README
Data Pre-Processing Scripts

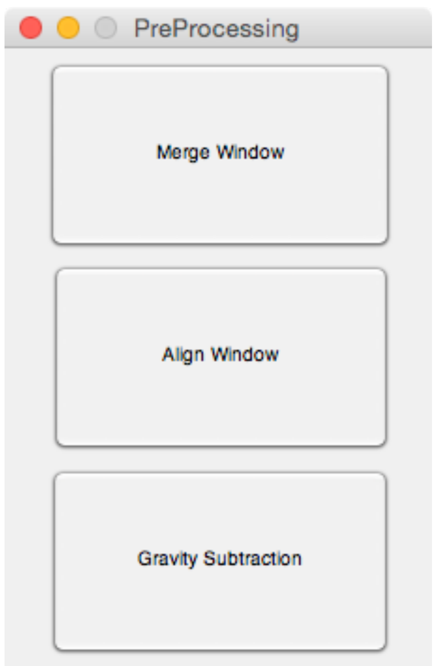
1. Data File

- Filename: “Pegasus_Sens_XXXX_xxxxxxxxxxxxx.txt”.
- The first 4 X’s are either alphabets or digits indicating the sensor ID and the last 13 x’s are all digits recording the time when the file has been generated.
- If you open the data file, you will see the data format illustrated in the following figure. The first row indicates what measurements each column corresponds.
  – Column 2 to Column 4 are raw accelerometer measurements in x axis, y axis and z axis. You need to divide them by 2048 to convert them in the unit of g (9.8m/s^2).
  – Column 5 to Column 7 are gyroscope measurements in x axis, y axis and z axis. You need to divide them by 16.4 to convert them in the unit of deg/s.
  – Column 8 to Column 11 are quaternions representing sensor orientation. You need to divide them by 1073741824 to normalize them.

```
Receiver time, Accel X,Y,Z, Gyro X,Y,Z, Quaternion W,X,Y,Z, dt(or)index
1374518266705,-500,-711,1929,6,9,-10,1052109383,180867810,-114286301,-14588665,-24846
1374518266705,-497,-689,1916,-5,1,-9,1052113696,180846855,-114276712,-14612491,-24841
1374518266705,-507,-681,1911,-3,8,-9,1052119512,180829803,-114247627,-14632121,-24836
1374518266705,-498,-696,1911,2,14,-11,1052123871,180829598,-114205154,-1465280[illegible],-24831
1374518266705,-500,-697,1907,-2,6,-8,1052128432,180815970,-114182456,-14670354,-24826
1374518266705,-506,-697,1921,-4,4,-7,1052133303,180796623,-114166113,-14686640,-24820
1374518266705,-500,-692,1910,-6,8,-6,1052140454,180770935,-114139334,-14698681,-24815
1374518266705,-500,-691,1911,-7,8,-6,1052148143,180742362,-114112108,-14711088,-24810
1374518266706,-497,-688,1906,-10,5,-5,1052156427,180704818,-114093643,-14723036,-24805
1374518266706,-498,-687,1916,-9,5,-6,1052164230,180670272,-114074524,-14737507,-24800
1374518266706,-491,-687,1909,-7,6,-6,1052171474,180640864,-114052559,-14750857,-24795
```

2.1 Pre-Processing Overview

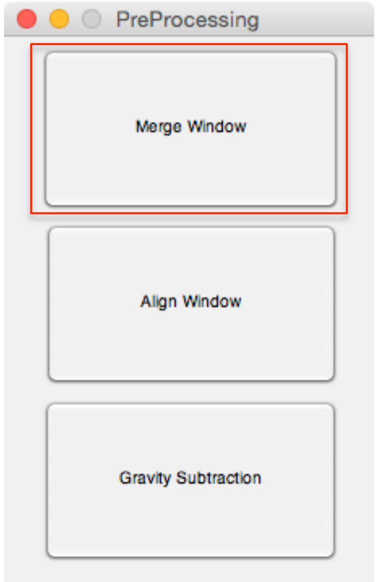
- After collecting a set of data, you can use the Pre-Processing tool to analyze it.
  - To launch the Pre-Processing tool: launch Matlab, set the current directory to the 'PreProcessingTool' folder, and type 'PreProcessing' in the command line
- A new window like the one in the following figure will pop up. The window includes 3 major functions the Pre-Processing tool can provide.



  - **Merge Window:** merge two data files into a single mat file (and normalize)
  - **Align Window:** align data collected from two sensors based on synchronization signals (and truncate)
  - **Gravity Subtraction:** subtract gravity component from acceleration signal

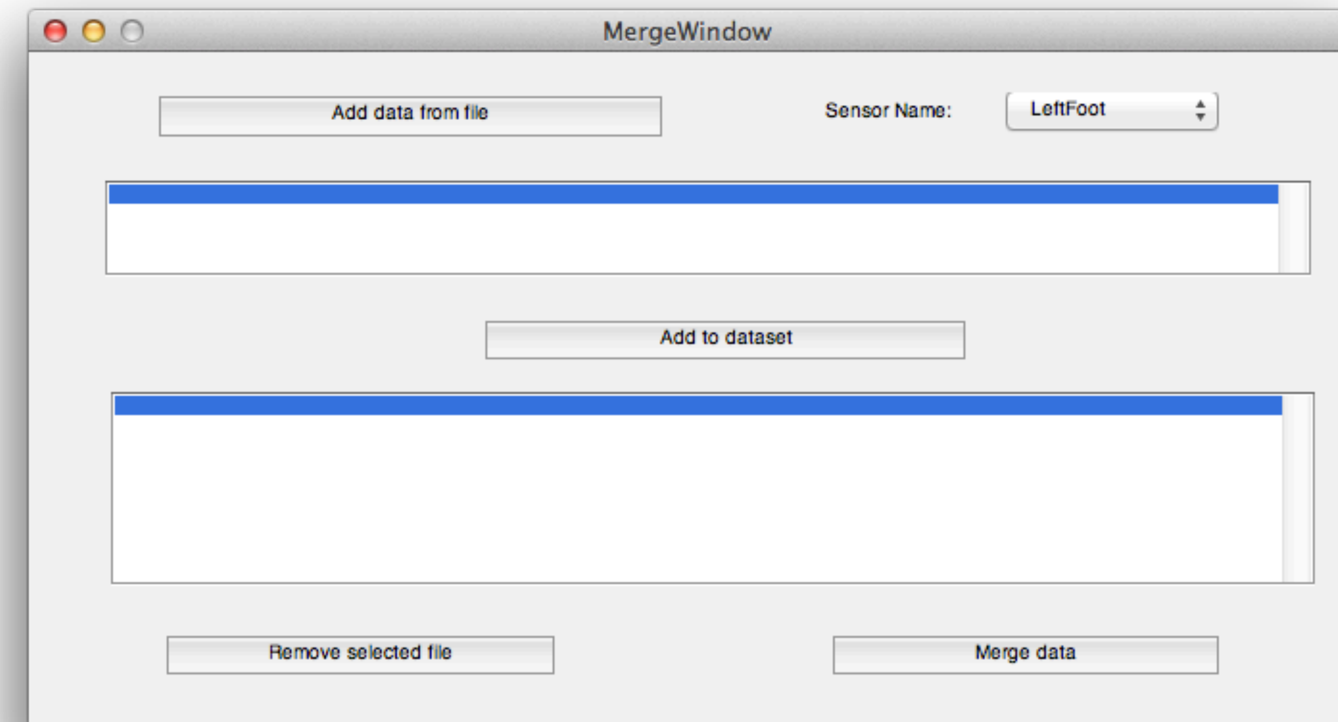
2.2 Merge Window

- If you have two data files (e.g. one generated from the sensor on position 1 and the other generated from the sensor mounted on position 2), the merge window will merge them into a single mat file.
- **If you only have one data file, you should still use it** because it scales the raw sensor measurements into their meaningful unit, i.e., g, and deg/s. Also it converts .txt file to .mat file which is preferred by MATLAB.
- The merge window can be opened by clicking "Merge Window" in the post processing window as highlighted in the following figure.



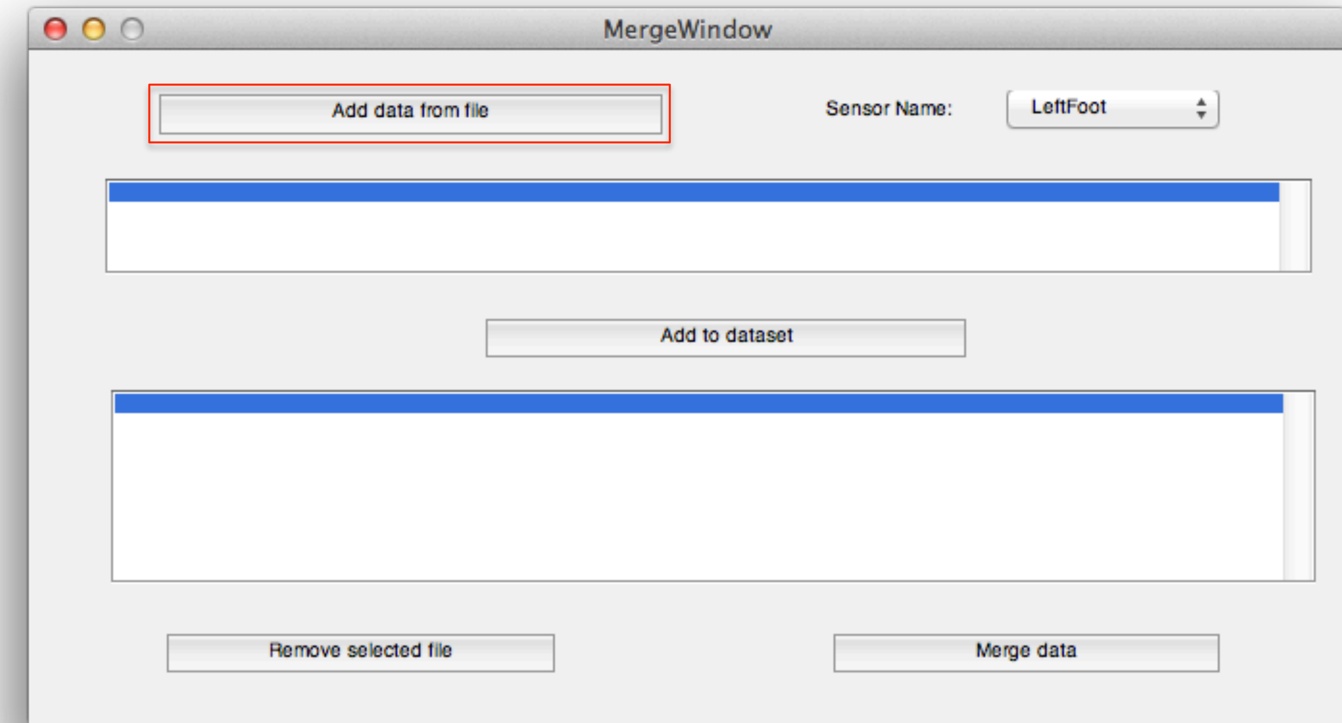
2.2 Merge Window (Open)

- A new window like the one in the following figure will pop up.



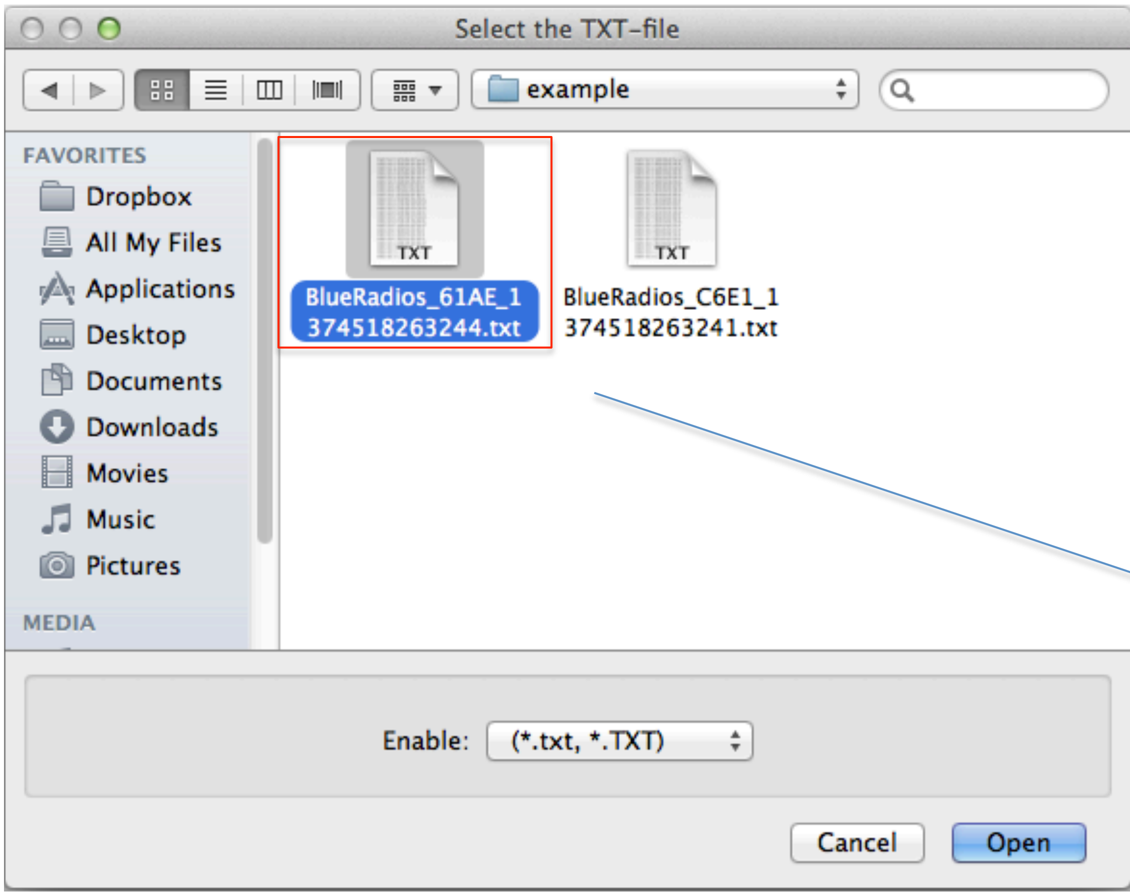
2.2 Merge Window (Add data from file)

- Click "Add data from file" to add a .txt file to the merge tool.



2.2 Merge Window (Add data from file)

- A new window will pop up and you can direct to the folder where the data files are.

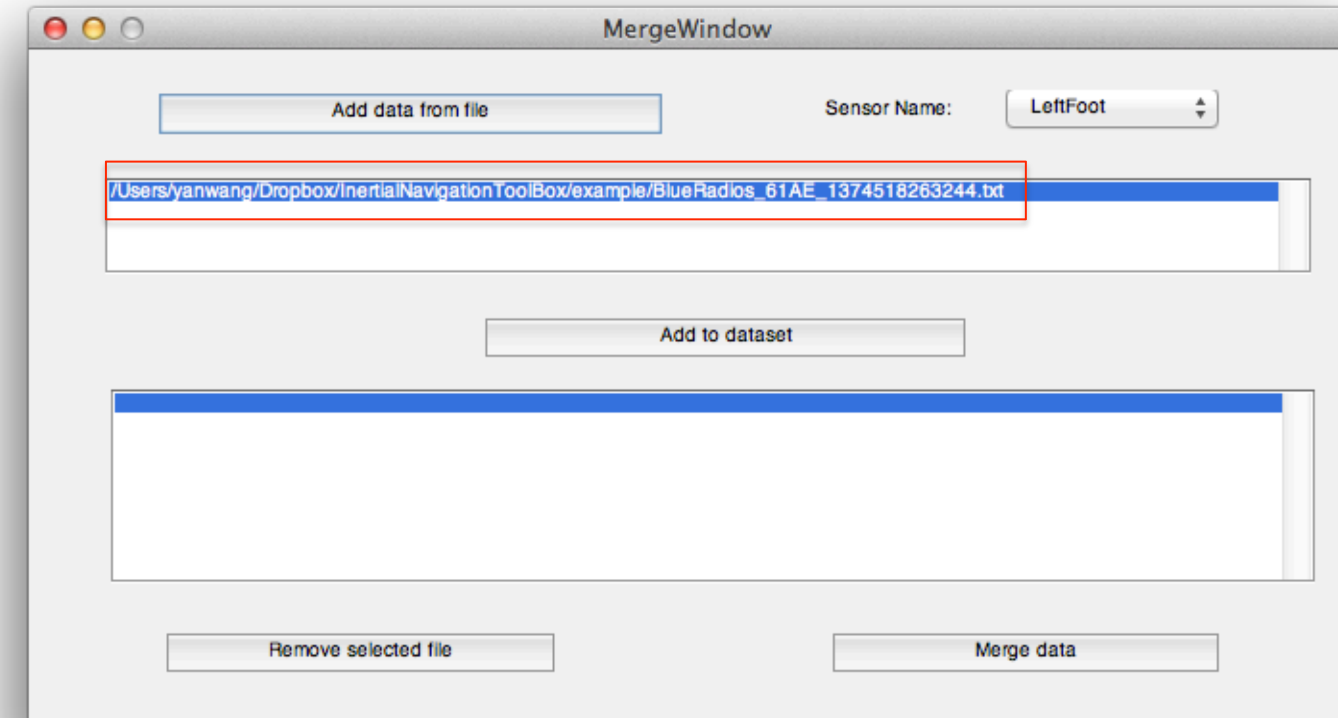


Note: These demo data were collected by our earlier version of sensors. Sensor 61AE was mounted on the left foot and Sensor C6E1 mounted on the right foot.

For the sensors you have, the file name should be "Pegasus_Sens_XXXX_xxxxxxxxxxxxx.txt"

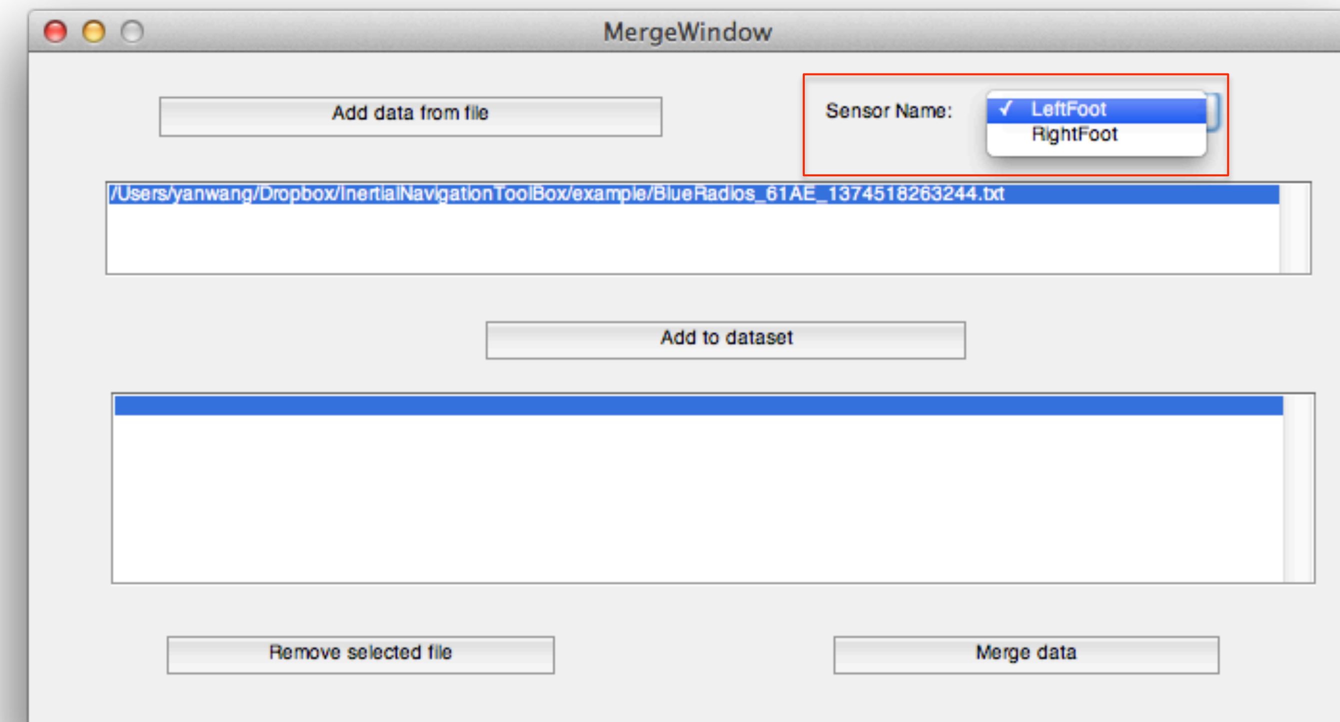
2.2 Merge Window (Add data from file)

- Double click the first file you want to add and its path will be displayed in the merge window.



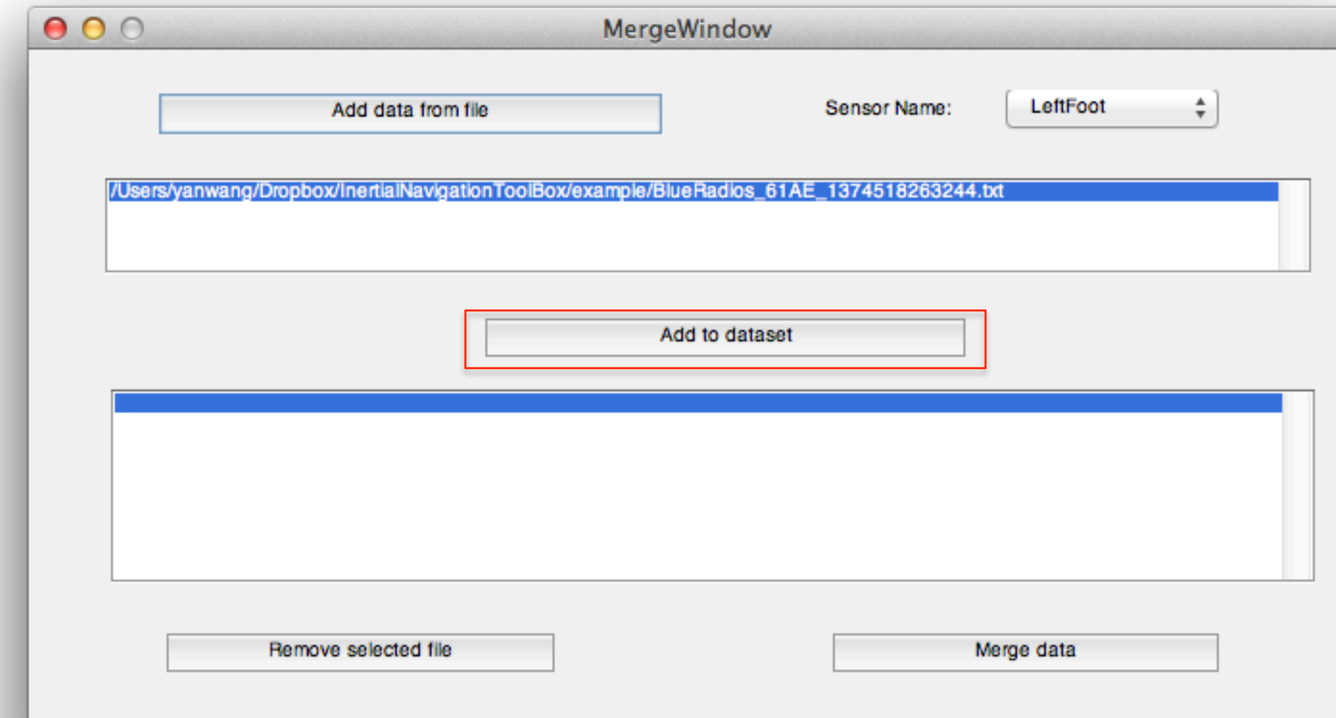
2.2 Merge Window (Sensor Name)

- You should select the sensor name based on the actual sensor mounting position. Since the data file, “BlueRadios_61AE_1374518263244.txt” was collected from a sensor mounted on the left foot, we choose “LeftFoot”.



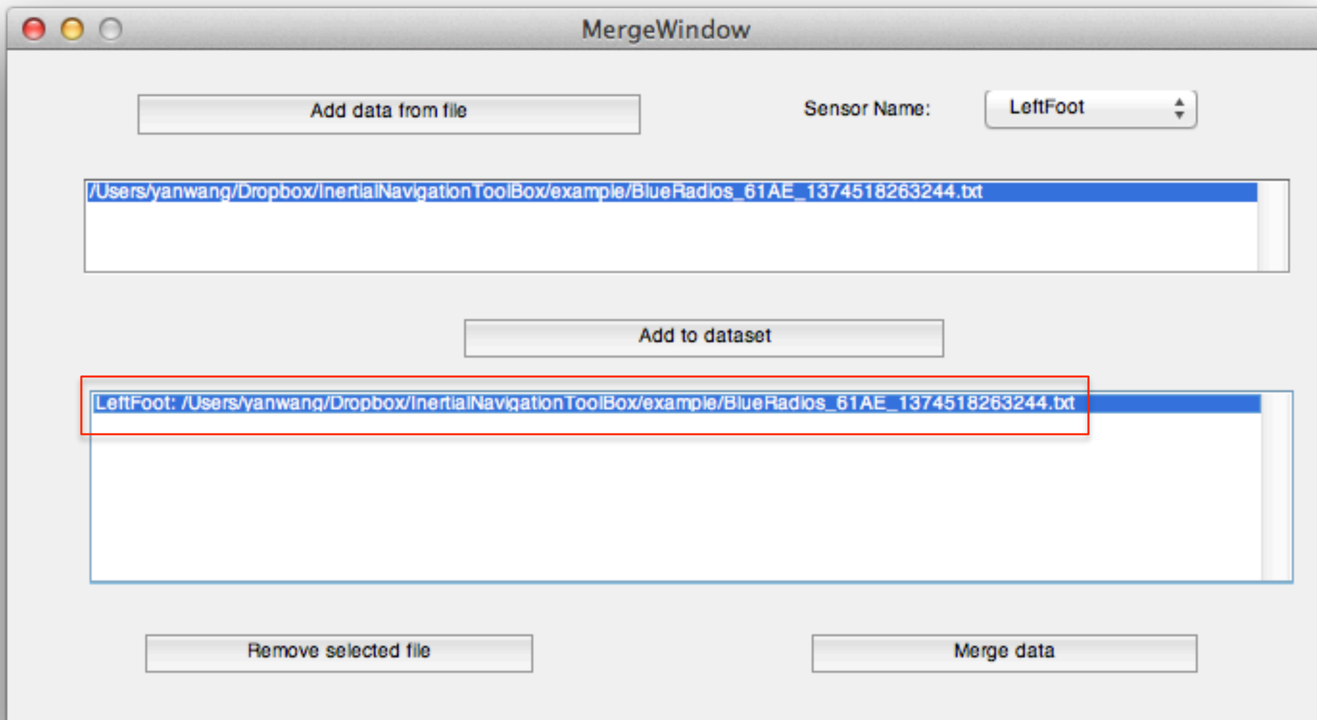
2.2 Merge Window (Add to dataset)

- After the data file has been selected as well as the sensor name, click "Add to dataset".



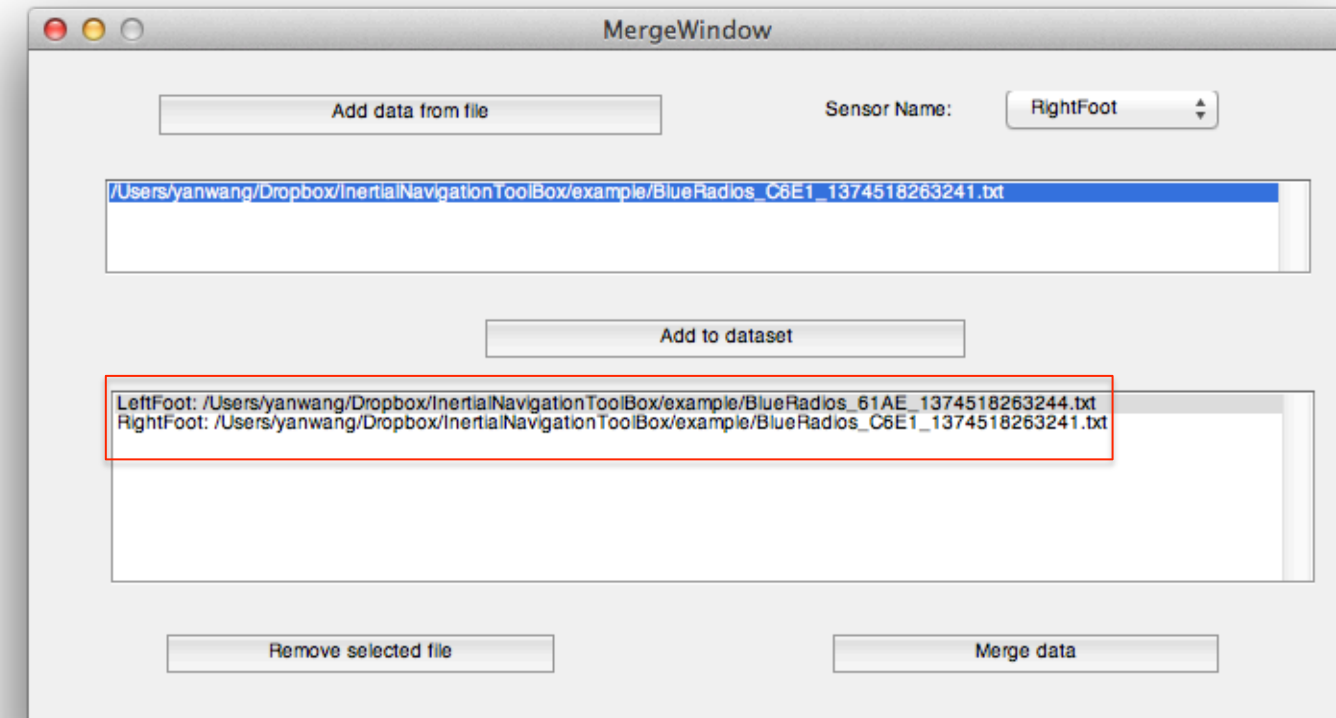
2.2 Merge Window (Add to dataset)

- The sensor name as well as the data file path will be displayed in the merge window.



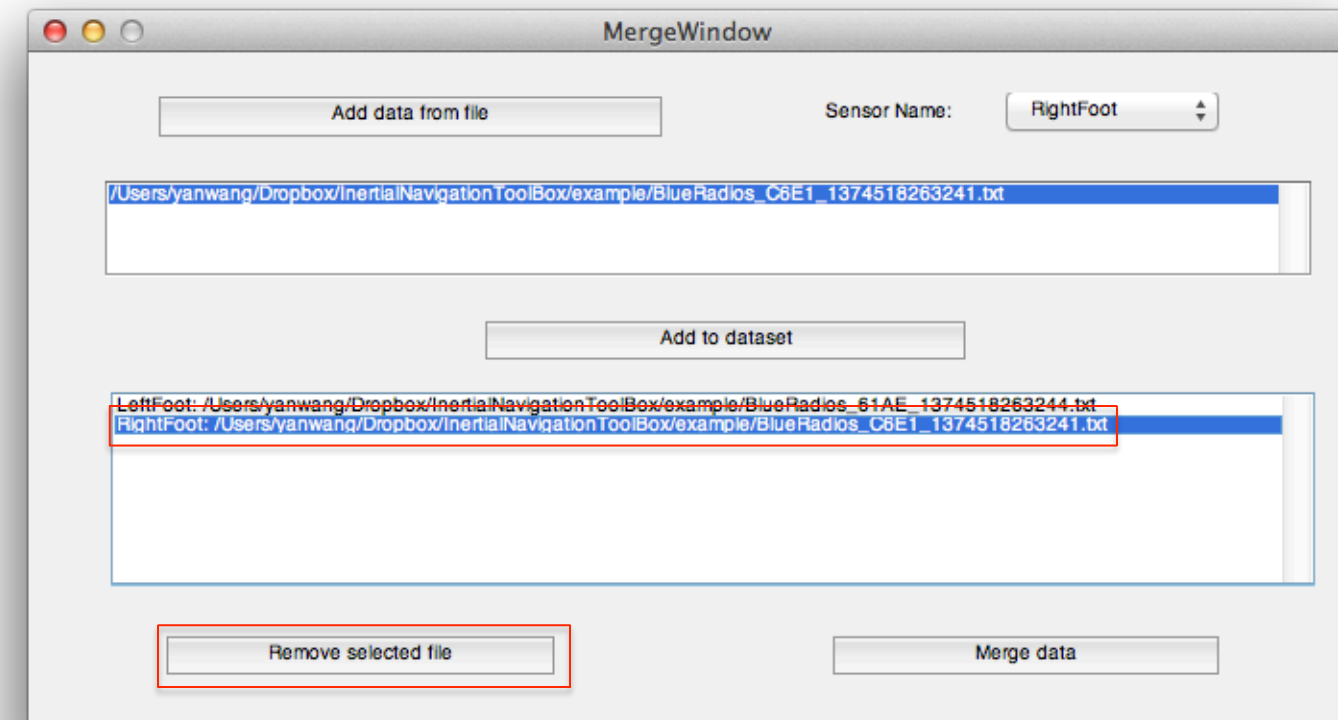
2.2 Merge Window

- If you have the other data file collected from position 2, you need to repeat the operation from “Add data from file” to “Add to dataset”. In this demo, we have two files. So after we add the data file collected from the sensor on the right foot, both of the data file paths will be displayed.



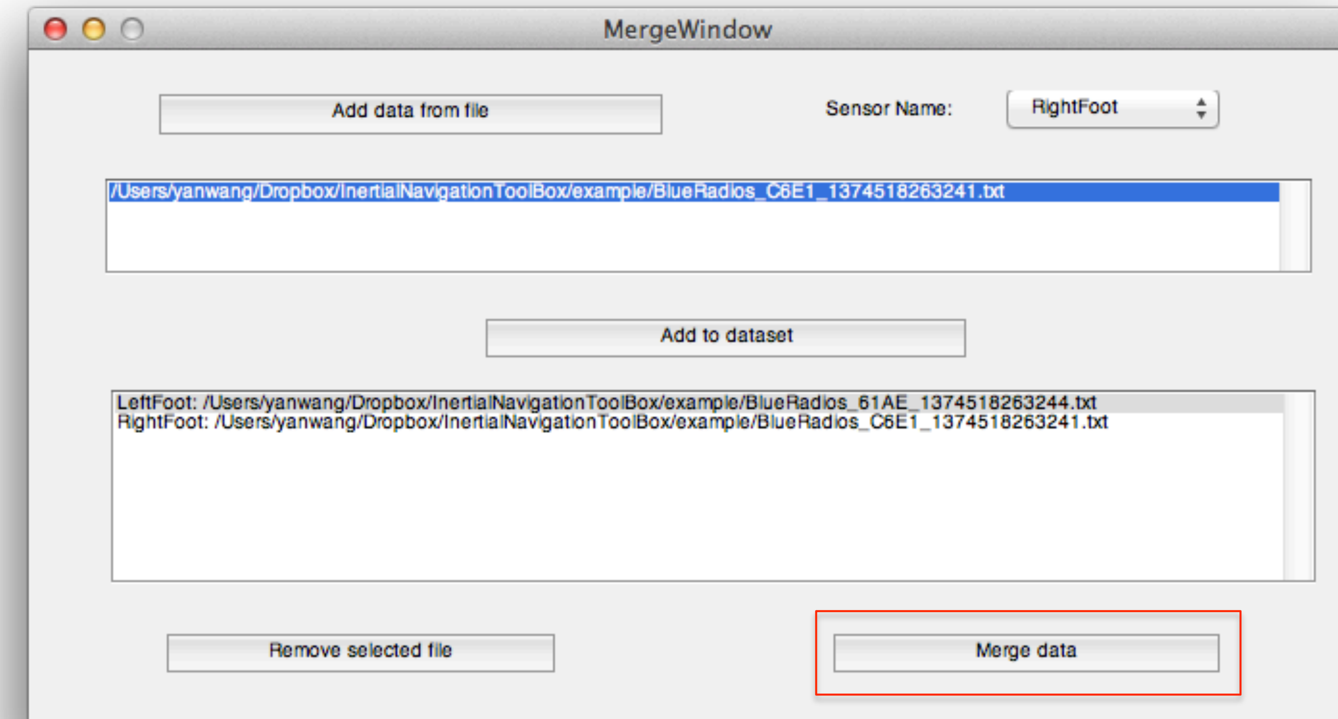
2.2 Merge Window (Remove selected file)

- There are cases when you added a wrong file or labeled a file with the wrong sensor name. You can remove the file path by first clicking the file and then clicking “Remove selected file”.



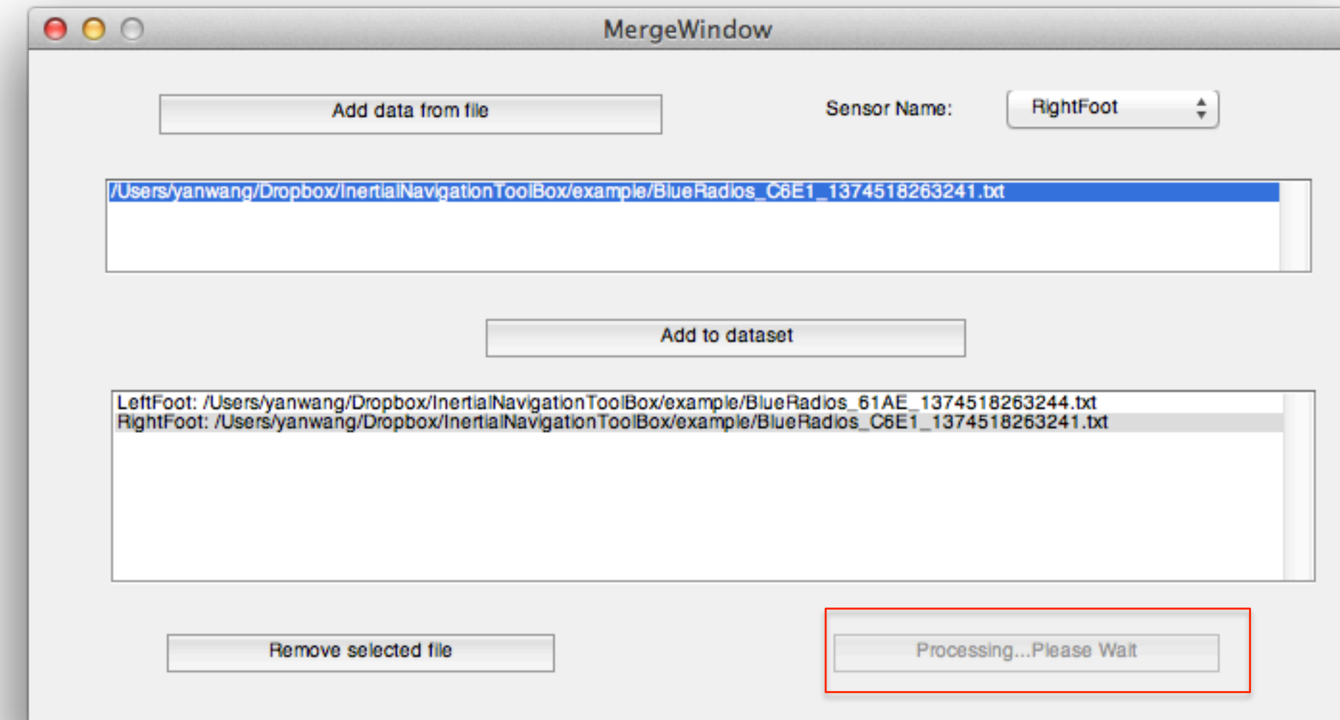
2.2 Merge Window (Merge data)

- Once both files are added (or if you are using a single sensor then once the file is added), we click Merge data.



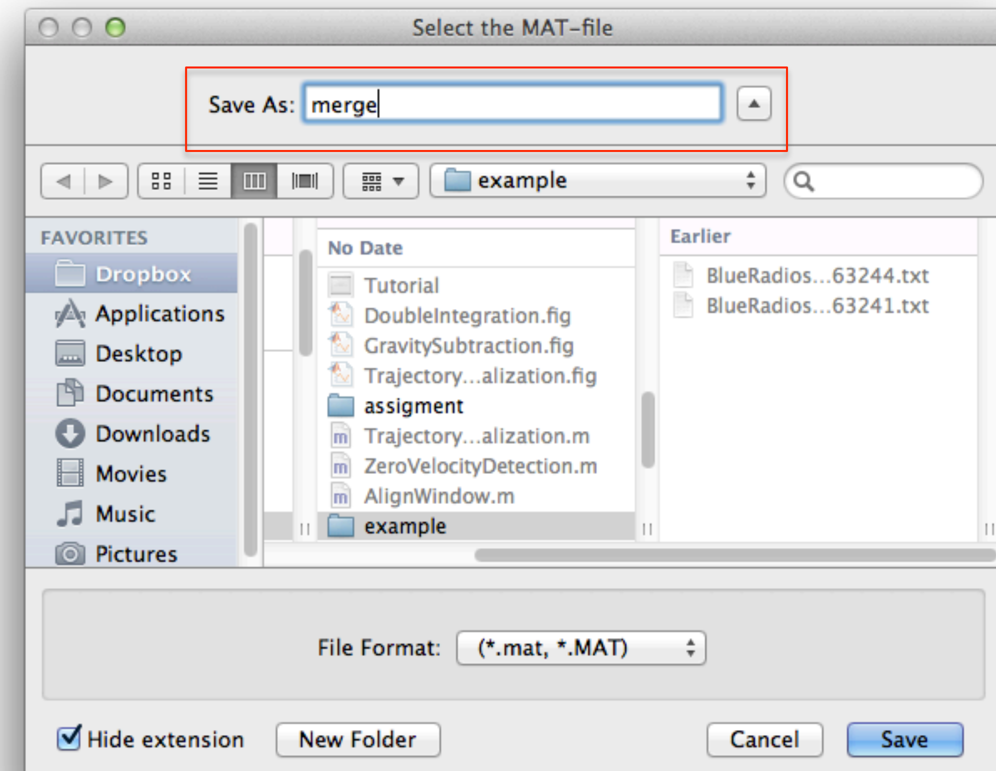
2.2 Merge Window (Merge data)

- The "Merge data" button will be disabled during the merging processing and it will display "Processing…Please Wait".



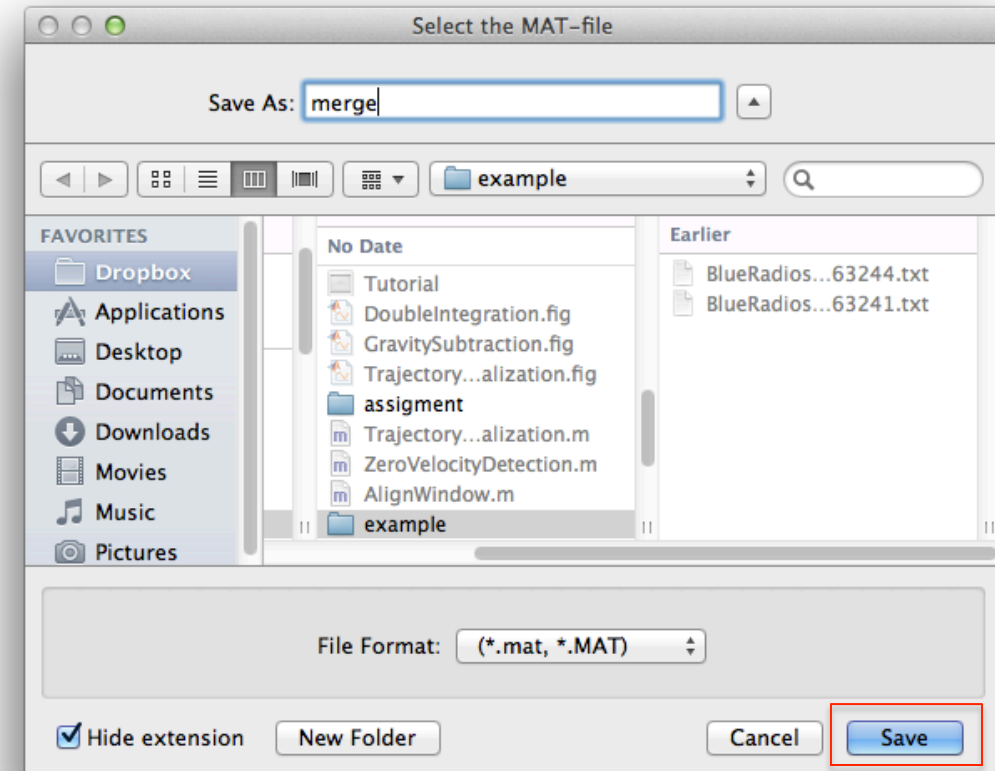
2.2 Merge Window (Merge data)

- After the merging has been done, a new window will pop up letting you direct to the folder where the .mat file you want to save and also name the file. Here we save it into the same folder where the .txt files are and name it as merge.



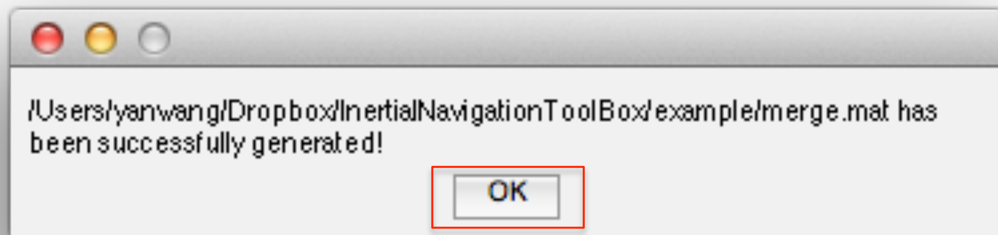
2.2 Merge Window (Merge data)

- By clicking save, the “merge.mat” file will be saved under the directory of “/example”.



2.2 Merge Window (Merge data)

- A message box similar to the following figure will pop up to inform you the generation of the .mat file. You can click “OK” to close the message box and also the merge window will be closed automatically.

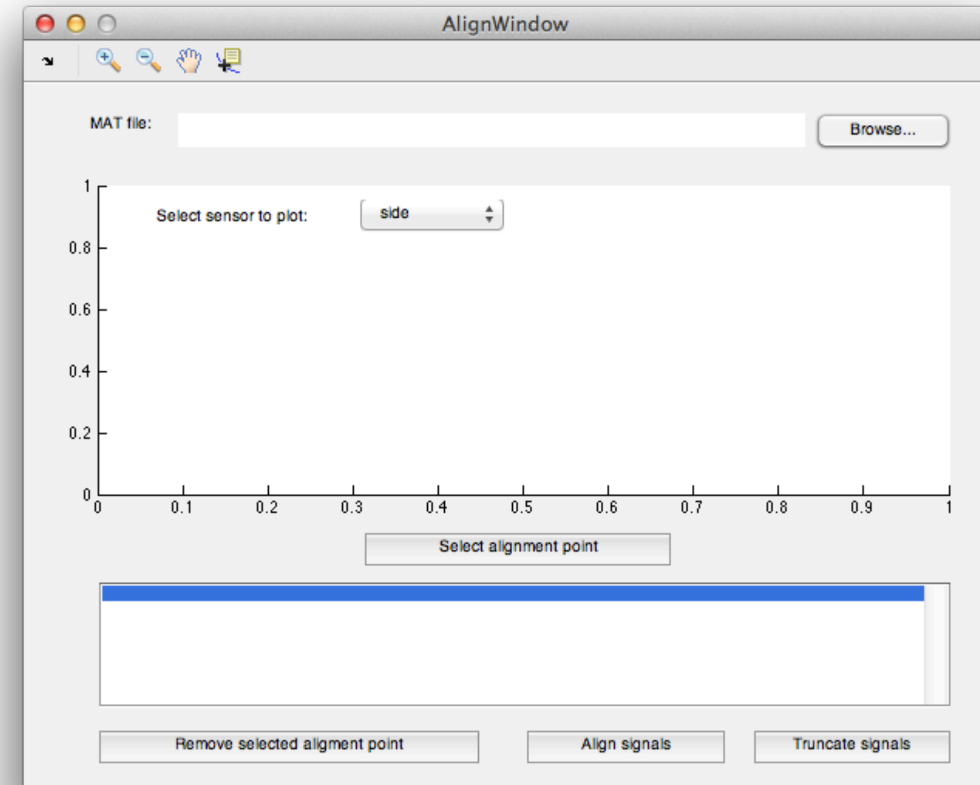


2.3 Align Window

- If you have two data files collected from two sensors, they are usually not very well synced. The align window help you go through manual data synchronization in a simpler way.
- If you only have one data file, you still need to use it because provides a simple way for you to truncate data where only the segment of data of interest will be retained for further analysis.
- The align window can be opened by clicking "Align Window" in the pre-processing window as highlighted in the following figure.

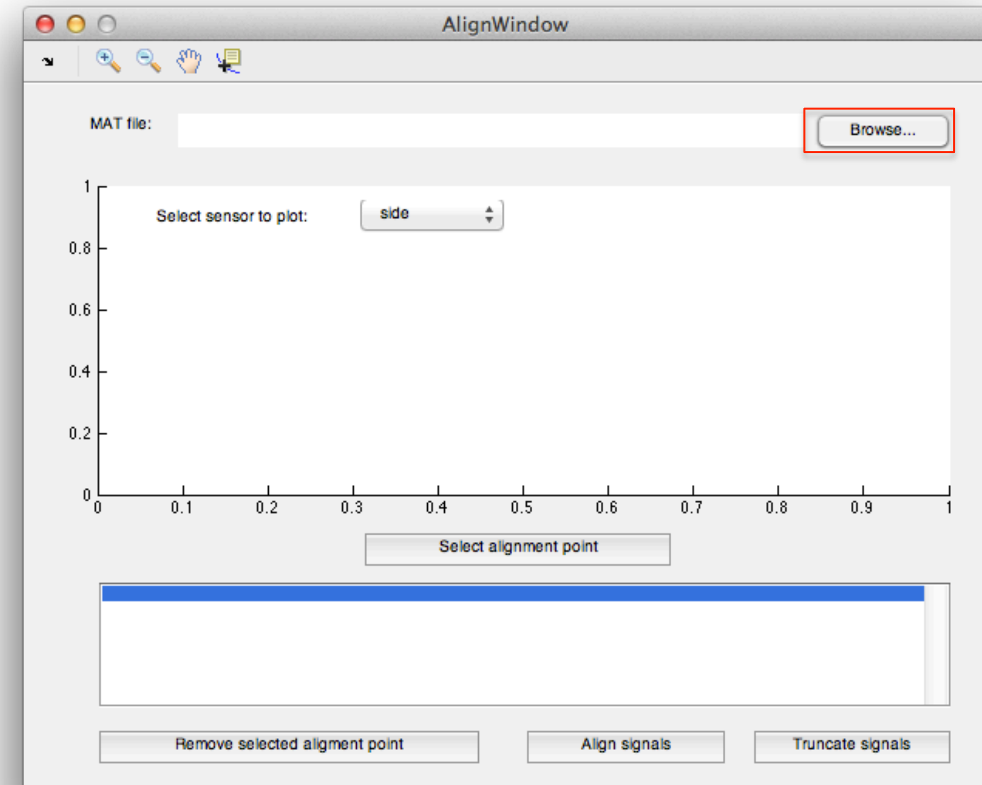
2.3 Align Window (Open)

- A new window like the one in the following figure will pop up.



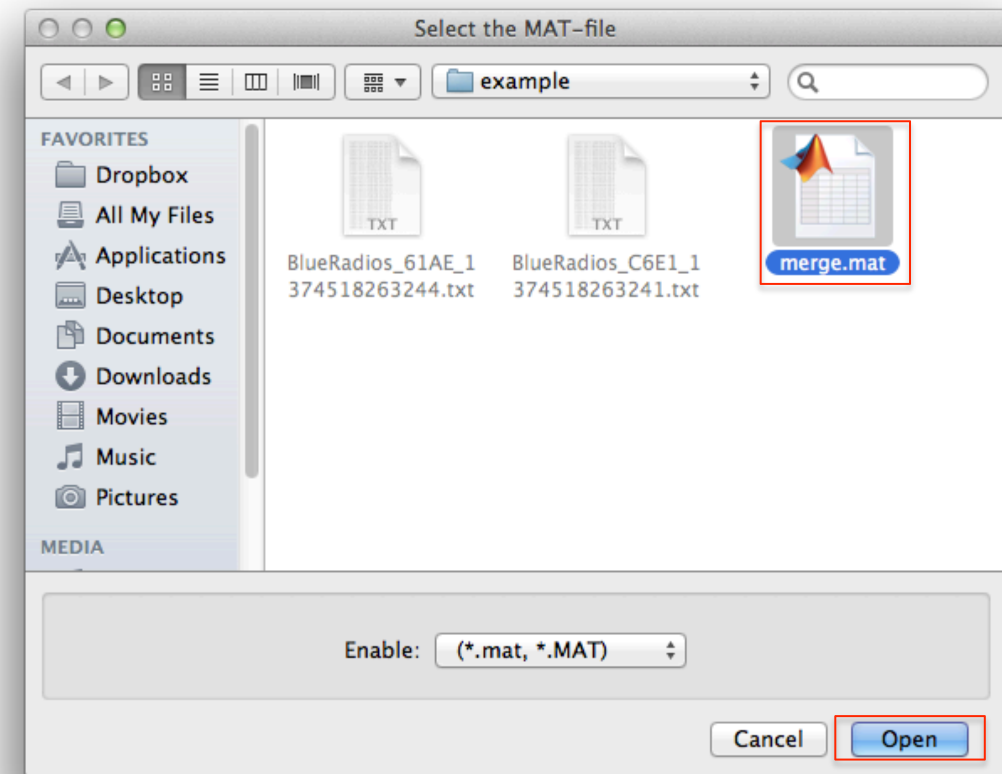
2.3 Align Window (Browse)

- You need first click “Browse…” to load the .mat file that has been generated using the merge window.



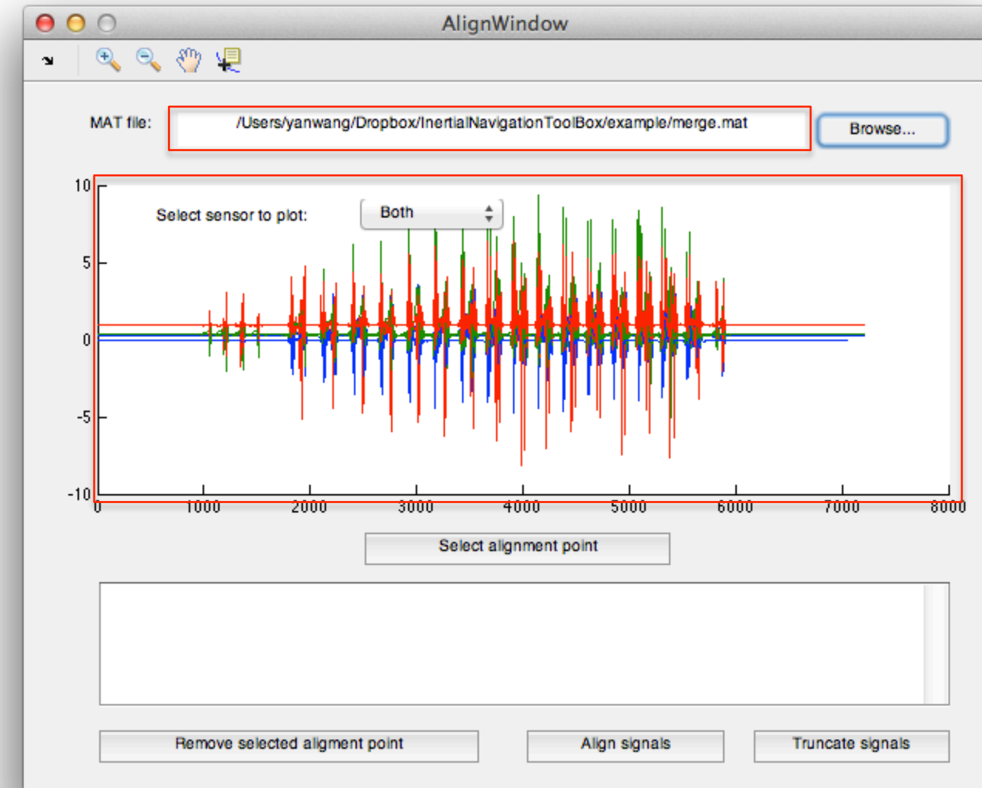
2.3 Align Window (Browse)

- A new window will pop up letting you direct to the .mat file you want to load. After you select the right file you want to load, click “Open”.



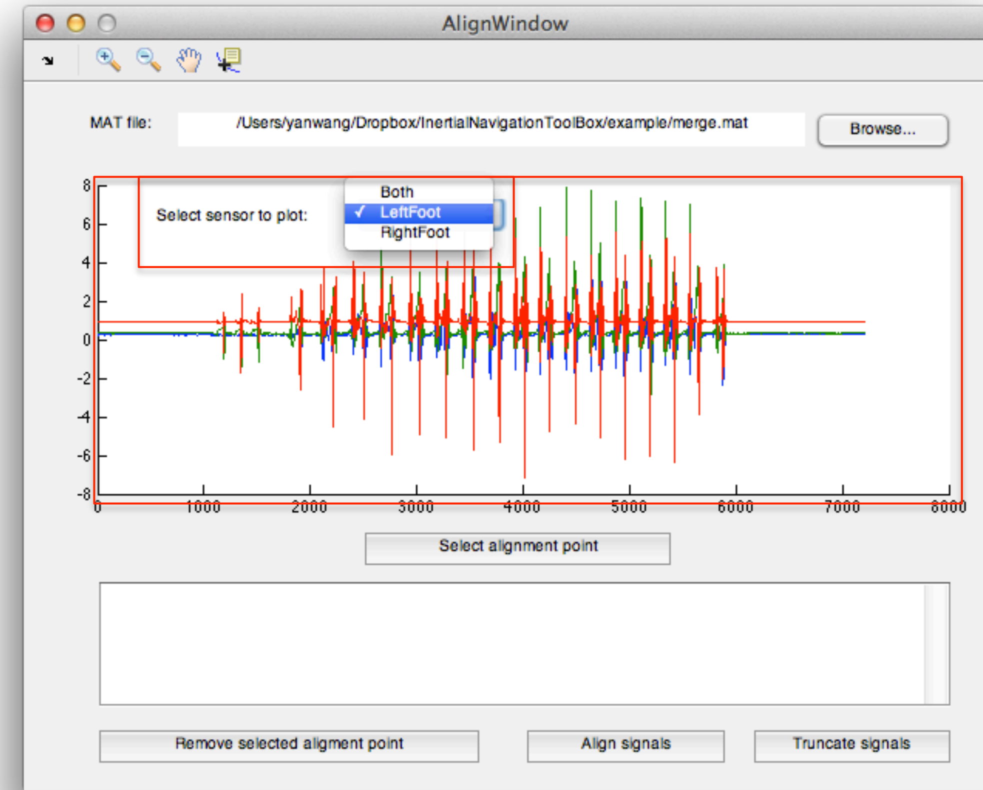
2.3 Align Window (Browse)

- Then the file path will be displayed in the align window. Also the acceleration data in the merge.mat will be plotted.



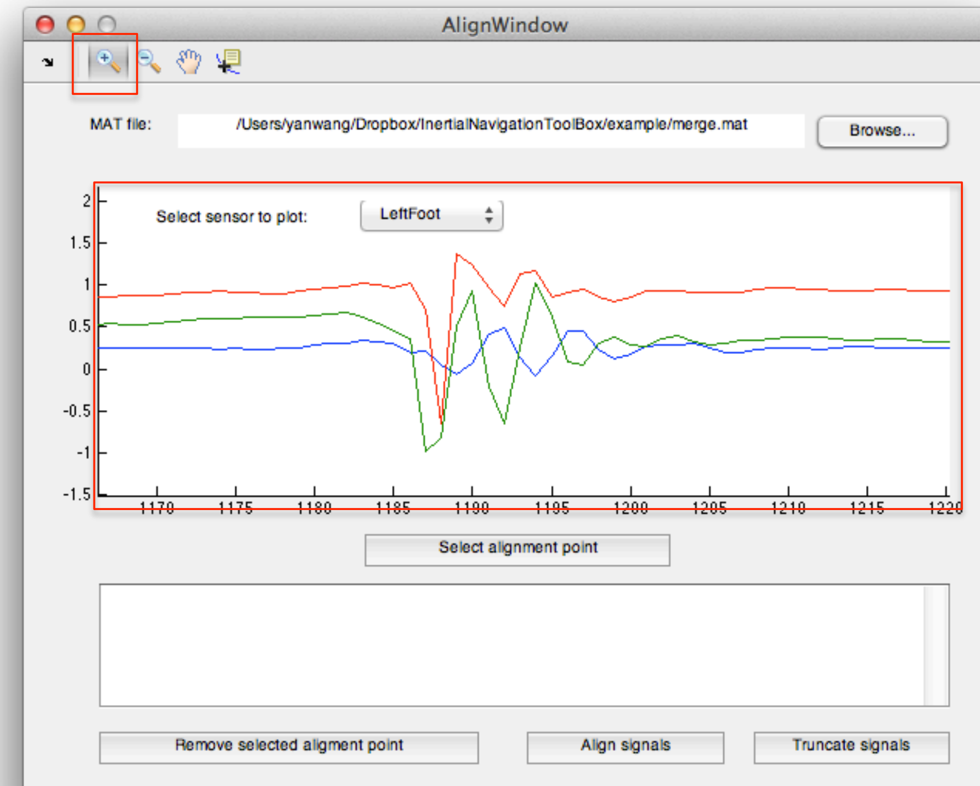
2.3 Align Window (Select sensor to plot)

- We can select the sensor to plot through “Select sensor to plot”. Here we select “LeftFoot”. So only the acceleration data collected from the sensor mounted on the left foot are being plotted.



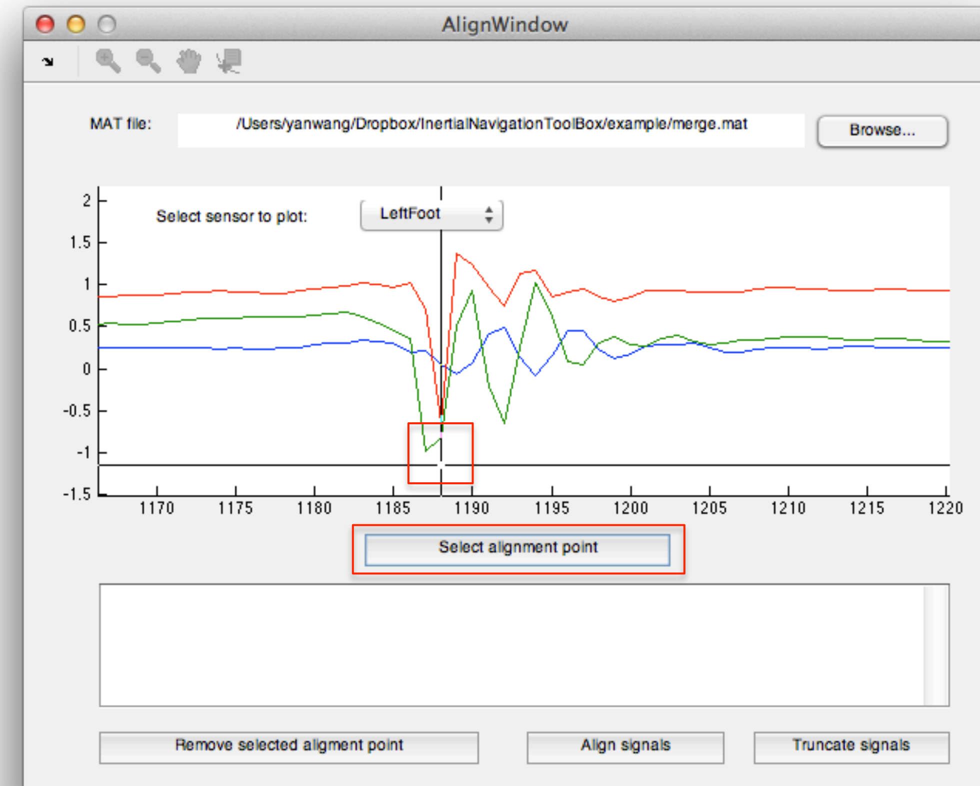
2.3 Align Window (Select sensor to plot)

- We can zoom into the synchronization signal by using the magnifier. Here we zoom into the first peak of the left foot acceleration signal.



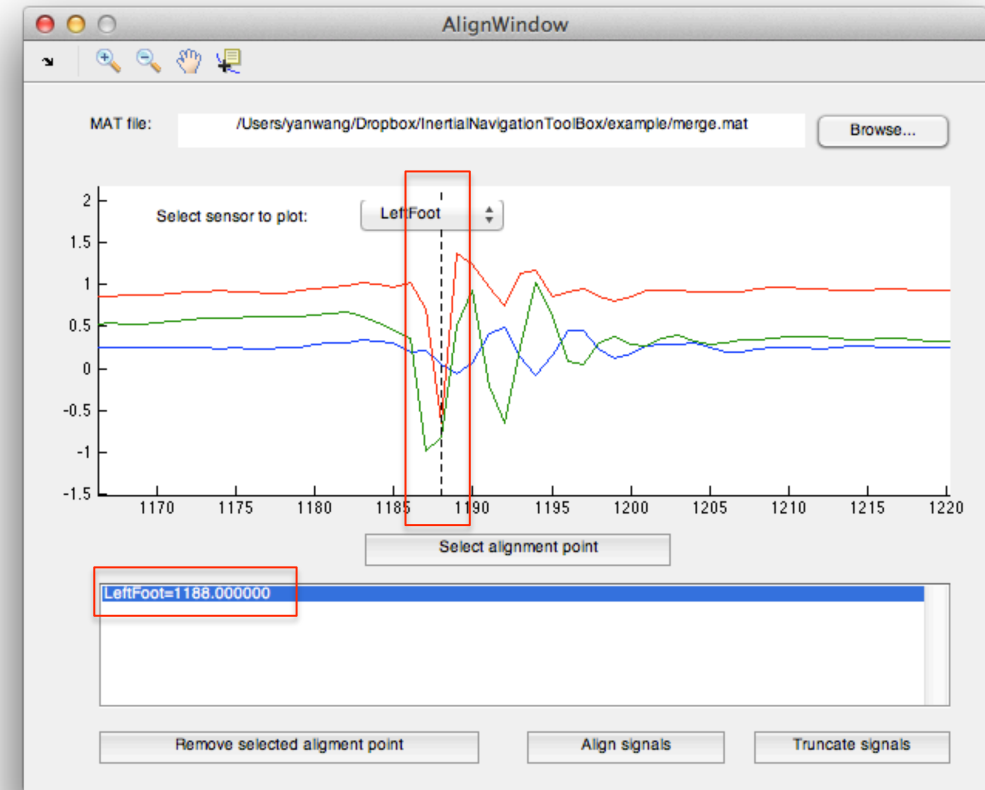
2.3 Align Window (Select alignment point)

- By clicking the “Select alignment point” button, the mouse will change to a cross. We need to target the center of the cross to the point where we think as a alignment point for the left foot signal. (only the x-axis position matters)



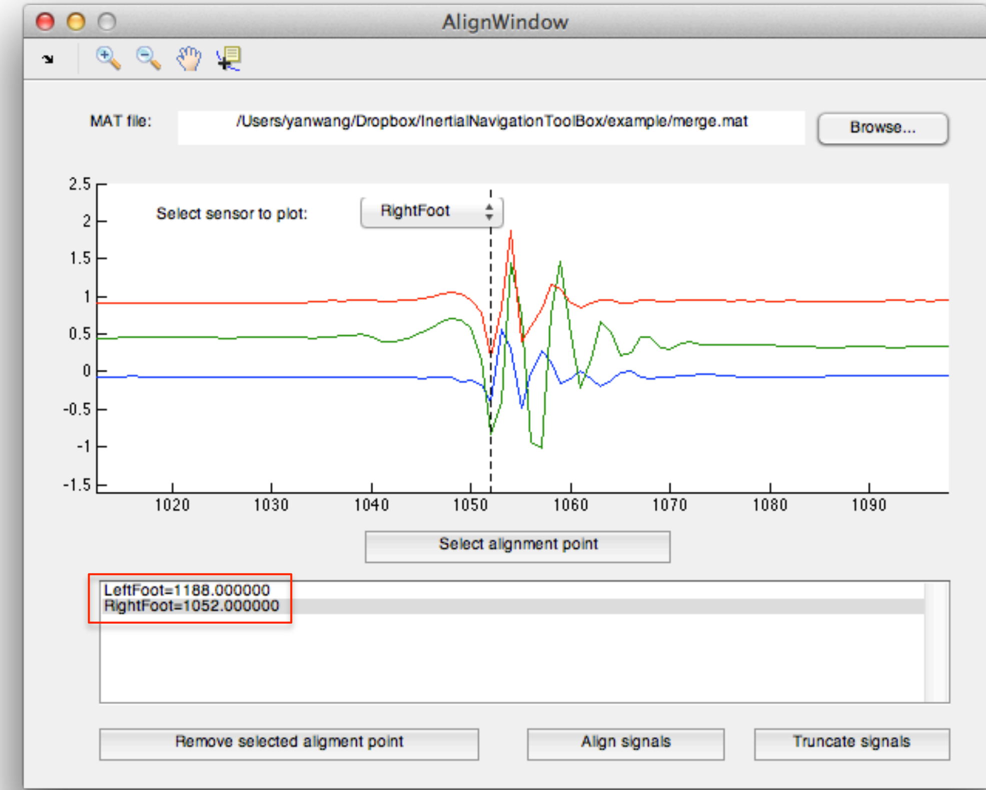
2.3 Align Window (Select alignment point)

- After clicking on the alignment point, a dotted line will be added to the point and the index of the point will be displayed as the alignment point for the left foot signal.



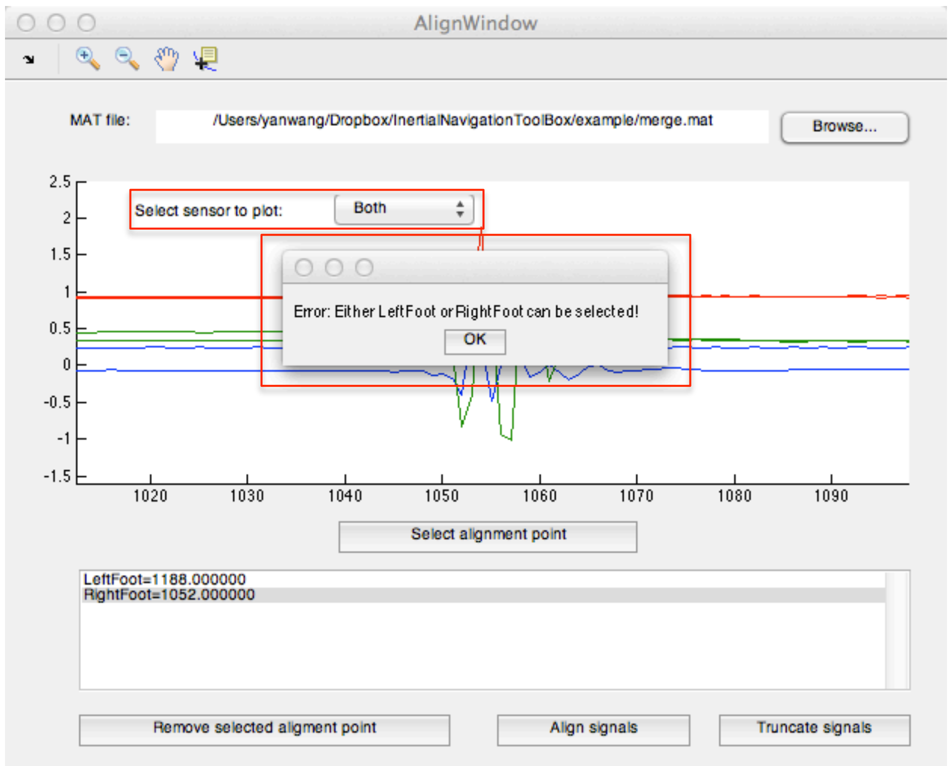
2.3 Align Window (Select alignment point)

- We can repeat this to select the alignment point for the right foot signal from “Select sensor to plot” to “Select alignment point”. Then the index of the alignment points for both left foot and right foot signals will be displayed where the two points are recognized as occurring at the same time (thus aligned).



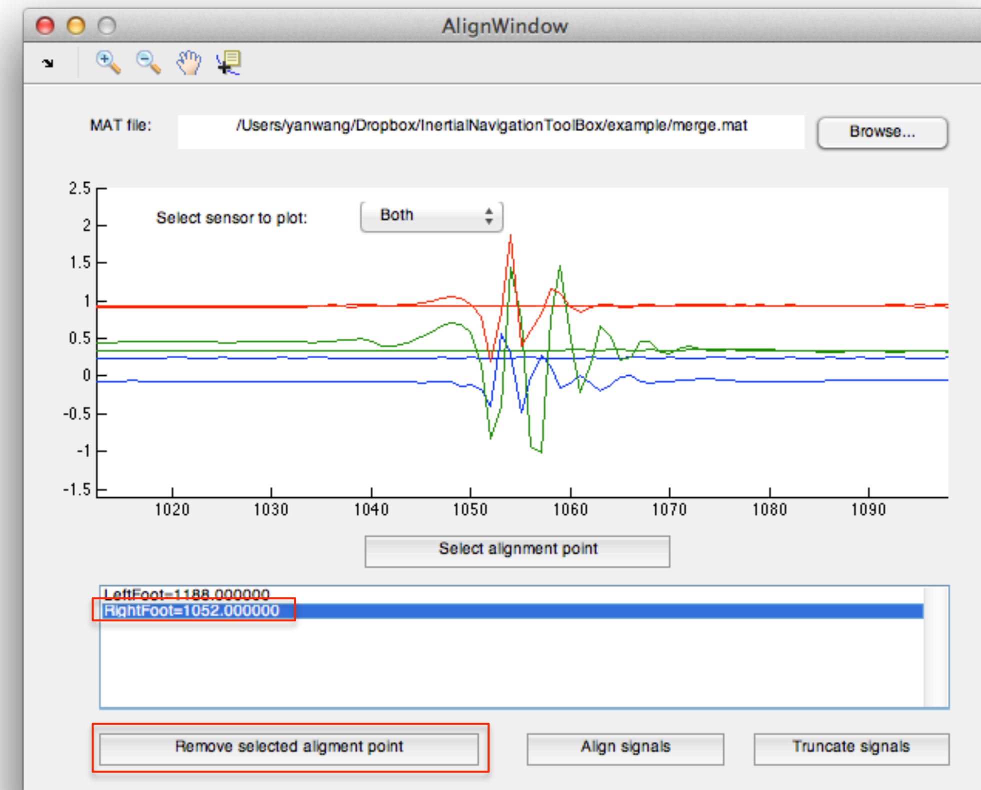
2.3 Align Window (Select alignment point)

- Note that you cannot select the left foot alignment point and the right foot alignment foot at the same time. They must be individually selected.



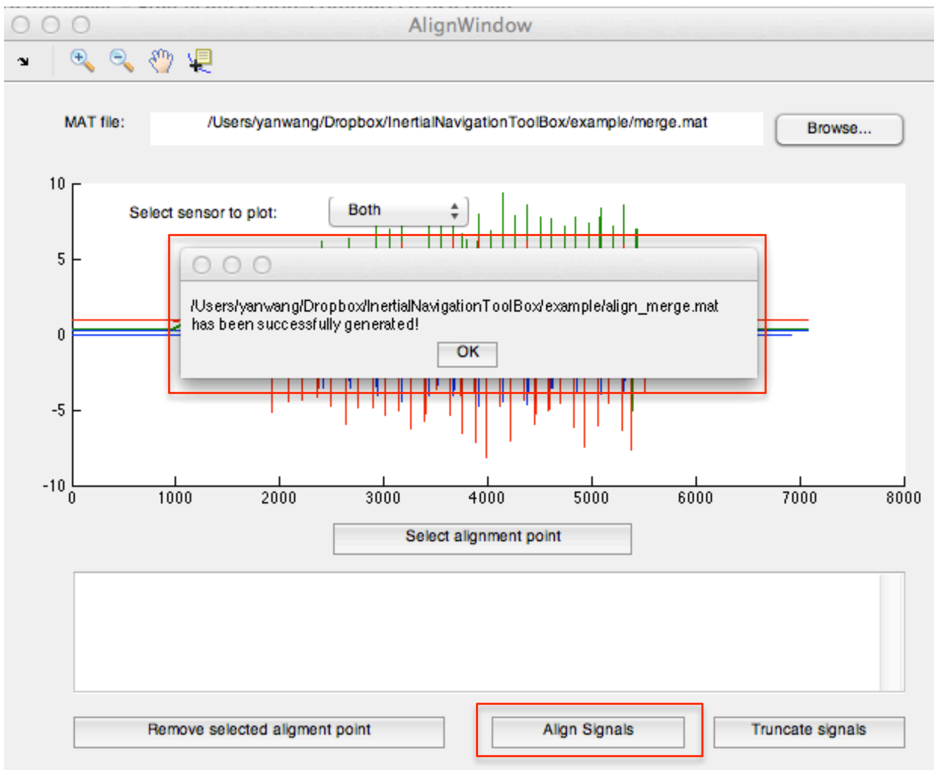
2.3 Align Window (Remove selected alignment point)

- There are cases when we select a wrong alignment point. What we can do is to click the wrong alignment point index and then click "Remove selected alignment point". Here we assume we select a wrong alignment point for the right foot signal. After we remove the current alignment point, we can reselect a right alignment point for the right foot signal.



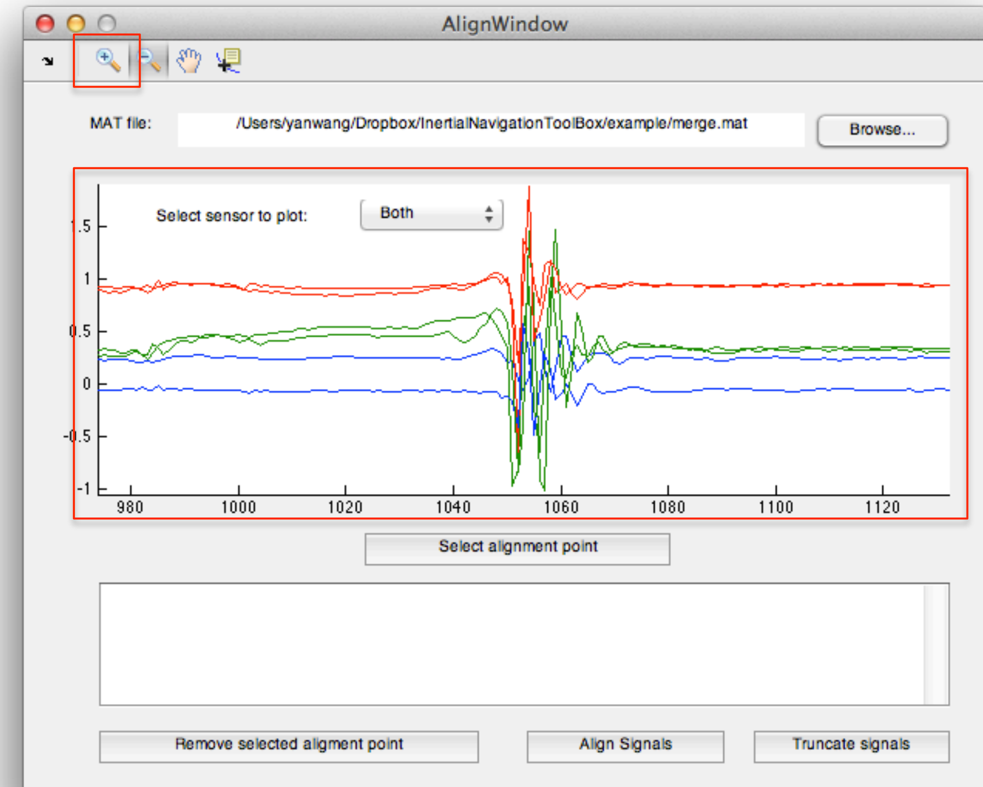
2.3 Align Window (Align signals)

- After everything is correct, click “Align signals” to align data collected from two sensors based on the alignment points. Then the window will plot the synced data with a message box saying “align_merge.mat has been successfully generated!”.



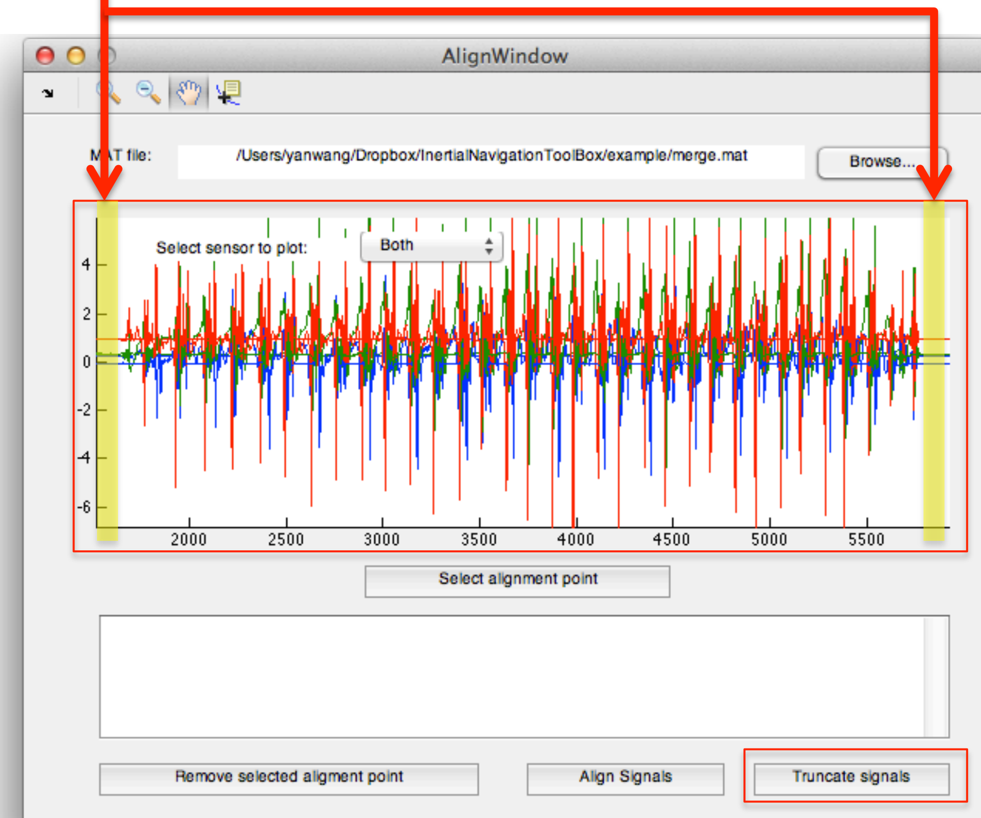
2.3 Align Window (Align signals)

- You can take a close look at the synced signal after clicking "OK" to close the message box and by using the magnifier.



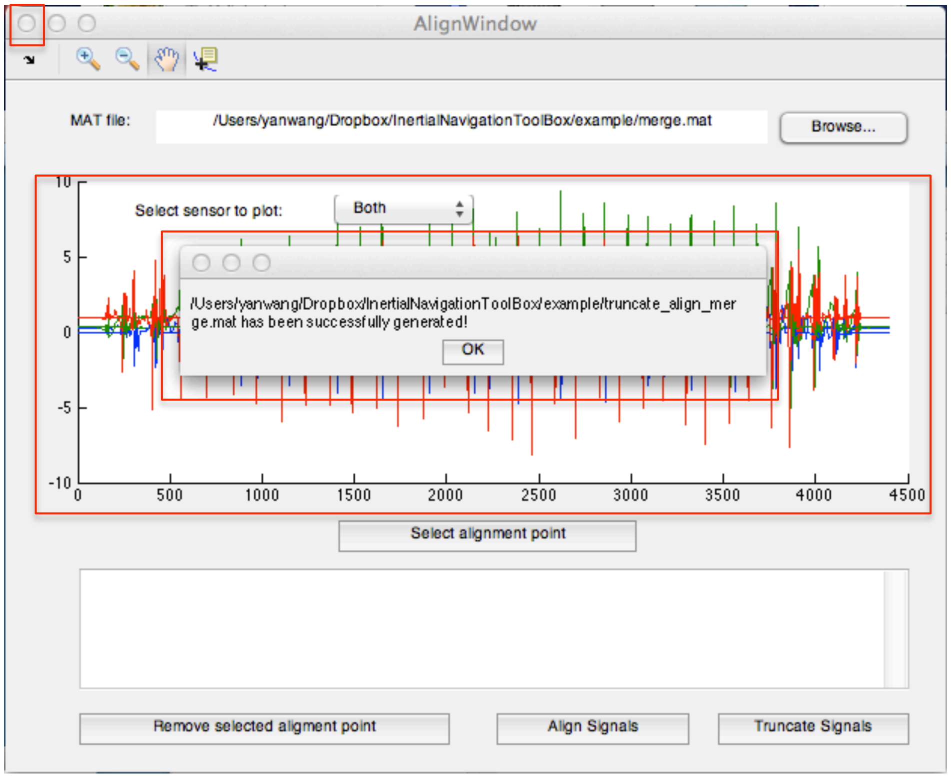
2.3 Align Window (Truncate signals)

- Zoom into the data segment of interest and click “Truncate signals” to truncate the data.
- Leave **the stationary periods** in the data. (We need to keep the ~3 seconds stationary periods before and after the data collecting session for gravity subtraction purposes.)



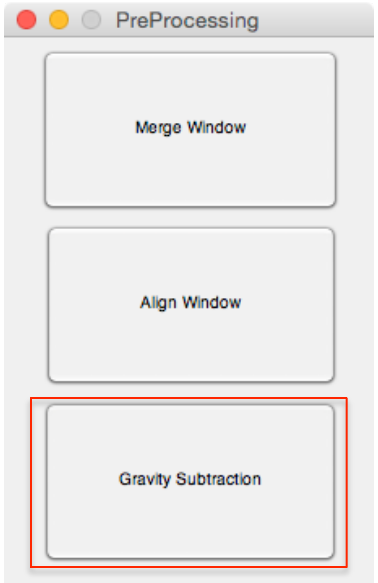
2.3 Align Window (Truncate signals)

- A message box will pop up saying “truncate_align_merge.mat has been successfully generated!”. Also the window will re-plot the data by only retaining the segment of interest. You can click “OK” to close the message box and take a close look at the signal. We are done with the align window and you can click the button at the top left corner to close the window.



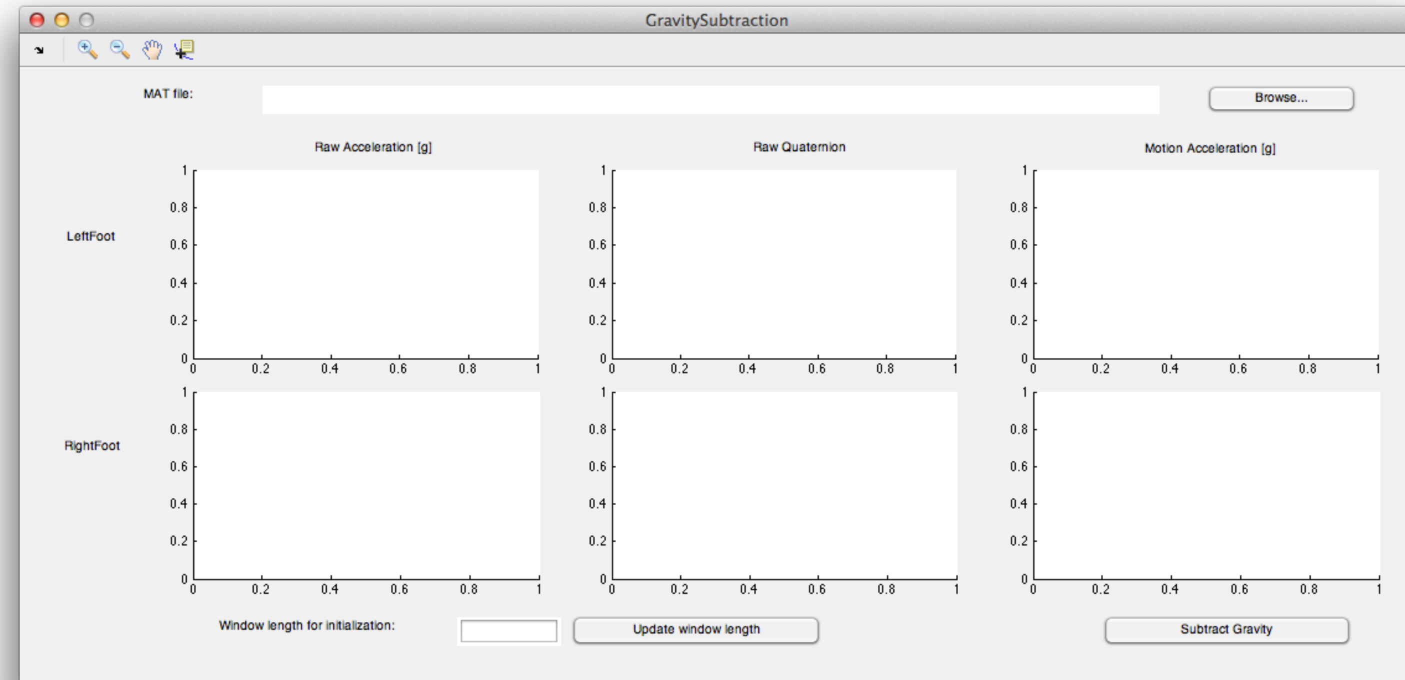
2.4 Gravity Subtraction

- The accelerometer measurements consists of two components. One is the gravity, which is constant both in direction and magnitude. The other is the motion acceleration generated by foot movements, which is what we are really interest in and can be used to infer foot velocity, displacement and walking distance.
- The gravity subtraction tool will subtract gravity from the accelerometer measurements and leave only the motion acceleration we are interested in. The tool can be opened by clicking "Gravity Subtraction" in the post processing window.



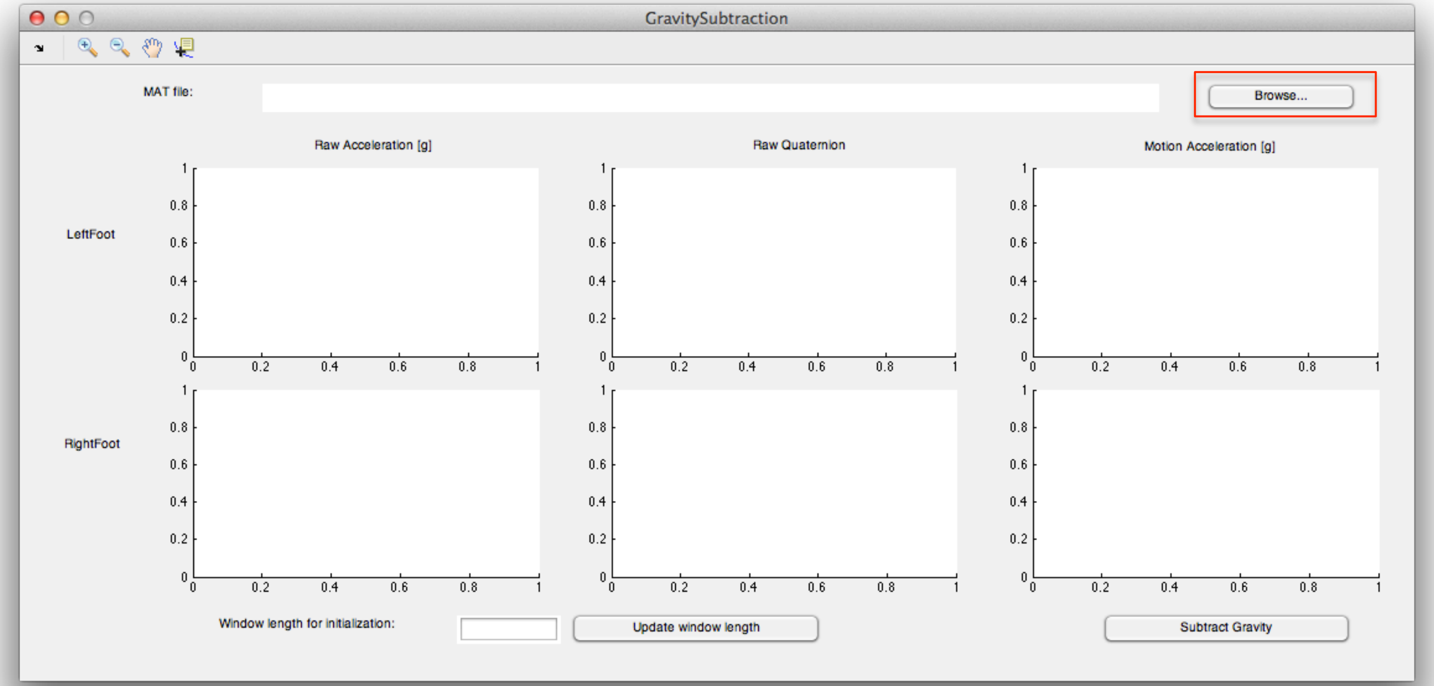
2.4 Gravity Subtraction (Open)

- A new window like the one in the following figure will pop up.



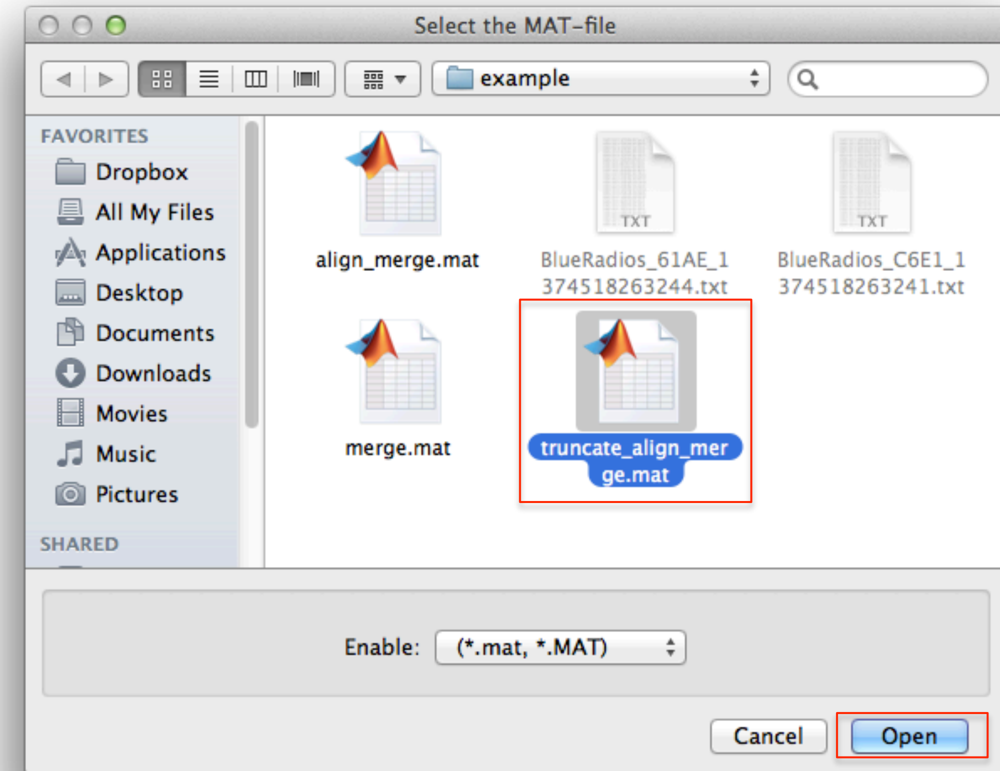
2.4 Gravity Subtraction (Browse)

- Click “Browse…” to load the truncated data file that has been generated using the align window.



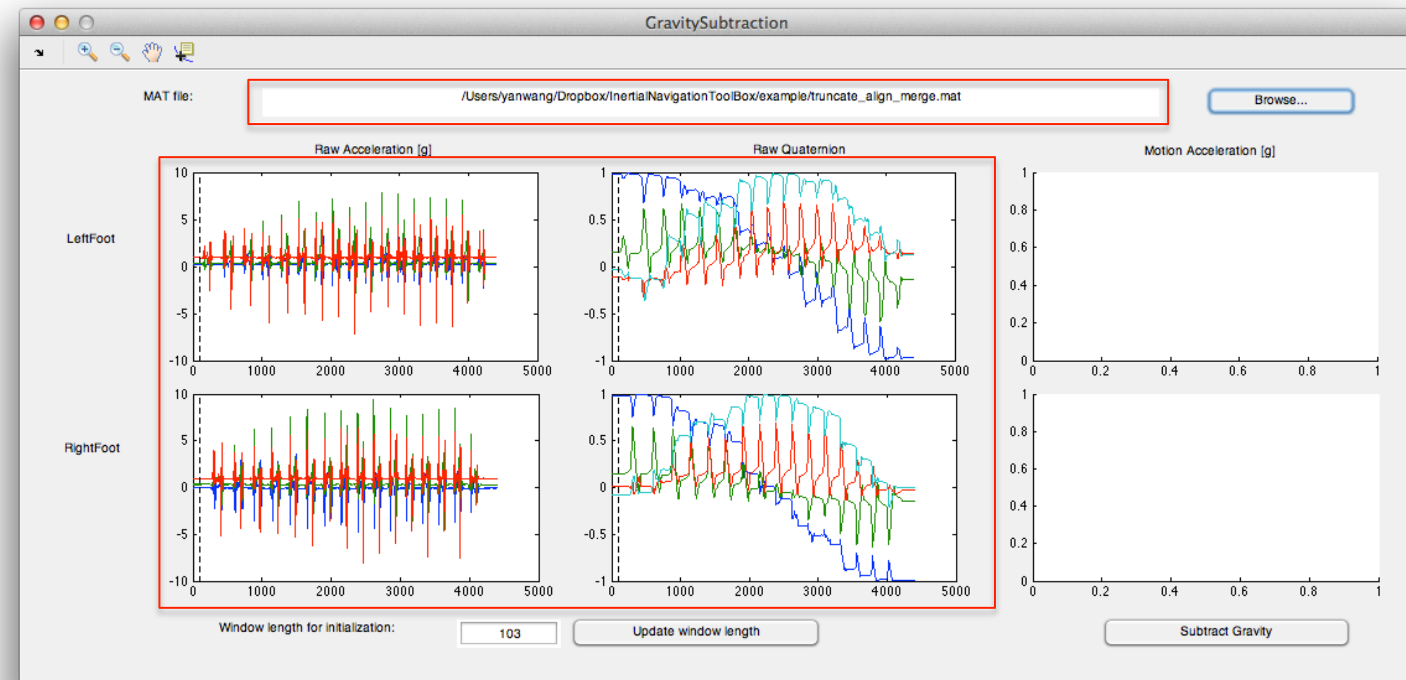
2.4 Gravity Subtraction (Browse)

- A new window will pop up letting you direct to the .mat file you want to load. Click the .mat file with truncated signal and click "Open" to load the data file.



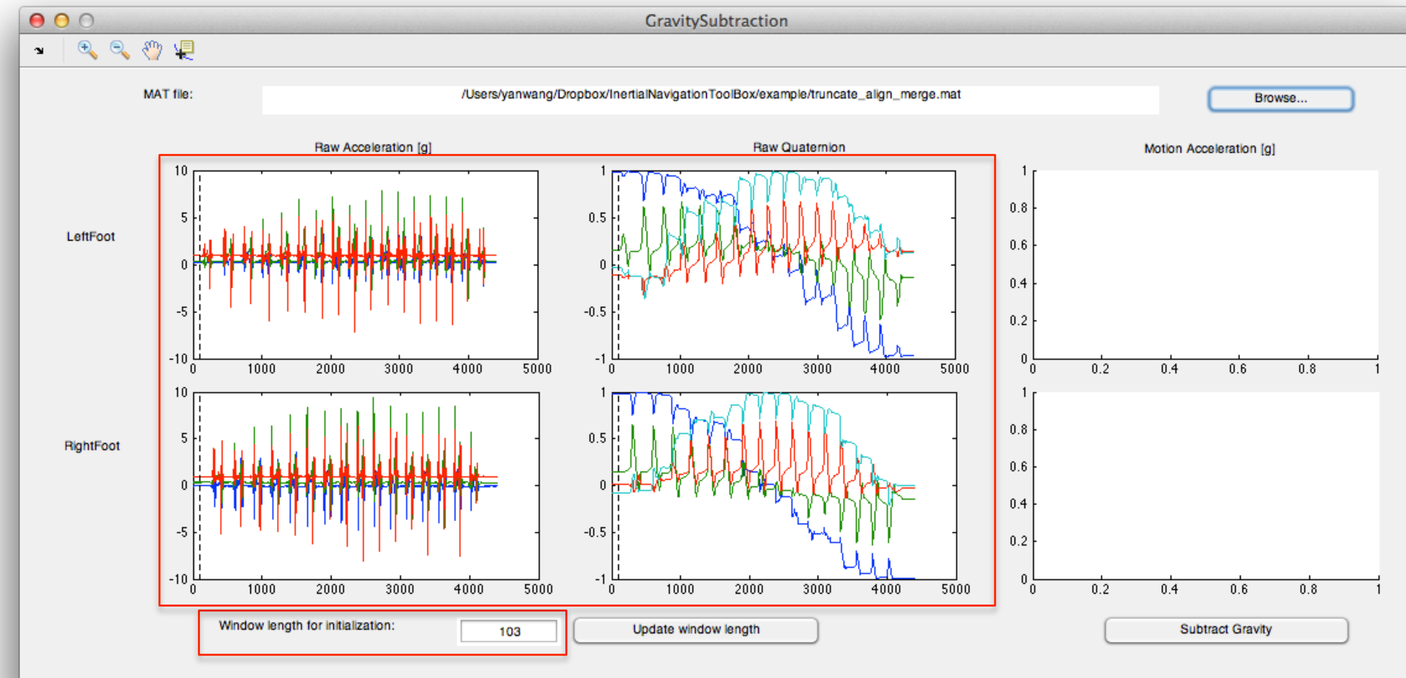
2.4 Gravity Subtraction (Browse)

- The .mat file path will be displayed in the window. Also the window will plot the accelerometer measurements and quaternions.



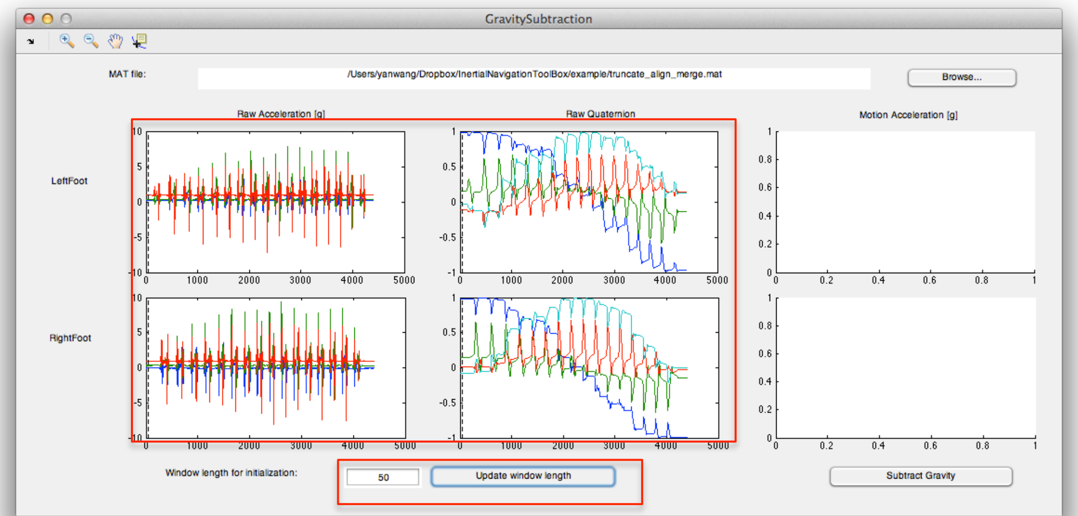
2.4 Gravity Subtraction (Window length)

- Besides the raw data plots, there is a dotted line in each plot, which with the first point in the data sequence, forms a window for initialization. The window length is also displayed at the bottom.



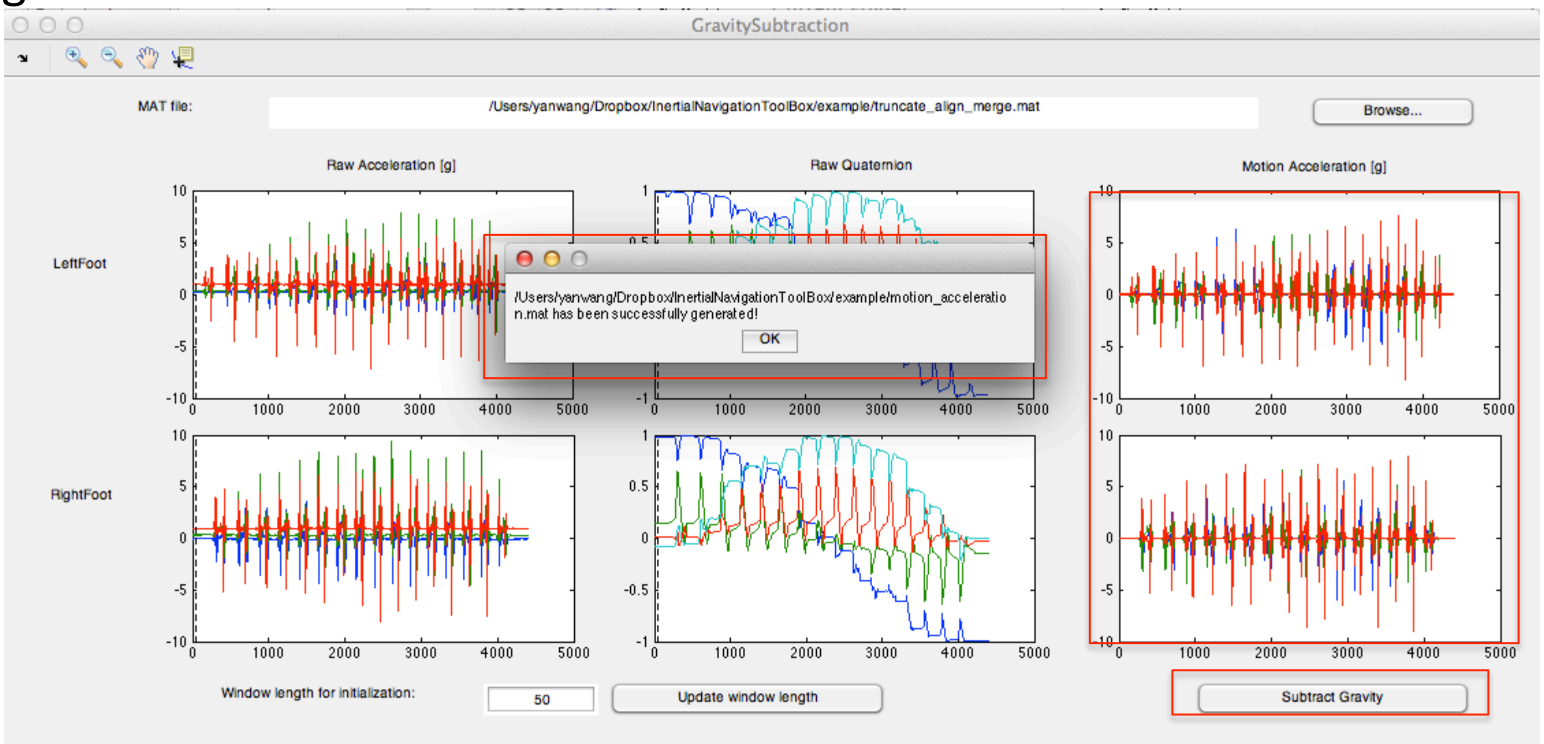
2.4 Gravity Subtraction (Window length)

- The window for initialization should not contain any motion signals. In other words, it should be stationary and quite flat. Though the algorithm inside the gravity subtraction can help detect such a window, it may make mistakes. In such situations, you can change the window length manually and click “Update window length” to re-plot the dotted line. Please remember the first point of the window is fixed. That’s why we need the truncate tool to truncate a data segment with flat starting and flat ending.



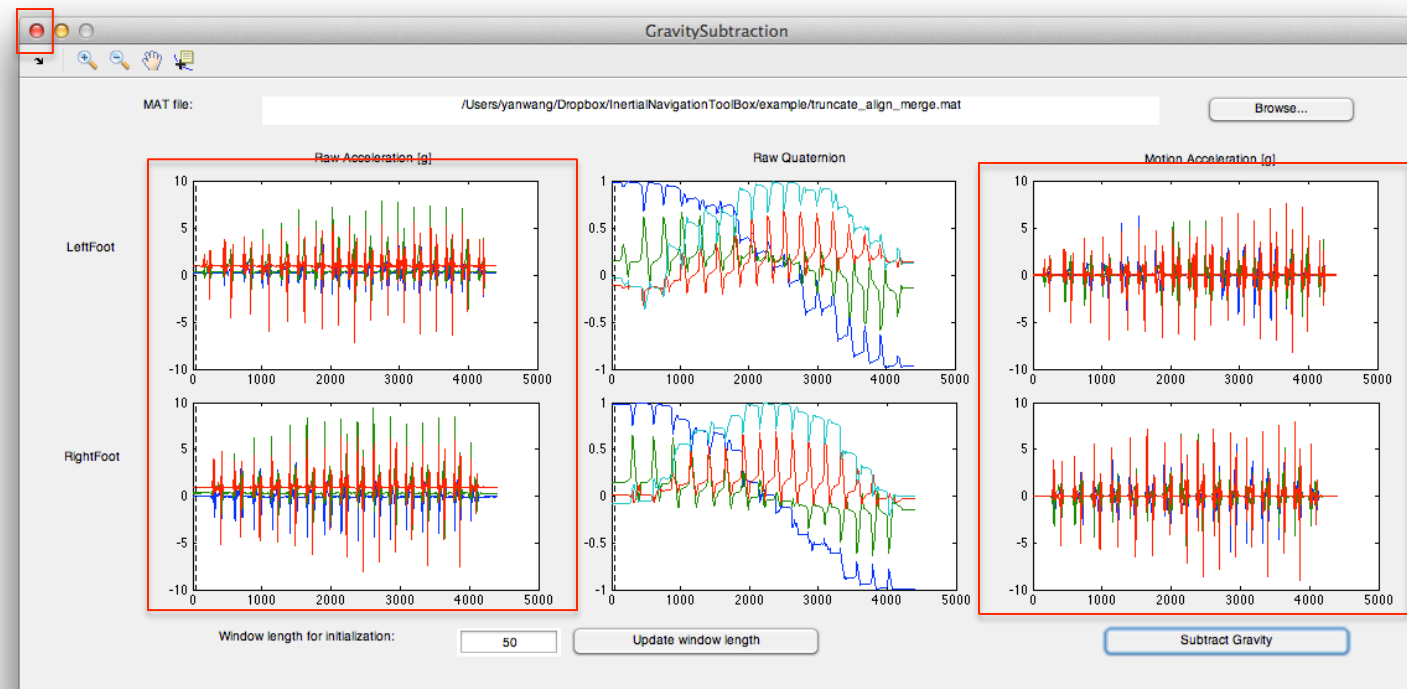
2.4 Gravity Subtraction (Subtract Gravity)

- After adjusting the window length to exclude any motion signals, click "Subtract Gravity" to subtract gravity from accelerometer measurements. The window will plot the pure motion acceleration. Also a message box will pop up saying "motion_acceleration.mat has been successfully generated."



2.4 Gravity Subtraction (Subtract Gravity)

- After clicking “OK” to close the message box. Then you can compare the accelerometer measurements before gravity subtraction and pure motion acceleration after gravity subtraction. When you are done, click the button at the top left corner to close the window.



3. Appendix – Data Format

- Merge.mat
- Align_merge.mat
- Truncate_align_merge.mat
- Motion_acceleration.mat

3.1 Merge.mat

- The "merge.mat" file
  - contains a structure with one or two fields depending on the number of sensors used. If two sensors were used, the *Position1* motion data can be retrieved from "data.Position1" and the *Position2* motion data can be retrieved from "data.Position2"

- The first three columns of the motion data are the x, y, and z axis accelerometer measurements.
- The following three columns of the motion data are the x, y, and z axis gyroscope measurements.
- The last four columns of the motion data are the quaternion estimations. All the data have been divided by the sensor sensitivity.
- The data formats of "align_merge.mat" and "truncate_align_merge.mat" are the same as "merge.mat".

3.2 Motion_acceleration.mat

- The “motion_acceleration.mat” file
  - contains four structures, “acc”, “acc_energy”, “acc_ref”, and “zv_window”. All of them having one or two fields depending on the number of sensors used similar to the situation of “merge.mat” file.

- **“acc.Position1” and “acc.Position2”**
  - **contain the x, y, and z axis motion acceleration in the global frame after gravity subtraction in the unit of “g”.**
- “acc_energy.Position2” and “acc_energy.Position2”
  - contain the energy of motion acceleration in the unit of “g^2”.
- “acc_ref.Position1” and “acc_ref.Position2”
  - contain the measured gravity in sensor’s own frame of reference.