Abstract

The introduction of robots has significantly improved numerous industries. Robotics are now heavily relied upon in almost every sector from manufacturing to defense, yet biology lags behind in this trend of automation. The vast majority of lab work is currently done by humans, making it slow and error prone. The startup LifeFoundry seeks to change this by creating a fully automated synthetic biology lab. Our goal for this class is to create a Cartesian robot that will be used in our lab to automate a number of tasks. The main hardware we will be designing includes a BLDC motor controller, a power distribution system, and central controller for the interfacing with the robot. This will be coupled with firmware for the motor controller, and software for the central controller. CAN bus will be used as a communication backend and the robot will be able to interface with the rest of our lab equipment. Ideally this robot will be able to operate fully autonomously with a high level of reliability. The motor controller design will be based on an open source project called ODrive, which we will adapt to our robot's specific needs. Changes on the hardware side include shrinking the PCB footprint and removing the extra channel on the board. Changes to the firmware will mostly focus on integrating the board with the rest of our control software, and adding better motion control. Some additions include path-planning for smooth movement, CAN bus communication, and custom encoder support. Software for the robot's central controller will be designed from the ground up to interface with our lab control system and coordinate motor movement to properly move the robot.

Project Goals

First Demonstration:

For our first demonstration we plan to have fully functional motor controllers and show basic movement of our robot. We will design a motor controller based on the open source ODrive board, adapting for our use case. In addition to the motor controller, we will have a basic central control system set up with primitive software for actually using the robot.

Second Demonstration:

In the second demo we want to have the basic robot structure finished, including finalized PCBs, and the central controller running reliably. We should be able to run the robot autonomously for short periods of time and send it commands through the main controller using a basic API. We will also work towards implementing more advanced features such as force sensing on all axes, a zero-g mode for the Z axis, and an interface for adding a tool to the robot.

Final Demonstration:

The final demonstration of our robot will ideally feature it as it will appear in our lab. At this point the robot should be able to run fully autonomously with very high reliability and include the ability to recover from software or hardware faults. A backend for diagnosing errors and tracking system stability should be implemented. The robot's API should be functional and well documented, allowing for quick integration with our existing lab control system. This demo will likely focus more on increasing system stability and usability rather than adding more features.

Tentative Schedule

Tuesday: 4:00pm-7:00pm
Wednesday: 4:00pm-7:00pm
Friday: 4:00pm-7:00pm  
Saturday 10am-4pm

## Final Report and Project Files

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