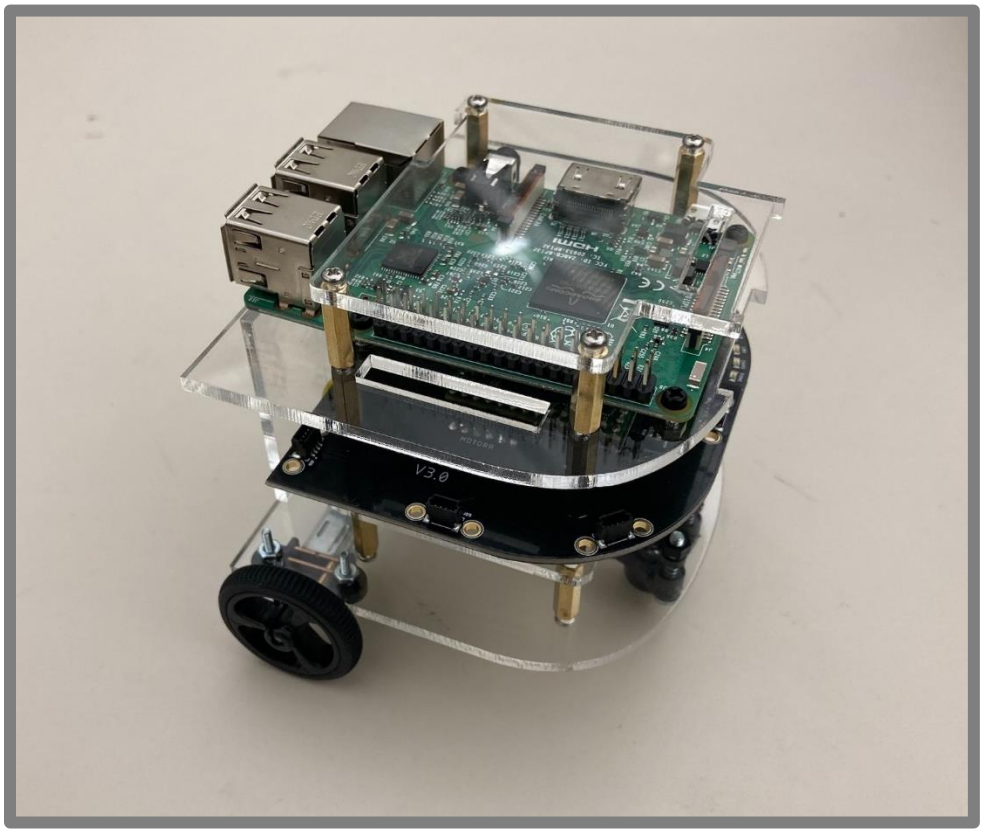
GRITSBot 3.0



User's Guide

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1 Purpose

The purpose of this document is to explain the general design elements, assembly, and usage of the GRTISBot 3.0 robot.

2 Printed Circuit Board (PCB)

The printed circuit board (PCB) houses the majority of the electronics on the robot and features circuitry for power and sensors. Some of the circuitry is taken from the GRITSBot 2.0 PCB while other components are copied and modified versions of circuitry from breakout boards.

This section will detail the core circuitry of the GRITSBot 3.0 PCB.

2.1 On/Off Switch

The On/Off switch turns on and off the 5V and 6V power circuits of the robot. The On/Off switch has no connection to the charging circuitry.

2.2 Status LEDs

Status LED	**Description**
PWR	On when On/Off switch is on and receiving power from battery/charger
LBO	Low battery indicator
CHRG	On when battery is charging or only charger connected.
DONE	On when batter is done charging.

2.3 5V Regulation

The 5V Regulation circuitry is taken and modified from Adafruit's PowerBoost 1000C board.

The circuitry takes power from the battery/charger and regulates it to 5V to power the Teensy, motor encoders, and motor driver.

2.4 6V Regulation

The 6V Regulation circuitry is taken from the GRITSBot 2.0 PCB.

The circuitry takes power from the battery/charger and regulates it to 6V for motor power.

2.5 Charging Circuitry

The charging circuitry is taken and modified from Adafruit's PowerBoost 1000C board.

The circuitry handles charging the robot battery and load-sharing between charger and battery.

2.6 Power Sensor

The power monitor is taken and modified from Adafruit's INA260 Breakout Board.

The INA260 power sensor is wired in series with the VBAT line directly after the charging circuitry and measures VBAT voltage/current and power usage.

If undesired, the PCB features pads for a jumper on the VBAT line to bypass the power sensor.

2.7 Teensy 4.0

The Teensy 4.0 is a low-level microcontroller board that handles sensor and motor driver communications and control.

The Teensy takes in 5V and provides 3.3V for sensor power. The Teensy can be connected to microUSB for programming.

WARNING: There is potential for damage to the 5V regulation circuitry if the Teensy is connected to microUSB without battery/charger power. The cause is unknown at the moment but may be due to pre-biasing the output of the TPS61030 chip. Ensure that the robot is fully powered through battery/charger first before connecting the Teensy with microUSB that has external power.

2.8 H-Bridge Motor Driver

The H-Bridge Motor Driver takes power from 5V regulation and uses 6V for motor power. The driver is controlled by the Teensy.

2.9 I²C Mux and Qwiic Connectors

The I²C is taken and modified from Sparkfun's Qwiic Mux Breakout.

The GRITSBot 3.0 features seven distance sensors with the same, unmodifiable I²C address, so I²C mux circuitry is needed to properly access all of them.

The GRITSBot 3.0 PCB includes Qwiic connectors for wiring to the distance sensors and holes for distance sensor mounts.

2.10 Inertial Measurement Unit (IMU)

The I²C is taken and modified from Adafruit's BNO055 Breakout Board.

2.10 Pi Power & Communication

The PCB features 4 pins for providing power and serial communication to a Raspberry Pi.

3 Other Electronics and Components

This section details other electronics and components not on the PCB.

3.1 Distance Sensors

The GRITSBot 3.0 features seven Adafruit VL53L0X Time of Flight Distance Sensors.

These distance sensors are connected to the PCB through a Qwiic cable and should be held using 3D-printed or laser-cut mount that can be bolted to the PCB.

3.2 Raspberry Pi

The GRITSBot 3.0 supports Raspberry Pi 3, 3b, 3b+, and 4.

The Raspberry Pi receives power from the Pi power pins on the PCB.

The Raspberry Pi serves as the main processor for the robot and communicates with the Teensy either through serial pins on the PCB or through USB

3.3 Pi Camera

The intended camera is a Raspberry Pi Camera V2, but the GRITSBot 3.0 should support any camera that connects to a Raspberry Pi through the CSI connector.

3.4 Motors

The GRITSBot 3.0 uses two geared motors with encoders from DFRobot.

3.5 Battery

The GRITSBot 3.0 uses a 3.7V LiPo Battery from Adafruit

4 Assembly

This section's purpose is to walk through the steps involved in putting together a working robot once all of the parts have been purchased or manufactured. To this end, the assembly process will require:

- 1x Cut Acrylic Pieces
- 2x 100:1 Motors
- 1x Pack of two wheels
- 1x Raspberry Pi (3B, 3B+, 4)
- 7x Printed or machined distance sensor mounts
- 7x ToF distance sensors
- 7x 50mm or shorter Qwiic connector wires
- 1x Front Caster Pack
- 3x Small Caster Springs
- 3x M3 Locknuts
- 1x 3.7V Lipo Battery
- 1x Teensy 4.0 board with pins soldered
- 8x M2.5x15mm brass male to female standoffs
- 4x M2.5x10mm nylon male to female standoffs
- 4x M2.5x20mm nylon male to female standoffs
- 4x M2.5 Locknuts
- 4x M2.5x6mm Screws
- 14x M2 Nylon Screws
- 14x M2 Nylon Nuts
- 4x 5cm Female to Female Jumper wires

4.1 Assembly With an Assembled Circuit Board

For this process, the steps are much simpler than without a circuit board, as all connections except the motor connections will involve no soldering.

1. First, solder pins to the Teensy 4.0 if they have not already been soldered. Only the outer pins are necessary. Place the teensy into the circuit board putting the pins through the holes in the marked section on the silkscreen. Solder the teensy into the PCB. Clip off the pins on the bottom as low as possible without damaging the solder joints.
2. Next solder the motor connectors that come with each motor into the holes marked motorR and motorL respectively. The order of colors from the back side of the PCB goes Red, Black, Yellow, Green, Blue, then white, but please review the pinouts on the circuit board to ensure your connector colors are the same pattern.
3. Thread a 50mm or shorter Qwiic connector through the two upwards facing holes in the distance sensor mount. Plug the end exiting the front of the mount into a distance sensor, then mount the distance sensor using 2x M2x8mm Nylon screws and secure them with 2x M2 Nylon nuts. Repeat this 6 more times to obtain 7x mounted distance sensors with qwiic jumpers out the back of the mount.
4. Plug in each sensor to its Qwiic header on the PCB then, using more M2x8mm Nylon screws and nuts, screw each distance sensor mount into the PCB. Set the PCB to the side gently once all 7 are mounted.

5. Begin with the bottom acrylic plate. This one has two rectangular holes near the bottom side and three screw holes in the front. First, screw 4 M2.5x15mm brass standoffs into lock nuts through the four rectangularly spaced holes in the plate. Use pliers to hold them while screwing into the locknut if necessary.
6. Place the motors into their mounting brackets, making sure the flat panel at the end of the gearbox lines up with the edge of the bracket. Mount the brackets+motors to the bottom side (opposite side to the standoffs) of the plate using the screws provided with the brackets.
7. Place the wheels onto the motor shafts and make sure the wheels are angled straight and do not rub against the acrylic. Place the rubber ring on the outside to tighten them and lock them in place.
8. Thread the screws into the three holes on the caster, then place the caster springs and the 2mm spacers that come with the casters. Thread the end of the screws through the acrylic plate and secure them in place with 3x 3mm Locknuts.
9. Next place the battery plate (rectangle with rounded corners) onto the standoffs and attach 4x 10mm nylon standoffs through it into the brass standoffs of the bottom plate, securing it in place.
10. Onto this plate, place the battery. Then bring the circuit board with the teensy attached close. Ensure the power switch is switched off (towards the bottom of the board) then plug the motor connectors into their corresponding motor and the battery into the battery connector. You should see no lights turn on if the switch is correctly turned off.
11. Place the wires under the circuit board on top of the battery in a way that will hold them and hide their excess length, then place the circuit board on top of the standoffs from the battery plate. Thread M2.5x20mm standoffs into the battery plate standoffs through the holes in the PCB, holding the PCB in place and tightening it down.
12. Place 4x 5cm female to female jumper wires onto the Pi communication and power pins located next to the teensy location. From the top the colors recommended are Red, Black, Grey, White (For 5v, Gnd, Pi Tx, Pi Rx).
13. Screw the Raspberry Pi into the next plate, which looks similar to the bottom plate of the robot, using 4x M2x8mm nylon screws and nuts.
14. Thread the four wires through the slot on the right side of the plate and connect them to pins 2,3,4,5 (5v, Gnd, Tx, Rx) from the top on the right column of pins in the same order they are on the PCB.
15. Attach the plate to the standoffs from the PCB using 4x M2.5x15mm brass standoffs
16. Screw on the top plate using 4x M2.5x6mm screws.
17. Press fit the back plate into the grooves, and press fit the camera mount plate into the front slots. If using a camera, mount the CSI cable and thread it through the slot before attaching the top plate and press it under the top plate to keep the cable out of the way. Then mount the camera to the camera mount.

5 Uploading Code and Using the GRITSBot 3.0

WARNING: There is potential for damage to the 5V regulation circuitry if the Teensy is connected to microUSB without battery/charger power. The cause is unknown at the moment but may be due to pre-biasing the output of the TPS61030 chip. Ensure that the robot is fully powered through battery/charger first before connecting the Teensy with microUSB that has external power.

Upload the Teensy code found in the Github Gritsbot3/Firmware/teensyCode folder into the Teensy on the PCB through its microUSB port. Remember to have the board powered on and connected to the battery or charge port before plugging in the Teensy. This will require the Gritsbot3/Library folder to be placed in your Arduino libraries and the Arduino IDE set up to work with Teensy 4.0 which can be done following this guide.

Image the Raspberry Pi SD card with the image provided in the Github and plug that into the Pi. Power the Pi by turning on the Gritsbot and connect the Pi to a monitor through the HDMI port or USB C port depending on which version you are using. Plug a mouse and keyboard into the rear USB A ports and use this to complete the setup of the Pi and add a Wi-Fi connection. Additionally a Wi-Fi antenna can be connected into the rear USB A ports for better signal.

6 Future Changes

- The Robotarium code and raspberry Pi code currently do not support the additional sensors on the Gritsbot 3.0. These will need to be updated to allow the correct transfer of the data, as well as adding the ability to disable sensors through their registers to force them into sleep or deep sleep modes.
- To the PCB, we would like to add a timer circuit to power off the Pi for a certain length of time, then to power it back on. This would be useful to have while charging to charge as quickly and efficiently as possible.
- Add additional pinout headers to the PCB or a Qwiic header to allow extra I2C connections for breakout boards.
- Add additional power and short circuit protection to the PCB to prevent chip damage from powering the board through the Teensy or touching the board while it is powered.
- Move PCB components to improve ground/power connections and heat characteristics.

7 Links and References

7.1 Bill of Materials

GRITSBot 3.0 BOM: https://docs.google.com/spreadsheets/d/1fcbRilmKaX-AO9ylUm2N9gINN3ZsyIf4CjUE0T1iR2c/edit?usp=sharing

7.2 GitHub

GRITSBot 3.0: https://github.com/Payday02/Gritsbot-3

GRITSBot 2.0 Hardware: https://github.com/robotarium/GRITSBot_hardware_design

7.3 Robotarium

Robotarium at Georgia Tech: https://www.robotarium.gatech.edu/