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# Industrial CAD-CAM System Based Remote Manufacturing Process Using Raspberry Pi Web Server

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**Abstract:** Information and communication technology could transfer industrial manufacturing to a new era with more services such as remote control and process monitoring. In this research, an approach of industrial machine process control based web server has been designed and implemented as an Industrial Internet of Thing Technology (IIoT). Raspberry Pi has been used for connection of the CNC machine to the internet and monitor the process in real time. A remote controller for mini CNC machine based on the internet has been designed and implemented comprising of the Grbl 0.9 J as a core element in controlling the motion of mini CNC machine. The web page has been designed using html, Java script and Node Package Manger (NPM). All packages and libraries used to implement the web are open source. A case study of designing and manufacturing system by UG-NX11 package to generate the G-code which is uploaded to the CNC milling machine web page through a CNC.JS WEB library. Also, a live webcam has been used to monitor the process of manufacturing.

**Key words:** Mini CNC, IIoT, Grbl 0.9 J, CNC.JS WEB, Raspberry Pi 3, packages

## INTRODUCTION

With the advanced in information and communication technology and its use in manufacturing system such as Computer Numerical Machine (CNC) the overall performance of such system has been increased rapidly (Aldeen *et al*., 2017). The supervision and control of manufacturing process based an internal is consider one of the key element of Industry 4.0 such technology is the Internet of Thing Services (IoTS) which offer services using the internet, more precisely, the Industrial Internet of Thing (IIoT) has becoming increasingly more growing topic in industry. The IIoT compound together intelligent machine, system analytic and monitoring. By doing so, the system would be more efficient, production and performance (Zhong *et al*., 2017). In particular networking technology and convergence networking based internet technology, this construction opens the manufacturing technology called e-mfg. Electronic manufacturing by collaborative reserach, especially for activates developed during the product developed cycle. This allow the developers to share information for CAD-CAM during product development (Alvares and Ferreira, 2008).

In this reserach, a web page has been designed using HTML5, JavaScript and node.js as a framework for rendering the HTML template web in python. The manufactured product is designed and using UG-NX11 package and the generated G-code is uploaded to the webpage at the CNC machine side a Raspberry Pi 3 is used as gateway and a host server for the web page which can provide the CNC machine by the uploaded information. Figure 1 shows a schematic diagram of the proposed remote controller system.

Recently, researchers have focus on the use of information and communication technology manufacturing processing and monitoring due to rapid development of cloud based internet of thing application. Hanwu and Yueming (2009) has introduced a virtual package based on VRML and web browser which has been applied for simulate of manufacturing method. A custom web application which control and monitor the process has been proposed by Radelja *et al*. (2012). Sheng *et al*. (2012) have developed a wireless data acquisition using lab view. Yu *et al*. (2013) proposed an interactive simulator web based for milling center to monitoring the performance of machine based on internet. Nehete and Bhide (2017) used a Raspberry Pi 3 as a server to monitor the performance of the manufacturing process globally. Merchant and Ahire (2017) introduced combination of industrial workstation and automated based on (IIoT) where a Raspberry Pi as server and controller.

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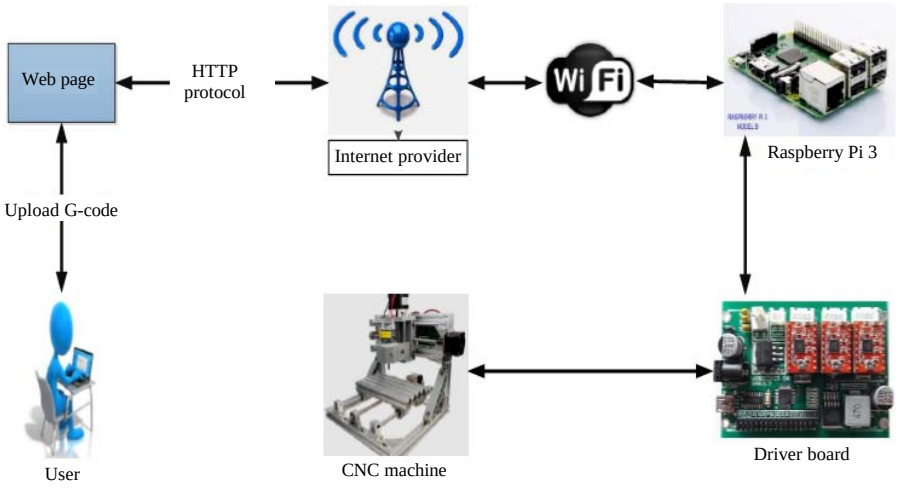


Fig. 1: Block diagram design of wireless controller system

## MATERIALS AND METHODS

**System description:** Figure 1 described the proposed web based hardware implementation manufacturing system consists of three main parts above, the proposed system consists of which are.

**Raspberry Pi:** Is single board card computer with facility to add a key board, mouse, display micro SD card with pre-installed operating system such as Linux distribution. This type of computers has a WiFi based IEEE 802.11 and a Bluetooth connectivity protocols. In this research, a Raspberry Pi 3 is used with Raspbian operating system (some distributive of Linux operating system).

**Mini CNC milling machine:** The mini CNC milling machine with grbl controller is suit for make non-metal processing such as wood, acrylic or the similar material. The dimension of the CNC machine is 260 mm in X-axis, 240 mm in Y-axis and 220 mm in Z axis, milling reserach area is 160×100×30 mm. A NEMA 17 stepper motor rated 12 V at 400 mA with a 1.8° step size is used in the three axes of the CNC machine, the machine parts and assembling are shown in Fig. 2. Spindle motor is DC motor with RS-775 spindle motor (12-36V DC), drill bits diameter 3.175 mm.

**CNC driving board:** The CNC driving board consists of an Atmeg 328 p Arduino Nano with MOSFET driving circuit of the 12 V three axis stepper motors as shown in Fig. 3. A Grbl 0.9 J open source software written in c-language which utilize the AVR microcontroller is used for controlling the motion of the machine. The Grbl can accept the G-code and drive the CNC machine according to the uploaded G-code.

## RESULTS AND DISCUSSION

**Proposed web based system design:** Web-based CAD/CAM structures that use unique environments or viewers for layout visualization, these systems are applied using either Java technologies (consisting of Java run-time surroundings, Virtual Reality Modelling Language (VRML) (Malahova, 2014). Generally speaking, the IoT required a web to control and monitor system there are same differences between conventional web application and IoT such as attributes and type of data in IoT the device collect real time data which my required a decision to be performance such a decision will define the next action.

In conventional web page, the mechanism of data transfer (upload or download) is performance by human, while IoT application, the devices is intelligent enough to transfer data.

In generally conventional web page may be updated every day or weeks while in IoT application it would be updated based on devise data variation.

CNC JS is a full-featured web-based interface for CNC running on Grbl and TinyG controllers. CNC JS consists of a server component and a user interface component. The server talks to the CNC controller over a serial connection using a USB port. The server component can run on a small computer like a Raspberry Pi . The server is written in the Java script programming language, using the node JS framework. The CNC JS user interface consists of a collection of Java script code that runs inside a web browser as shown in Fig. 4.

To initiate the system an IP address for the CNC js web server is required. The router will assign an IP address to the Raspberry Pi during its boot sequence, this IP will be the same address of the web page along with

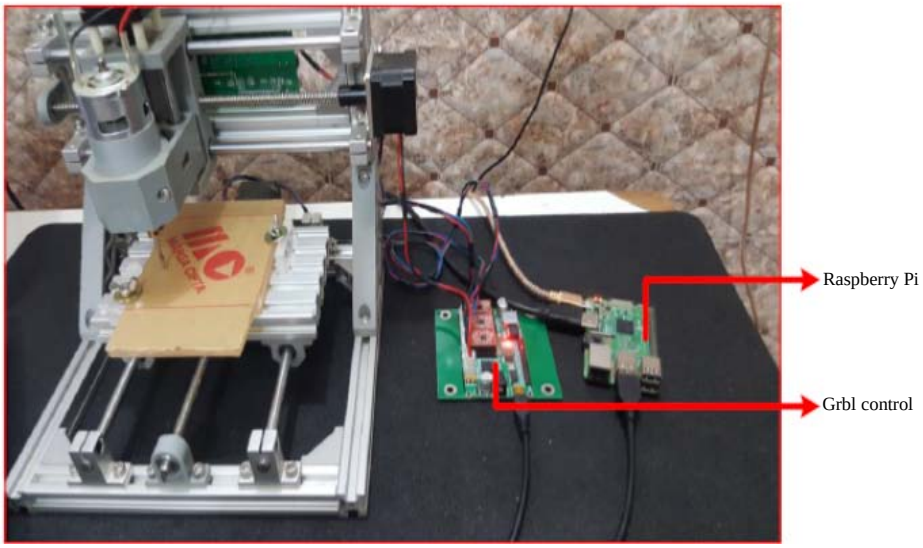


Fig. 2: Mini CNC machine with Grbl 0.9 J controller and Raspberry Pi 3

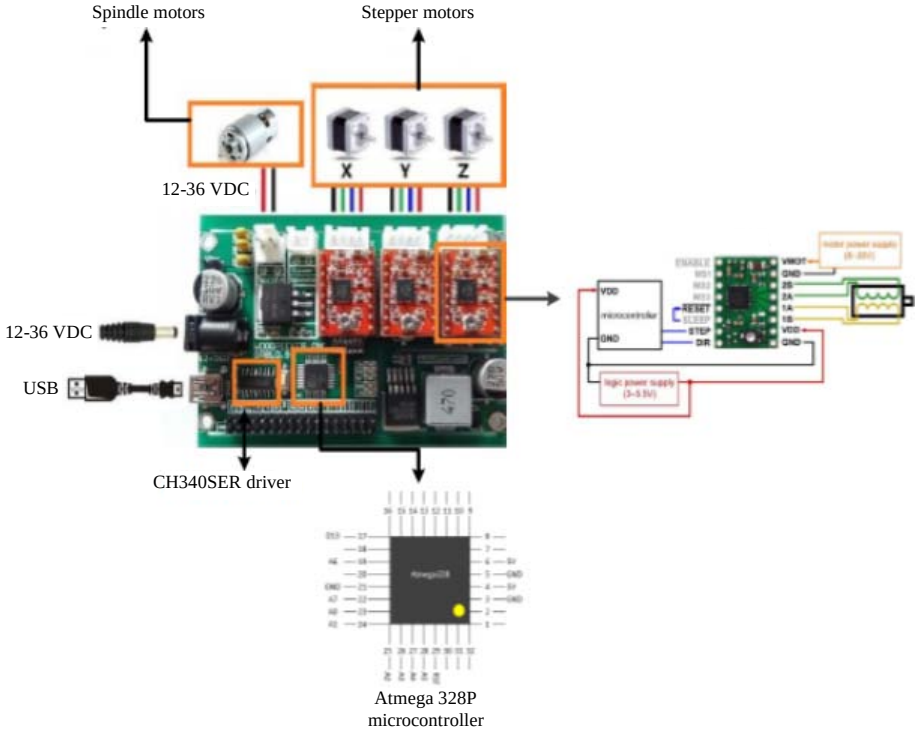


Fig. 3: Grbl 0.9 J 3-axis stepper motor driver board

any available port. In this research, the CNC JS web page has an IP address of 192.168.0.107:8000. In the user side who may use a PC or any smartphone, the system can be started by entering the assigned IP address in any browser and a web page as shown in Fig. 5 would be lunched. In this web, user can upload the required G-code by pressing the "upload G-code" button and start the manufacturing process. All information about the manufacturing could be monitor during the process also, a live web cam is available for visual monitoring. Figure 6 shows the tool path and the process of manufacturing while Fig. 7a-c shows the manufacturing cycle starting from uploading the G-code and finish the required product.

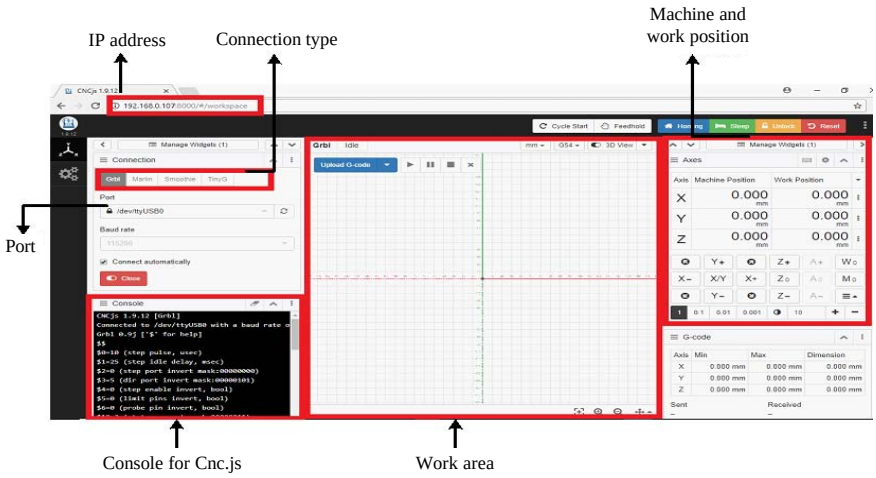


Fig. 4: The proposed web page

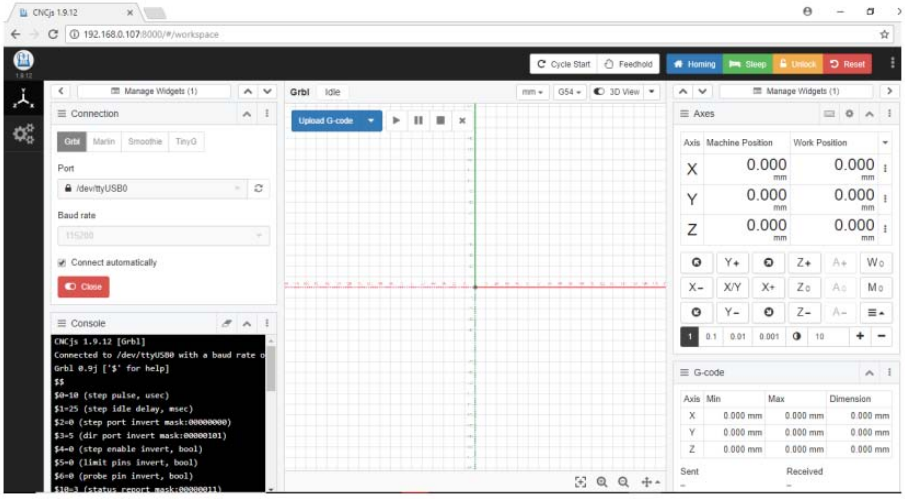

Fig. 5: Proposed web page design using CNC.JS server

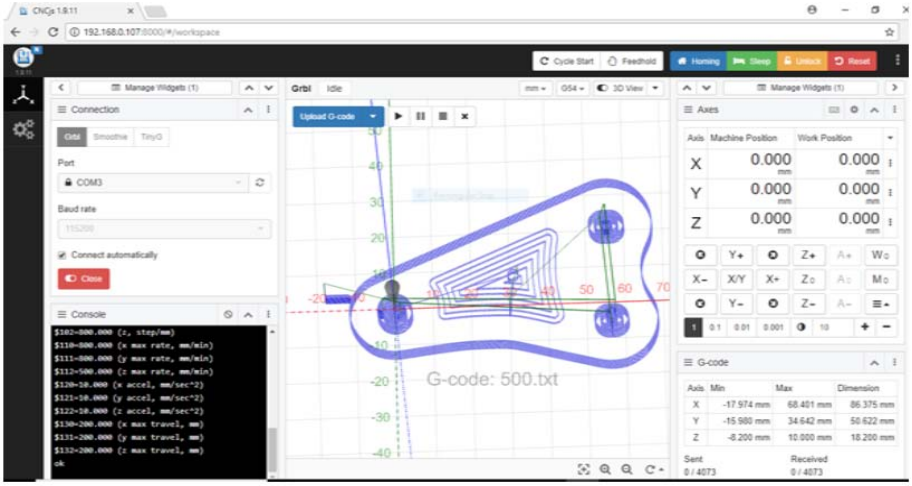


Fig. 6: Tool path simulation through CNC JS web

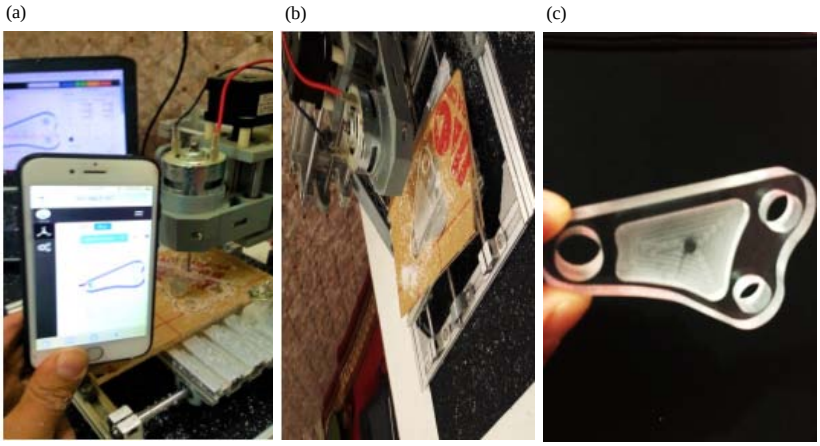


Fig. 7: Manufacturing process cycle: a) Web page; b) Tool path and c) Final product

## CONCLUSION

The use of Internet of Things (IoT) for manufacturing process can increases the system efficiency and productivity by reducing the time and cost required that the system should be robust and reliable for future reserach of the proposed system, a security of the network could be studied more such that system protection against introduces.

## REFERENCES

Aldeen, S.O.S., I.R.K. Al-Saedi and F.M. Mahel, 2017. Prototype wireless controller system based on raspberry Pi and arduino for engraving machine. Proceedings of the UKSim-AMSS 19th International Conference on Modelling and Simulation (ICMS'17), May 26-27, 2017, University of Cambridge, Cambridge, England, UK., ISBN: 978-1-5386-2735-8, pp: 69-74.

Alvares, A.J. and J.C.E. Ferreira, 2008. A system for the design and manufacture of feature-based parts through the internet. Intl. J. Adv. Manuf. Technol., 35: 646-664.

Hanwu, H. and W. Yueming, 2009. Web-based virtual operating of CNC milling machine tools. Comput. Ind., 60: 686-697.

Malahova, A., 2014. A methodology for developing web-based CAD/CAM systems: Case studies on gear shaper cutters. Ph.D Thesis, Cranfield University, Cranfield, England, UK.

Merchant, H.K. and D.D. Ahire, 2017. Industrial automation using IoT with raspberry Pi. Intl. J. Comput. Appl., 168: 44-48.

Nehete, R.O. and A.S. Bhide, 2017. Raspberry PI 3 based control and monitor remote machine automation. Intl. J. Eng. Comput. Sci., 6: 20151-20155.

Radelja, H., D. Haskovic, L. Sikulec, M. Plancak and M. Krsulja *et al*., 2012. Concept for online web machine tool control based on open source. Proceedings of the 8th International DAAAM Conference on Baltic Industrial Engineering, April 19-21, 2012, Tallinn University of Technology, Tallinn, Estonia, pp: 216-221.

Sheng, Z.Q., Z.Z. Liang, C.B. Zhang and L. Dong, 2012. LabVIEW-based wireless monitoring system of CNC machine tools. Appl. Mech. Mater., 121: 2075-2079.

Yu, T., X. Zhang, W. Liang and W. Wang, 2013. A web-based virtual system for turn-milling center. Intl. J. Adv. Manuf. Technol., 67: 2395-2409.

Zhong, R.Y., X. Xu, E. Klotz and S.T. Newman, 2017. Intelligent manufacturing in the context of industry 4.0: A review. Eng., 3: 616-630.