Progress Report: Boo-Bot

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CS 370

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Project Overview

The goal of this project is to create a small, remote controlled robot. This robot, nicknamed the "Boo-Bot" by the authors, is capable of sending real-time video/audio and taking real-time controls over the internet, allowing it to be controlled from anywhere with a network connection. A specific goal is to allow this bot to be controlled via Twitch live-stream chat, yielding more participation during demos.

Throughout construction, this project has been made as from-scratch as possible. This has included designing of circuitry, PCBs, and 3D printed parts, as well as bare-metal coding for drivers, communication, and interaction.

This progress report will go over work done, project direction, and next steps.

Software Development

Software work done so far can be sectioned into two areas: OS/Systemd and Twitch. While this progress report will only give a brief overview, specifics will be provided in a final report.

OS and Systemd

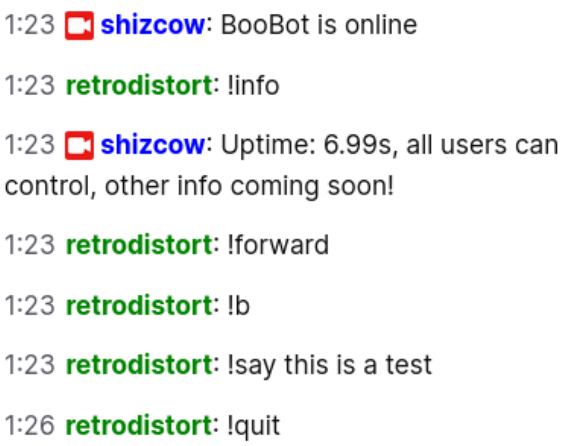
In order to link external hardware (camera, microphone, speaker, etc) with other software being written, we needed both an OS and drivers. We chose stock Raspbian light as a starting point, due to its exhaustive support for our Raspberry Pi 3 A+, then wrote some systemd modules to interface with our external components. The camera was dead-simple to get working great, as the `raspivid` package is built in and very fast. The speaker amplifier and microphone were a bit harder to set up. Interfacing over I2C, these parts should theoretically work with minor setup, but we ran into some UDEV issues. At this point, I2S devices are working great, with the caveat of needing to be ran with root privileges – for some reason.

Twitch Bot

With the environment set up, work could begin on interfacing with Twitch. It was decided that a Twitch bot would be written from scratch in Rust – the twitchchat crate was eventually decided on. The source code for the current iteration of the bot can be found on GitHub. After a significant amount of work was completed, the bot went online with no issues.

During development, the authors discovered Flite, an open-source offline-only terminal-based text to speech engine. Surprisingly, it could be dropped right in to the twitch bot with zero issues, taking in `!say` commands from Twitch chat and playing synthesized speech straight out of the I2S speaker.

Below are two screenshots: one of Twitch chat and the other of terminal output running on the Pi. This shows the bot joining a Twitch chat and accepting commands from another user. While the movement commands are yet to be implemented, `!say` and various information commands are complete.

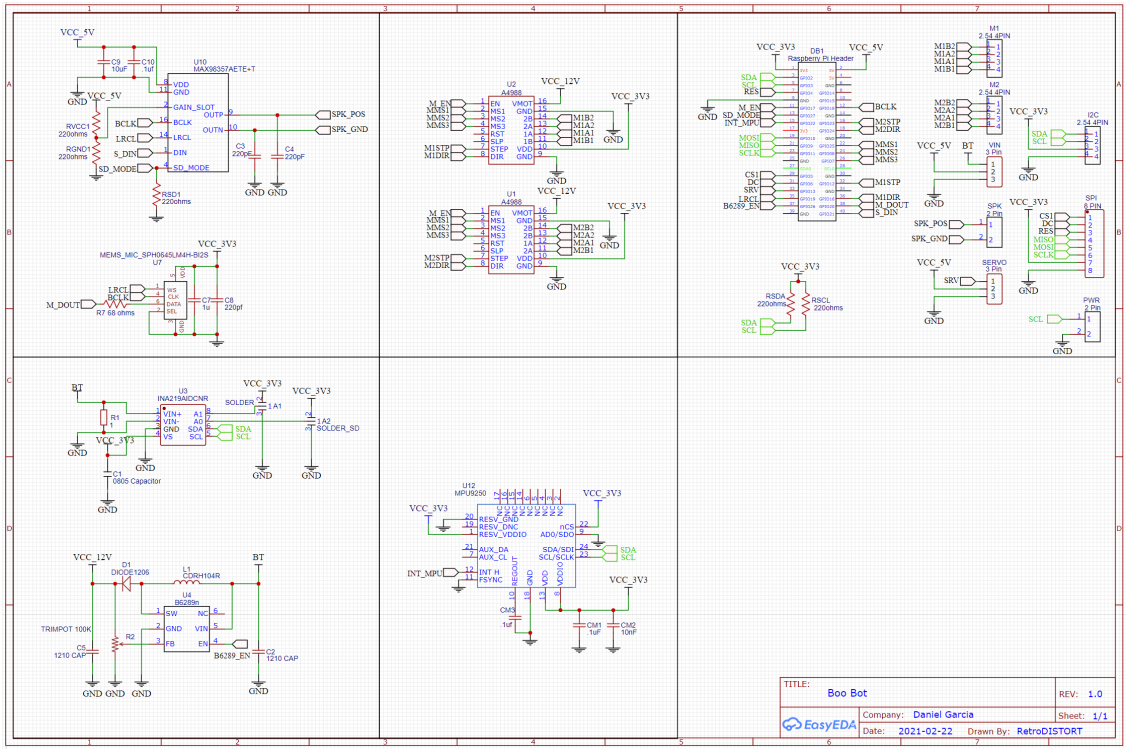


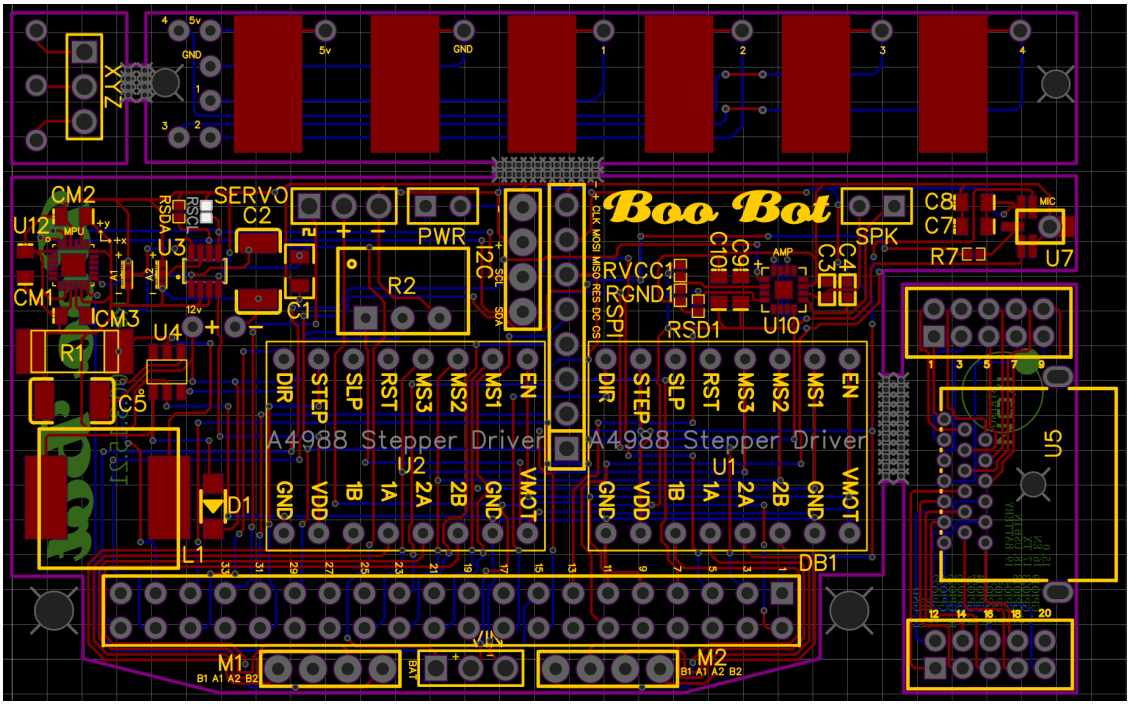

```
> cargo run -- -c src/twitch_config.toml
    Finished dev [unoptimized + debuginfo] target(s) in 0.11s
     Running `target/debug/twitch -c src/twitch_config.toml`
connecting, we are: shizcow
joining: shizcow
Connected!
moving: Forward
moving: Backward
saying phrase 'this is a test'
Bot exited gracefully
```

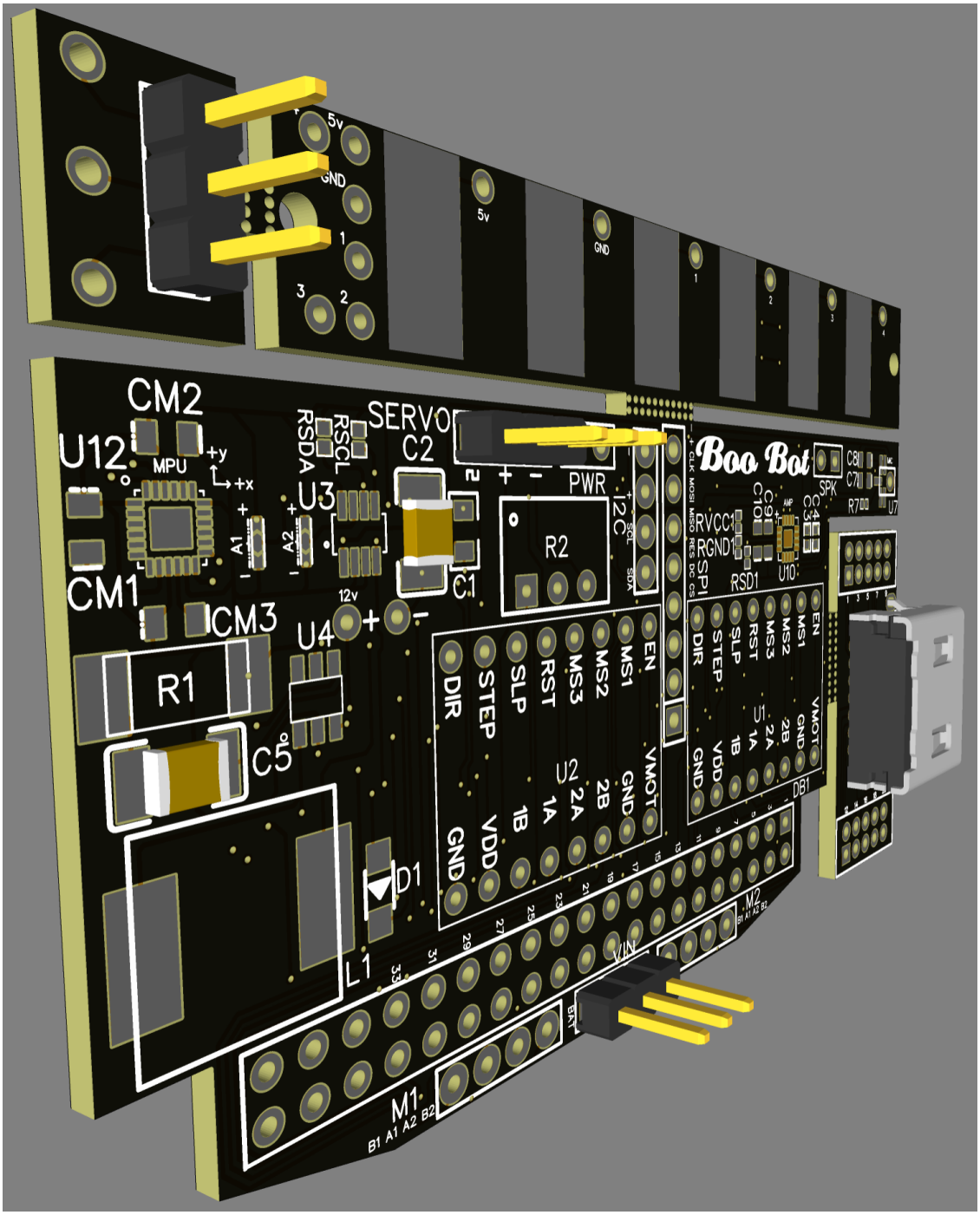
Next Steps

Once hardware development is complete, the movement commands can be implemented. After this, we aim to address the previously mentioned UDEV issues. At that point, auxiliary peripherals may be programmed for – as much as time may allow.

Hardware Development







Attributes to Evaluate

For this project, we have chosen to evaluate the *Limitations* and *Cost* attributes. This section will give an overview and analysis of each in turn.

Limitations

Both the current test stages and the envisioned final product of this project will have significant limitations. The first is in processing power. As this device is meant to be small, relatively low-cost, and passively cooled, the Raspberry Pi 3 A+ is one of a few great choices here. And while it is more than able to meet the base requirements (video processing, interfacing with peripherals, network communication) expandability is rather low. As such, far-future stretch goals such as fully autonomous driving, peer-to-peer swarm communication, and full server hosting may not be attainable without significant engineering.

A second limitation is in the choice of hosting. The current iteration of the project uses Twitch for controlling the bot over long distances. While this is a relatively easy solution to execute, Twitch struggles with low-latency streaming. As such, although the bot is able to push video feed with very low latency, Twitch is bottlenecking the stream delay. During testing, we measured this delay to be between 3 and 7 seconds.

Another limitation of Twitch streaming is resolution and bit-rate. While the bot can just reach 60fps 1080p streams, Twitch throttles incoming connections to specific resolutions, bitrates, and framerates. After some testing, we Twitch would only display what is (after bitrate compression) approximately 720p at a locked 24fps. Future iterations of this design using custom streaming servers may be able to overcome all the limitations we have been experiencing with Twitch.

Cost

Bill of Materials

Below is a bill of materials for this project, including all hardware used. All components are purchased from various EBay stores, with shipping times between one and three weeks.

Amount	Component	Price Ea ($)	Description	Cost ($)
2	Drivers	3.16	A4988 Stepper Motor Driver Module	6.32
2	Motors	3.98	MINEBEA NMB 2-phase 4-Wire 18° Stepper Motor	7.96
1	Amp	4.99	MAX98357A I2S Class D amplifier	4.99
1	Speaker	0.99	8 ohm speaker	0.99
1	Lipo	15.05	Lipo battery pack	15.05
1	Microphone	7.51	I2S MEMS Microphone SPH0645LM4H	7.51
1	Voltage Regulator	0.79	B628 3-24V to 12V 2A Adjustable Boost Step-Up Converter	0.79
10	Capacitors	0.466	16v 1000UF Electrolitic SMD	4.66
1	Raspberry pi	29.99	Raspberry Pi 3 Model A+ 2018 model	29.99
1	9-axis MPU	4.60	MPU9250 (Gyro, Accelerometer, Compass)	4.60
1	ADC	1.69	INA219 DC current and voltage sensor	1.69
1	Servo	1.79	SG90 9G Micro Servo Motor	1.79
1	Display	2.95	0.96“ I2C OLED Display	2.95
1	SD Card	5.00	32 GB Class 10 Micro SD Card	5.00
1	PLA Filament	5.00	100g Black PLA filament 1.75 mm	5.00
1	PCB	8.00	5 Custom PCBs from EASY EDA	8.00
			Total:	107.29