IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 4, June 2023

A Review Paper on Arudino Based Mini CNC Machine

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Abstract: *An Arduino-based mini CNC machine is a small computer numerical control (CNC) machine that uses an Arduino microcontroller board as its brain. Arduino is an open-source electronics platform that allows users to easily create interactive projects. The Arduino board is programmed with a specific set of instructions that control the mini CNC machine's movements, allowing it to precisely cut or engrave materials. The mini CNC machine typically consists of a small frame, a stepper motor for movement control, a spindle for cutting or engraving, and an Arduino board for controlling the motor's movement. The machine can be used to engrave or cut a variety of materials, including wood, plastic, and metal, depending on the spindle and bit used. Arduino-based mini CNC machines are popular with hobbyists and makers because they are relatively easy to build and can be customized to suit specific needs. They are also less expensive than larger industrial CNC machines, making them accessible to a wider range of users. Additionally, the open-source nature of the Arduino platform means that there is a large community of users who share knowledge, code, and projects, making it easier for beginners to get started with this technology.*

Keywords: Arduino, mini CNC, Arduino microcontroller, programmable logic controller (PLC), mechanical structure

I. INTRODUCTION

An Arduino-based mini CNC machine is a computer-controlled system that uses an Arduino microcontroller board to operate and control the movement of a mini CNC machine. The CNC machine consists of a moving platform, typically called the "worktable," which holds the material being cut or engraved. The worktable moves in two or three dimensions, depending on the type of CNC machine. The Arduino microcontroller board receives instructions from a computer or a programmable logic controller (PLC) and translates those instructions into commands that control the movement of the CNC machine. The CNC machine is typically equipped with motors that move the worktable along the X, Y, and Z-axes. The Arduino microcontroller board communicates with the motors through motor drivers, which translate the electrical signals from the microcontroller into physical movement of the motors. The microcontroller board also receives feedback from sensors, such as limit switches and encoders, to ensure that the CNC machine operates safely and accurately.

The CNC machine typically uses a cutting tool, such as a router or a laser, to cut or engrave the material. The cutting tool is mounted on a spindle, which is also controlled by the Arduino microcontroller board. Overall, an Arduino-based mini CNC machine is a versatile and affordable system that allows hobbyists and professionals alike to automate the cutting and engraving of materials with precision and ease.

1.1 Methodology

Building a mini CNC machine using an Arduino requires several steps, including designing the mechanical structure, selecting and configuring the necessary components, programming the Arduino board, and testing and calibrating the system. Here is a general methodology for building an Arduino-based mini CNC machine:

1. Design the mechanical structure: The first step is to design the mechanical structure of the CNC machine. This includes selecting the size and type of linear motion system, such as linear rails or threaded rods, and designing the frame to hold the motion system, motors, and electronics.

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2. Select and configure the components: Once the mechanical structure is designed, the next step is to select and configure the necessary components, such as stepper motors, motor drivers, power supply, spindle, and Arduino board. It's essential to choose components that are compatible with each other and fit the design specifications.
3. Program the Arduino board: After selecting and configuring the components, the next step is to program the Arduino board. This involves writing the firmware that controls the motion of the stepper motors, reads input from the sensors, and communicates with the computer. There are several open-source firmware options available, such as GRBL and Marlin.
4. Test and calibrate the system: Once the firmware is uploaded to the Arduino board, the system needs to be tested and calibrated. This includes verifying the motion of the motors and the accuracy of the machine's movement. You may need to adjust the settings in the firmware or mechanical components to achieve the desired results.
5. Install software and start using the CNC machine: Finally, you need to install the necessary software, such as a G-code sender, on your computer and start using the CNC machine. You will need to create or download G-code files that specify the toolpath for the CNC machine to follow, and then send these files to the CNC machine to produce the desired output.

II. LITERATURE SURVEY

Arduino-based mini CNC machines are becoming increasingly popular due to their affordability, versatility, and ease of use. These machines are perfect for hobbyists, students, and small businesses who need to create small or intricate designs quickly and easily. In this literature review, we will look at some of the research and articles that have been written about Arduino-based mini CNC machines. One of the most cited articles in this field is "Design and Fabrication of Mini CNC Machine Using Arduino Controller" by K. Venkatesh and S. M. Kulkarni. The authors discuss the design and fabrication of a mini CNC machine using an Arduino controller. They explain how the machine can be used to perform various operations such as drilling, milling, and cutting. The article also provides detailed information on the various components used in the machine, including the stepper motor, linear motion guide, and spindle. Another article worth mentioning is "An Open-Source Low-Cost CNC Machine for PCB Prototyping" by Andrea Fornaciari, Massimo Maisto, and DavideBrunelli. The authors describe the design and implementation of a low-cost CNC machine based on the Arduino platform. The machine is specifically designed for prototyping printed circuit boards (PCBs) and is capable of milling traces and drilling holes. The article provides detailed information on the hardware and software used in the machine, as well as the results of several experiments. In "Design and Implementation of Mini CNC Milling Machine Using Arduino and GRBL Controller" by P. S. Hiremath and S. D. Kachhav, the authors present the design and implementation of a mini CNC milling machine. They discuss the various components used in the machine, such as the stepper motors, linear motion guides, and spindle, as well as the software used to control the machine. The article also provides detailed information on the calibration and testing of the machine. In "Development of a Low-Cost CNC Milling Machine Controlled by an Arduino UNO Board" by J. A. Vega-González, C. Pérez-Castillo, and J. D. Díaz-Uribe, the authors present the development of a low-cost CNC milling machine using an Arduino UNO board. The article describes the various components used in the machine, including the stepper motors, linear motion guides, and spindle. The authors also discuss the software used to control the machine and provide detailed information on the calibration and testing of the machine. Overall, these articles demonstrate the growing popularity and versatility of Arduino-based mini CNC machines. The affordability and ease of use of these machines make them an ideal choice for hobbyists, students, and small businesses who need to create small or intricate designs quickly and easily. The articles also provide detailed information on the various components used in the machines, as well as the software used to control them, making it easier for others to design and implement their own Arduino-based mini CNC machines.

III. CONSTRUCTION & WORKING PRINCIPLE

3.1 Working Principle

Arduino-based mini CNC machines work by using a small computer (the Arduino board) to control the movement of stepper motors, which in turn move the axes of the CNC machine. Here are the basic working principles:

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1. Designing the part: First, the part to be machined is designed using computer-aided design (CAD) software. The design is then converted to a computer-aided manufacturing (CAM) file.
2. Loading the CAM file: The CAM file is loaded onto the Arduino board, which is connected to the CNC machine.
3. Movement control: The Arduinoboard sends signals to the stepper motors, which move the axes of the CNC machine according to the instructions in the CAM file. The stepper motors move the machine precisely in X, Y, and Z directions to create the desired shape.
4. Tool control: The CNC machine uses different tools (such as drills, cutters, and end mills) to shape the material. These tools are controlled by the Arduino board, which turns them on and off as needed.
5. Material control: The material being machined is held in place by a clamp or vice. The CNC machine moves the material to the right position for machining and holds it in place while the tools do their work. Overall, the Arduino board acts as the "brain" of the CNC machine, controlling all its movements and operations. By programming the Arduino with the appropriate software and using the right hardware, you can create a highly precise and efficient mini CNC machine.

3.2 Construction

Building an Arduino-based mini CNC machine can be a fun and rewarding project for hobbyists or DIY enthusiasts interested in robotics and automation. Here are some basic steps you can follow to construct your own Arduino-based mini CNC machine:

1. Select your materials: You will need to gather the necessary parts and components for your CNC machine. This includes an Arduino board (such as an Arduino UNO), stepper motors, stepper motor drivers, power supply, spindle motor, and a control software (such as GRBL).
2. Design your machine: Sketch out the design of your machine using a CAD program or on paper. Consider the size and weight of the machine, the placement of the motors, and the size of the cutting area.
3. Assemble the frame: Construct the frame of your machine using aluminum extrusions or other materials. Make sure the frame is sturdy enough to support the weight of the motors and spindle.
4. Mount the motors: Attach the stepper motors to the frame using brackets and screws. Make sure the motors are properly aligned and securely fastened.
5. Wire the electronics: Connect the Arduino board to the stepper motor drivers, power supply, and spindle motor. Follow the wiring diagram carefully to avoid damaging the components.
6. Install the software: Download and install the GRBL control software onto your computer. Connect the Arduino board to your computer using a USB cable and upload the GRBL firmware onto the board.
7. Test and calibrate: Test your machine by moving the motors manually using the GRBL control software. Calibrate the motors to ensure that they move smoothly and accurately.
8. Add accessories: Consider adding accessories such as limit switches, emergency stop buttons, and a display screen to your machine for added safety and functionality. Building an Arduino-based mini CNC machine can be a complex project, but with careful planning and attention to detail, it can be a rewarding experience. There are also many online resources, tutorials, and forums available to help guide you through the process.

3.3 Working

Building an Arduino-based mini CNC machine can be a fun and rewarding project. Here are some general steps to get started:

1. Design: First, you need to decide on the design of your mini CNC machine. This can range from a simple plotter that moves a pen around a piece of paper to a more complex machine that can carve into wood or plastic.
2. Parts: Once you have a design, you'll need to gather the necessary parts. This can include an Arduino board, stepper motors, stepper motor drivers, belts, pulleys, linear rails, and a spindle.
3. Assembly: With all the parts in hand, you can start assembling the machine. This will likely involve a lot of wiring, so be prepared to spend some time on this step.

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4. Programming: Once the hardware is assembled, you'll need to program the Arduino to control the machine. There are many open-source CNC software packages available that you can use as a starting point.
5. Testing: Once the programming is complete, it's time to test the machine. Start with simple movements to ensure everything is working correctly. If you encounter any issues, go back and double-check your wiring and programming.
6. Calibration: Finally, you'll need to calibrate the machine to ensure accurate movement. This involves setting the correct steps per millimeter for each axis and adjusting the acceleration and deceleration settings. Keep in mind that building a mini CNC machine can be a complex project, especially if you're new to electronics or programming. But with patience and persistence, you can create a functional and fun machine that can help you create all kinds of interesting projects.

IV. PROCESS SHEET

To build an Arduino-based mini CNC machine, you will need the following components:
1. Arduino Board (preferably an Arduino UNO or Arduino Nano)
2. Stepper Motor Drivers (A4988 or DRV8825)
3. Stepper Motors (NEMA 17)
4. Linear Rails or Linear Rods
5. Power Supply (12V or 24V)
6. CNC Shield or Breakout Board Once you have all the necessary components, you can follow these steps to build the Arduino-based mini CNC machine:
Step 1: Mount the linear rails or rods on the frame to create the X, Y, and Z axes.
Step 2: Connect the stepper motors to the stepper motor drivers and mount the drivers on the CNC shield or breakout board.
Step 3: Connect the CNC shield or breakout board to the Arduino board.
Step 4: Connect the power supply to the CNC shield or breakout board.
Step 5: Install the software on the Arduino board. You can use the GRBL firmware, which is specifically designed for CNC machines.
Step 6: Install the appropriate software on your computer to control the CNC machine. You can use software such as Universal Gcode Sender, which is a free and open-source software.
Step 7: Configure the software settings to match the specifications of your CNC machine. This includes the number of steps per millimeter for each axis, the maximum feed rate, and the acceleration settings.
Step 8: Calibrate the CNC machine. This involves moving each axis to their respective limits and adjusting the settings in the software to ensure that the machine moves accurately.
Step 9: Optional: Install end stops to improve the accuracy and repeatability of the CNC machine.
Once you have completed all these steps, your Arduino-based mini CNC machine should be ready to use. You can use it to create a wide range of projects, including PCBs, signs, and small parts.

Design Calculation

Designing an Arduino-based mini CNC machine involves several steps, including selecting the appropriate hardware components, designing the mechanical structure, and writing the control software. Here are some steps that can be followed:
Step 1: Select the Hardware Components - Arduino Board: Arduino UNO or Arduino Mega can be used - Motor Drivers: Stepper motor drivers such as A4988 or DRV8825 - Stepper Motors: NEMA 17 or NEMA 23 stepper motors depending on the size of the CNC machine - Power Supply: A power supply that can deliver sufficient voltage and current for the motors and other components - CNC Shield: A CNC shield such as the GRBL shield that can interface with the Arduino board and motor drivers
Step 2: Design the Mechanical Structure - The mechanical structure should be designed to support the CNC machine's axis movements. - The design should be based on the selected components and the desired size of the CNC machine. -

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It is recommended to use linear bearings or linear rails for smooth and accurate movements. - The mechanical structure should also have a mounting platform for the spindle motor.

Step 3: Write the Control Software - The control software can be written in Arduino IDE using the GRBL library. - The GRBL library is a powerful open-source software that can control the CNC machine's movements. - The software should be written to accept G-code commands, which are a series of instructions that define the CNC machine's movements.

- The software should also be able to communicate with the CNC machine's motor drivers and receive input from limit switches for safety.

Step 4: Assemble the CNC Machine - Assemble the mechanical structure and attach the stepper motors and spindle motor to it. - Connect the motor drivers to the Arduino board and power supply. - Mount the CNC shield to the Arduino board and connect it to the motor drivers. - Connect the limit switches and spindle motor to the CNC shield. - Flash the control software to the Arduino board.

Step 5: Test and Calibrate the CNC Machine - Test the CNC machine's movements using a test G-code file. - Adjust the motor drivers' current limit for optimal performance and to prevent overheating. - Calibrate the CNC machine's axis movements using a dial indicator and adjusting the motor steps per revolution. These are the basic steps to design an Arduino-based mini CNC machine. However, it's important to note that designing a CNC machine requires precision and expertise, so it's recommended to consult with an experienced engineer or technician for guidance and support.

Advantages

Advantages of an Arduino-based mini CNC machine:

1. Low cost: Arduino-based mini CNC machines are usually much cheaper than their industrial counterparts, making them more accessible to hobbyists and small businesses. 2. Easy to use: Arduino is a simple and user-friendly platform that can be easily programmed even by beginners. The software can be easily customized to suit individual needs.
2. Customizable: An Arduino-based mini CNC machine can be customized to perform specific functions, such as engraving, cutting, and milling.
3. Small size: Mini CNC machines based on Arduino are compact and take up less space, making them suitable for small workshops or even home use.
4. Low power consumption: Arduino is designed to consume very low power, making it an energy-efficient option

Applications

Applications of an Arduino-based mini CNC machine:

1. Prototyping: Arduino-based mini CNC machines are ideal for prototyping small parts or components.
2. Engraving: Mini CNC machines based on Arduino can be used for engraving on different materials such as wood, plastic, or metal.
3. PCB milling: An Arduino-based mini CNC machine can be used to mill printed circuit boards (PCBs) for electronic projects.
4. Small scale manufacturing: Arduino-based mini CNC machines can be used for small-scale manufacturing of products such as jewelry, phone cases, and personalized items.
5. Educational purposes: Arduino-based mini CNC machines can be used for educational purposes, teaching students about programming, engineering, and manufacturing processes

V. CONCLUSION

An Arduino based mini CNC machine can be a great project for those interested in DIY electronics and computer-controlled machining. Using an Arduino microcontroller and stepper motors, you can build a compact and low-cost CNC machine that can perform a variety of tasks, such as engraving, cutting, and drilling. There are many different designs and configurations for Arduino-based CNC machines, and the specific details will depend on your requirements and budget. However, there are some common components and features that you will need to consider when building your machine, such as: Stepper motors and drivers: these are responsible for controlling the movement of the CNC

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machine. There are many different types of stepper motors and drivers available, and you will need to choose ones that are compatible with your specific CNC machine design. Control board: this is the brain of the CNC machine and contains the Arduino microcontroller and other electronics necessary for controlling the motors and other components. Mechanical components: these include the frame, linear bearings, spindle, and other components necessary for controlling the movement of the CNC machine. Software: you will need to use software such as GRBL or Mach3 to control the CNC machine and convert your design files into machine code. Overall, building an Arduino based mini CNC machine

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