DESIGN AND DEVELOPMENT OF WIRELESS CONTROLLER FOR CNC MACHINING

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ABSTRACT

The computer numerical controlled (CNC) machines have become important element in manufacturing process development. The technology of the control CNC machining is not only for remote monitoring and adjustments in the production process only, but also the production plans are in line to be achieved. Wireless technologies can support both of the user needs and also provide the cost-effective solutions. This way, the initial solution for the engineers to use CNC (Computer Numerical Control) to run a manufacturing program is by using wireless controller. This wireless controller for CNC machine, using a concept that allow the user to sit at the computer (sometimes called client) and controls or remote the other computer machine (sometimes called Host) in different location without used any wire through it. This thesis is focus on controlling 3 axes controller and automated gripper controller during machining process in CNC machining. The project that assigns "Design and Development of a Wireless Controller for CNC Machining", it used a remote desktop application for Windows 7 and Windows XP. It is quite common for a remote desktop application to be used to control a host computer that is far from the client, connected only via the Internet. This project also used a Visual Basic programming in developing to control 3 axes and an automated gripper CNC machine. Program of controller 3 axes and automated gripper will be control by using execute programming method. Execution in computer and software engineering is the process by which a computer or a virtual machine such as CNC machine carries out the instructions of a computer program. Instructions in the wireless controller will trigger the sequences of 3 axes controller program action, to execute program in CNC machine. Those actions produce effects according to the instructions in the controller CNC machine program. From this project, the criteria in the selection aid focus in type of nature of control requirement by the application such as wireless controller for windows based and verify the wireless controller for CNC machining setup.
ABSTRAK

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CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

The manufacturing process has already undergone significantly
processes changes during the past two decades. The main contribution of these
changes has been the implementation of numerical control (NC) in
manufacturing machines, that has evolve from simple automatic positioning
machines to a computerized numerical control functions (CNC). Computerized
numerical control (CNC) is a microcomputer that used to perform all the
numerical control functions. [1] The computer numerical controlled (CNC)
machines have become important element in manufacturing process
development.

The technology of the control CNC machining is not only for remote
monitoring and adjustments in the production process only, but also the
production plans are in line to be achieved. [4] Therefore, in order to improve
the performance in machining process, many demands in order to improve the
control performance have been presented. [2]

There are demand in order to improve the performance in CNC
machining, one of the way is by using wireless controller for CNC machining.
The reliability of new wireless CNC technologies, and the public acceptance or
wireless systems, manufactures are going change their CNC machine controller
to be wireless.
Wireless process control has been a popular topic recently in the field of industrial control. [3] Wireless technologies can support both of the user needs and also provide the cost-effective solutions. This way, wireless is being adopted for many new applications such as connect computers, allow remote monitoring, provides access control and to provide a solution for environments where wires may not be the best solution [8].

1.2 PROBLEM STATEMENT

At present, the rapid development of network and communication has produced some changes. It also brings changes to the intelligent machine that has been formed distributed, and it is an unstoppable in trend of the development of manufacturing technology. [5] The increase in demand for a convenient manufacturing environment, were solved by using wireless controller in CNC machining. [6] The problems that have been encountered by this project are:

1. Disadvantage of wired.

2. Wireless coverage.

3. Difficulty to integrate of different operating system (OS).
1.3 PROJECT OBJECTIVE

The objectives of this project are:

1. Design and develop a wireless controller for CNC machining.
2. Verify the function ability of the wireless controller in CNC machining.

1.4 SCOPE OF PROJECT

1. Design a wireless controller system for CNC machine using Remote Desktop.
2. Wireless controller is for windows based CNC machine only.
3. Testing and verify the wireless controller for CNC machining setup.
CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will review of the historical background of the project study which is about the CNC machining controlled by wireless and the method of study involved. In this literature review also will briefing the earlier work undertaken from the journal research.

2.2 CNC Machines

A computer numerical control (CNC) machining system has been developed. The system in CNC machine has several of axes, a microprocessor, system software and automatically programmed tools (APT) processor. The CNC system is designed to include fundamental features with simple software format and small scale construction. An APT processor is developed, which can be used to link a geometric file devised by a commercial computer aided design software package to the CNC machine. [1]
The computer numerical controlled (CNC) machines in modern manufacturing systems have become important elements. The CNC machines generally can divide into two parts: the mechanical parts with servo drive system and the servo controller that control the multi-axis motion of the mechanical parts. [2] In general, the CNC machine is composed of the X-Y table and Z-axis motion mechanism. Where each of motion axes is driven by an individual actuator system.

The evolution of CNC machine technology has been paced by dramatic increases in machine programming and controlled capabilities. All these advances have given the manufacturing industry ability to exercise a new and greater degree of freedom in the designing and manufacturing products. [1]

2.3 Control System

The control system is important in engineering field, and it is a device or set of the device to control, manage, command, direct or regulated behavior of other device or system. A control system consist of subsystem and process (or plants) assembled for the purpose of obtaining a desired output with desired performance, given a specified input. [3]

The importance in modern manufacturing of CNC machine, such as machine tools cannot be overstated. The machine tool is supported by servo system that provides two fundamental functions that was regulation and maneuvering. The control of a servo mechanism of CNC aided machines is fundamental yet important, because it coordinates multiple feed axes to track a three-dimensional tool path accurately to ensure the quality of work piece. [9]

The regulation function is required to maintain the controlled object at a desired position in the presences of external distribution in maneuvering control,
the motion can be classified in two cases point to point (PTP) and countering (or tracking) when controlled object is moved along a prescribed trajectory. In PTP control the final positioning accuracy and the transition time are important while the transient path is of secondary importance. Positioning a drill bit in machining center is a typical example of PTP controller. In tracking control, the controlled object must be moved along a desired trajectory and the error during transient must also be minimized. Example of tracking control is can be found in milling operation such as machining in circular work-piece. [8]

In this system, controlled using conventional system should be updated to accommodate the needs of customer in manufacturing sector. Therefore, the CNC machining controlled by wireless system has been introduced to increase the capabilities production rate to be more efficient in the production factory.

2.4 Wireless Technology

Wireless technologies represent a rapidly emerging area growth and importance for providing all over access to the network for all of their users. Home users, students and professionals increasingly want to not bind network access in from general-purpose rooms, meeting rooms, auditoriums, and even the hallways of all kinds of buildings. Recently, the industry has made significant progress in resolving some constraints to the widespread adoption of wireless technologies. [4]

Some of the constraints have included disparate standards, low bandwidth, and high infrastructure and service cost. Wireless technologies can both support the user needs and provide cost-effective solutions. This way, wireless is being adopted for many new applications: to connect computers, to allow remote monitoring and data acquisition, to provide access control and security, and to provide a solution for environments where wires may not be the
best solution. What follows is an overview of existing wireless technologies and related issues. [7]

2.4.1 Communication medium

As wired communications utilize a physical conductor (copper or optic fiber) to connecting the transmitter and receiver for transmit information from one place (or places) to another electrically, wireless utilize electromagnetic waves as the communication medium. Thus, wireless communication involves radio frequency communication, microwave communication, and infrared short-range communication to maintain communication channels between its devices. [7]

2.4.2 Communication mode

Devices in a wireless network are set up to either communicate indirectly through a central place or directly, one to the other. The first is called “Infrastructure Mode”, which requires one or more base stations or access points where all communication will be intermediated. [14] The other is called “Ad Hoc Mode”, which does not require any access points, once user devices communicate directly with each other in a peer-to-peer manner [7], as shown in the Figure 2.1.

Figure 2.1: Typical configuration of a wireless network: A) Ad Hoc Mode and B) Infrastructure Mode [7]
Since there is no need to purchase or install access points, Ad Hoc Mode involves a cost savings and rapid setup time. Regarding the question of performance, in an Ad Hoc WLAN (Wireless Local Area Network) can be higher than in an infrastructure WLAN because of no need for packets to travel through an access point. [7]

Nevertheless, this assumes a relatively small number of users, otherwise the amount of interference for all computers will increase, and since each one is trying to use the same frequency channel. Therefore, for a larger enterprise where there is a strong need to access applications and servers on a wired network, it is required the use of multiple access points to separate users onto non overlapping channels to reduce medium access contention and collisions. [10]

2.4.3 Wireless local area networks

Wireless Local Area Networks (WLAN) are implemented as an extension to wired LANs within a building and can provide the final few meters of connectivity between a wired network and the mobile user.[7] WLAN configurations vary from simple, independent, peer-to-peer connections between a set of PCs, to more complex, intra-building infrastructure networks. [15]

WLANs are based on the IEEE 802.11 standard, which in 1997; the IEEE released as the first internationally sanctioned standard for wireless LANs, defining 1 and 2 Mbps speeds. In September 1999, they ratified the 802.11b “High Rate” amendment to the standard, which added two higher speeds (5.5 and 11 Mbps) to 802.11, operating in the unlicensed industrial, scientific and medical (ISM) band at 2.4 GHz.[7]

The basic architecture, features and services of 802.11b are defined by the original 802.11 standard, with changes made only to the physical layer. These changes result in higher data rates and more robust connectivity. [11]
2.4.4 Bluetooth

Bluetooth is a technology specification for small form factor, low-cost, short-range wireless links between mobile PCs, mobile phones, and other portable handheld devices, and connectivity to the Internet. Bluetooth enables electronic devices connect and communicate wirelessly through short-range, ad hoc networks known as piconets. Each device can simultaneously communicate with up to seven other devices within a single piconet. Each device can also belong to several piconets simultaneously. Piconets are established dynamically and automatically as Bluetooth enabled devices enter and leave radio proximity. [7]

A fundamental Bluetooth wireless technology strength is the ability to simultaneously handle both data and voice transmissions. This enables users to enjoy variety of innovative solutions such as a hands-free headset for voice calls, printing and fax capabilities, and synchronizing PDA, laptop, and mobile phone applications to name a few. [5]

Bluetooth operates in the unlicensed industrial, scientific and medical (ISM) band at 2.4 to 2.485 GHz, with data rate up to 3 Mbps. The operating range depends on the device class, varying between 10 an 30 meters in most common mobile devices, and between 10 and 100 meters primarily in industrial use cases [12]
2.4.5 Wireless Devices

To setup a wireless network it depends on what the scale of the network that needed. Nevertheless, the basic wireless devices required are the access point and the wireless network interface card (NIC), as follows:

- **Access Point (AP):** This piece of hardware acts as a bridge between the wired network and wireless devices. It allows multiple devices to connect through it to gain access to the network. An AP can also act as a router; a means by which the data transmission can be extended and passed from one access point to another. [7]

- **Wireless Network Interface Card (NIC):** A wireless network card is required on each device on a wireless network. A laptop usually has an expansion (PCMCIA) slot which the network card would fit in to. A desktop computer would need an internal card which will usually have a small antenna or an external antenna on it. These antennas are optional on most equipment and they help to increase the signal on the card. These two basic wireless devices, which are shown in Figure 2.2, allow communication between plenty of mobile devices such as: laptops, notebooks, tablets, PDA’s, Smartphone’s and 3G cards. [7]

![Figure 2.2: Two basic wireless devices: A) Access Point and B) Wireless Network Interface Card](image)
2.4.6 Wireless Important Issues

As with any relatively new technology, there are many issues that affect implementation and utilization of wireless networks. There are both common and specific issues depending on the type of wireless network. Some of the common factors include electromagnetic interference and physical obstacles that limit coverage of wireless networks, while others are more specific, such as standards, data security, throughput and easiness of use.

2.4.7 Wireless Coverage

An important issue for wireless technology is coverage. Coverage mainly depends on the output power of the transmitter (wireless card or access point), its location and frequency used to transmit data.[17] For example, lower frequencies are more forgiving when it comes to physical obstacles (walls, stairways, etc.), while high frequencies require clear line of sight. For each particular application, throughput decreases as distance from the transmitter or access point increases.

2.5 Wireless in Manufacturing System

Present basis of knowledge management is the efficient share of information. The challenges that modern industrial processes have to face are the multimedia information gathering and system integration, through large investments and adopting new technologies. Driven by a notable commercial interest, wireless networks like GSM or IEEE 802.11 are now the focus of industrial attention, because they provide numerous benefits, such as low cost, fast deployment and the ability to develop new applications. However, wireless nets must satisfy industrial requisites such as scalability, flexibility, high
availability, immunity to interference, security and many others that are crucial in hazardous and noisy environments. [13]

The automatic data collection aided by CNC machine like monitoring and supervision systems, adds precision and control improvements into decision-making process. Such improvements of production mass stimulate more and more the introduction of new technologies into the productive process. In this context, wireless technology is poised to advance manufacture management’s ability to control and monitor the CNC machine events as they occur. As wireless technology can add a significant degree of independence in a manufacturing operation, workers can access part and process specifications from locations where wired networks are impractical. Thus, adding wireless capability on the factory, it is possible to increase production efficiency and employee productivity, besides being proper to constant manufacture factory layout changes. [7]

The introduction of computer numerical control (CNC) machines and direct numerical control (DNC) networking or communication, radically changed the manufacturing industry. Since the CNC machine controllers are capable of executing programs stored in their available memory without operator intervention, the number of machining steps that required human action have been dramatically reduced. Adding wireless capability on the factory, it is possible to simplify installation, eliminate cabling, and make machine tools mobile with wireless networking. [13]

These cable-free machines can be moved at will anywhere within that facility. Regarding the network and DNC configuration it depends on the current network infrastructure, security policies, and factory usage. The options vary depending partly on the capabilities of the firewall being used and the IP architecture.

Another solution is to have the DNC server and the CNC programs on the secure office LAN and just the CNC machines on the wireless shop-floor manufacturing network. And a third option is to use a firewall to completely separate the wireless shop-floor network from the office network.[3] The DNC server is dual homed (two network cards) to allow access to both the wireless shop-floor network and the office LAN. Unlike other conventional, expensive
shop-floor data collection systems, the employees do not have to walk over to a fixed computer workstation and physically type in their information, leaving room for errors, and the loss of valuable production time. In case the current method of data collection is manual, wireless technology allied to automatic shopfloor data collection, eliminates the manual identification sheets, which are frequently damaged, lost, or misplaced. [18]

Besides the WLAN’s, an alternate is the use of Bluetooth serial ports at the CNC, where the operator does not have to physically connect a wire from the CNC to the notebook, eliminating grounding problems and tripping on the cable. Using encryption and spread spectrum technology it can be assured security and interference resistance to the wireless network. Thus, the deployment of wireless on the shop floor gives flexibility that saves time and drives down costs while providing secure, mobile access to the networks. This way, it is possible to increase shop efficiency and employee productivity. [7]

2.6 Remote Controlled in CNC Machining

Remote control and remote access by wireless for many new CNC machines become a standard features. Over any network or the internet is enables to real-time remote and monitoring of unattended CNC machines. This capability is convince to control and monitor machines from anywhere with several benefit that increased productivity and profitability through decreased machine downtime, service and training costs. The device is used by seamlessly integrates into common network using a standard LAN and wireless router. The CNC machines functions via the Internet, so that machine can be operated to manipulate the process, regardless of the distances to the actual machine. [7]

Remote control and remote access can also be explained as a remote control of a computer by using another device connected via the internet or another network. This is widely used by many computer manufacturers and large businesses' help desks for technical troubleshooting of their customers' problems. There are various professional first-party, third-party, open source,
and freeware remote desktop applications, some of which are cross-platform across various versions of Windows, Mac OS X, UNIX, and Linux. The project that assigns "Design and Development of a Wireless Controller for CNC Machining", it used a remote desktop application for Windows 7 and Windows XP.

The remote desktop work requires that the client, or "master," and remote, also called the "slave" or host, computers be connected to the same network. This remote desktop network can be wired or wireless. Wired networks can use direct connections or connections through routers, while wireless networks can be formed using routers or the Internet. It is quite common for a remote desktop application to be used to control a host computer that is far from the client, connected only via the Internet.

The controlling computer displays a copy of the image received from the controlled computer's display screen. The copy is updated on a timed interval, or when a change on screen is noticed by the remote control software. The software on the controlling computer transmits its own keyboard and mouse activity to the controlled computer, where the remote control software implements these actions. The controlled computer then behaves as if the actions were performed directly at that computer. In many cases the local display and input devices can be disabled so that the remote session cannot be viewed or interfered with. [7]

The capability of remote desktop is convince to control and monitor machines from anywhere with several benefit among these are, increased productivity and amazing convenience with the ability to control and monitor machines from anywhere. It also profitability through decreased machine downtime, service and training cost. [13]
2.7 Remote Desktop Development

At this stage will develop a wireless controller, to be ensured that CNC prototype machine capable of functioning and fully controlled by a computer (master) without using any cable through it. For the first, window (computing) is the base of operating system in basic computer. There are several types of sturdy window that can be use in this project, which are Window XP and Window 7.

To meet the demand in wireless controller of the modern environment now, it is more practical when using Window 7 as a master computer for controlling the slave computer Windows XP.

2.7.1 Remote Desktop

The remote desktop is an application that allows the user to controlling the desktop. Remote desktop is an application that allows users to control the desktop. It certainly has the ability to control the entire content from a computer (master) to a second computer (slave) or machine.

This application gives the “master” computer superiority accessing to all of the contents on the remote computer, and often provides features like file transfer and control programming to the other computer without using any wires. One version of the remote desktop application comes standard with all new Windows computers, but the other versions furthermore available for operating system (OS) as for Mac and Linux and as well as between systems, such as Linux and Windows.