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Wireless CNC Plotter Using Internet of Things

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Abstract:

In this paper, we aim to develop a less expensive wireless CNC plotter three axis control machine that uses microcontrollers and IoT for its operation. The goal is to create a CNC plotter that can etch text and graphics onto a flat surface. Disassembling discarded DVD/CD drives and using their stepper motors for X and Y axis movements and a miniature servo motor system to move the marker along the Z axis were used to create the mechanical model of the CNC machine. G-Code, the language of the CNC machine, was generated and transmitted to the model wirelessly. The G-Code is received and understood by the microcontrollers, which then communicate the appropriate signals to the motors to correctly plot the design or text onto the paper.

Keywords — **CNC Plotter, Wireless, G-Code, Microcontrollers, IoT.**

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I. Problem Statement

Many jobs that involve movement or action that keep repeating everyday were substituted by the CNC machine from humans as the human concentration becomes lower as time passes while the product quality and quantity fabricated by machine will be maintained. However, most of the common CNC machinery involves serial communication using cables and wires which can be a major source for problems like wearing down of wires, loose connections, improper connections, etc. Therefore, the main motive of this project is to make the CNC machine wireless by integrating it with IoT using NodeMCU, thereby eliminating the use of excessive wires and making the device portable.

II. Introduction

Computer numerical control is a very broad term that encompasses a variety of types of machines all with different sizes, shapes, and functions. But the easiest way to think about CNC is to simply understand that it is all about using a computer to control a machine that carves useful objects from solid blocks of material. A CNC machine takes codes from a computer and converts the code using software into electrical signals. The signals from the computer are then used to control motors. Since the motors can turn very small amounts the machine is able to move in highly precise movements repeatedly. This technique reduces human effort and utilization of vitality and time.

The most popular way to operate CNC machines is in a wired mode, which involves feeding the machine instructions via a wire connection between the CNC and the instruction generator (PC). This analysis work proposes and implements a wireless communication-based CNC, that is designed to eliminate the use of wire connections in the system and make the system portable. The mechanical model of the system is designed using scrap DVD/CD drives and use a servo motor for movement along the Z-axis.

The project's wireless component was handled by NodeMCU, with the Arduino serving as the machine's brain. Stepper and servo motor control was taken over by an L293D motor driver shield which translated control signals from the Arduino into mechanical movements. Using the Inkscape program, G-Codes are created and wirelessly transmitted to the NodeMCU. The Arduino receives the G-Code instructions from the NodeMCU and understands and executes each one to plot the desired design onto the paper or a plane surface.

III. Modelling Approach

The following steps make up the method used to model the CNC plotter:

A. Physical Model

The physical model of the machine is designed using scrap DVD/CD drives. The stepper motors are initially removed once the drives have been disassembled. The drives are then put back together and secured perpendicularly to one another using L-clamps.

B. X and Y axis Movements

The stepper motors that were removed from the drives and attached to the model in such a way that any combination of motor movements falls within the 40mm x 40mm drawing space are used to generate the X and Y axis movements.

C. Z-axis Movements

The Z-axis movements of this device are made possible by a marker or pen that is twine connected to a servo motor. According to the specified command, the servo motor controls the Z-axis movements.

D. Machine Control

The stepper and servo motors are connected to an L293D motor driver shield which is mounted on top of an Arduino UNO. The Arduino UNO receives commands and sends corresponding control signals to the motors via the L293D motor shield. A NodeMCU is also connected to the Arduino UNO and this entire system is mounted on the back of the machine.

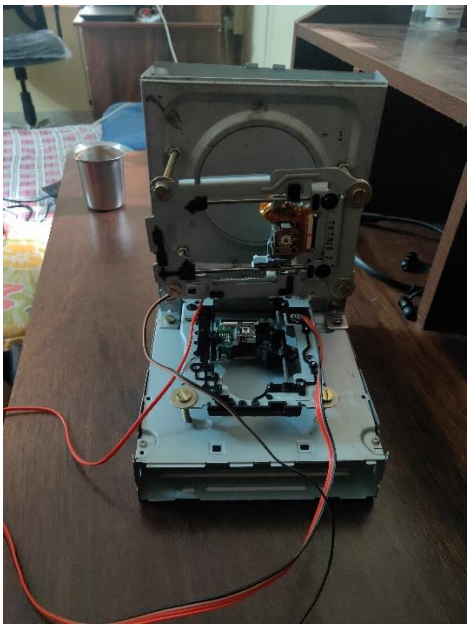

Fig I Assembled X and Y axis of the Plotter (Front View)

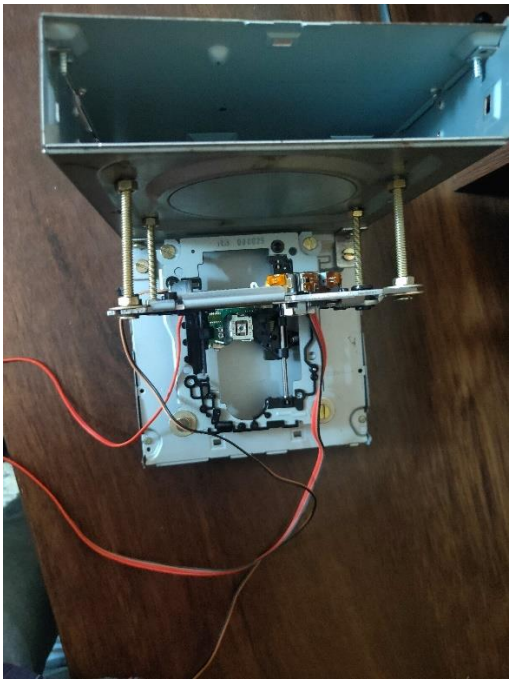

Fig II Assembled X and Y axis of the Plotter (Top View)

IV. Proposed Methodology

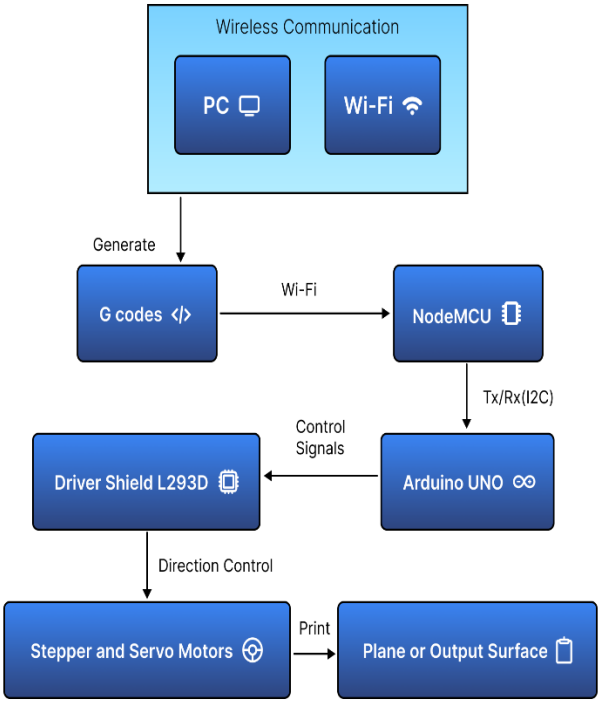

Fig III Block Diagram of the Plotter

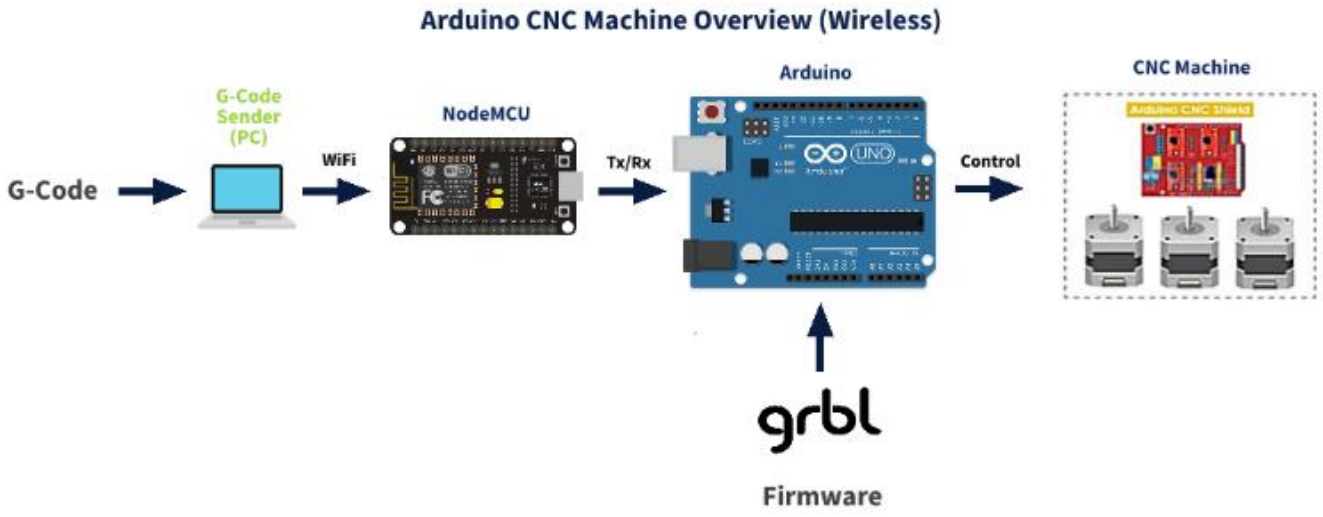

Fig IV Wireless CNC Machine Overview

As per the Fig III, G-Codes for a particular image are first generated on the PC using the Inkscape software. This G-Code file is then sent to the NodeMCU wirelessly through Wi-Fi. The NodeMCU scans the G-Code file after receiving it, then uses serial communication to transmit the commands to the Arduino. Line by line, the Arduino reads the commands and processes them before sending control signals to the L293D motor driver shield. The shield receives these control signals, controls the stepper and servo motors in accordance with those directions and speeds, and effectively plots the required image onto the paper.

V. WORKING

The steps that make up the CNC Plotter's operation are as follows:

A. G-Code Generation

G-codes for any image is generated using the Inkscape software. First, the image is copied onto the template in Inkscape. Then, a bitmap of the image is traced, which will generate a continuous clear outline of the image onto the canvas. An offset of this outline is produced, and the file is saved as a G-Code file using the MakerBot G-Code extension.

B. Connect to the Plotter

The NodeMCU quickly establishes a Wi-Fi connection after powering on the CNC plotter machine. Then, using any web browser, the user establishes a connection to the NodeMCU using its IP address that has the '/upload' extension appended. The NodeMCU acknowledges the client connection and responds by delivering the client an upload website (Fig VIII).

C. G-Code File Processing

After the G-Code file is uploaded to the NodeMCU, the file is stored on the NodeMCU's built-in file system, SPIFFS. The webpages are also stored on this 4MB of memory storage which implements a flat structure file system. The stored file is then opened and is read one line at a time and is sent to the Arduino Uno, until the end of file is reached, via serial communication using Tx/Rx pins. The NodeMCU wait for an "ok" response from the Arduino before sending the next line

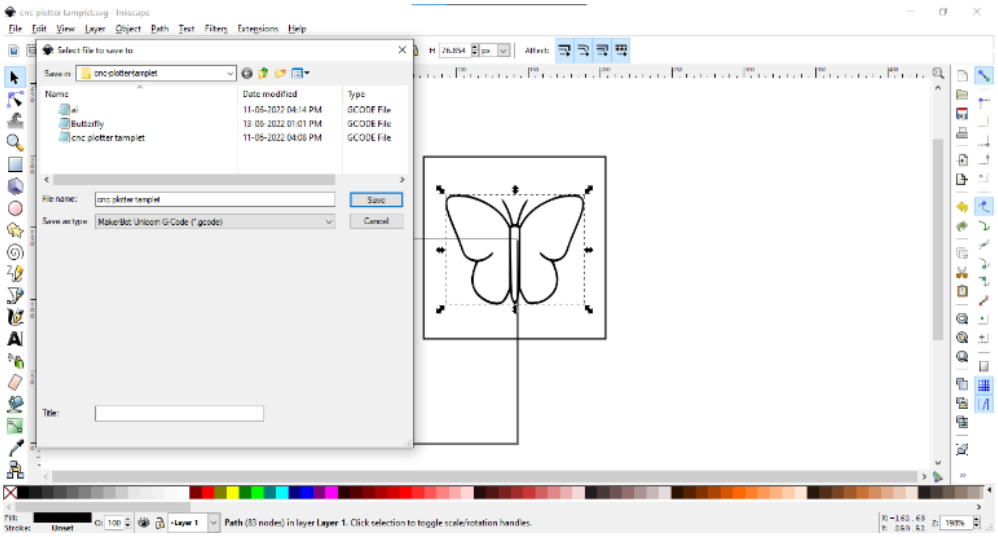

Fig V G-Code Generation using Inkscape

of commands.

D. G-Code Interpretation

G-Codes are received by the Arduino in a byte-wise fashion where each byte represents a character. The Arduino performs cleaning of the G-Code instructions where comments are ignored, whitespaces are removed, and only meaningful instructions are processed. The formatted instructions are translated into control signals by the Arduino and sent to the L293D motor driver shield for execution.

E. Plotting

L293D motor driver shield receives the control signals from the Arduino UNO and performs the necessary steps to execute the instruction. After the instruction is executed, an "ok" response is sent to the NodeMCU and waits for the next line of command to be sent.

F. Finish

After every command from the G-Code file is executed successfully, the file is closed, and a success web page is sent by the NodeMCU to the user to indicate that the execution was successful.

VI. RESULTS

Wireless CNC plotter was successfully implemented. We observed that the final model of the system works seamlessly using the NodeMCU ESP8266 to connect to the network and receive the G-Code file. The G-Code file was read, and instructions were sent to the Arduino instantly without any delay. The Arduino received these instructions, processed them, and successfully plotted the entire desired design without any errors.

Fig VI Wireless CNC Plotter

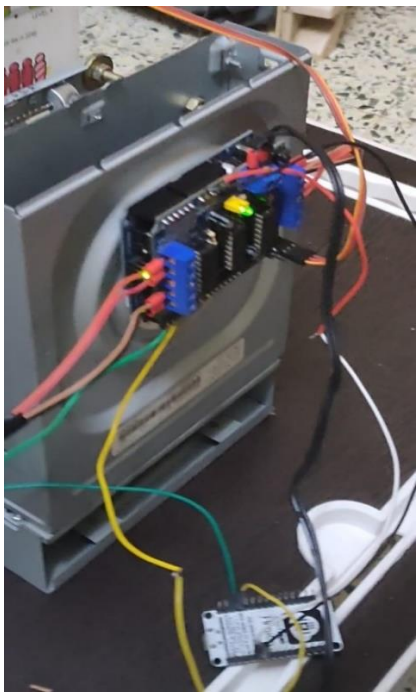

Fig VII Microcontrollers attached to the back of the CNC plotter

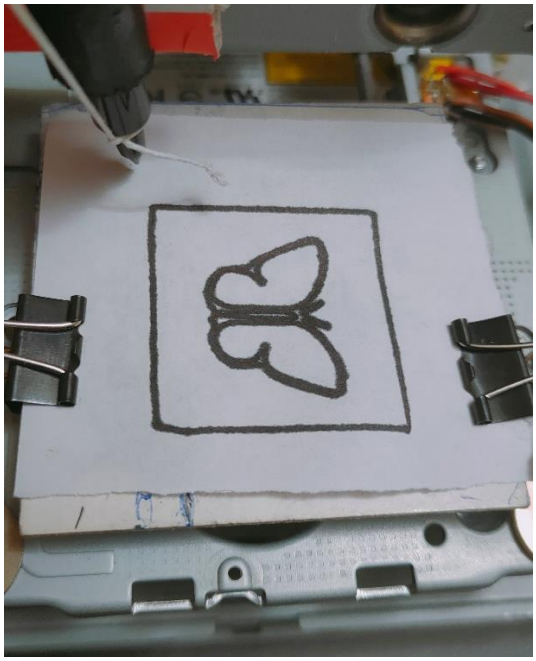

Fig VIII Image plotted by the Wireless CNC plotter

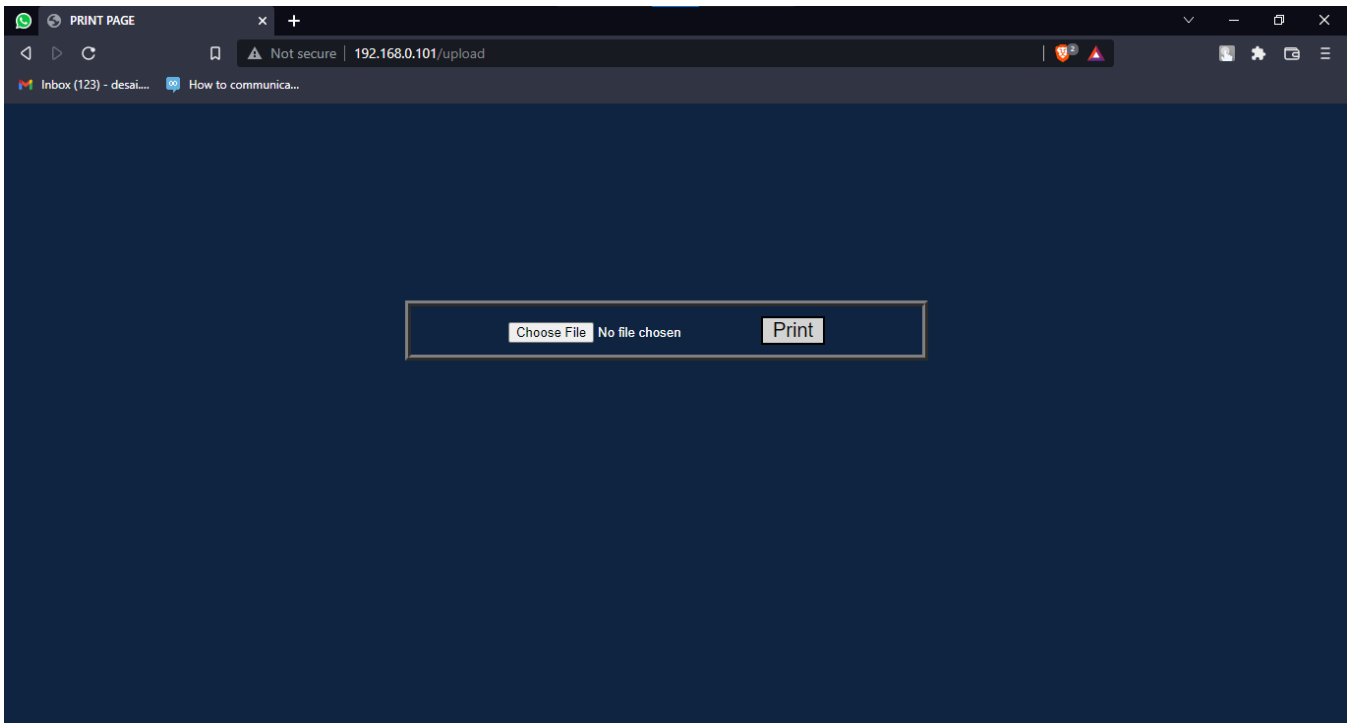

Fig IX Upload webpage sent by the NodeMCU

VII. CONCLUSION

With the advancement of technology and the increasing demand for production, CNC has been a breakthrough technology in industries and manufacturing plants. As per the result, we built a CNC Plotter that works wirelessly using IoT. This paves way for remote access and control of CNC machines from anywhere in the world thereby increasing the flexibility of usage and efficiency of the CNC machines. We anticipate using this methodology for many more CNC technology implementations that currently employ wired mode of communication techniques in the future.

VIII. FUTURE SCOPE OF THE PROJECT

- CNC Plotter can be modified into more complex and sophisticated applications like 3-D Printing, Milling and Drilling Industries, etc.
- Plotting mechanism can be replaced with a laser engraver to implement a wood carving or engraving machine.
- To safeguard the connection to the plotter, additional security measures at the hardware and network levels might be incorporated.
- The plotter's output can be improved with the use of strong, high-precision stepper motors.

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