms from several vendors, interoperate through other methods, applications, and demonstrate consistency in style of user interaction (Gao *et al.*, 2010). In other words, Open Architecture Control is a concept that arose from the need for versatility in a computer-assisted environment. There is a variety of hardware implementation and networking, together with advanced NC programming technologies in the latest generation growth of the CNC system (Majda and Powałka, 2017).

A new-found approach of ISO data model analysis has been implemented, which is based on the Laboratory Virtual Instrument Engineering Workbench (LabVIEW) framework (Yusof and Latif, 2016). Although CNC motion control methods based on LabVIEW software had been implemented in previous approaches (Sang and Xu, 2017), none had used the LabVIEW software framework for ISO data model interpretation. According to (Yusof and Latif, 2016) several areas must be focused on for the implementation of these types of systems. Therefore, the CNC controller element of software, also referred to as a translator for ISO 6983 data interface model will be discussed in this study. The experiment has been done successfully and each design takes around 18 to 25 minutes to finish the cutting process. These three different designs of different tool path strategies to check the machine execution.

1.1 Problem Statement

The CNC machinery has been proven to be cost-effective in mass, batch, and several other single item manufacturing scenarios. The majority of significant contributors to the commercial viability of CNC technology are fast production speeds, product uniformity, decreased feature denial, less expensive equipment, a smaller amount of machinist intervention, and ease of machining convoluted forms (Lin, 2018). The limitation of CNC Milling was the sizing axis coordination and size of tool bit. This model cannot meet the demands of today's manufacturing environment. The majority of the existing systems are high cost and black-box in nature.

Workers might still press the wrong buttons, create incorrect orientations, and misplace pieces on a jig. Operator mistake might contribute to machine accuracy issues. (Latif, Yusof, Nassehi, *et al.*, 2017). As a consequence, developing and implementing custom control functions for machine tool builders is extremely challenging (Sang and Xu, 2017). As a result, this system is complete in terms of both hardware and software such as the Human Machine Interface (HMI) platform, input/output functionality, networking, data interface model, and so on. Unsurprisingly, every producer of machine tools uses patented hardware and software. Consequently, this form of proprietary controller model prevents the customer from independently installing and interfacing indigenously new designed or commercially purchased functional modules to improve the machine's functionality. In addition, milling machines are far more expensive than manual devices. The first expenditure for these robots is thought to be prohibitively expensive. They also require high maintenance costs and can be expensive to repair. CNC machinery does not eliminate the need for expensive tools. They also necessitate significant maintenance expenditures and might be costly to fix. The use of CNC technology sometimes doesn't eradicate the necessity for costly tools.

To address these concerns, open-architecture control technologies strive to create independent controllers of the manufacturer's skill, accepting the customer to purchase hardware and software from a variety of vendors and easily build the equipment they have purchased.

1.2 Research Objective

This research aimed to develop of virtual component technology-based CNC system for ISO 6983 data interface model. Three objectives were set up to attain the goals of this research. The objectives were:

- To develop a three-axis soft CNC motion control system for a three-axis milling machine incorporating virtual components to execute ISO 6983.
- To integrate a development system using a three-axis CNC milling machine to implement the production method.
- To test system experiments to be used validate the production framework.

1.3 Scope of Research

The Scope of this research are as follows:

- Only influences the motion of a three-axis milling unit.
- Only a Windows-based problem has been exacerbated.
- Just operate with the GRBL controller, which appears to be able the hardware using G-Code.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

Through this part, the investigator discusses and focuses on related hypotheses of the development of an ISO 6983 data interface model-based CNC system based on virtual component technology. Many scientific initiatives that can be linked to this initiative were mentioned in the literature review. The knowledge acquisition of an ISO 6983 data interface model-based CNC system and more evidence correlated is depicted from the available journals, conference papers, thesis, book and other sources. The highlights concerning this research are processed in the subtopics of this chapter.

2.1 Insight of CNC Machine

CNC is the computerization of system tools that are managed via computer programmes to produce a certain product shape. Computer-aided design (CAD) and computer-aided manufacturing (CAM) programmes are employed in advanced CNC applications to build product designs. The programmes generate a computer file, which is then processed by a post processor to retrieve the instructions required to run a specific machine and inserted through CNC machines for output (Aktan *et al.*, 2016).

Most of the CNC devices are configured using the ISO 6983 G and M code languages. The ISO 6983 data interface standard is commonly used in numerical control apparatus manufacturing processes. CNC machines use the ISO 6983 data interface format, also referred to as G-code. Since their development, these machine tools have progressed in a wide range of applications, including milling, spinning, grinding, tube welding, and cutting robots. During this project, CNC Milling Machine has been chosen.

2.2 Elements of CNC System

The main parts of the CNC machine are Input Devices, Machine Control Unit (MCU), Machine Tool, Driving System, Feedback System and display unit.

i. Input Devices

The input devices are employed in the input of the component programme in the CNC machine. Three input devices are commonly used such as a punch tape reader, magnetic tape reader and computer via RS-232-C communication.

ii. Machine Control Unit (MCU)

The CNC machine's main component is the Machine Control Unit (MCU). The CNC machine's control is handled entirely by the MCU. Among the MCU's functions are:

- It decodes the encoded data that is supplied into it.
- It interprets the ciphered command.
- It employs statistical approaches such as linear, circular, and helical to create axis motion commands.
- It sends axis motion commands towards the amplifier circuits, which then drives the axis systems.
- It retrieves position and speed feedback signals for each driving axis.

iii. Machine Tool

A CNC machine tool will always be equipped with a sliding table as well as a spindle for controlling direction and velocity. The X and Y axes of the machine table are controlled, while the Z axis of the spindle is handled.

iv. Driving System

A CNC machine's driving system is made up of circuit elements, drive motors, and ball lead screws. The MCU sends signals toward the amplifier circuits indicating the position and velocity for every axis. The commands are then amplified in order to activate the drive motors. The ball lead screw is then rotated by the actuating drive motors to align the machine table.

v. Feedback System

Transducers that function as detectors make up the feedback system. It is often mentioned as a measurement method. It is equipped with position and speed sensors that constantly monitor the direction and velocity of the cutting tool at all times. The signs in those sensors are received by the MCU, and the difference seen between reference and information signals is used to produce command indicators for rectifying speed and location faults.

vi. Demonstration Unit

The CNC machine's programming, instructions, and other important data are shown on a panel.

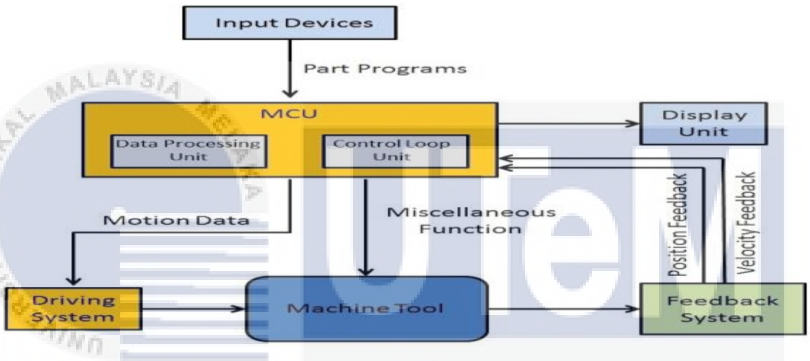

Figure 1 shows the Flow Process of CNC Machine

[Source: (The Complete CNC Guide', 2020)]

Figure 1 depicts the block diagram of a CNC machine. That the very first objective is to develop and input the G and M code part programme through the CNC machine's Machine Control Unit. All data processing occurs in the MCU, and it creates all motion commands and transmits them to the drive system based on the programme that has been developed. The drive system eventually operates while the MCU transmits motion orders. The drive system regulates the motion and velocity among its mechanical system. The referral program measures the machine tool's location and speed and delivers an input command toward the MCU. The response shows a displayed in the following information in the MCU, and whether there are mistakes, the MCU fixes problems and directs fresh signals toward the machine tool so that the successful implementation may take place. The output device serves also as the machine's eye, allowing it to view all instructions, programmes, and some other essential functions.

2.3 Type of CNC Machine

CNC machines are categorized as follows:

i. CNC Laser Cutting Machine

Figure 2 shows CNC Laser Cutting Machine

A laser that uses for this machine technology to vaporize materials, resulting in a cut edge. Laser cutting is accomplished by concentrating the output of a strong laser, very frequently using optics. A movement control unit is used by a commercial laser for cutting materials to match a CNC or G-code of the shape to either be cut it on substance. The CNC is used to guide the substance or laser beam produced. Because there is no cutting edge that could be polluted either by a substance or contaminate the material, the benefits of laser cutting involve simpler operation handling and less infection of the product.

ii. CNC Lathe Machine

Figure 3 shows CNC Lathe Machine