UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

Hands-free Following Cart

ECE 445 - Team 16

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Introduction

- Issues with landscaping/small construction:
  - Inefficiency in repetitive tasks
  - Creates unsafe environment
- Our cart solves this problem by being able to carry heavy objects, follow a user or preset coordinates and increase workplace safety

Objectives

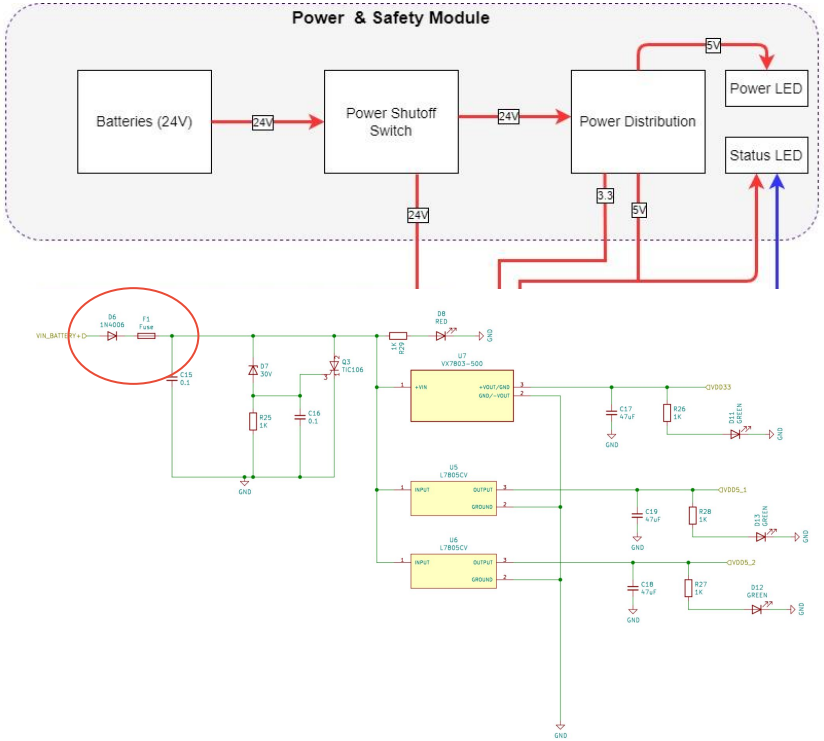
- Our project is intended to be used in a landscaping environment where there is a need for heavy loads to be transported in a timely manner
- There are existing tools that serve this purpose, e.g. wheelbarrows for outdoor work or Automated Guided Vehicles (AGVs), there are downsides to each that our solution eliminates
- The Handsfree Cart is designed to be able to navigate anywhere outdoors where a person is able to go, including ramps, while also following the user at a predetermined distance

High-Level Requirements

- Must be able to move **150-200 pounds** of material without any external assistance
- Follow users/preset GPS points at a **distance of 2 meters** at up to **7 mph** while avoiding collisions that cause damage to cart or to property
- In case of failure, alert the user if within range and also flash lights on cart for a visual alert

Power and Safety Module - Design

- Provide 24+ volts for the drivetrain subsystem
- Provide 5v and 3.3v to sensors and for any off board devices
- Circuit protection for shorts and any overdraw to protect pcb
- Hard power kill switch
- Voltage and power LED indicators



Power and Safety Module - Calculations

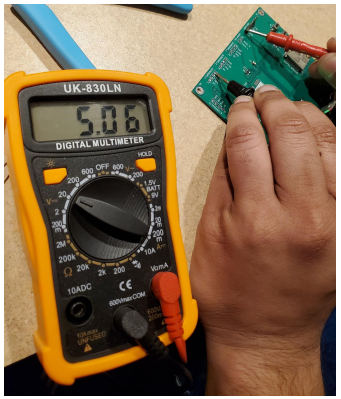
Part Identifier	Part Name	Communication Protocol	Number Needed per board	Supply current per device [A]	Supply Current per board [A]	Supply Voltage Min [V]	Supply Voltage Typ [V]	Supply Voltage Max [V]	Estimated Power Consumption [W]
	ESP32-WROOM-32UE	Multiple available	1	0.5	0.5	3	3.3	3.6	1.65
	GPS Module	UART	1	0.025	0.025	2.8	3.3	4.3	0.0825
	Compass	SPI	1	0.00045	0.00045	2.8	3.3	3.6	0.001485
	Ultrasonic Sensors	SERIAL	6	0.015	0.09		5		0.45
	Motor Drivers	PWM	2	0.1	0.2	5	5	30	1
	LEDs	PWM	60	0.025	1.5	4.8	5	5.1	7.5
									0
	Motors (Max RPM)	PWM	2	18.4	36.8	24	24	24	883.2
					0				0
					0				0
					0				0
					0				0
Max/Total	Max/Total		60	18.4	36.8	24	24	30	893.883985

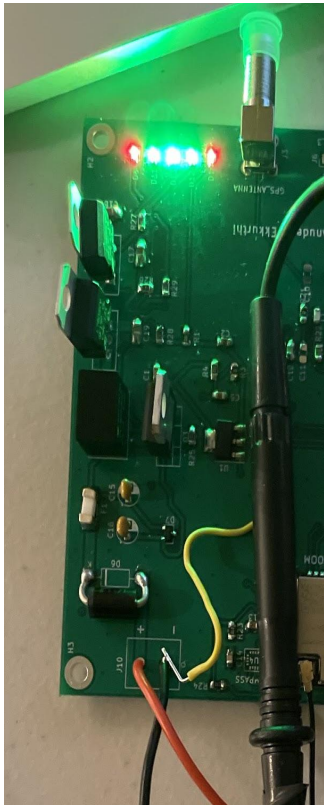
	Current	Power		Board Power Consumption	Need to Rate for this
Total 3.3V	1.733985	0.52545		0.81545	1.223175
Total 5V	1.45	0.29			
Total 24V	883.2	36.8			
Battery Rating	886.383985	531.830391			

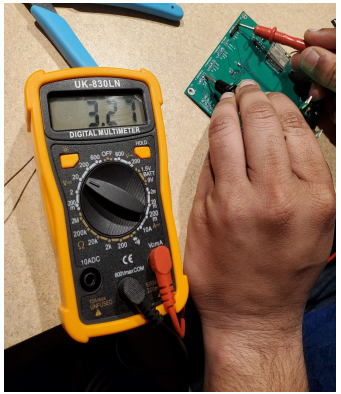
P=VI

Power and Safety - Verification & Improvements

- 5v regulator temperature issues
- Additional 3.3v and 5v external rails
- Connectors for all sensors instead of directly soldering them to the board

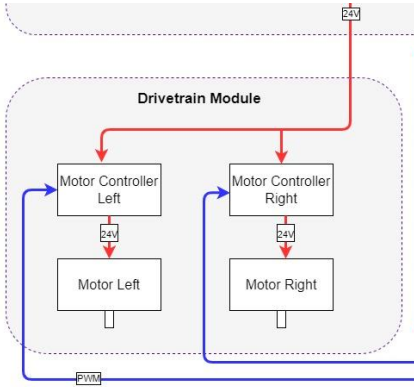






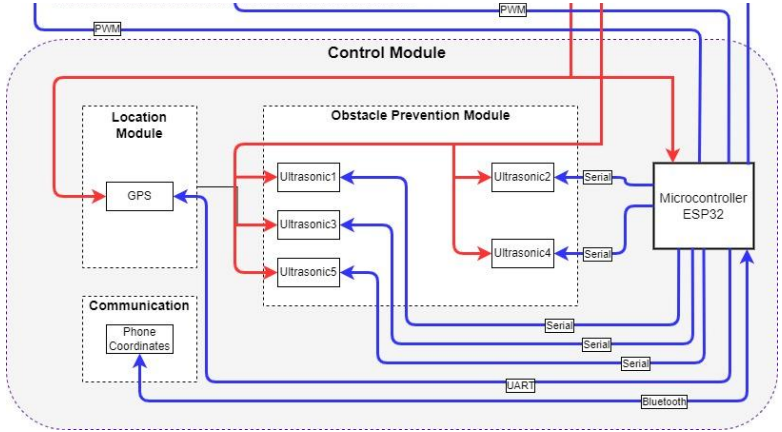
Drivetrain Module

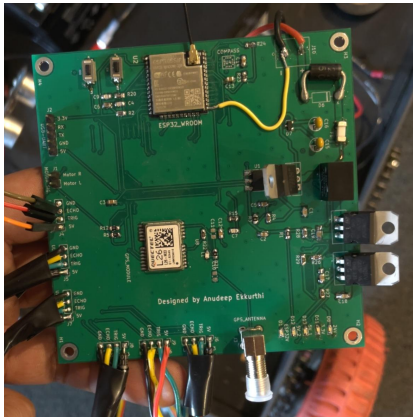
- Drivetrain - motors and motor controllers to control speed and direction safely given input drive signals
- 350 Watt brushed DC motors
- 30A Continuous and 80A Peak DC motor controllers

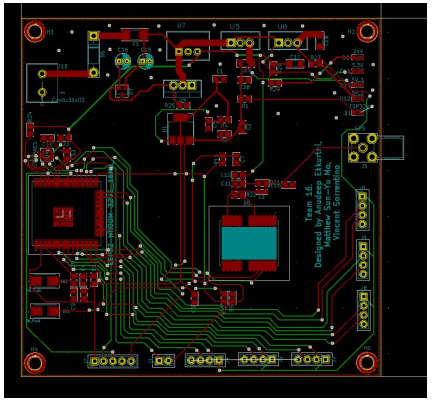


Control Module

- Location - cart location via GPS module
- Communication - share updates and commands via bluetooth low energy
- Obstacle prevention - avoid objects in close proximity and also attempt to detect sudden terrain changes



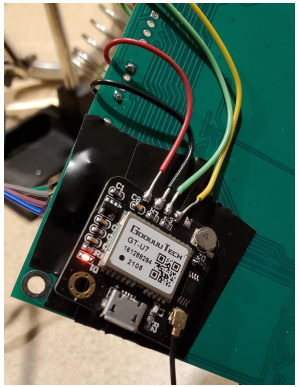




GPS - Overview

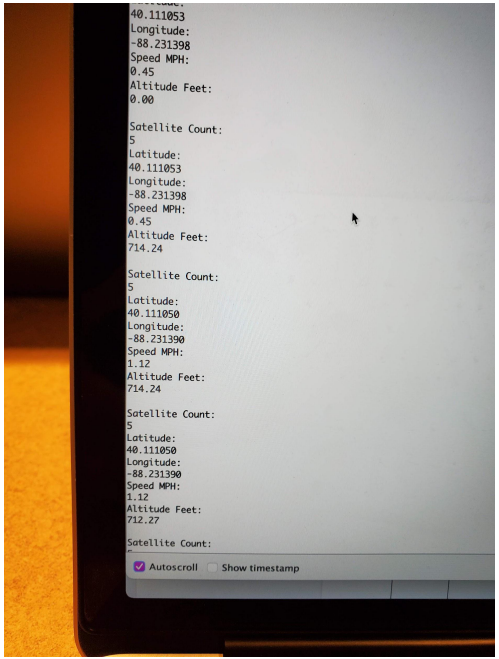
Quectel L26-M33

- Accurate latitude and longitude of cart within 2 meters
- Fast update rate on location changes



Issues

- Quectel Chipset failed
  - Designed per data sheet specifications
  - Two chips produced no output and processed zero input requests



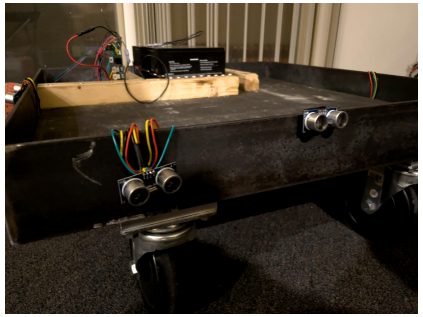
Solution

- NEO-6M GPS worked well, we tapped unused serial pads on the V2 PCB
- We would like to work with NEO-6M in the future, but issues with stock

Obstacle Prevention - Overview

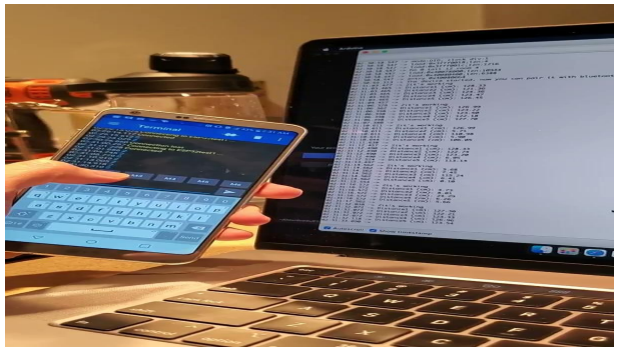
Ultrasonic sensors

- Cheap way to detect distance changes and halt cart for safety
- 5x HC-SR04 Sensors were mounted around the cart



Issues

- Timeout issue due to poor quality of cheap clone costed us a few days of debugging
  - Software solution - echo pin to input then pulse and revert to output
  - Hardware solution - capacitor between Vcc and Echo pins



Long term solution

- Use refined ultrasonic sensors in the future and 3xd print brackets to stabilize them on the cart

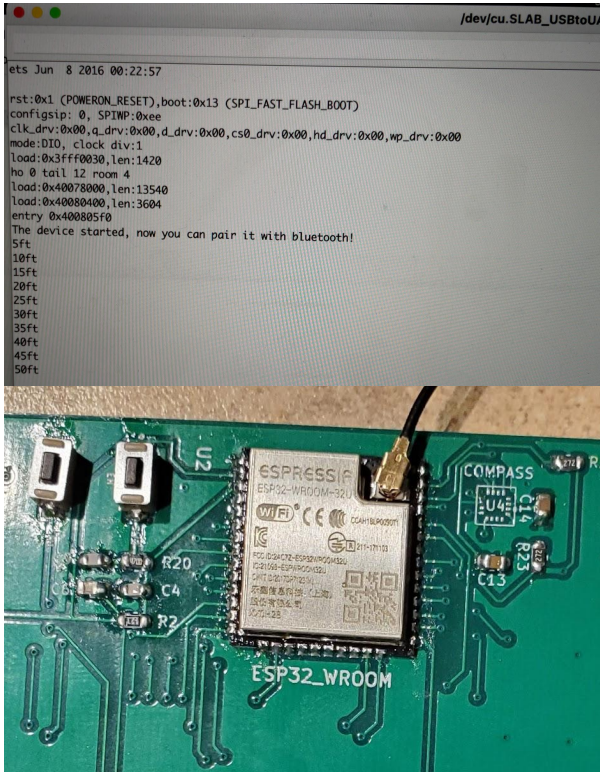
Microcontroller and Bluetooth - Overview

Bluetooth LE

- Integrated into ESP32 chip instead of using Bluetooth transceiver
- Supports a data rate of up to 150 Mbps, and 20 dBm output power at the antenna to ensure the widest physical range

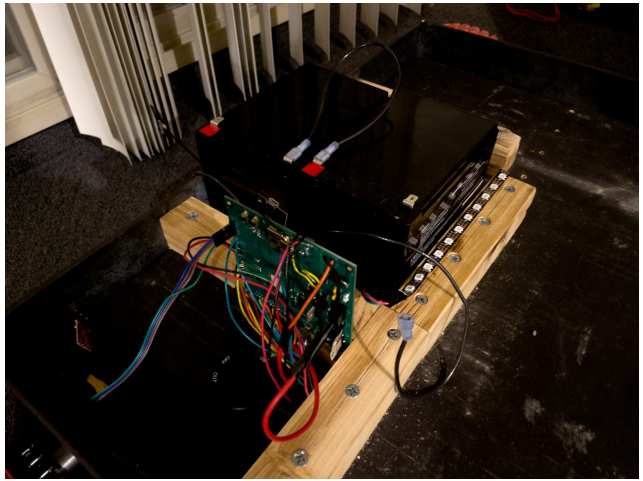
ESP32-WROOM-32UE

- Handle multiple communication protocols - UART, Serial, I2C, PWM
- GPIO for all sensors and devices onboard
- Serial monitor communication with computer



Problems Encountered

- GPS did not work inside of ECEB or indoors, needs clear sight to sky
- Semiconductor shortage
    - Redesign circuits due to parts not available in stock
    - Critical components were not available in the market, so had to make design choices limited by market and shipping constraints
- Communication limitations on ESP32 pins required tacking wires into other GPIO pins to communicate with different on board devices



Software Issues

- ESP32 does not support analogWrite() function to generate PWM signal to control motor speed
- TinyGPS++ required for library for both Quectel and NEO-6M modules
- Many additional libraries required to bring subsystems together
- Unable to attain phone's GPS location due to iOS privacy issues and Blynk datastreams setup

Completed Product

Video of Completed Product performing basic drive functions within stated weight range

Thank You!
Questions?

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