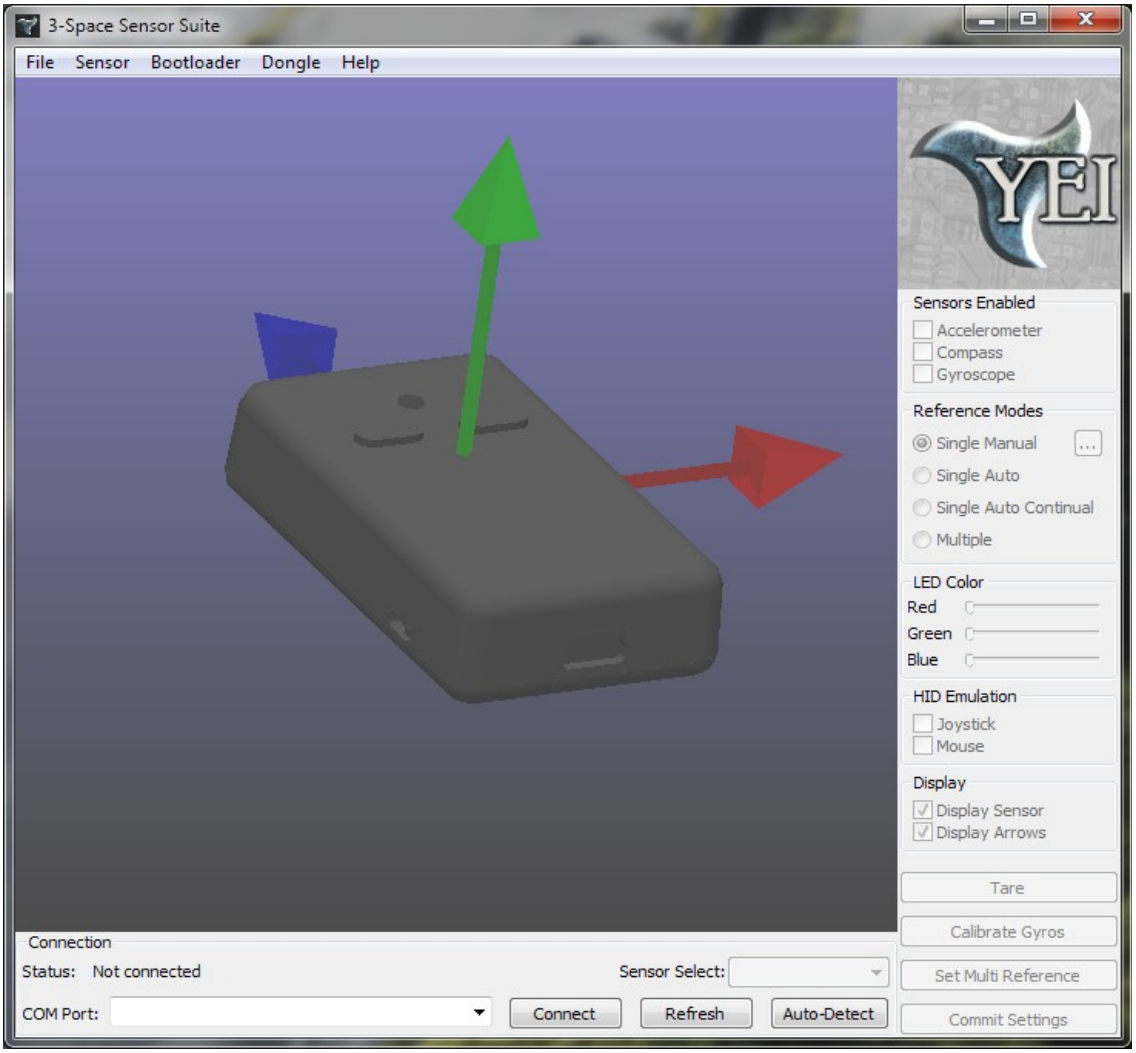
3-Space Sensor Suite Manual

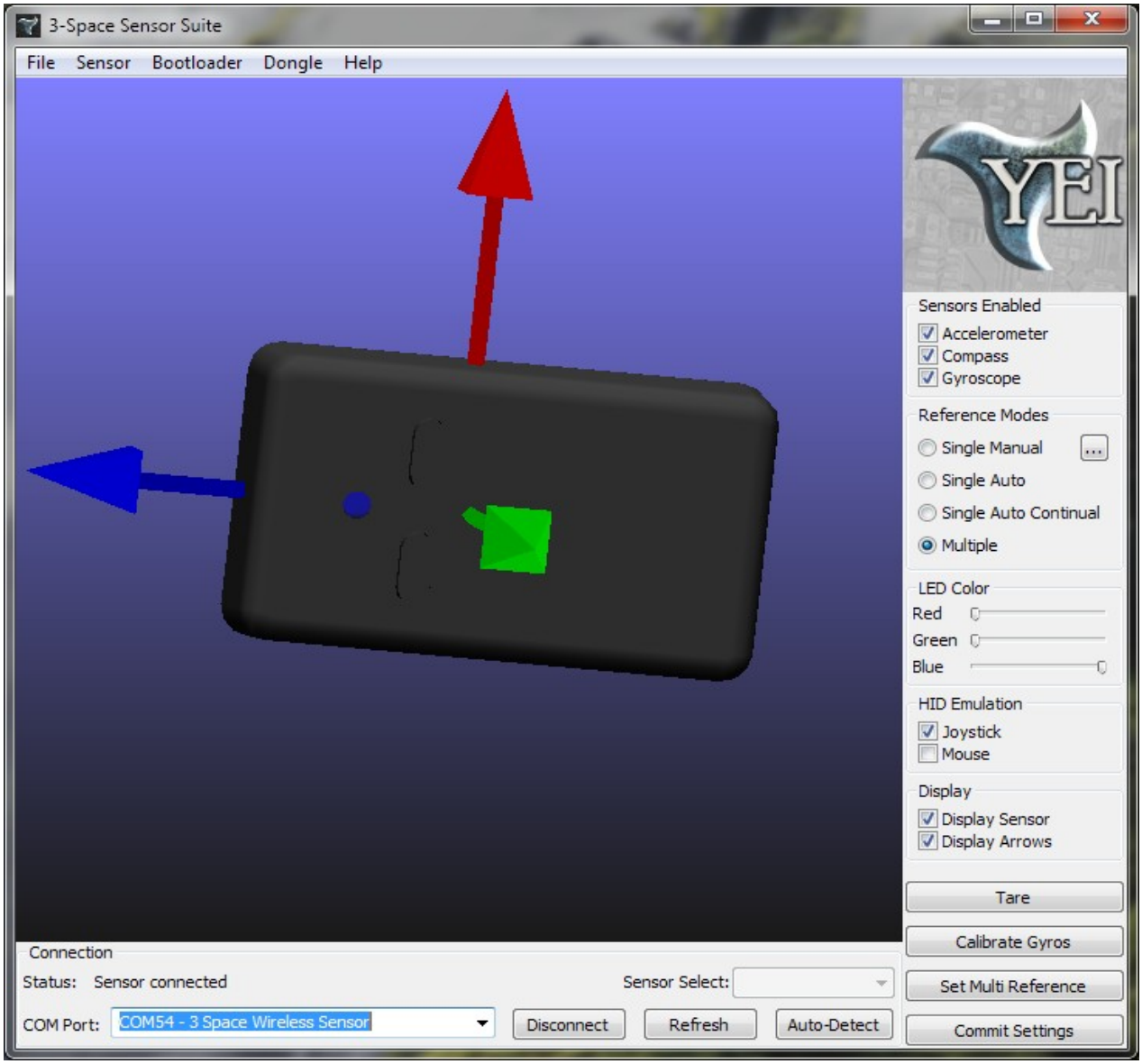
The purpose of this manual is to explain how to use the 3-Space Sensor Suite, a program which gives access to features of the sensor and its data through a graphical user interface.

Selecting a COM port



Upon running the suite program, you will see an area along the bottom of the window labeled “Connection”, with a drop down list of all COM ports on the machine, some of which correspond to 3-Space Sensors or 3-Space Dongles. Select the COM port corresponding to the sensor/dongle you wish to use, and the suite will attempt to connect to it. If you would like to use the terminal mode to communicate directly with the chip instead of using the graphical interface, go to File->Switch to Terminal Mode. Bear in mind that this mode is more difficult to use and is intended only for advanced users.

Connecting to a Sensor



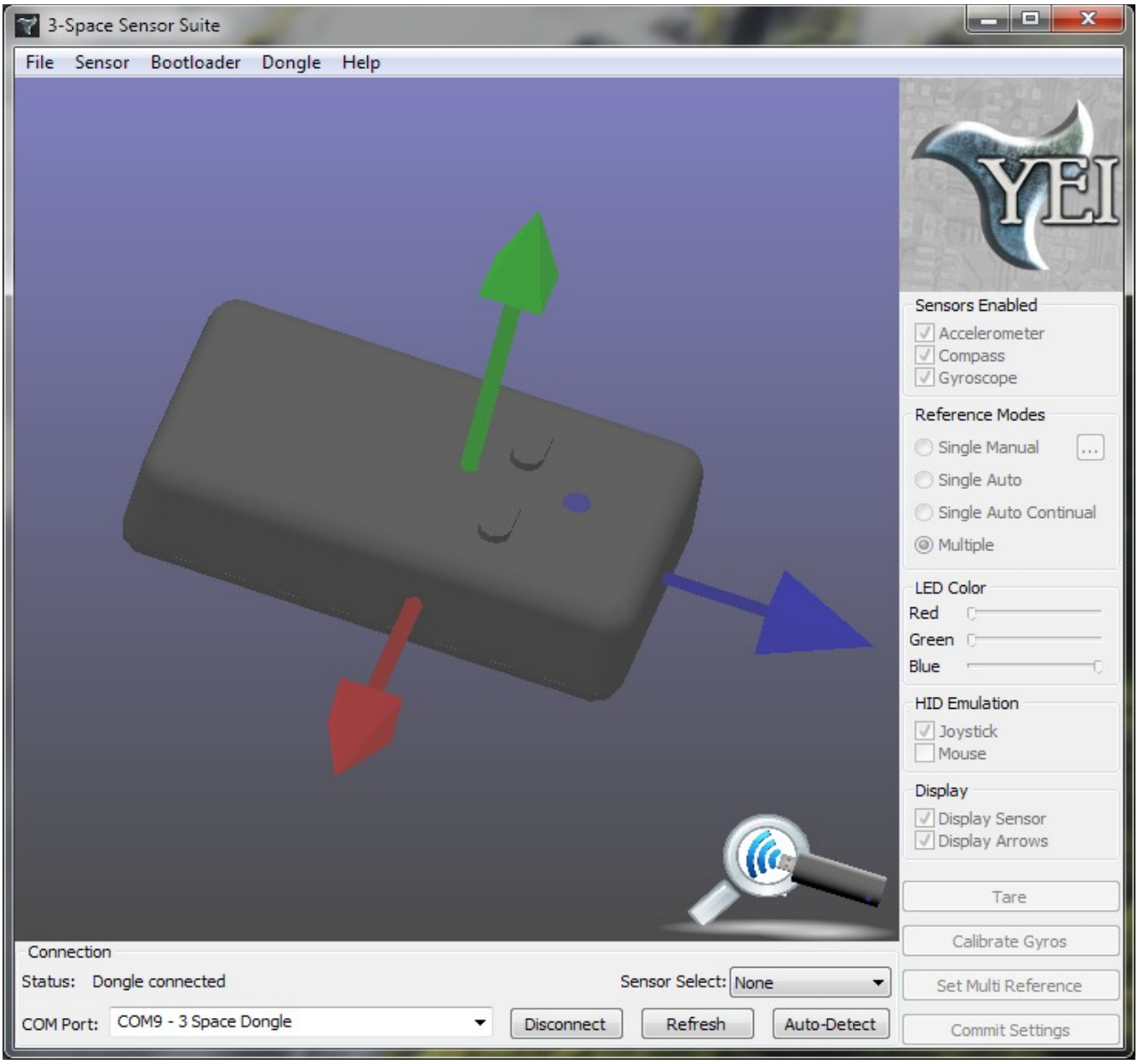
If a sensor is present on the selected COM port, the features on the right hand side of the window should be enabled. The first thing that you should take note of is the large area in which an image of the sensor appears. This image will rotate along with the sensor as you move it, and will be your best indication of whether the sensor is properly calibrated or not. There are red, green and blue arrows to represent where the sensor's local positive X, Y, and Z axes are(by default) respectively. Take note that the default orientation for the sensor is the green arrow pointing up, the red arrow pointing to the right, and the blue arrow facing away from you.

Along the side are some of the more common commands you can issue to the sensor. From top to bottom:

- **The sensor disabled/enabled list.** This allows you to see how the sensor will perform with some of its component sensors turned off. For example, with the gyros disabled, the sensor will respond more slowly to changes in orientation. With the accelerometer disabled, the sensor will jitter less, but will be missing an axis of data.

- **Reference mode.** This allows you to change how the sensor chooses what vectors it uses to act as zero vectors for the accelerometer and compass.
  - **Single manual uses a single**, manually set reference vector set at all times.
  - **Single auto** automatically generates a reference vector set based on gravity and north once, and keeps that set.
  - **Single auto continual** generates a reference vector in the same way as single auto, but does it every cycle.
  - **Multiple** keeps 24 sets of reference vectors and chooses from them on the fly based on which ones seem to best match the current situation. Each one of these 24 is meant to represent one of the 24 possible orientations where the axes of the sensor are lined up with the axes of the world(gravity, north, and their cross product).
- **LED Color.** Move the sliders to change the color of the sensor's LED.
- **HID Emulation.** Choose what human interface devices the sensor is acting as: a joystick, a mouse, neither, or both. Be warned that if the sensor is not properly calibrated, the mouse mode may put your mouse in a state that will be difficult to get out of without unplugging the sensor entirely. If you unplug it due to this, you will lose any changes made since you last committed, but no other ill effects should occur.
- **Display.** This determines what is shown in the main window, allowing you to turn on and off the sensor model and arrow being drawn there.
- **Tare.** Tare chooses the sensor's current orientation as the zero orientation(the one where it thinks the red arrow is pointing right, the green pointing up, and the USB plug towards the user). You will want to check to make sure the sensor appears this way on the screen when you have it in that position in the real world as soon as you start up the suite. If not, put it in that position and press the Tare button.
- **Calibrate Gyros.** Another thing you may want to do as soon as you start up the suite, and before taring the sensor. Make sure the sensor is perfectly still and press the button. The calibration will finish immediately.
- **Set Multi Reference.** This button indicates that the sensor's current orientation should be mapped to the nearest of the 24 world axis aligned orientations. This can be used to erase errors seen when attempting to align the sensor in the real world and the image of the sensor in the suite. Please note that if this button is used while the sensor is in multiple reference mode, it will be placed in single auto continual reference mode. Please note that these changes will be saved to the sensor automatically, and do not need to be committed.
- **Commit Settings.** Any changes made to the sensor during a session in the suite will be lost when the sensor is unplugged or the computer is powered down unless this button has been pressed after those changes were made. This also means that you can experiment with changes to the sensor without having to worry about messing up the sensor, as they will all be temporary unless this button is pressed.

Connecting to a Dongle

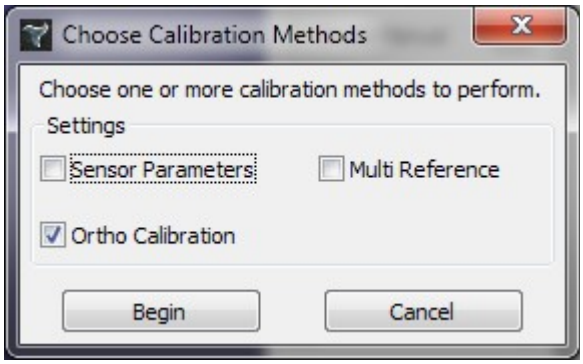


When connecting to a dongle, the sensor options on the right will remain disabled while the dongle is not connected to a wireless sensor. The "Sensor Select" box will become available when connected to a dongle. This allows you to select which sensor address the suite communicates to through the dongle. If it is set to "None", the dongle will not try to communicate with any sensor, but will remain connected to the Suite so other dongle settings may be changed. If there is a wireless sensor at that address and the pan id and channel match on the dongle and the wireless unit, the dongle should connect to the wireless sensor. The suite may then be used to communicate with that sensor in the same way as a wired sensor.

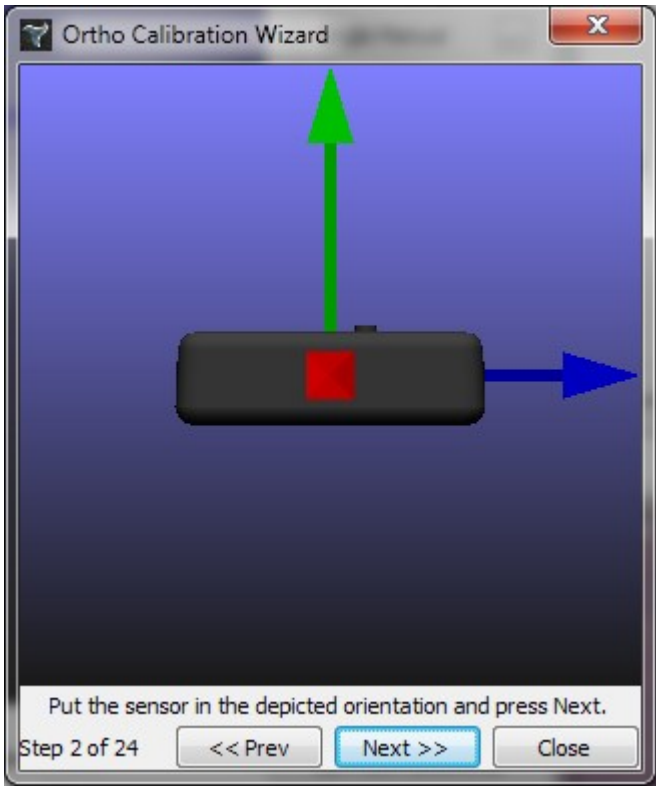
Sensor Menu

On the menu bar, the first item you will see after file is Sensor. This contains commands that are useful, but not quite as common as those that appear on the main window. In Other Commands, we have:

- **Sensor Info(and Wireless Settings).** This screen will display the sensor's serial number and version string. If it is a wireless sensor, it will also let you see and change the pan ID and channel.
- **Run Ortho Calibration Wizard.** This wizard will help you set up several of the sensor's calibration options. First, a screen will appear asking you to select which options you would like to use to calibrate the sensor.



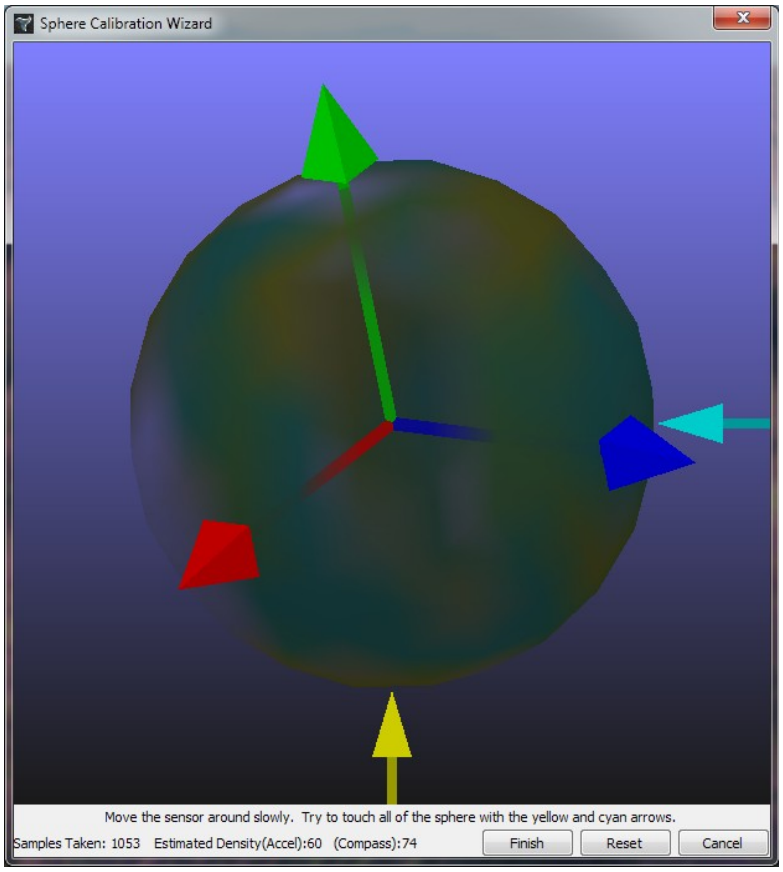
After choosing begin, the wizard will display a picture of the sensor that will show you an orientation you should put the sensor in.



Put the sensor in that orientation and press Next, making sure to hold the sensor still until the picture moves to a new orientation. The sensor will then move on to indicate the next orientation in which you should put the sensor. There are 24 orientations to collect data from. Please note that these changes will not be saved to

the sensor and should be committed if they are to be kept. The exception is the multi-reference and ortho-calibration tables, which will be overwritten and committed if those options are selected. The calibration given for sensor parameters by this wizard is not as accurate as that given by the sphere calibration wizard, but this wizard has a shorter process to estimate these parameters.

- **Run Sphere Calibration Wizard.** This wizard will walk you through collecting a relatively complete set of compass and accelerometer data from which sensor parameters can be calculated.



Move the sensor around slowly, trying to touch every part of the sphere with the yellow and cyan arrows. They will leave their colors behind on the sphere wherever they touch, allowing you to see how complete the data set is. The more green the sphere looks, the more complete the data is. The arrows will disappear and data will stop being recorded while the sensor is moving too quickly. This is to ensure that the accelerometer data is not affected by motion based disturbances. At the bottom of the window, the wizard will say how many data samples it has, and will estimate about how dense the data is, in degrees. Lower numbers are better for density. When the data set seems complete(a mostly green sphere), hit the finish button. If you want to start over, hit reset. If you want to quit without calibrating using the data, hit cancel.

- **Reset Multi Reference.** Clears all the multiple reference mode reference vector sets. If, when using multiple reference mode, you start getting strange results(which can occur if Set Multi Reference was used when the sensor was not in an orientation that corresponds to one of the world axis aligned ones), using this command will allow you to start over and take another shot at calibrating multiple reference mode. Please note that this change will be saved to the sensor automatically, and does not need to be committed.
- **Reset Ortho Calibration.** Clears all the ortho-calibration data. Please note that this change will be saved to the sensor automatically, and does not need to be committed.
- **Restore Factory Settings.** If you want to restore the sensor to how it was originally, erasing any changes you have made to it, use this command. Please note that if you want to keep the sensor in this state once you have used this command, you need to press the Commit Settings button. Otherwise, the sensor will return to

the state it was in prior to the run of this command when it next boots up.

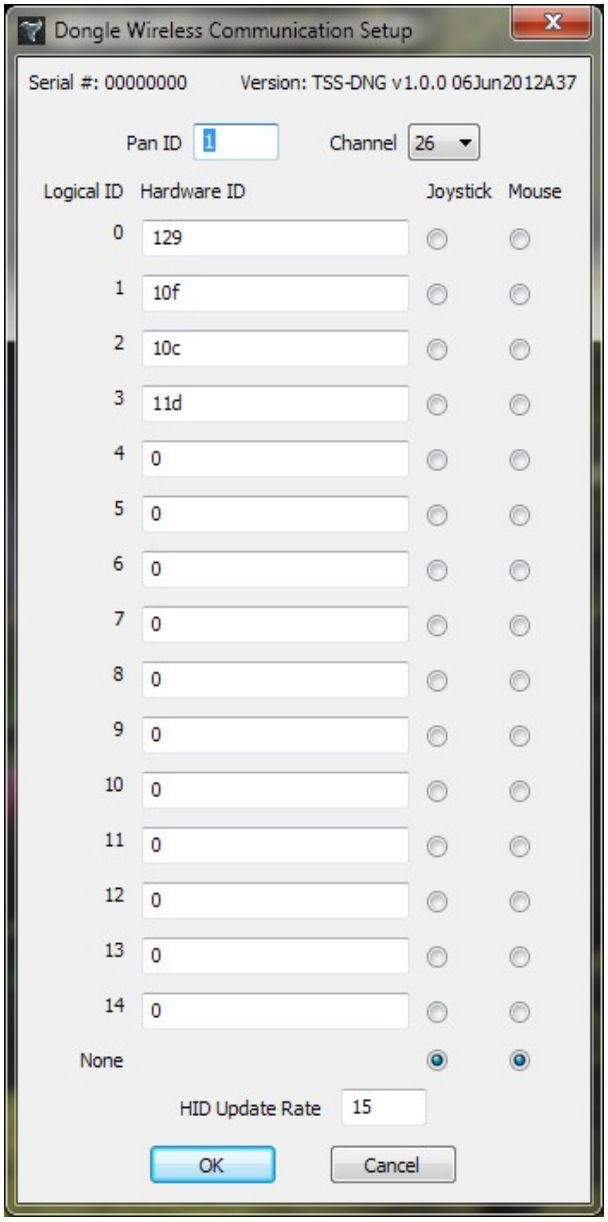
- **Put Mouse in Absolute/Relative Mode.** These options will put the mouse into absolute or relative mode and then will reset the sensor so they can take effect. Make sure to commit any changes you have made that you would like to keep before using this.
- **Save/Load Settings to/from File.** These options will let you save sensor settings to a file, or load settings onto the sensor from a file. When saving you will be given choices as to which settings you would like to save.
- **Wireless Communication Settings.** If the sensor you are connected to is a wireless sensor, this option can be used to set the pan id and channel of the sensor. These settings must match those of a dongle for the wireless sensor to be able to communicate with it.
- **Update Firmware.** This will update the firmware of the sensor. It will let you choose an xml file that contains the firmware update data, and then will begin the updating process. The sensor will not be useable during this time, and any changes that were made to the sensor, regardless of whether they were committed, will be wiped out, as the firmware updater rewrites that entire area of memory. Do not unplug your sensor while this process is occurring, as it will leave the firmware in an indeterminate state. If something does go wrong during this process, you may close the suite and run it again. If the suite detects an incomplete program on the sensor, it will give you the option to try to update the firmware again. You will not be able to use the sensor normally until a complete set of firmware has been written to it.
- **Reset Sensor.** This will reset the sensor, causing any uncommitted changes on the sensor to be wiped out.

Bootloader Menu

If a firmware update fails, the sensor or dongle will be left in bootloader mode. This menu gives you the option to try to update the firmware again, or, in some cases, to return to the previous firmware.

Dongle Menu

This menu provides options for the dongle. The only difference between the options provided here and the same options provided on the sensor menu is that the Wireless Communication Settings screen also includes address slots.

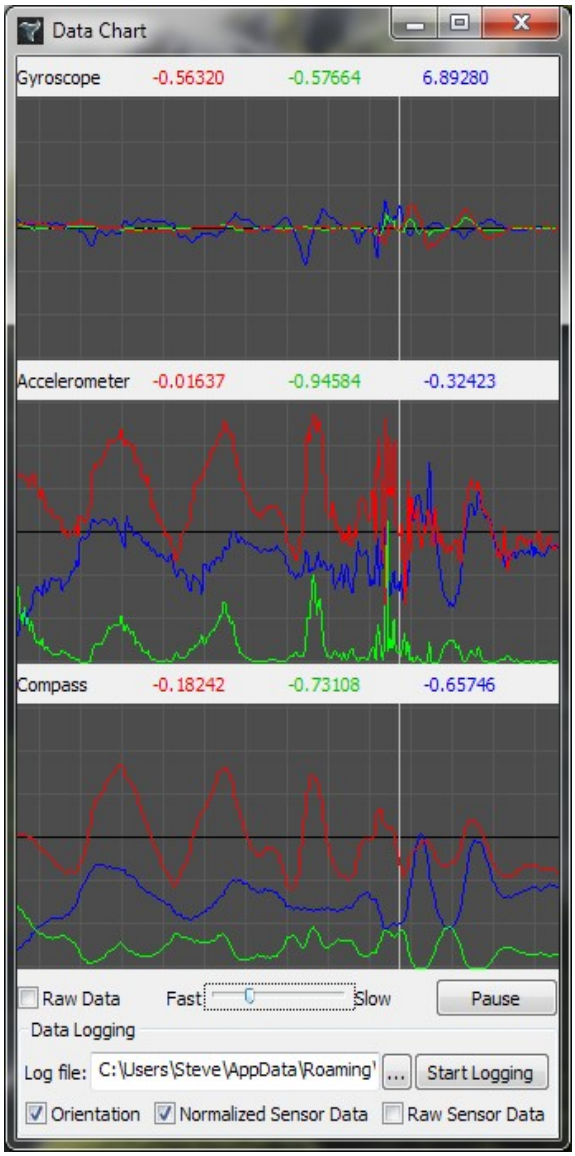


On this screen, enter the serial number of a wireless sensor into the address slot you would like to communicate with it on. You may later select that address in the Sensor Select box on the main window to communicate with that sensor.

Advanced

The second menu on the menu bar contains advanced options for those who would like more information or more control over the 3 Space Sensor.

Data Chart

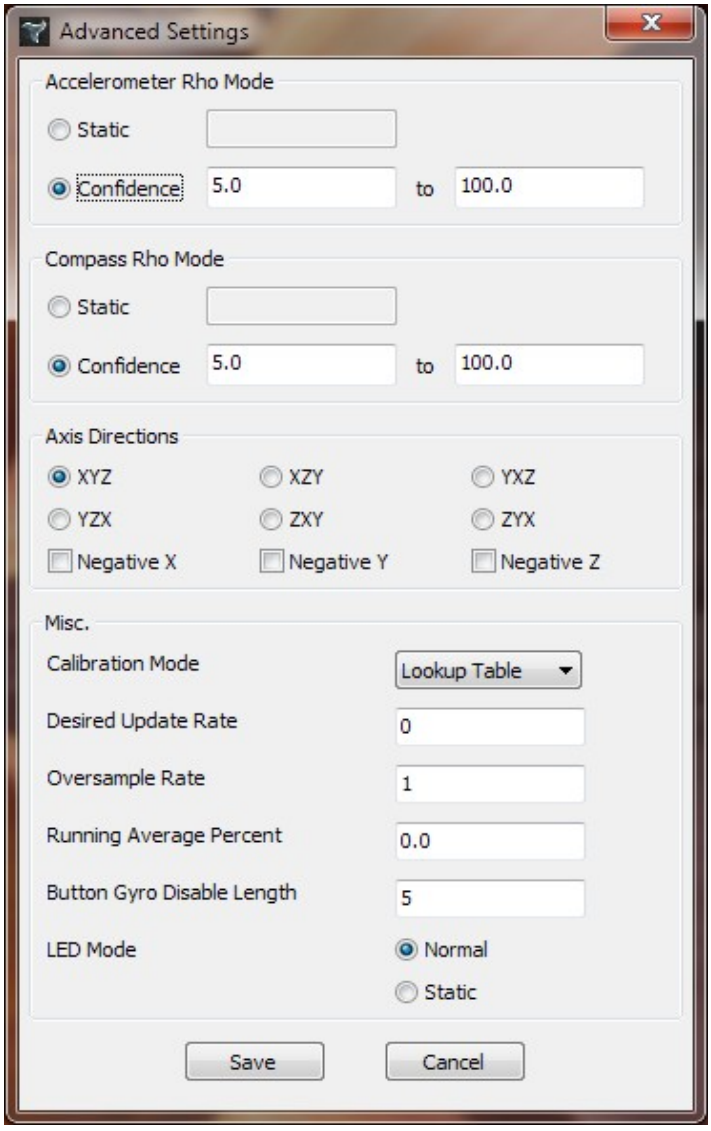


This tool provides graphs of the data being read from the gyroscope, accelerometer, and compass, and provides tools to work with this data.

- **Charts.** Each component sensor has a chart which displays the data being read from it. On each chart, the red graph is the X axis, the green chart is the Y axis, and the blue chart is the Z axis. The accelerometer and compass readings each indicate which vector of the sensor along which their particular world vector(either gravity or north) resides. For example, if you tilt the sensor until the nose is pointing at the floor, the accelerometer will read the vector (0,0,1), in order to indicate that the positive Z vector of the sensor is pointing in the direction of gravity.

- **Speed Slider.** The Fast->Slow slider affects only the speed at which the graph moves and how much data it shows, it has no affect on logging.
- **Raw Data.** The Raw Data option allows you to see graphs of the data coming from each sensor raw, as it looks with no additional processing whatsoever(e.g. accelerometer vectors are not normalized, scale and bias are not taken into account).
- **Logging.** In addition to showing you graphs of this data, this window also provides a logging option in which it will gather sensor data and place it into a file for later processing. To use this, simply put the name of the log file you wish to create in the Log file text field, and push Start Logging. This will create a log file with that name in the 3 Space software directory. If there is already a log file in that directory with the same name, this data will be appended to it. Be aware of that if you were intending to have a log file with only the new data you are about to receive. When you have collected the data you want, push Stop Logging. The Pause button will temporarily stop both the graph and any logging that may be occurring. Use the check boxes below the log file field to select which pieces of data you would like to have placed in the log file. The orientation that is logged is in angle-axis format, with four components that are, in order: angle, axis x component, axis y component, axis z component. The Normalized Sensor Data and Raw Sensor Data options log the same sorts of data that are displayed in the charts, with the same components in the same order as they appear there.

Settings



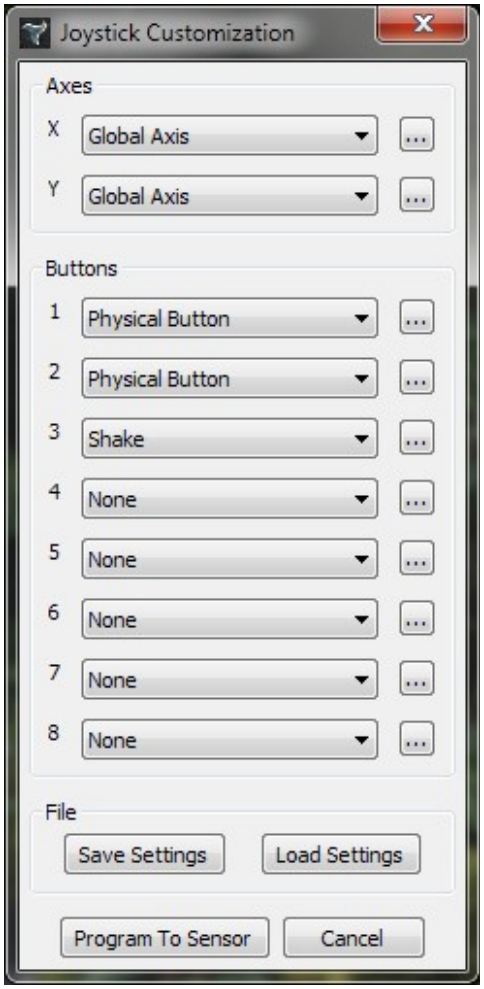
This window provides access to settings that you won't need often, but can still be useful.

- **Rho Modes.** Both the accelerometer and compass have a value, rho, which indicates how much they will be favored compared to each other and to the gyroscope. A low value of rho(such as 1) indicates that the sensor in question will be favored more, and a high value(such as 100) means it will be favored less. In static rho mode, the given sensor will always have the given rho value. In confidence rho mode, a confidence factor from 0 to 1 is assigned to the sensor based on the acceleration occurring on the accelerometer and the relationship between the readings from the accelerometer and compass, and this confidence factor interpolates between the minimum and maximum given rho values. The purpose of this mode is to allow the gyroscope to take over when the accelerometer is giving readings that include more than gravity, or when the compass is being affected by unusual magnetic forces.
- **Axis Directions.** This allows you to change what axis each of the natural axes of the sensor read as. For example, selecting ZXY mode means that the X axis of the sensor(the axis pointing out of the right hand side of it) will show up as the third(Z) component of any data coming out of the sensor. Likewise, Y will be the

first(X) component and Z will be the second(Y). This feature is in place for those who are used to different axis systems than the one that is natural to this sensor. Each axis can also be flipped using the controls along the bottom of this box. Note that these apply to the axes after the mode conversion, so in the above example, checking the negative X box would result in the X component of any data coming from the sensor being negative Y.

- **Calibration Mode.** This determines how the data is calibrated inside the sensor. Bias and scale are always applied, but there are also options for applying the calibration matrix for each sensor to the data as well, or the lookup table data for the accelerometer and compass. The gyroscope's matrix will be applied to it in either Matrix or Lookup Table mode, as it does not have a lookup table.
- **Desired Update Rate.** This value specifies how long in microseconds you would like each sensor cycle to take. A value of 0 indicates that you would like the sensor to run as fast as possible, i.e. you would like each cycle to take 0 microseconds. This is called the desired update rate because it will only be honored as closely as it can. It will never be able to reach 0 microseconds, but it will come as close as it can. This setting is useful if you would like the sensor to run slower or if you would like it to run at a more stable rate.
- **Oversample Rate.** This determines how many sets of sensor readings should be obtained each cycle to derive the orientation from. More samples per cycle slows down the update rate of each cycle, but helps to reduce error.
- **Running Average Percent.** This determines how strong of a running average is being used on the final orientation reading. A higher running average percent will cause the output orientation to be smoother and less shaky, but will also cause it to respond to changes in orientation more slowly. 0 means no running average will happen at all, and larger values(up to the maximum of .97) will cause the running average to become stronger.
- **Button Gyro Disable Length.** This determines how long the gyroscope will be disabled when one of the physical buttons on the sensor are pressed. The shockwaves the buttons send through the sensor can cause the gyroscope to give incorrect readings, and so this setting is in place to prevent these. This value is expressed in number of cycles. More cycles will provide more insurance that this will not happen, but will leave the gyroscope disabled for longer. Increase this value if you notice that the buttons are causing problems with orientation.

Joystick and Mouse Customization



The joystick and mouse on the sensor are represented as a series of configurable virtual axes and buttons. This window allows you to change the way the axes and buttons on either the joystick or mouse function. Each axis and button has a number of operation modes you can choose from.

Axes

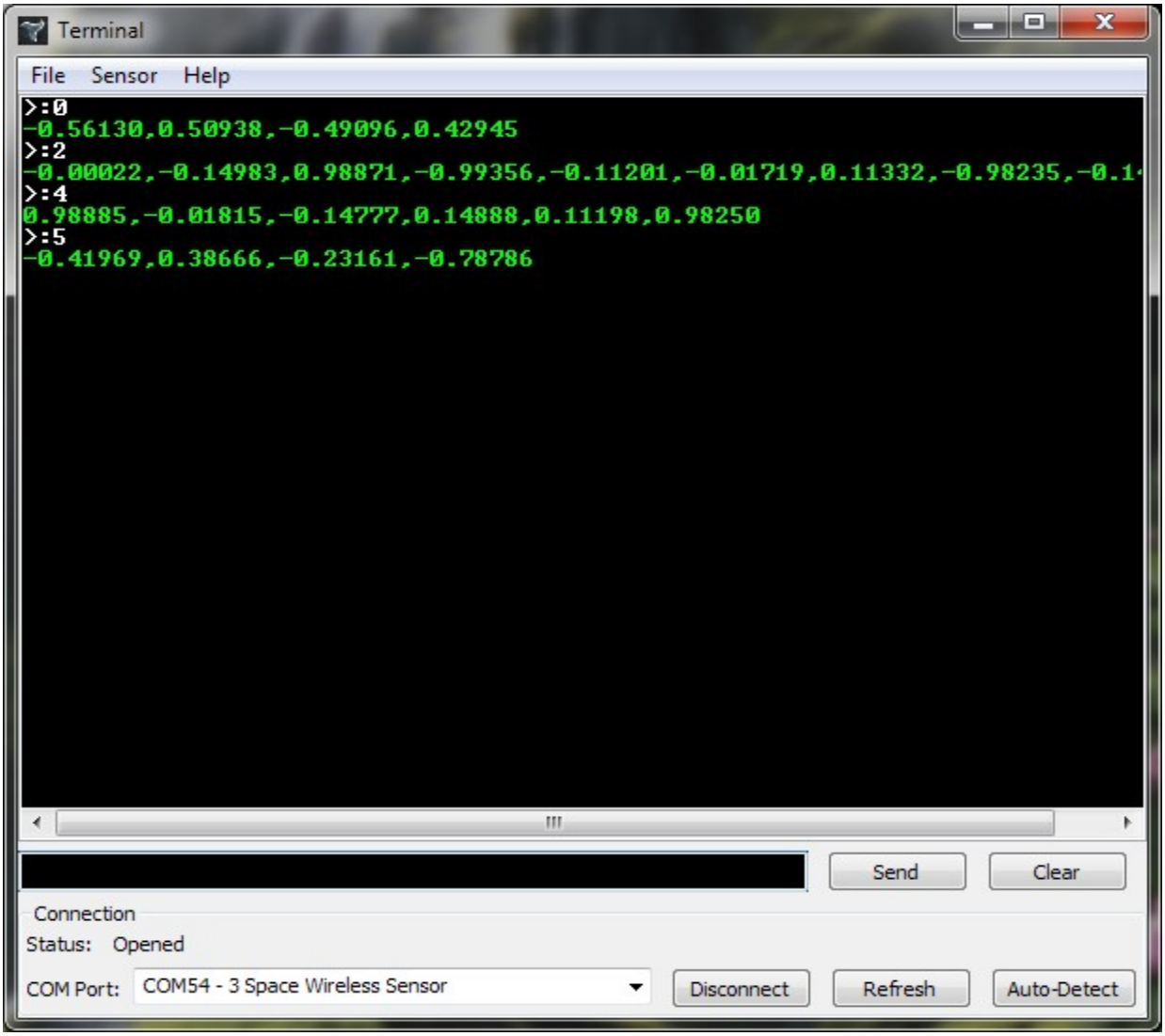
- **Global Axis.** This mode uses as its axis value the component of a vector local to the sensor along a global vector. For example, using a local vector of (0,1,0) and a global vector of (1,0,0), the axis would be at its maximum when the top of the sensor was facing right and at its minimum when the top of the sensor was facing left.
- **Screen Point.** This mode acts as though a vector on the sensor is pointing directly at a point on an imaginary computer screen. The screen is always assumed to be in front of the sensor, in the positive Z direction. A single axis of this mode only contains information about a single axis of the screen, i.e. if it was meant for the x axis of the mouse it would probably only contain information about the X component of this screen. The "Distance from origin" parameter sets how far away on the Z axis the screen is from the origin, and the "Size on this axis" parameter determines how wide/tall the screen is on that particular axis. You may use whatever units you like for these 2 values, as the units will cancel out during calculations. The "Sensor direction axis" parameter determines which axis of the sensor the pointing vector will be. Z is the most likely choice for this, as this means the front of the sensor is intended to point at the screen. "Button press halt duration"

determines how long the position on this virtual screen will be frozen for when a physical button is pressed. This makes this mode more useful as a mouse as it allows mouse selections to be made without as much movement from the cursor and prevents some cursor motion that occurs due to the physical act of pressing the buttons.

Buttons

- **Physical Button.** This is the simplest of the button modes, as it simply maps one of the virtual buttons directly to one of the sensor's physical buttons. <Label which button is which somewhere.> Choose from among the buttons on the sensor; whichever you pick, the virtual button will be activated when that one is pressed and deactivated when it is released.
- **Orientation Button.** This mode will activate the virtual button when a certain vector on the sensor is pointing in roughly the same direction as a global vector. The "Max Distance" parameter indicates how close the dot product of the two vectors must be to 1 for the button to activate. For example, if the local axis was (0,0,1), the global axis was (0,1,0), and the max distance was 1, the button would be activated so long as the forward direction of the sensor was not pointing downward(as long as it was within 90 degrees of up).
- **Shake Button.** This mode will cause the button to activate whenever the sensor is shaken. The shake threshold is the amount it has to be shaken. This unit is a multiple of the acceleration due to gravity. So, if the shake threshold is .5, the chip will have to experience an acceleration greater than half the acceleration due to gravity for the button to activate. Note that due to the nature of acceleration, stable behavior should not be expected from the resulting button activations. They will occur when the chip is moved a certain amount and only then, but during that period of time the presses are sporadic.

Terminal Mode



Terminal mode allows you to communicate directly with the sensor without the aid of the graphical interface. For instructions on how to communicate using terminal commands, see the 3-Space Protocol Reference document.

- **Main Terminal Window.** This box displays all data sent to and received from the sensor. Data that was sent is white and is preceded by a '>' character. Data received from the sensor is green.
- **Send Box.** The little black box at the bottom of the window. Type text in to this and press enter or Send, and the text will be sent to the sensor, with a newline at the end.
- **History.** While in the Send Box, pressing the up key will retrieve the previous command, while the down key will return to more recent commands.