A Five-Motor Robotic Platform for Software Training Application

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Abstract

Students often express dissatisfaction with robot car kits and simulated environments, arguing that these do not represent "real" robotics. However, identifying a hands-on project that offers at least five degrees of freedom, millimeter-level precision, and minimal risk of damage has proven challenging.

The **5Motor** robot addresses this gap by providing a cost-effective, accessible platform that supports programming via G-code, either directly or through a Python wrapper. Its open architecture enables students to engage with a wide range of robotics concepts — including kinematics, motion control, and video analysis — making it a practical and educational tool for robotics training.

1 Hardware

The 3D printed needs for accuracy metal components for all contact joints. So ball bearings and linear bearings (MGN09) are used. Only one type of motor is used for all axis: a Nema14 pancake stepper motor.

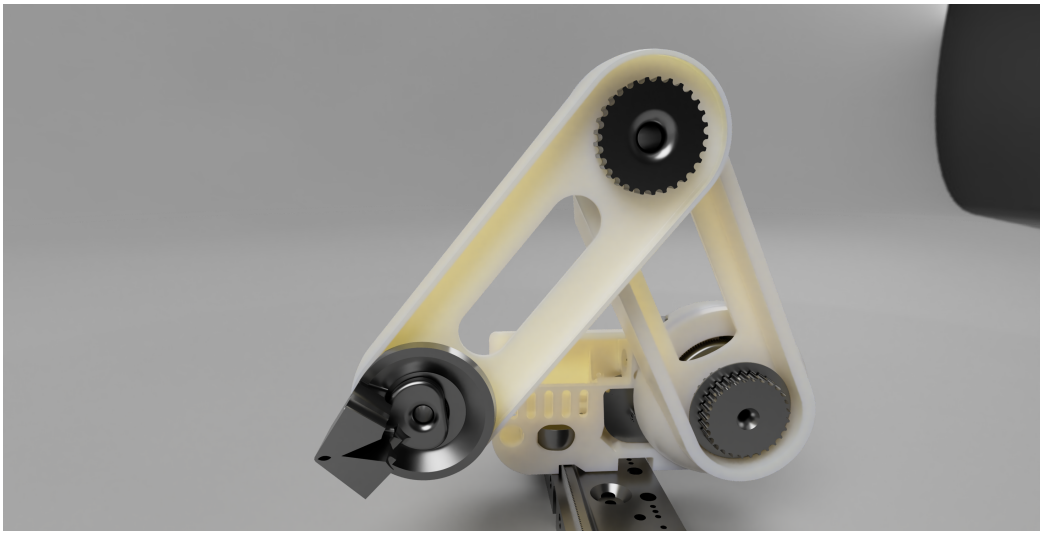

Figure 1: Rendering of the 5Motor robot

The design allows students to do mistakes. If a hard limit is ignored, the force of the motors is small so it just crashes into the wall with just loosing allignment, and not causing damage. This minimal force has as a consequence, that the motors for the hand motion can not be lifted in the upper arm[1]. Thus the movement is transmitted via HTD 5M belts, so the belt drivers can be printed.

The Robot can be seen in action on youtu.be/BwlxCkYBifw. The 3D files are published on github.com/ChKendel/5Motor.

2 Firmware

The Robot is running FluidNC to receive GCode and send current to the motors. The board is based on an ESP32 and some TMC2209 Drivers.

[1] any motor in the upper or lower arm would demand a stronger motor in the shoulder, and thus the danger of damage.

3 Python Software

Students can either use the GCode directly on the firmware. Or use a python wrapper for more sophisticated kinematics.