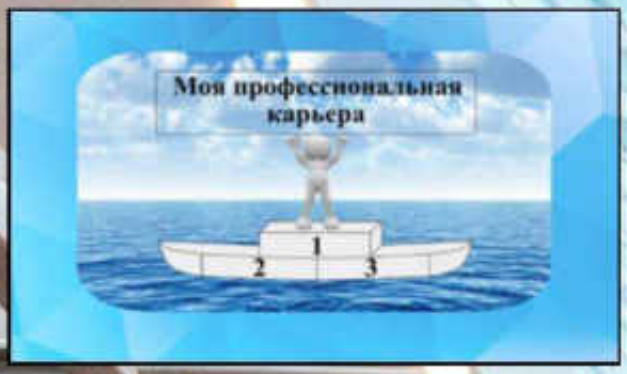

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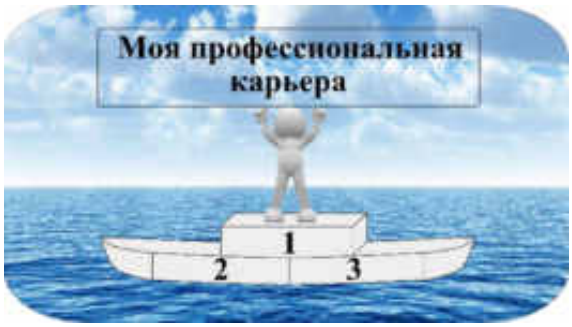

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Название публикации: «DESIGN AND DEVELOPMENT OF A PORTABLE DIY CNC MACHINE»

Annotation: *This article presents the conceptualization, design, and development of a compact, portable CNC (Computer Numerical Control) machine aimed at hobbyists, educators, and makers. Unlike commercial machines that are often expensive or bulky, this DIY CNC solution emphasizes accessibility, modularity, and ease of use—without compromising on performance. Inspired by the minimalism of devices like Cubiio X, the system integrates open-source software, lightweight materials, and a custom motion system to deliver a truly portable digital fabrication tool.*

Keywords: *medical robotics, surgical robots, artificial intelligence, robotic surgery, telemedicine, healthcare automation, precision medicine, robotic-assisted surgery*

Mechanical Design: Compact Form, Modular Function

The mechanical design of the CNC machine focuses on three key goals: portability, modularity, and ease of assembly. Drawing inspiration from Cubiio X's compact structure, this CNC uses a lightweight aluminum extrusion frame. The frame is designed to be both strong and light, enabling users to transport and store the machine easily.

The motion system is based on a three-axis Cartesian configuration using linear rails and a belt-drive (or lead screw) mechanism. The typical working area is 200mm x 200mm x 50mm, but the frame size is easily customizable depending on user needs.

Key components of the mechanical design include:

- Aluminum extrusion frame (2020 or 2040 series)
- NEMA 17 stepper motors for X, Y, and Z axes
- Belt or lead screw system for smooth and accurate motion
- 3D-printed or machined mounts for motors and endstops
- Tool mount adaptable for spindle, laser, or pen plotting
- Modular control unit mount for ease of access and upgrades

The design ensures that each component is easily replaceable or modifiable. The entire structure can be disassembled for transportation, and setup requires only basic hand tools.

Electronics and Control System: Open and Customizable

The control system is centered around affordability and compatibility with open-source tools. An Arduino Uno paired with a GRBL-compatible CNC shield forms the core of the control electronics. Stepper motor drivers (such as A4988 or DRV8825) provide precise motor control, while endstop switches offer safety and homing capabilities.

The electronics setup includes:

- Arduino Uno + GRBL CNC Shield (v3)
- A4988 or DRV8825 stepper motor drivers
- 12V or 24V DC power supply
- Micro limit switches for homing
- Emergency stop button (recommended)
- PWM output for controlling spindle speed or laser power
- Optional cooling fan and enclosure for electronics

GRBL firmware interprets G-code commands and controls the stepper motors accordingly. This setup is fully compatible with open-source host software such as **Universal G-code Sender (UGS)**, **bCNC**, or **Candle**. Users can generate toolpaths using software like **Fusion 360**, **Inkscape** (with plug-ins for laser or G-code export), or **FreeCAD**.

The modular electronics design encourages experimentation and upgrades. For example, users can later integrate touchscreen interfaces, Wi-Fi control modules (like ESP32), or automated tool changers.

User Experience and Use-Cases: Empowering the Maker

Beyond technical performance, this CNC machine was designed with the end user in mind—whether that user is a student, teacher, hobbyist, or small-scale designer. The entire system is plug-and-play, with clear labeling, pre-configured firmware, and minimal setup requirements.

Initial calibration is simple and guided through the software interface. The machine supports real-time jogging, auto-homing, and basic G-code visualization.

Typical use-cases include:

- Laser engraving on wood, leather, acrylic, or paper
- PCB prototyping using flat-end milling bits
- Small-scale woodworking (engraving or cutting thin sheets)
- Artistic pen plotting and vector drawing
- Educational tool for teaching CNC principles and mechatronics

The system is particularly useful in educational settings due to its low cost, safe operation, and transparent hardware/software setup. Students can learn about motion control, firmware configuration, CAD/CAM workflow, and practical problem-solving—all in one compact device.

For hobbyists, this CNC serves as a reliable fabrication tool that opens up possibilities in custom part creation, signage, and prototyping. Its portable nature allows users to carry it to maker fairs, workshops, or co-working spaces.

Conclusion

This project demonstrates that powerful digital fabrication tools can be both accessible and portable. Through careful selection of components, open-source control systems, and thoughtful mechanical design, the DIY CNC machine delivers functionality comparable to commercial solutions—at a fraction of the cost. Inspired by the clean and mobile design philosophy of Cubiio X, this machine aims to put creativity and precision into the hands of anyone with curiosity and a screwdriver.

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