

Design And Implementation of A Wifi- Controlled Wall Plotter Using Arduino and CNC Shield For Image-To-G-Code Applications

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Abstract— This work discusses the design and construction of a WiFi-controlled wall plotter in order to establish a low-cost and versatile method for executing big projects. The plotter consists of an Arduino Uno board equipped with a CNC shield, an A4988 motor driver to control the x- and y-axes, and servo motors to drive pen movement, contained in a lightweight, transportable frame. A special mobile app translates the picture into G-code and transfers it wireless to the Arduino via WiFi, enabling users to sketch digitally on the wall. This installation provides a new means of wireless wall lighting suitable for educational lecturing, DIY artwork, and prototyping. Its low price point and ease of use make it appealing to a customer segment consisting of educators, artists, and enthusiasts.

Keywords - Arduino Uno, CNC shield, G-code conversion, Stepper motors, Wireless drawing system, Educational robotics, Affordable prototyping.

I. INTRODUCTION

Art has for long been an optimum method for aesthetic improvement of domestic, learning, and commercial environments. Creating wall designs at a large scale is conventionally achieved by commissioning professional artists or buying expensive pre-made items. Such procedures not only present a high bill but also compromise on creativity as well as ease of access to small-scale operations or individuals. Wall plotters—electric wall-drawing systems—are more flexible but generally costly, cumbersome, and hard to use.

This project offers a WiFi wall plotter solution that overcomes these issues. It is portable, affordable, and small-scale and is easy to use with no technical requirements. The setup combines an Arduino Uno microcontroller with a CNC shield, stepper motors, and servo motors to achieve accurate control. The users upload their designs to a smartphone app, which

interprets the images as G-code and wirelessly transmits the instructions to the plotter through WiFi. This gadget democratizes wall art by minimizing costs and providing flexibility. The project merges affordability with precision to suit different user needs such as schools, DIY enthusiasts, and interior decorators. By doing away with the requirement for costly materials and expert help, it offers a green solution for making customized designs. Important parts like GT2 timing belts, A4988 motor drivers, and a pen holder made from 3D printing guarantee smooth and accurate movements along the x- and y-axes. The plotter is light, transportable, and versatile to various wall surfaces. In short, this WiFi wall plotter revolutionizes conventional methods of wall art by providing a cost-effective, user-friendly, and scalable solution. It fills the gap between professional equipment and general usability, making it a perfect fit for various applications.

II. PROBLEM STATEMENT

Over the past few years, increasing labor costs and artist shortages have posed serious issues for companies requiring custom wall designs, paintings, and large-scale artwork. Companies like advertising, public art, and interior design usually turn to experts in order to get intricate walls made that need both time and skill. Creating art by hiring someone, though, can be quite costly, particularly for schools, small companies, and independent artists. Also, the scarcity of skilled artists skilled enough to carry out extensive wall projects makes them harder to come by and consequently more costly to hire. Wall building makes it hard for individuals and companies to realize their ideas at affordable and efficient rates. For instance, commercial establishments (from retail outlets to supermarkets) tend to need specially created wall

products meant to beautify and improve the atmosphere and experience of customers. The unaffordability and shortage of artists may hinder or postpone such an activity, impacting the aesthetic and nature of imagery. supply. Schools can employ wall art to design interactive learning spaces; hobbyists look for cheap tools to realize their artwork. Wall painting methods, though, consume a lot of resources and time and so are not suitable for small jobs or for those who cannot afford professional services. such competitions. This plotter system is designed around the Arduino platform, employing stepper motors for its movement and WiFi modules for remote control. Designers are able to transfer designs to G-code through a specialized mobile application, enabling them to design walls remotely without training. This automation not only reduces custom wall murals in cost; it also offers a user-friendly, easy-to-use solution to numerous uses in business, education and DIY settings. Reducing the necessity for custom work, WiFi-controlled wall painter is a user-friendly, easy-to-use device that responds to the needs of today's practical, graphic design and layout solutions.

III. DESIGN OF THE SYSTEM

A. Arduino Uno and CNC Shield

Arduino Uno is the central board that is utilized in controlling the entire wall plotter system with the microcontroller ability to execute accurate motor movements from G-code commands[1]. Having a CNC shield added to Arduino facilitates easy wiring and organization through the exclusive slots for the motor drivers and simple connection with the WiFi module. Arduino Uno is a widely used microcontroller with a user-friendly development environment, and it is simple to use even for professional developers and beginners. Its straightforward coding and extensive online support community enable users to simply correct problems and modify things without the need for expert programming skills.

B. Stepper Motors

NEMA 17 stepper motors driven by A4988 motor drivers ensure precise movement along the x and y axes, which is critical for plotting precise walls. Stepping resolution and current are regulated by the A4988 drivers to prevent overheating and vibration and ensure accuracy for drawing precise designs.

Torque:

Holding Torque at Continuous Current: 0.35 Nm.

Peak Holding Torque:

0.5 Nm: This amount of torque is sufficient to drive the x and y axes without sacrificing precision when plotting large-format walls. Having a medium or long one would be ideal for applications where there is longer endurance under load[2].

Step Angle:

1.8° per Step: Provides step resolution of 200 steps per revolution, and can be upgraded using micro-stepping with the application of the A4988 driver. Fine positioning is attained, which is critical for exactness and intricate wall drawings[3].

C. A4988 Drivers

The A4988 motor driver is compact and efficient and capable of being used in driving NEMA 17 stepper motors in a wall plotter system. It supports micro-stepping resolution of up to 1/16th step, and this guarantees smooth and precise motor movement, essential in fine wall pattern design. The driver supports a motor voltage of 8V–35V and a logic voltage of 3.3V–5V and is therefore entirely compatible with the Arduino Uno and CNC shield. It can source up to 2A per coil with good heat sinking, but it will typically run at a more conservative setting (around 1A–1.5A) for safety against overheat. It can be easily trimmed by the onboard potentiometer, so that the motor is being supplied adequate power without overstressing its rated value[4].

The A4988 also includes overcurrent and thermal protection within itself to prevent system damage in the case of high-load or long-duration operation. Its step-and-direction interface makes it simple to hook up directly to the Arduino, enabling precise motor control with minimal programming complexity. With the CNC shield, the A4988 also gives a clean and organized connection layout, preventing wiring errors and making installation simpler. Its micro-stepping functionality also enhances the plotter's resolution, with up to 3200 steps per revolution in 1/16th micro-stepping configuration[5]. This controlled precision delivers exact motion along the x and y axes, critical for plotting intricate designs on a vertical plane.

To perform optimally, proper calibration of current limit and micro-stepping resolution is necessary. Heatsinks or cooling solutions are recommended for heat dissipation when used for long periods of time. While the A4988 is a suitable choice for normal use, more performance-oriented drivers like the DRV8825 can be employed for heavier loads or greater accuracy. Overall, the A4988 motor driver is cheap, reliable, and easy to use, making it a suitable choice for your WiFi-controlled wall plotter.

D. Frame Design

The frame for the wall plotter consists of aluminum V-profiles in order to give a light yet strong structure. On the vertical axis, there is a 4x2 cm profile in place to ensure enhanced stability because it carries the prime load during the plotting. On the horizontal axis, a 2x2 cm profile provides assistance in keeping overall weight reduced without sacrificing stiffness. The V-profiles provide the motion system with a good foundation and ensure the system is portable. Their construction also perfectly supports the rollers and GT2 timing belts, giving smooth travel along both axes.

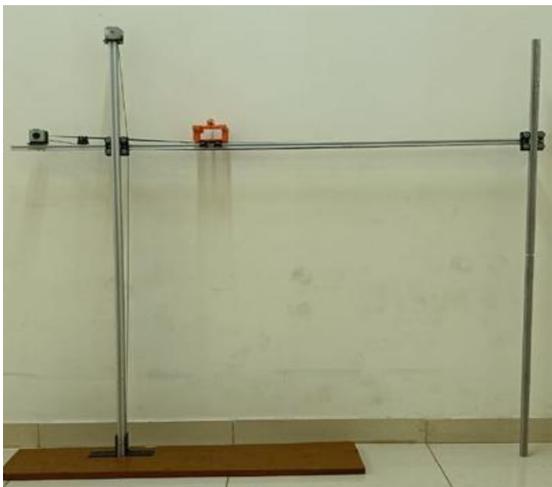


Figure 1: Frame

E. Motion Mechanism

Rollers are utilized on the x and y axes to provide low-friction smooth movement. The rollers are fastened firmly on the aluminum V-profiles in a manner such that their direction is not twisted while in use. Movement on the x and y axes is created through the utilization of a GT2 timing belt along with pulleys. The GT2 belt, featuring rounded teeth on the profile, allows for minimum slippage with exact transmission

of movement, a critical feature required for correct plotting. The assembly provides high repeatability, required in producing precise and detailed designs.

F. Vertical Axis and Pen Holder

The vertical axis also features a 3D-printed pen holder mounted on the roller and motor-driven through the GT2 belt. The pen holder comprises a rack-and-pinion gear, with the pinion gear resting on a mini servo motor. The vertical motion of the pen is precisely controlled using a rack-and-pinion mechanism such that it can pick up or set down from or on the wall surface according to need. This kind of system can be very effective for plotting sensitive designs with periodical raising of the pen for generating sharp and clean plots.

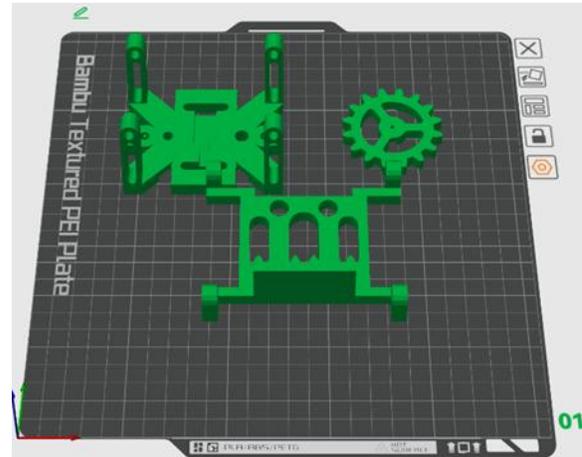


Figure 2: Sliced model of pen holder

G. Integration of Timing Belts and Pulleys

The GT2 timing belts and pulleys are components of the motion system. The belts are utilized for transmitting power from motors to rollers with high accuracy, and the pulleys provide smooth and coordinated motion. The integration enables the plotter to function efficiently with precision even in high-speed motion.

IV. PROJECT GOALS AND OBJECTIVE

Wall decoration has been made available in two basic ways: through commissioning trained artists or through pre-printed stickers. Both have limitations in them. Professional artists, as skilled as they are, are very expensive and time-consuming and thus out of reach for small businesses, schools, or individuals. Pre-printed stickers being what they are, are non-

personalizable and restrict the users from creating their own original output.

The project will bridge the gap by offering a new, low-cost, and flexible solution.

WiFi wall plotter allows one to design and personalize their walls according to their preference. It provides an easy way of doing wall paintings without training or experience. With the low cost and easy technology, the project offers an efficient solution for bulk wall design.

The specific objectives of the project include:

- *Customization: To enable individuals to create unique, personalized wall art by converting digital designs into precise, large-scale graphics.*
- *Accessibility: To develop an intuitive mobile application that allows users to upload images, convert them into G-code, and execute designs seamlessly.*
- *Cost-effectiveness: To provide a low-cost alternative to traditional methods, making wall art more affordable for small businesses, schools, and hobbyists.*
- *Commercial Viability: To produce a product that is scalable to be sold to interior design companies or provided as a rentable tool for temporary applications.*
- *Precision and Efficiency: To implement GRBL software for exact coordination of motors and limit switches, providing precise plotting with a smooth motion.*
- *Portability: To produce a system that is lightweight, modular in nature, easy to set up, transport, and store*
- In summary, this project seeks to redefine the creation of wall art as a sustainable, flexible, and cost-effective tool for personal and business use. By overcoming the shortcomings of conventional methods, it creates new opportunities for artistic and functional design.

V.IMPLEMENTATION

Project implementation of the WiFi-controlled wall plotter was a step-by-step process of assembling the hardware, coding the software, and calibrating/testing

the system so that it performed its intended function. Each process was done with detail, ease of operation, and flexibility.

Hardware assembly commenced with the building of a lightweight yet strong aluminum frame from V-profiles. The frame was intended to bear accurate movement on x- and y-axes and be light enough to transport for use. Stepper motors (NEMA 17) were securely fixed on the frame, and GT2 timing belts were fitted to propel rollers along the axes.

A. Hardware Development

Hardware installation started with the building of a light but strong aluminum frame made of V-profiles. The frame was to hold accurate motion on x- and y-axes but needs to be light in weight so that it can be shifted from one place to another with ease. Stepper motors (NEMA 17) were attached to the frame securely, and GT2 timing belts were added to drive the rollers along the axes.

A rack-pinion mechanism pen holder was 3D printed to fit a specific size and mounted on the vertical axis. The pen stand had been made to fit different writing tools to be able to utilize in different projects. A mini servo motor was mounted on the pen holder to enable controlled disengagement and engagement with the wall surface, a necessity for fine designs.

CNC shield and A4988 motor drivers were installed on the Arduino Uno board to manage motor operations. Wiring was guided to ensure neat and error-free connections between components and power supply. Heatsinks were installed on the A4988 drivers to prevent overheating during prolonged operation.

B. Vertical Axis and Pen Holder

The software component comprised the interfacing of GRBL firmware with Arduino. GRBL is aware of G-code instructions and has high control over the movement of the motor. An application was developed specifically as a user interface to facilitate image-to-G-code translation. The application communicates with Arduino via WiFi for remote monitoring as well as remote control of wall plotting.

C. Vertical Axis and Pen Holder

The motors were well-calibrated to provide accurate step resolution and silky-smooth movement. Calibration included fine tuning the current limits of

the A4988 drivers via onboard potentiometers to optimize performance without compromising component life. Micro-stepping setup was adjusted for high-resolution motion.

Testing was done by operating the plotter on different wall surfaces, such as smooth and semi-rough, to test performance. Sample designs were printed to test accuracy, speed, and consistency. Calibration was done to make minor adjustments and achieve consistent performance. Test users provided feedback on the usability and effectiveness of the device.

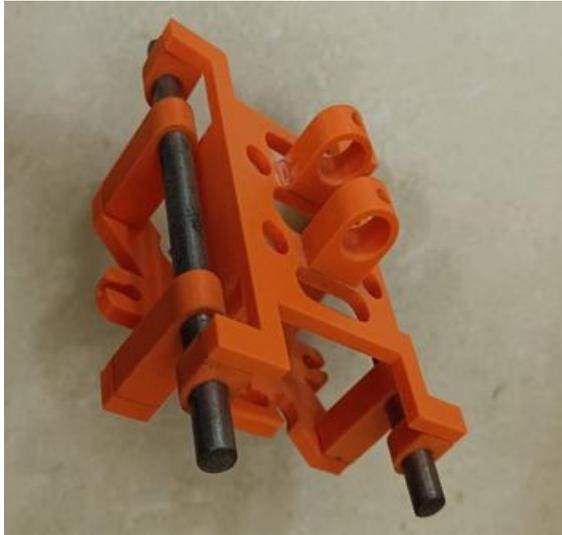


Figure 3: 3D printed pen holder

VI. RESULTS AND DISCUSSION

The wall plotter under WiFi control was tried to identify its accuracy, usability and flexibility. The findings emphasized the effectiveness of the system in achieving its design goals, with some areas noted for future development.

A. Vertical Axis and Pen Holder

The wall plotter was very accurate, with ± 1 mm of deviation for intricate designs. This was made possible by accurate stepper motor calibration and the use of GT2 timing belts, which minimized slippage to their lowest levels. The speed tests indicated that the plotter could be operated at 15 cm per minute on average without compromising on accuracy. This kind of speed is sufficient for most applications, including the creation of large-scale designs and intricate wall designs.

Another benefit was simplicity of use. Test users found the mobile app interface easy to use, upload photos, and initiate plotting without necessarily having any knowledge of technology. Wireless capability was enabled through the WiFi connectivity, with the end effect being greater convenience and less setup time.

B. Applications

The plotter was a versatile product and was applied in a broad range of application fields:

- 1) *Interior Design: The plotter is able to create customized murals, wall coverings, and office and home business logo designs at a low-cost alternative to employing skilled artists.*
- 2) *Do-It-Yourself Art Projects: Hobbyists can easily incorporate their own art projects as individualized wall art for personal bedrooms or special occasions.*
- 3) *Demonstrations for teaching: The plotter may also be used as an interactive demo machine by workshops and schools as an educational tool to teach students about the theoretical sides of design, programming, and robotics by connecting theory to practice.*

The findings indicate the educational potential of the wall plotter as an excellent learning and creative instrument.

C. Vertical Axis and Pen Holder

While the system performed well in well-controlled experiments, there were certain limitations discovered:

- 1) *Wall Surface Compatibility: The printer was incompatible with textured or rough walls, and this affected the pen contact and quality of the design.*
- 2) *Plotting Area: The physical size of the frame constrains any size design. A larger size design would require a larger plotter.*
- 3) *Speed Optimization: Although sufficient for typical usage, the speed can be optimized for mission-critical use.*

These limitations allow room for further expansion, e.g., the addition of adaptive coping for harsh surfaces and more advanced motor control for increased velocity.

VII. RESULTS AND DISCUSSION

The WiFi wall plotter is serving its purpose very well by providing an inexpensive, easy way to create customized wall designs. The project is a wonderful

combination of accuracy, mobility, and price and thus an excellent device for numerous applications. Based on GRBL software and an Arduino platform, it is a good motor controller and has the capability to execute intricate designs easily. The included mobile app makes the task easier by having an easy-to-use interface for image upload, G-code generation, and wireless transfer to the plotter.

The system is democratizing the creation of wall art with the low-cost approach being offered versus the more traditional and sometimes expensive methods. Some of the possible applications are interior decorating, art for DIY projects, and education. The plotter can be used in schools as a demonstration tool for teaching STEM, and companies and hobbyists would appreciate the low cost and ease of use. The project is addressing current limitation in wall art creation and is an ecological solution that reduces the demand for professional service. While successful, there are some disadvantages. The plotter is not larger than its frame size, and therefore the plotting area has a maximum limit. It also does not handle rough or uneven wall surfaces well, which affect the quality of the designs. The speed, while good enough for most, can be improved further for bigger projects. The future work will focus on overcoming these disadvantages. Some of the improvements feasible are making the plotter larger to handle larger designs, integrating adaptive mechanisms to handle irregular surfaces, and improved motor control for higher speed. More integration of IoT technology can make it possible to upload designs to the cloud and monitor remotely, expanding its use. With the integration of advancements, the plotter can be designed into a scalable, commercial device that can meet different user requirements.

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