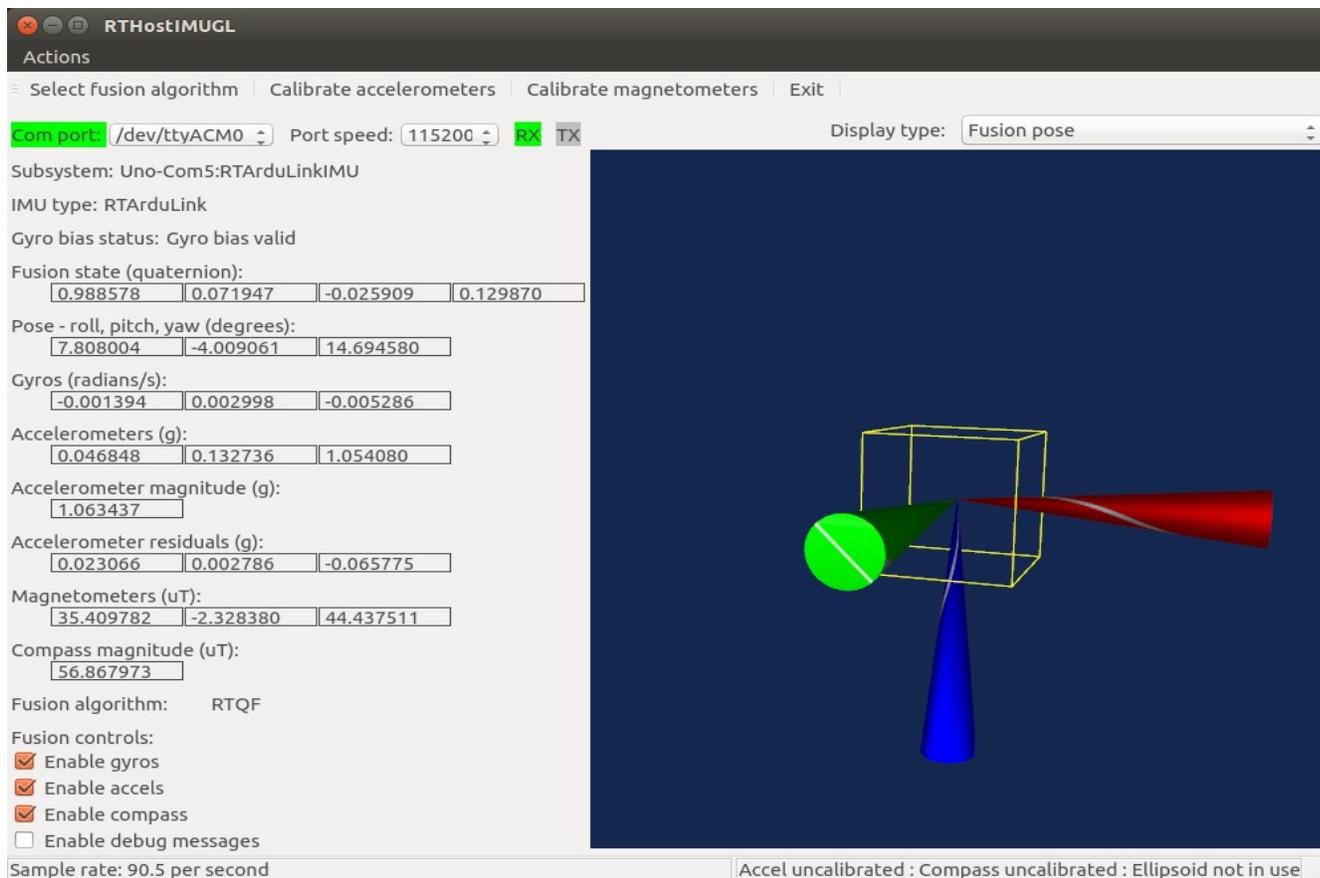# RTIMULib Calibration

Introduction

RTIMULibDemo, RTHostIMU and RTHostIMUGL all support the generation of calibration data for the RTIMULib library. The end result is a file in the working directory called RTIMULib.ini that contains all of the generated settings. This file can then be used with the library in any other application and the library will operate in calibrated mode. There's no need for custom apps to have to generate the data if one of the standard supplied apps is used for this purpose. Since generation of the calibration data is the complex part, this makes writing apps that use RTIMULib a lot easier!

RTIMULib supports the following IMU calibration options:

- Compass min/max calibration. This is a simple scheme that obtains the minimum and maximum readings from the magnetometers and then scales the readings based on these values.

- Compass ellipsoid fitting. This is a secondary (optional) stage to the min/max calibration that further refines the response by fitting an ellipsoid to the magnetometer readings and shrinking these coordinates so that they fit on the surface of a sphere located at the origin. This option requires GNU Octave on the host system.

- Accelerometer calibration. This uses a simple min/max system to scale the accelerometer outputs to between -1g and +1g when not being artificially accelerated.
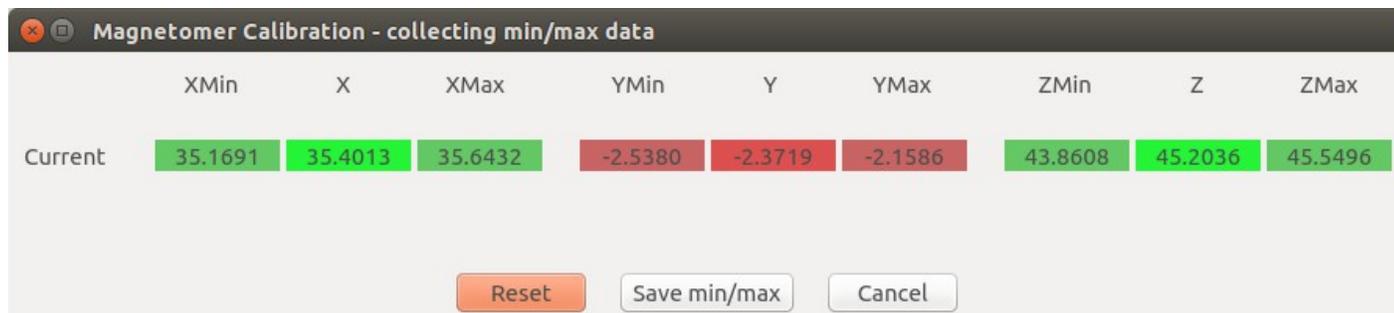
Magnetometer (Compass) Calibration

If no calibration has been performed (or an existing RTIMULib.ini file has been deleted), the app display will look like this:
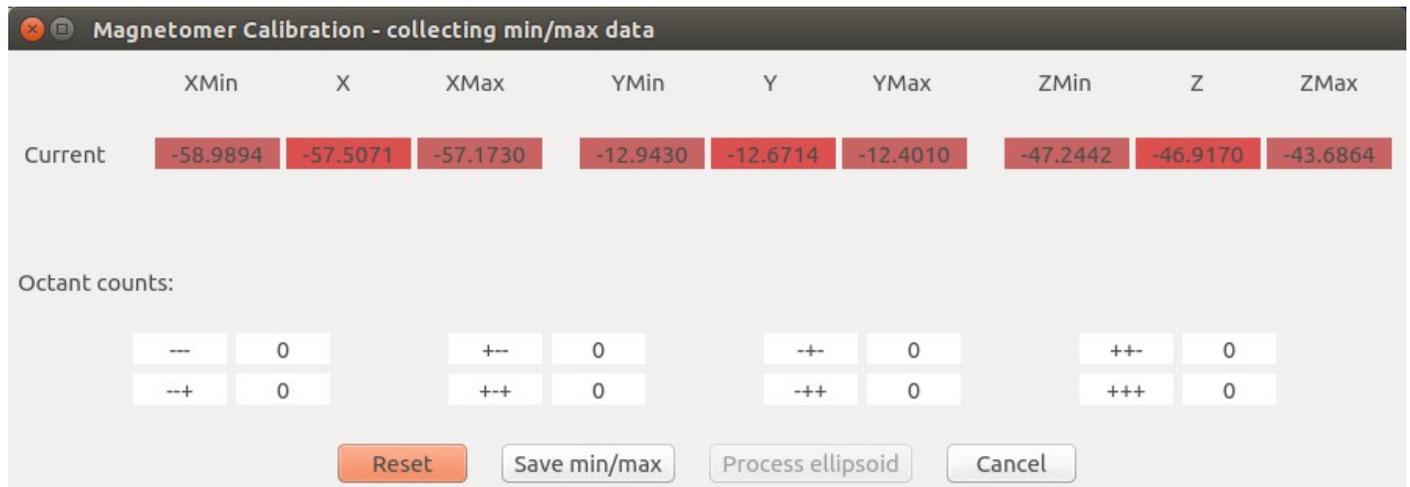
You can see the calibration status at the bottom right. In this case, no calibration is being performed. Note that RTHostIMUGL is used for this document but RTHostIMU and RTIMULibDemo all have the same capabilities.

Compass Min/Max Calibration

To start the calibration process, click on the "Calibrate Magnetometers" option. You'll see something like this:

	XMin	X	XMax	YMin	Y	YMax	ZMin	Z	ZMax
Current	35.1691	35.4013	35.6432	-2.5380	-2.3719	-2.1586	43.8608	45.2036	45.5496

Reset   Save min/max   Cancel

or:

Which one is obtained depends on whether or not the ellipsoid fitting software is available. The software checks the following locations:

- ./RTEllipsoidFit

- ../RTEllipsoidFit

- ../../RTEllipsoidFit

and checks for the presence of the Octave source file RTEllipsoidFit.m. If this is not found, the upper display will result and only min/max compass calibration will be available. Note that Octave needs to installed and working on the host system for ellipsoid fitting to work. For Windows, use:

http://sourceforge.net/projects/octave/files/Octave%20Windows%20binaries/

and for Ubuntu/Raspbian execute: sudo apt-get install liboctave-dev.

The first thing to do is the min/max calibration. To do this, point one axis of the IMU straight down and waggle it around a bit to find the maximum (or minimum) value. The software will capture the extrema automatically. Turn the IMU upside down and repeat for the minimum (or maximum) value. Repeat this for the other two axes. You'll see something like this:

Note that the minima and maxima are of somewhat similar absolute value for each of the axes. Press the "Save min/max" button to save this data. If ellipsoid fitting isn't available, this will complete the process and the data is written to the RTIMULib.ini file.

Compass Ellipsoid Fit Calibration

Once the min/max calibration has been completed, the display will look like this:

The octant counts show how many samples have been collected in each octant (an octant is one eighth of the volume of a sphere, split up by positive and negative axes). To ensure good coverage, the software requires a minimum of 200 samples per octant. It's necessary to wave the IMU around in all orientations to get as many different paths across the surface of the sphere as possible.

When at least 200 samples have been obtained in each octant, the following will be displayed:

Note that the "Process ellipsoid" button has now been enabled. Press this and the software will run the

Octave program RTEllipsoidFit.m in order to generate the correction data to be applied to the

magnetometer outputs. Once the program completes (it take a second or two), the result will be written

to the RTIMULib.ini file and the app will start using it:

Note that now it is saying that the compass is calibrated (this means that the min/max calibration is operating) and that ellipsoid fitting correction is being to the result.

It's also possible to visualize the ellipsoid using an included Octave script. The RTIMULib ellipsoid sample data is stored in the RTEllipsoidFit directory as a file call magRaw.dta. This is the file that the script mag_cal.m uses to display the raw data and the corrected data. Start Octave and then run the script mag_cal.m. The result is a plot something like this:
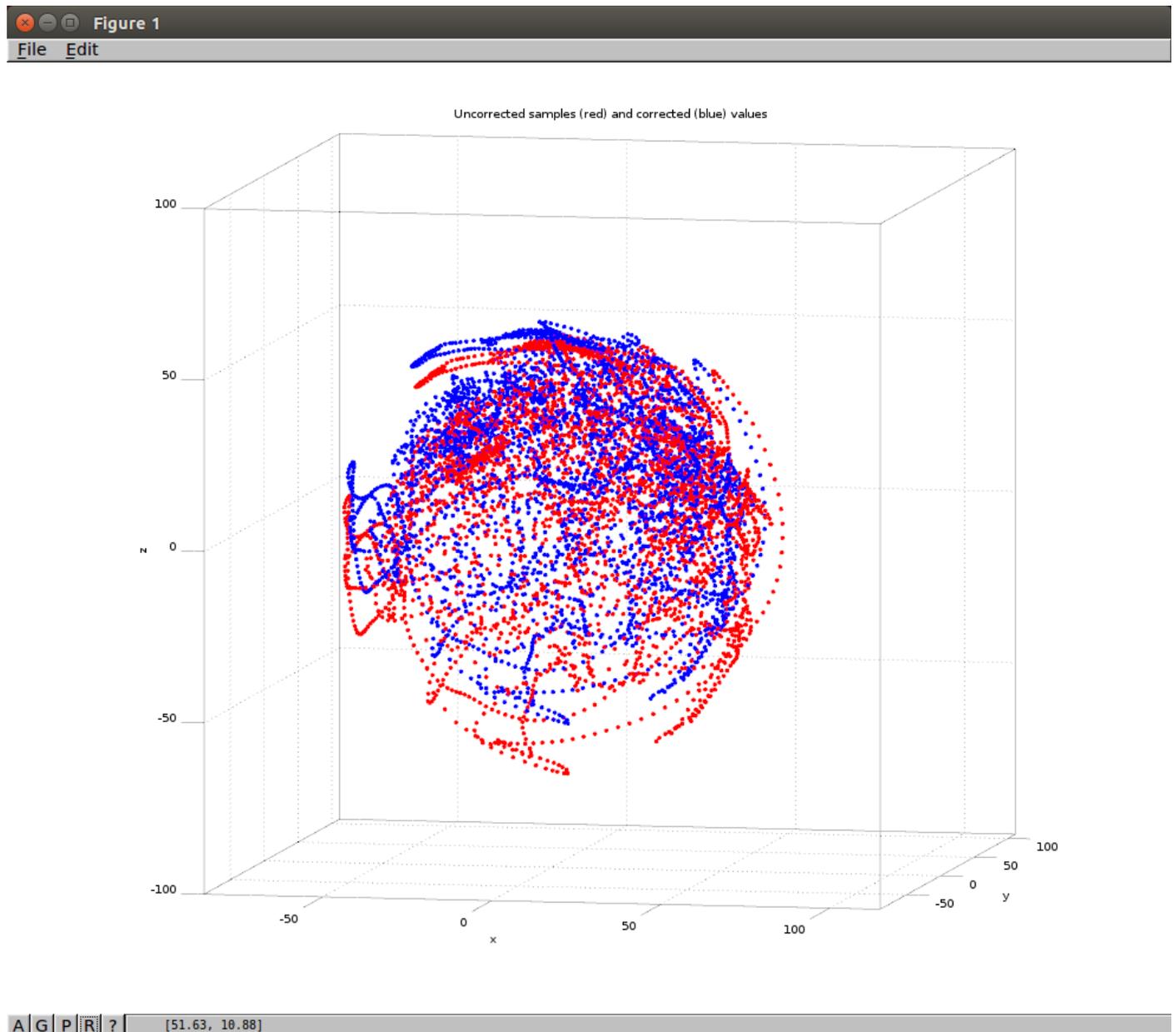
Accelerometer Calibration

Clicking on the "Calibrate accelerometers" button results in this display:
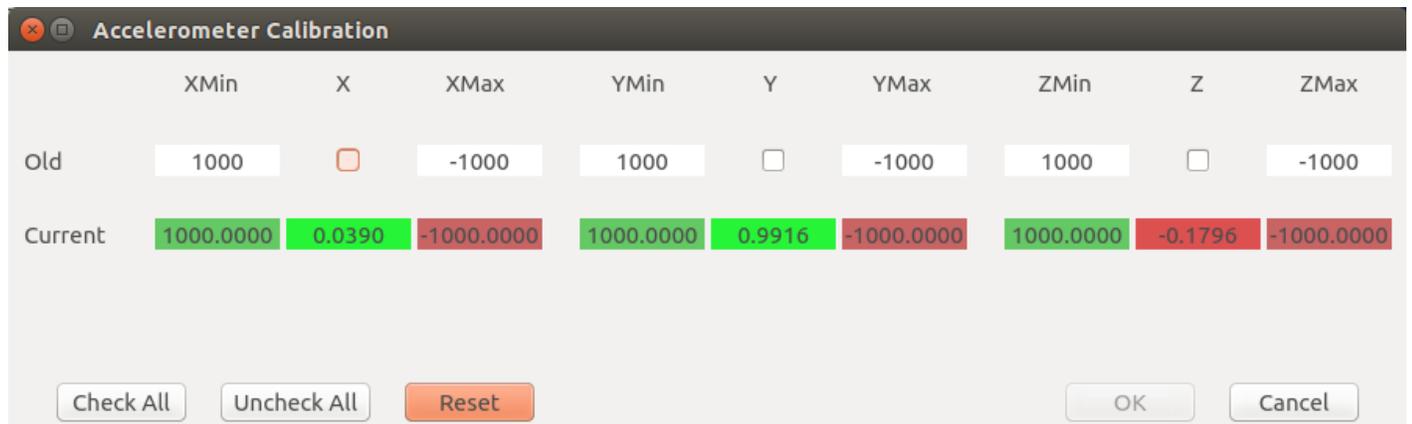
This is what is seen if there was no previously valid data. If there was, you may see something like this:

This allows a single axis to be tuned if necessary as only an axis with its check box ticked will change its min/max data. To get back to the initial state, press "Check All", "Reset" and then "Uncheck All".

The actual calibration is best performed for each minimum and maximum at a time. Assuming starting with the positive X axis, position the IMU so that something close to the maximum X reading is obtained and then check the box for the X axis to enable it:

Accelerometer Calibration								
	XMin	X	XMax	YMin	Y	YMax	ZMin	Z	ZMax
Old	1000	☑	-1000	1000	☐	-1000	1000	☐	-1000
Current	0.1124	1.0931	1.1160	1000.0000	-0.0547	-1000.0000	1000.0000	0.1093	-1000.0000

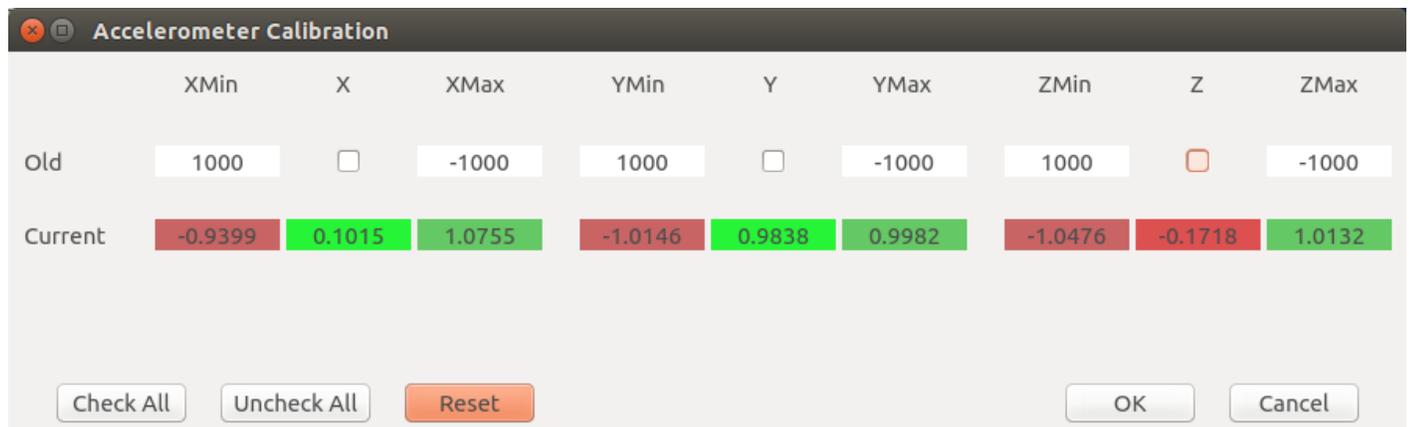Check All   Uncheck All   Reset   OK   Cancel
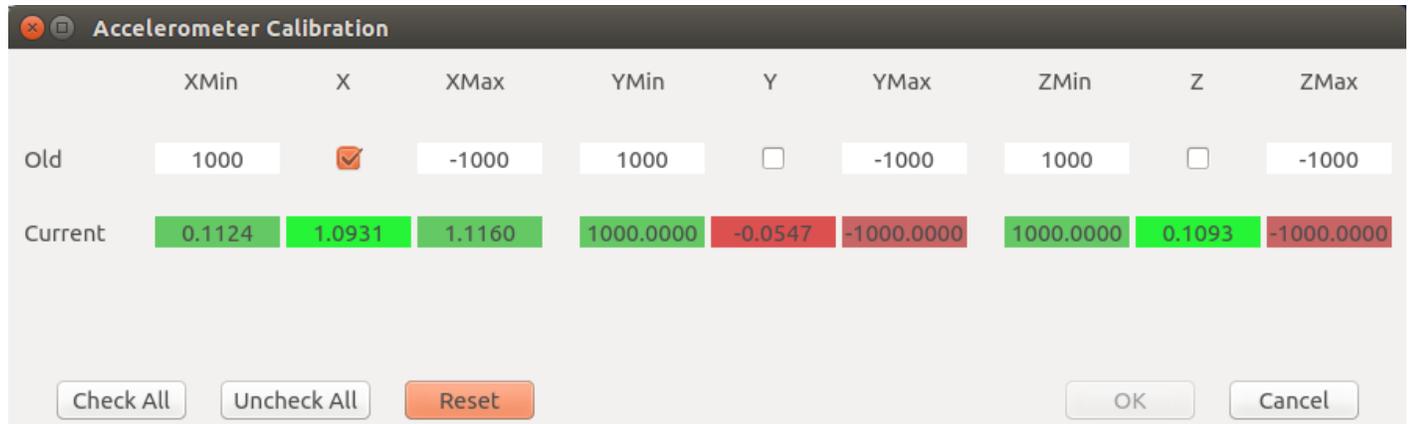
Very slowly (and without jerking the IMU at all), move the IMU around to obtain the maximum value.

Then untick the enable box. Turn the IMU around and do the same for the negative X axis:

Accelerometer Calibration								
	XMin	X	XMax	YMin	Y	YMax	ZMin	Z	ZMax
Old	1000	☑	-1000	1000	☐	-1000	1000	☐	-1000
Current	-0.9323	-0.9213	1.1032	1000.0000	-0.1171	-1000.0000	1000.0000	-0.0468	-1000.0000

Check All   Uncheck All   Reset   OK   Cancel
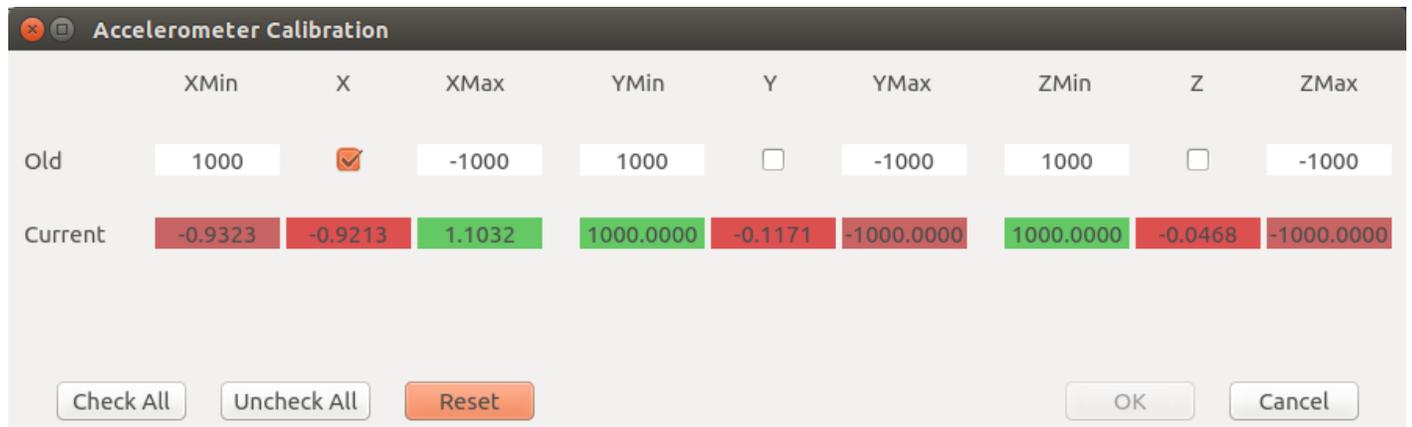
Once the minimum has been obtained by gently moving the IMU around, untick the enable box. If a maximum of minimum got messed up, check the enable box, press "Reset", uncheck the enable box and repeat the process.

This must be done for all three axes and then it will display something like this:

Accelerometer Calibration								
	XMin	X	XMax	YMin	Y	YMax	ZMin	Z	ZMax
Old	1000	☐	-1000	1000	☐	-1000	1000	☐	-1000
Current	-0.9399	0.1015	1.0755	-1.0146	0.9838	0.9982	-1.0476	-0.1718	1.0132

Check All   Uncheck All   Reset   OK   Cancel

Press "OK" to save the accelerometer calibration data to RTIMULib.ini. The main window should then look like:
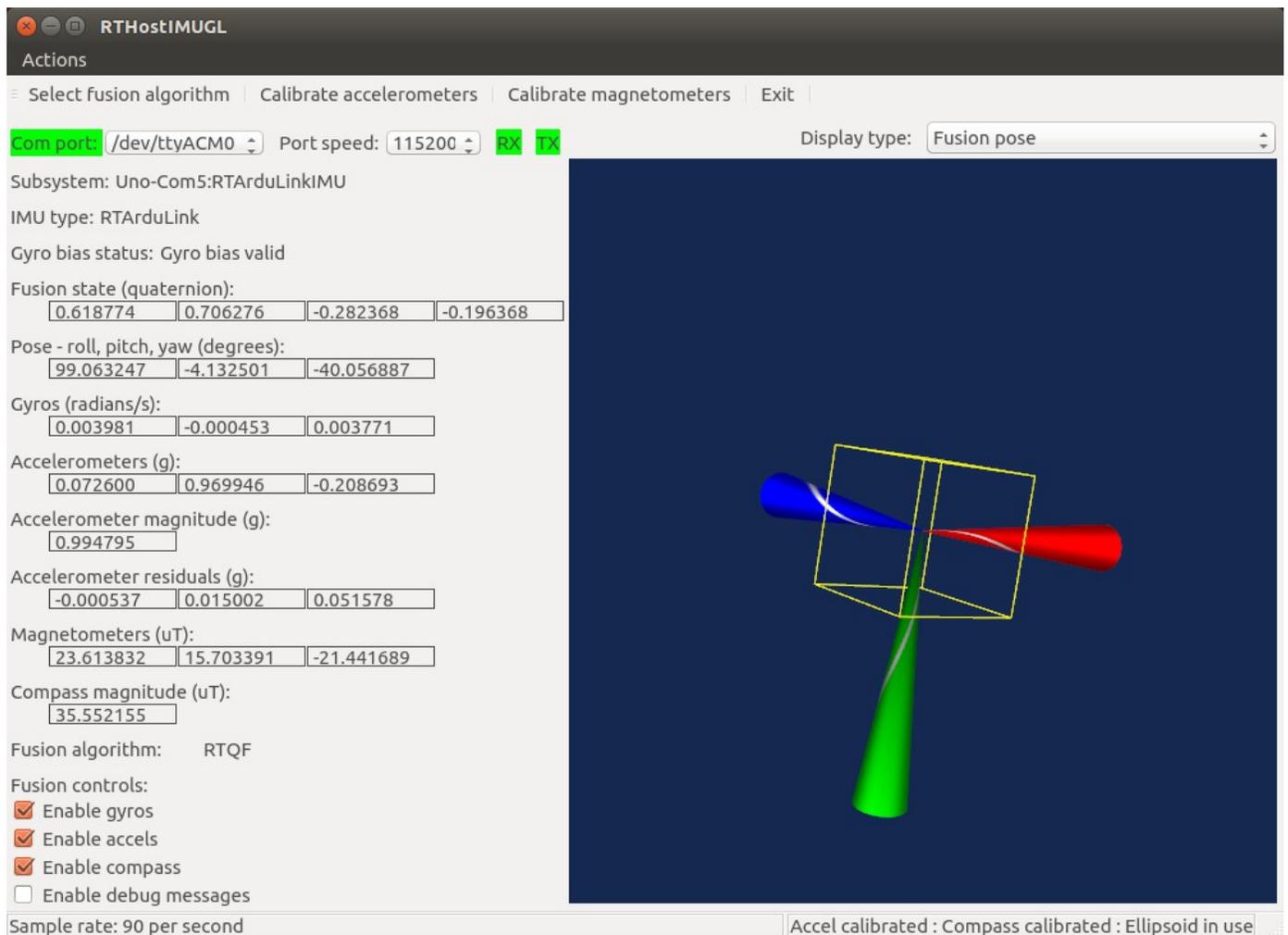
The status box now shows that the accelerometers are operating in calibrated mode. As a double check, if the IMU is stationary, the "Accelerometer magnitude" value should be very close to 1g. If it isn't, the calibration procedure should be attempted again.