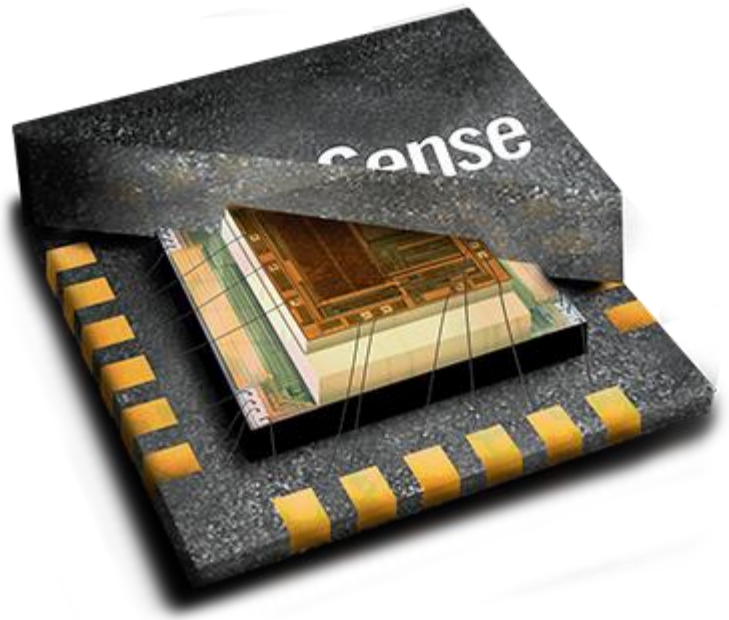
IMU Backpack and Raspberry Pi Use Guide



Raspberry Pi

Raspberry Pi Hardware Set-up

Make sure to have HDMI Cable, micro-usb adapter, and female-to-female jumper cables

Plug micro-usb into the Pi's power port, and connect HDMI to a monitor.

Raspberry Pi Software Set-up

If one is setting up a Raspberry Pi from scratch, follow these steps to configure the Pi to be ready for testing:

Default Login Credentials

Login: Pi

Password: Raspberry

Downloading Image

Download a Raspbian Image from this link: https://www.raspberrypi.org/downloads/raspbian/

If link does not work, search for Raspbian Image Operating System on Google.

Upload the image using WinDisk imager onto a Mini-SD card
https://sourceforge.net/projects/win32diskimager/

Terminal

If the screen defaults to the GUI, navigate to the Terminal (black box icon) to type in commands

Changing Keyboard Layout (Optional)

If special characters are required, it may help to change keyboard layout. To do this, type the command

```
Sudo dpkg-reconfigure keyboard-configuration
```

Then choose the keyboard model used, if the model is unknown, select

Logitech Cordless Desktop and Select English (US) Layout.

Press enter until the terminal is visible again or unless additional options need to be configured.

Connecting to GTother

Type

```
sudo nano /etc/wpa_supplicant/wpa_supplicant.conf
```

And change file to the following:

```
ctrl_interface=DIR=/var/run/wpa_supplicant GROUP=netdev
update_config=1

network={
    ssid="GTother"
    psk="GeorgeP@1927"
}
```

After the file has been changed, type

```
Startx
```

to enter the GUI. After the GUI has loaded, go to the web browser and navigate to the GTother login page and type in credentials.

You may need to take it to Wreck Techs to get the MAC address recognized by the network

Installing I2C

Install i2c-tools utility via the following commands:

```
Sudo apt-get install python-smbus
Sudo apt-get install i2c-tools
```

A guide on adafruit to setting up i2c:

https://learn.adafruit.com/adafruits-raspberry-pi-lesson-4-gpio-setup/configuring-i2c

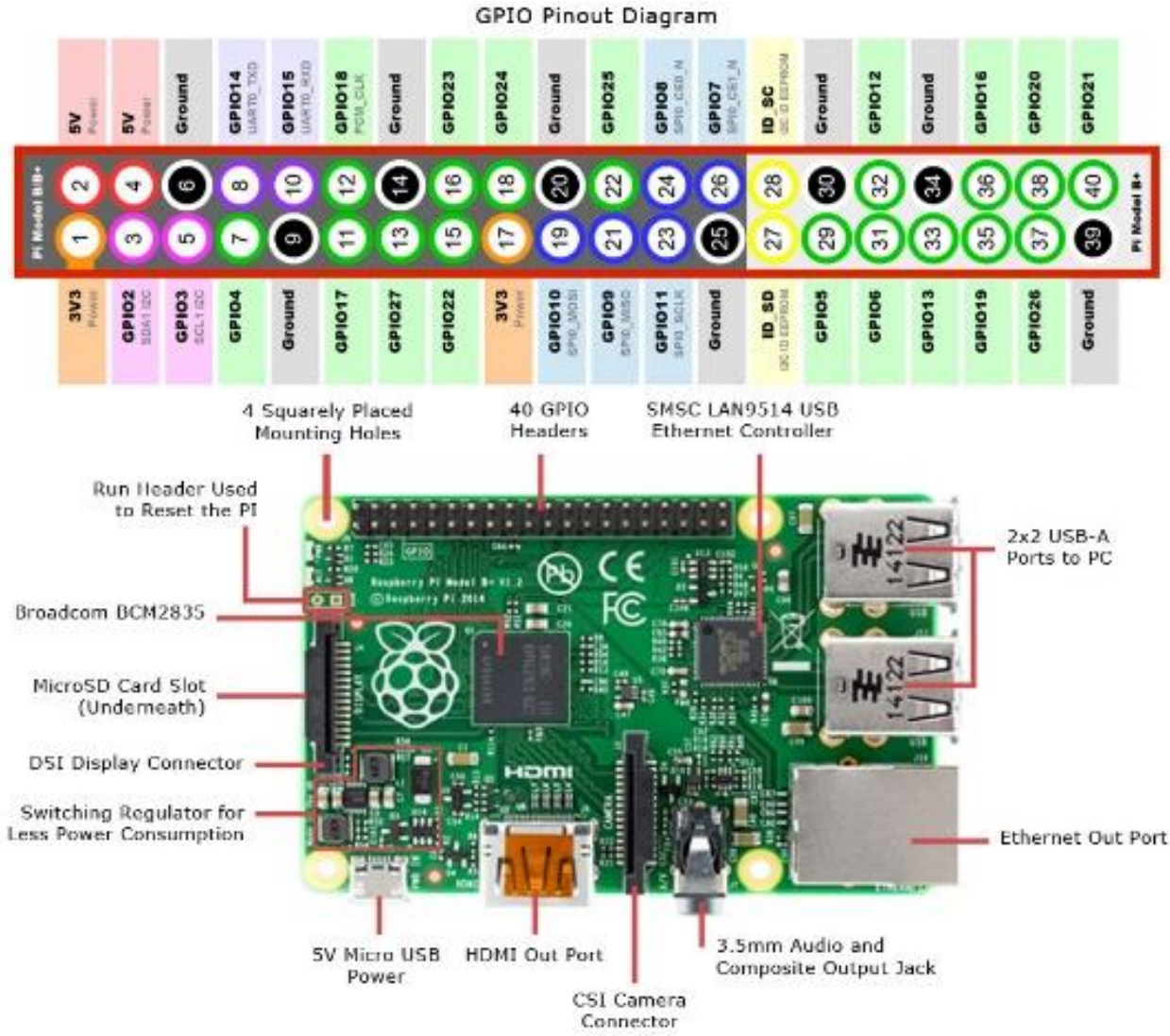
GPIO Pinout Diagram

Attach VCC to 3V power on Pi (Pin 1)

Attach GND to GND on Pi (Pin 6)

Attach SCL to SCL on Pi (Pin 5)

Attach SDA to SDA on Pi (Pin 3)



SSH and FTP Setup

- SSH is useful for sending commands to the Pi remotely from another workstation.
- FTP is useful for sending and receiving files directly to and from the Pi to another workstation.
- After the Raspberry Pi has connected to the internet, obtain the IP address of the Pi by typing

```
ifconfig
```

- On the terminal in the Pi.
- If you're not sure the Pi is connected, type

```
ping google.com
```

- and see if you get responses.
- Take the IP Address and type it into the correct locations on the Putty and WinSCP GUI.
- When prompted, type in Login and Password information.

Download Putty: http://www.putty.org/

Download WinSCP: https://winscp.net/eng/download.php

Running and Editing the Code

First navigate to the directory with the code. To run the code, simply type

```
sudo python (filename)
```

To edit any file, use the nano interface (unless you happen to know vi better, in which case you probably don't need this guide)

```
sudo nano (filename)
```

To debug I2C, type the command

```
Sudo i2cdetect -y 1
```

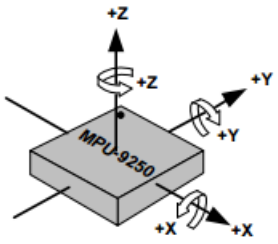
And see if register 0x68 appears. If not, the backpack is not being recognized.

IMU Backpack

Handling the sensor

Use super glue to attach the backpack to the back of the cockroach.

Make sure the x-axis points to the roach's head.



Making a new backpack

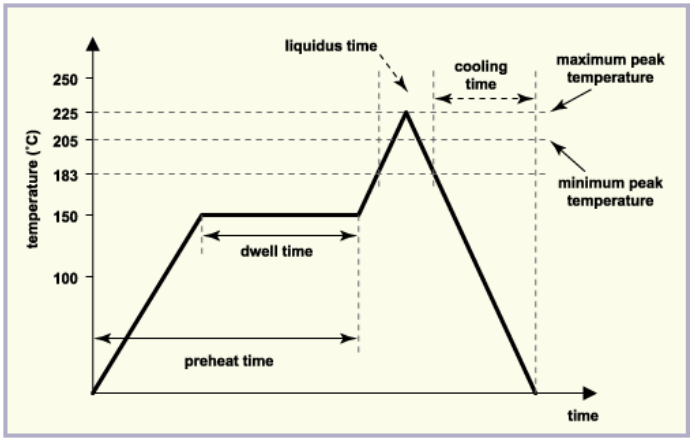
To make a new sensor backpack from scratch, you will need:

- MPU-9250 chip from Invensense
- Soldering Paste
- 1mm pitch interconnect header https://www.mill-max.com/products/socket/860-XX-XXX-10-002000
- 100nF capacitors size 0603
- 10K resistors size 0603
- Milled PCB according to Eagle file
- Reflow Station
- Flux pen
- Tweezers

1. Cut out PCB according to the Eagle File. There is an electronics shop near the Invention Studio that can do this. The GVU Lab at Tech Square also has the capability to mill PCBs.
2. Apply flux to the copper feet on the MPU chip outline
3. Apply soldering paste to the copper pins on the MPU chip outline. Make sure to completely cover all the copper feet on the outline
4. Apply flux to the bottom of the MPU chip
5. Align the MPU Chip to the copper pins and according to the Eagle file. Use tweezers for precision placement
6. Use a reflow station to fire hot air at the chip
7. Make sure to follow the reflow diagram and methods listed below
8. Once chip is soldered on, you can use same method to solder on the capacitors, resistors, and wires, but it is also fine to use a regular soldering iron albeit slightly more difficult.

Reflow Soldering Diagram

This graph is a rough outline of the temperature curve that optimizes solder paste connections. The entire process lasts about 10 minutes. Temperature of the gun may be adjusted higher if needed.



Maintain approximately 4 cm separation from the hot-air gun head to the components. Do not bring the head too close to the components.

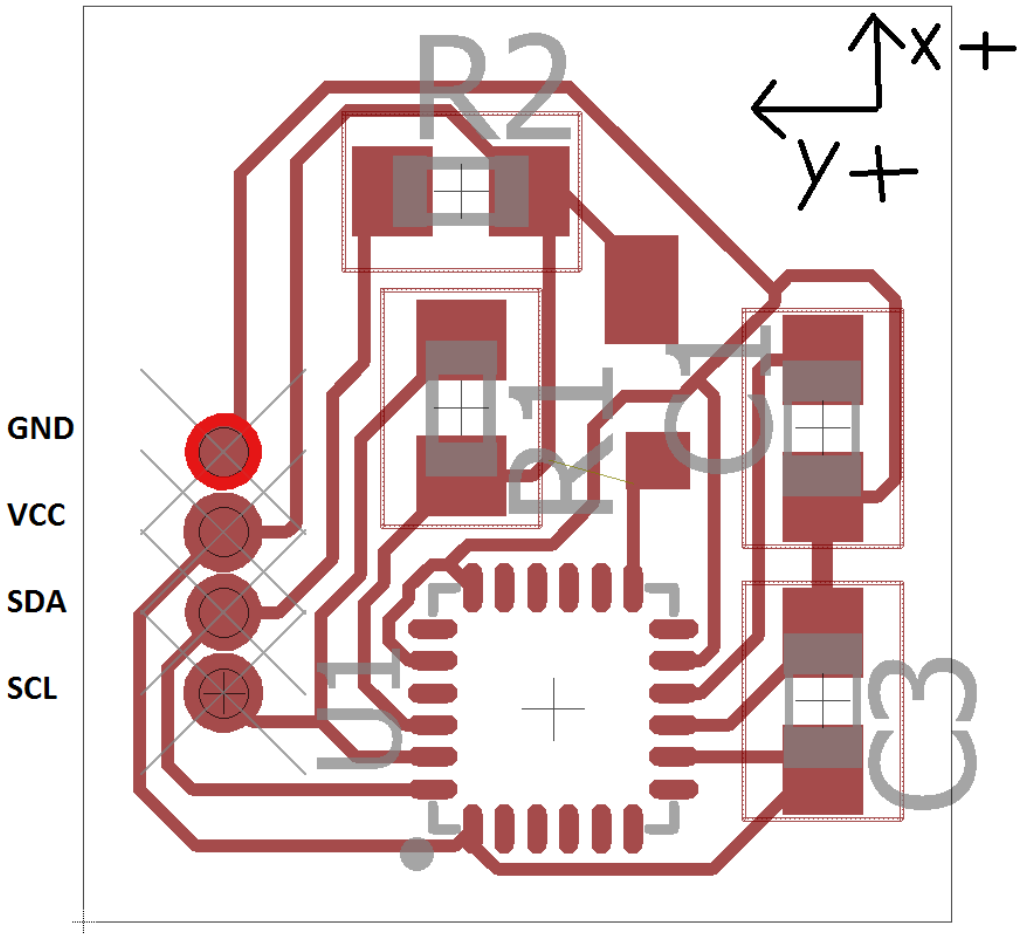
Make sure to cool the component down slowly to avoid temperature shock.

Soldering on new wires

- Strip jumper cables on one end of the wire so that the copper insides are exposed. Unspool silver wire to approximately 75 cm in length. Strip about 2cm of the plastic coating off of the silver wire on each end. Solder one end to the pin on the MPU chip, and solder the other end to the exposed jumper cable.
- Repeat for all four pins.

IMPORTANT:

- *The color of the pins matters. By convention, use Red for the VCC pin, Blue or Black for the GND pin, Yellow for SDL, and White for SDA. Maintain this convention to prevent erroneous wire connections and electrical shorts.*



Testing

The Emsnsr breakout board can be used to test and compare functionality of the PCB.

Most of the time problems on the PCB can be attributed to poor cable management, bad soldering, or electrical shorts. Double check wiring and connections before operating the device.

MPU-9250 Documentation

Register Map and Descriptions:

http://media.digikey.com/pdf/Data%20Sheets/InvenSense%20PDFs/MPU-9250.pdf

Product Specifications:

https://moderndevice.com/wp-content/uploads/2014/09/PS-MPU-9250A-01.pdf

Emsensr Circuit Documentation:

https://www.embeddedmasters.com/datasheets/embedded/MPU-9250-BOB%20Datasheet.pdf

Data Analysis

Data Structure

The code output a CSV file titled “imuData” along with the number of the data and a possible extension to signify the code used to obtain the data.

The data is formatted according to the following:

Time	Accel X	Accel Y	Accel Z	Gyro X	Gyro Y	Gyro Z

Take the formatting into account when extracting data from the CSV files and processing them

Processing Methods

Complementary Filter

Filter to remove gyroscope drift and assist in calculation of angles.

Pitch, Roll Angle calculations

Calculations are detailed in code

Kalman Filter

Algorithm for filtering data. Highly accurate

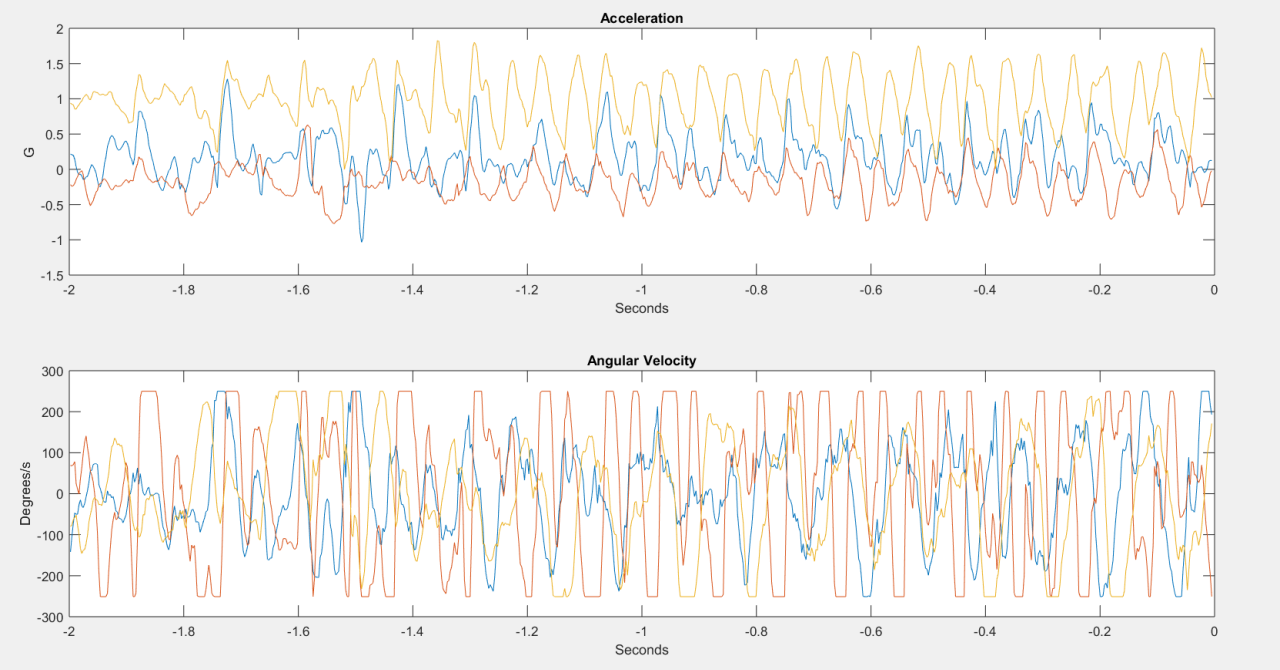
Madgwick AHRS

Low computational-load algorithm that can achieve higher accuracy than that of the Kalman Filter. Can be used to process 9-DOF data (Accelerometer, Gyroscope, and Magnetometer).

Example Graphs

Below is a typical graph of data that is obtained with the code. There should be clear cycles of acceleration depicting the roach moving back and forth.

The angular velocity graph has peaks where the velocity exceeds the measurable amount. The code has been corrected for this error, but when obtaining a graph with similar artifacts, the most likely cause is high angular velocities.



Code

https://github.com/Wxia33/agile-systems-lab