NeuroMap System QuickStart Guide

NeuroMap System

NeuroMap

NeuroMap Reports

NeuroMap Explorer

NeuroMap System

Getting Started

The NeuroMap System consists of unique hardware & software components designed to non-invasively record motor unit (MU) behavior from the surface of the skin:

Hardware:

- Trigno Galileo sensors

Software:

- NeuroMap
- NeuroMap Reports
- NeuroMap Explorer

Installation

- Download and run the EMGworks 4.7 installer from the Delsys website
    - Make sure you are logged in as an administrator
    - After installation, open EMGworks Acquisition to activate & register your software using the included 32-character license key
- Download and run the NeuroMap installer from the Delsys website to install all three NeuroMap software programs
    - Make sure you are logged in as an administrator
    - During installation, accept the prompt to install MATLAB RunTime v9.3 (even if it has previously been installed)
    - After installation, open NeuroMap and email the two codes generated to support@delsys.com. You will receive a reply within 24 hours containing two activation codes; input these codes to activate your NeuroMap software

System Requirements

- Windows 64-bit operating system (Windows 10 recommended)
- At least 2.0 GHz processor clock speed (3.0 GHz recommended)
- At least 2 processor cores (4 recommended)
- 2 GB of HDD space for NeuroMap Explorer and MATLAB RunTime installations (SSD recommended)
- At least 4 GB of RAM per processor core

NeuroMap

Overview

NeuroMap software processes EMG signals into motor unit data by a process called "EMG decomposition." For more information, see the *EMG Decomposition* section of the References
.

Inputs to Software:

Unaltered EMG data collected from Galileo sensors in .hpf format

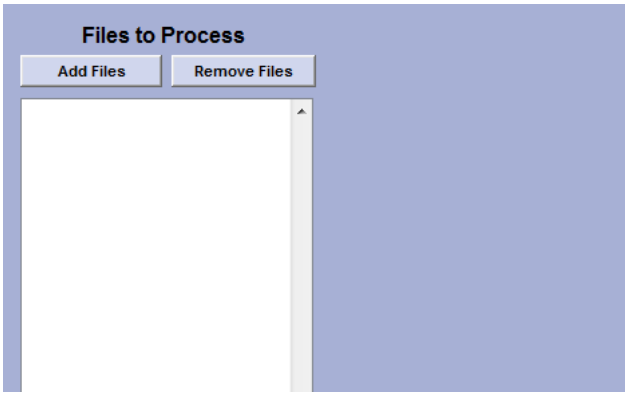
Outputs of Software:

Motor unit data in .dhpf format

Processing EMG Signals

Load files

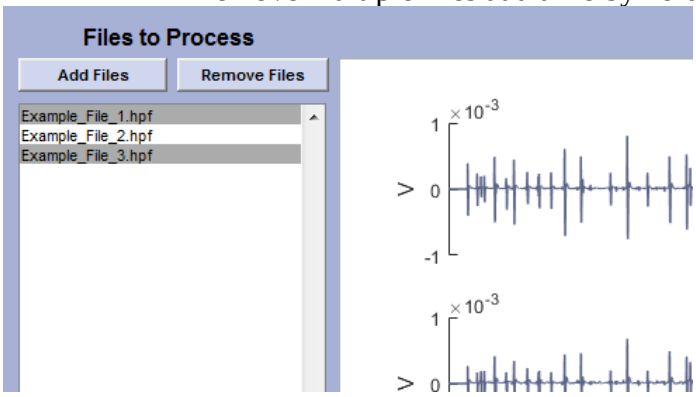
Load files for processing by clicking the "Add Files" button. Select multiple files by holding SHIFT or CTRL.



Note: Only HPF files containing unaltered data from Trigno Galileo sensors will be loaded for processing.

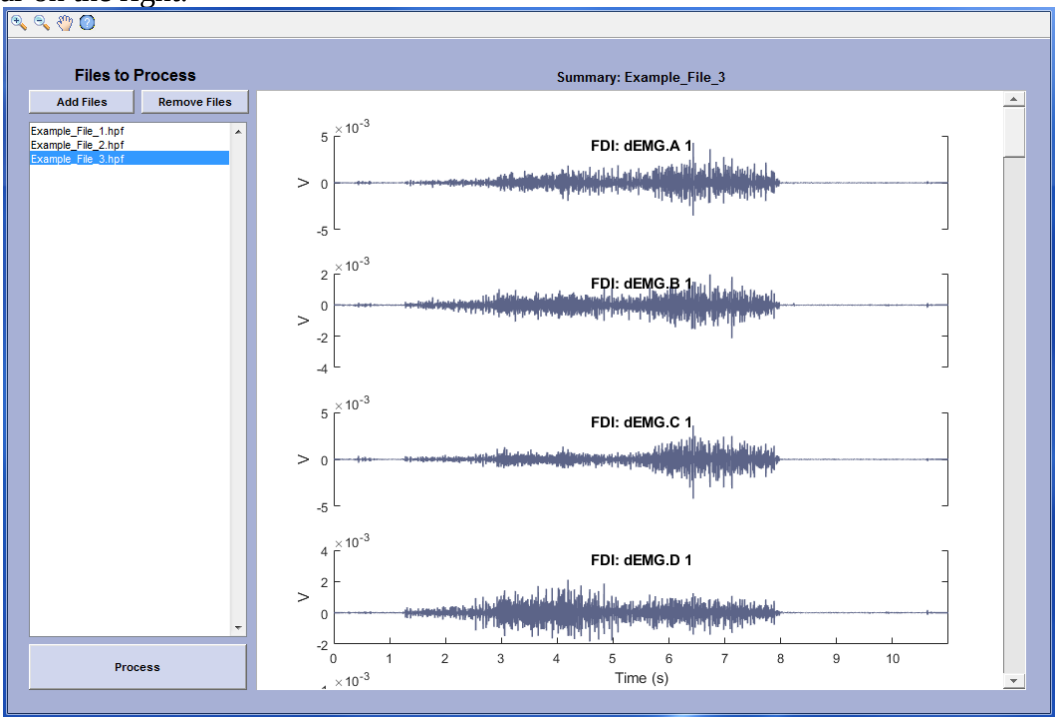
Remove files

Remove files you do not wish to process by selecting files within the "Files to Process" list and clicking the "Remove Files" button. Remove multiple files at a time by holding SHIFT or CTRL.



Preview files

Preview a single file by selecting it from the file list. Check additional data channels by using the scroll bar on the right.



Note: Long files can take up to 10 seconds before display.

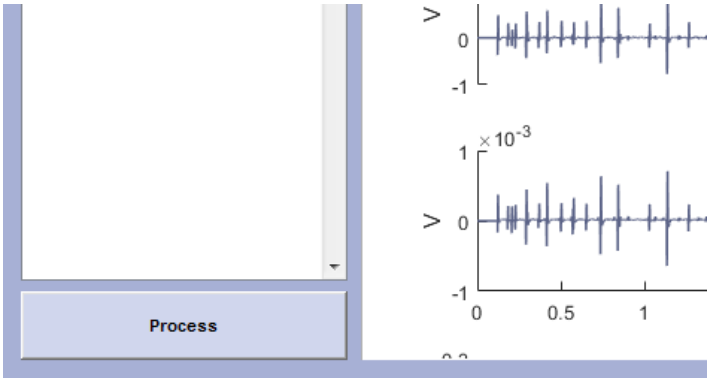
Process files

Process the files in the file list by clicking the "Process" button and choosing a save location for the motor unit data files that will be created. Note that file processing is resource-intensive and can take up to 1 minute per second of data, so we recommend processing file batches on PCs that will not be used for the duration.

Important Notes:

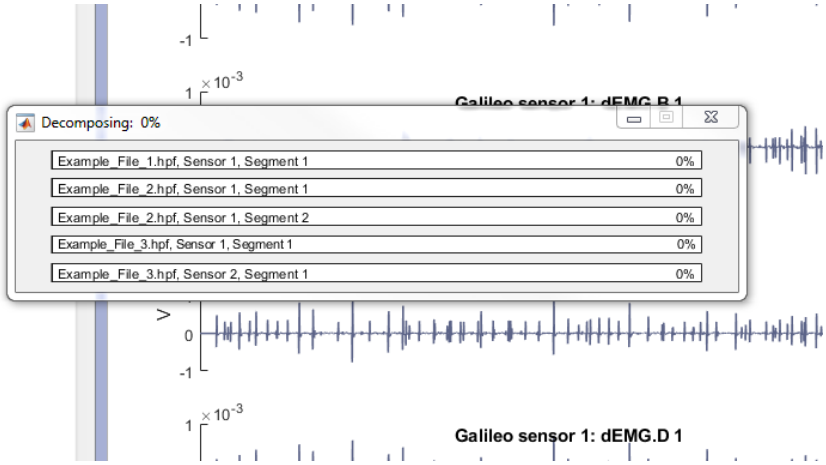
- *Do not close progress windows or NeuroMap software while processing files*
- *Ensure your PC will not sleep, restart or update while processing files*
- *Close other programs to free up computer resources and improve processing speed*

Intermediate files will be saved to your chosen save location during processing. Do not move, open, or delete these files until processing has fully completed or the files may be corrupted.



Processing progress

The progress window monitors processing progress for each sensor and segment of a file.



Note: Individual segments are created if clipping is present in the file. For more information, see the "Files with Clipping" section of the User Guide.

Each progress bar will update as each segment finishes processing:

- **Green:** Successfully found motor unit data *add pic*
- **Red:** Failed to find motor unit data *add pic*

Progress bars may not complete in order due to the parallel processing architecture of the software. If no motor unit data were found from any sensors or segments within a single HPF file, no corresponding DHPF file is created.

Viewing Results

After processing, the progress window closes automatically and the results screen appears.

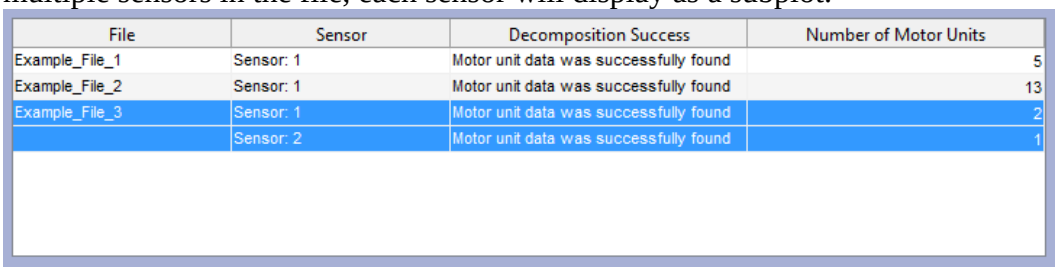
Important Notes:

- *Files are saved in the selected folder in dhpf format*

- *If the algorithms were unable to find motor unit data in a file, an output file will not be saved*

View results from entire file

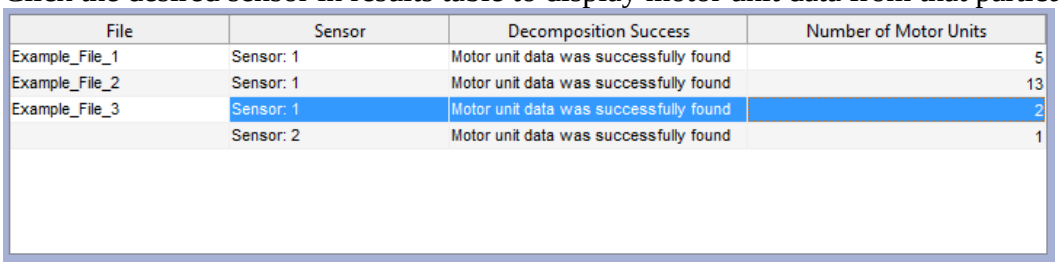
Click the desired file in the results table to display motor unit data from that file. If there are multiple sensors in the file, each sensor will display as a subplot.



File	Sensor	Decomposition Success	Number of Motor Units
Example_File_1	Sensor: 1	Motor unit data was successfully found	5
Example_File_2	Sensor: 1	Motor unit data was successfully found	13
Example_File_3	Sensor: 1	Motor unit data was successfully found	2
	Sensor: 2	Motor unit data was successfully found	1

View results from single sensor

Click the desired sensor in results table to display motor unit data from that particular sensor.



File	Sensor	Decomposition Success	Number of Motor Units
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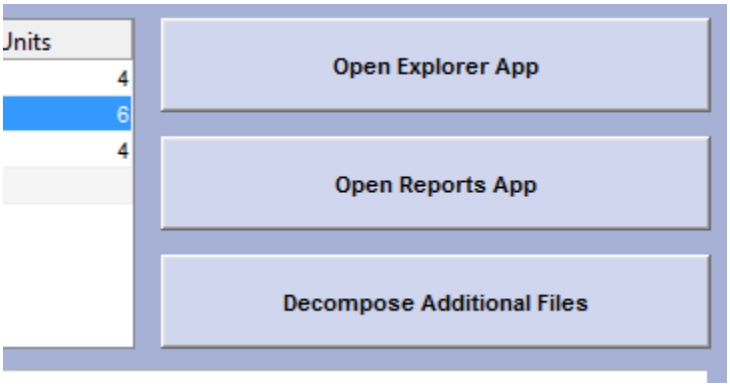
Example_File_2	Sensor: 1	Motor unit data was successfully found	13
Example_File_3	Sensor: 1	Motor unit data was successfully found	2
	Sensor: 2	Motor unit data was successfully found	1

Next steps

Process additional files by clicking the “Decompose Additional Files” button or move on to data analysis and launch NeuroMap Explorer or NeuroMap Reports by clicking their respective buttons.



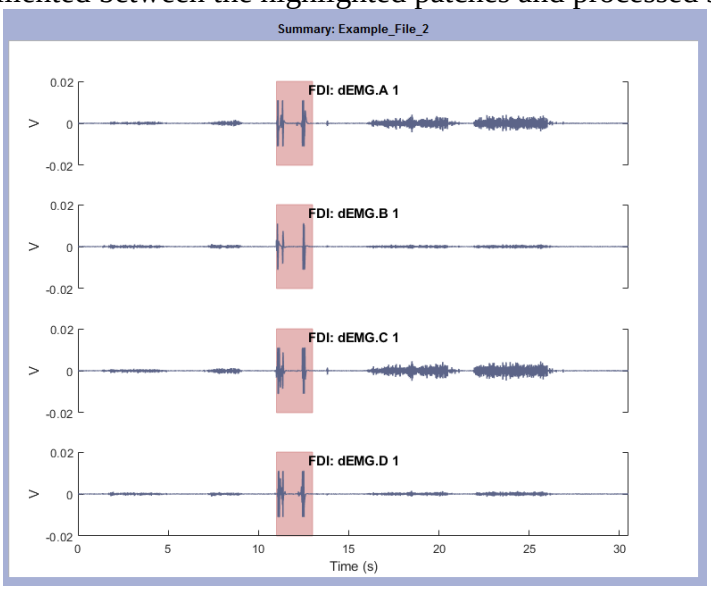
Signal Clipping Check

Clipping across all four EMG channels of a Trigno Galileo sensor indicates that the sensor detached from the skin. If this occurs, there is no guarantee that the sensor was replaced in the same position, and there may be multiple distinct subsets of motor units present in the same file.

In this case, NeuroMap software processes the EMG signal segments between each instance of clipping separately. After processing, the results for each segment will be brought back together and saved in the same file.

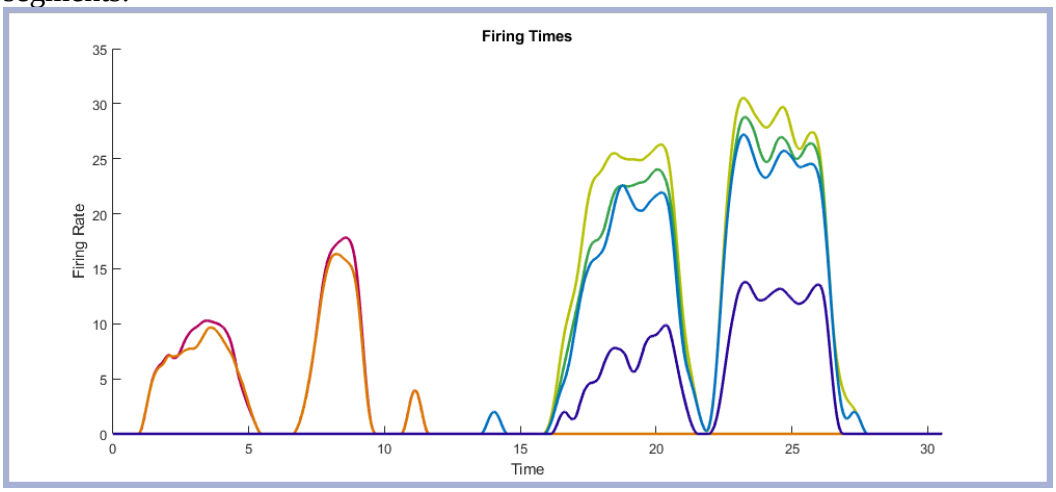
Identifying signal clipping

A red patch highlights clipped areas of the EMG signal while previewing files. The EMG signals are segmented between the highlighted patches and processed separately.



Motor unit data from clipped signals

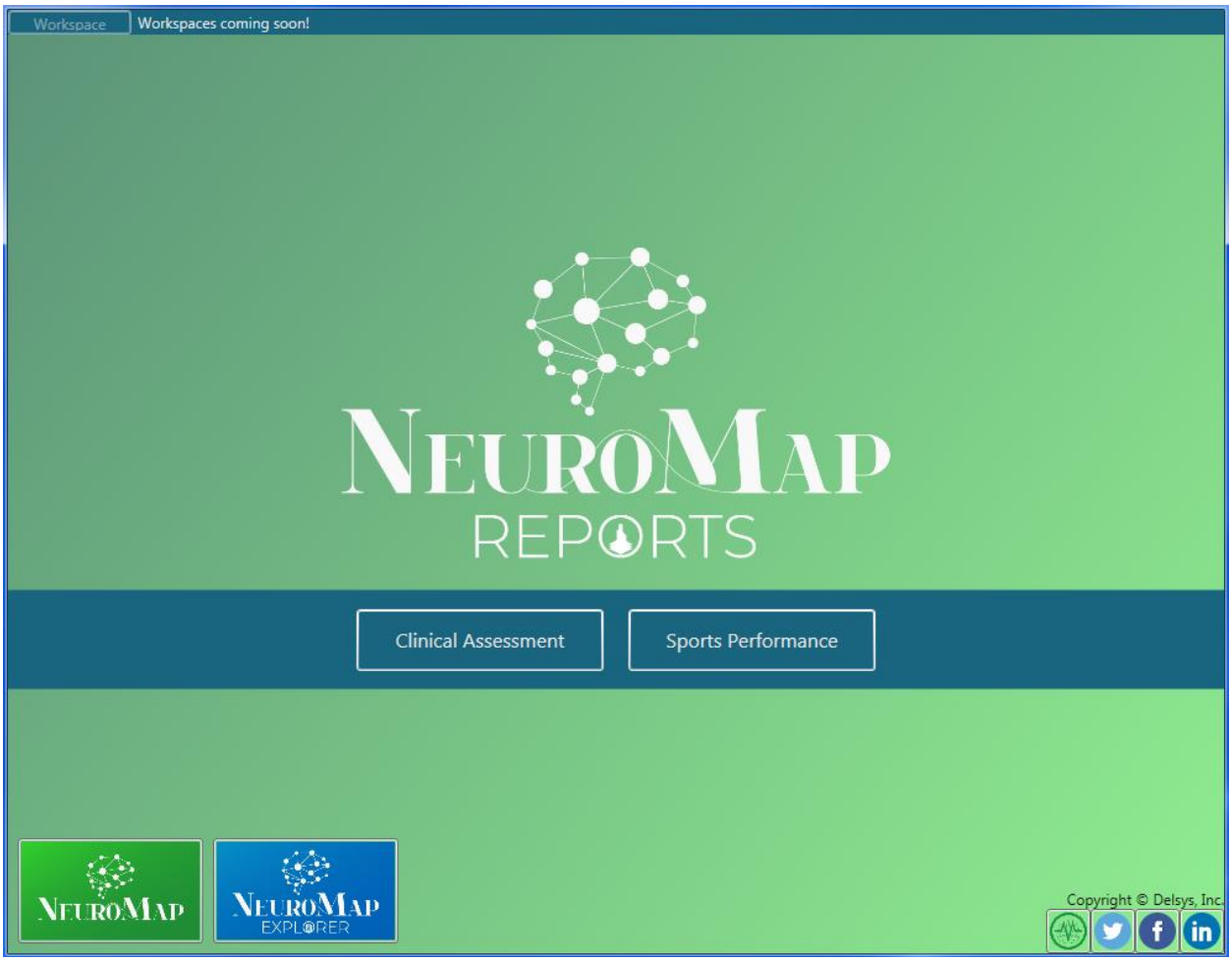
Since each segment processes independently, motor units will not be compared across segments. Therefore, each segment will have a unique subset of motor units, with no overlap between segments.



NeuroMap Reports

Overview

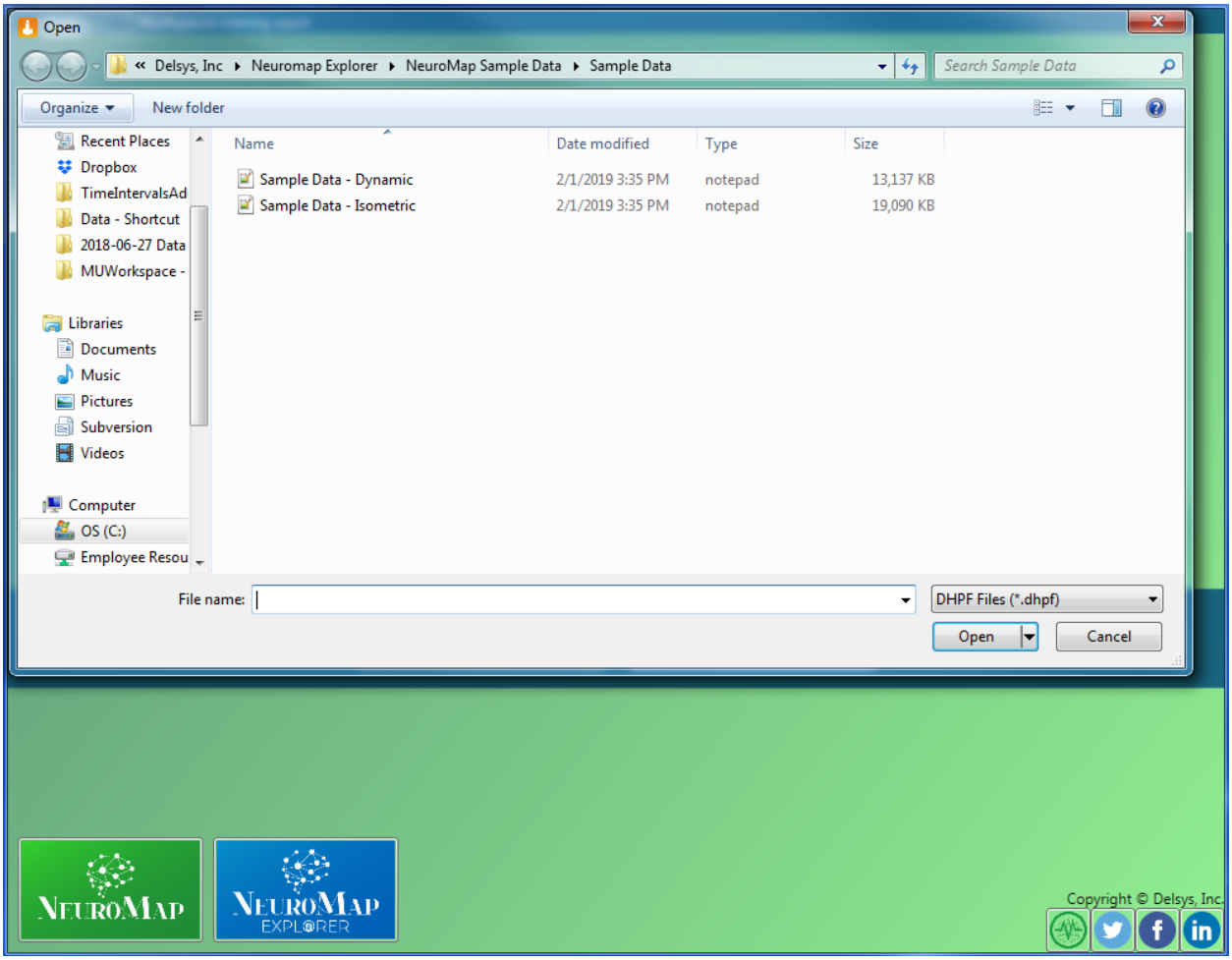
NeuroMap Reports automatically calculates metrics & generates easy-to-read reports from your MU data files. Click either of the buttons on the home screen to get started.



Load & Visualize MU Data

Load files

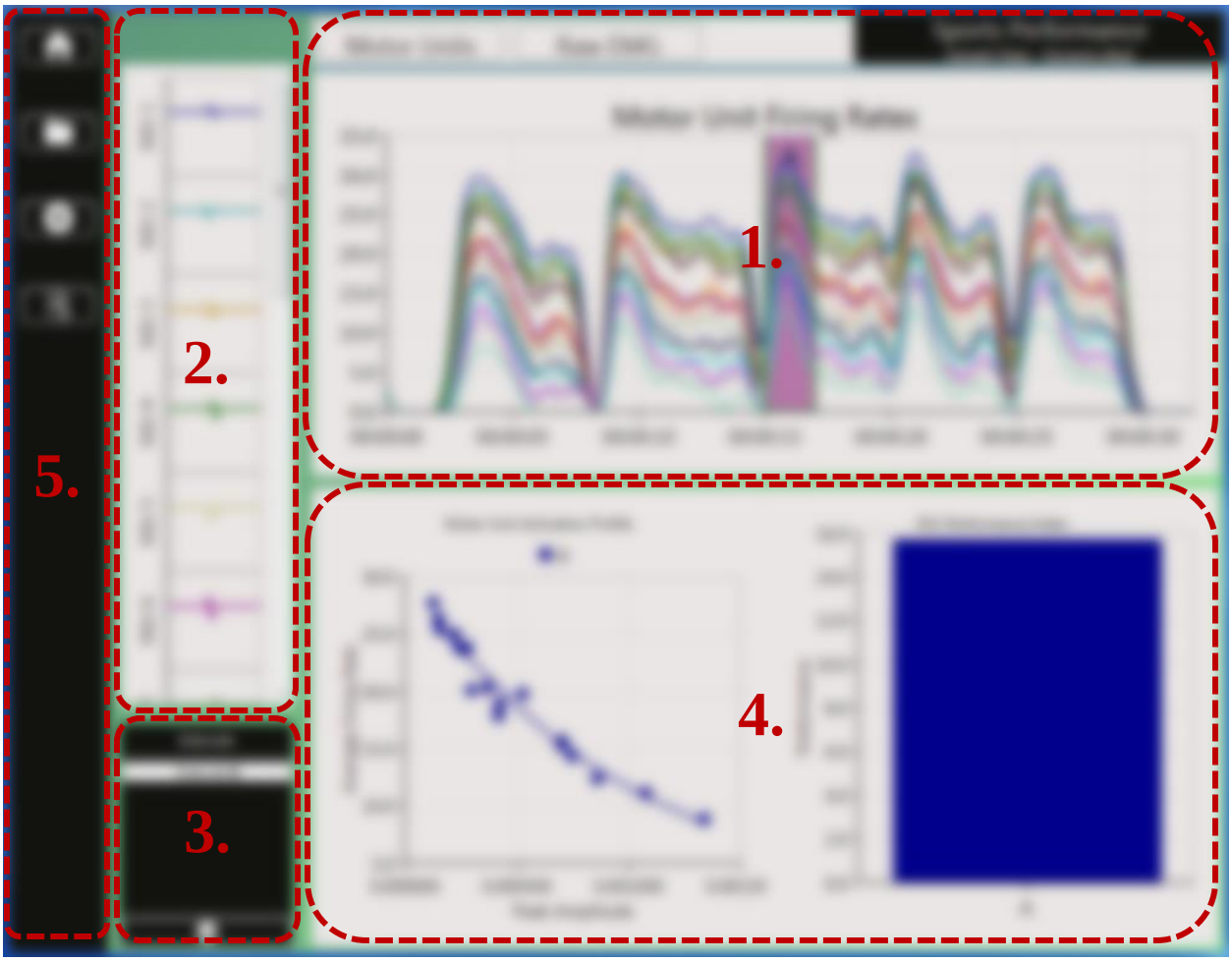
After clicking either report module for the first time, choose a MU data (.dhpf) file to open.



Note: Currently, NeuroMap Reports loads only one MU data (.dhpf) file at a time; multi-file analysis will be included in a future release.

User interface

Once a MU data file is loaded, both report modules share a similar user interface:

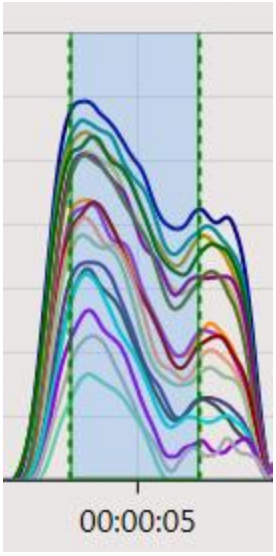


1. **Plot Panel:** Visualize raw EMG data & MU firing rates
2. **MUAP Panel:** View MUAP waveforms
3. **Interval Panel:** See the list of analysis intervals, select active interval, and remove intervals
4. **Report Preview Panel:** Report-specific figures & charts corresponding to the active analysis interval
5. **Toolbar:** Return to home screen, load new MU data files, add analysis intervals and generate PDF reports

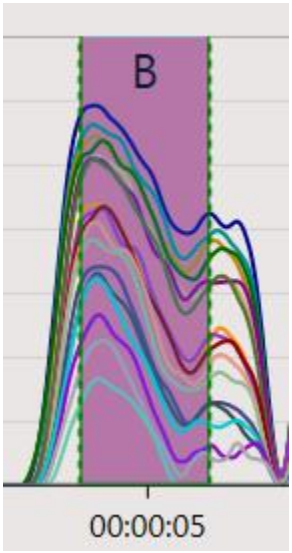
Select analysis intervals

Analysis intervals are user-selected time periods of interest. Both NeuroMap Report modules generate report outputs for each analysis interval created.

Analysis intervals appear as shaded regions on the MU Firing Rates plot:



Drag the dotted vertical lines to adjust the width of the analysis interval, or drag the shaded region to move the analysis interval. Lock the analysis interval in place by right-clicking on the shaded region:

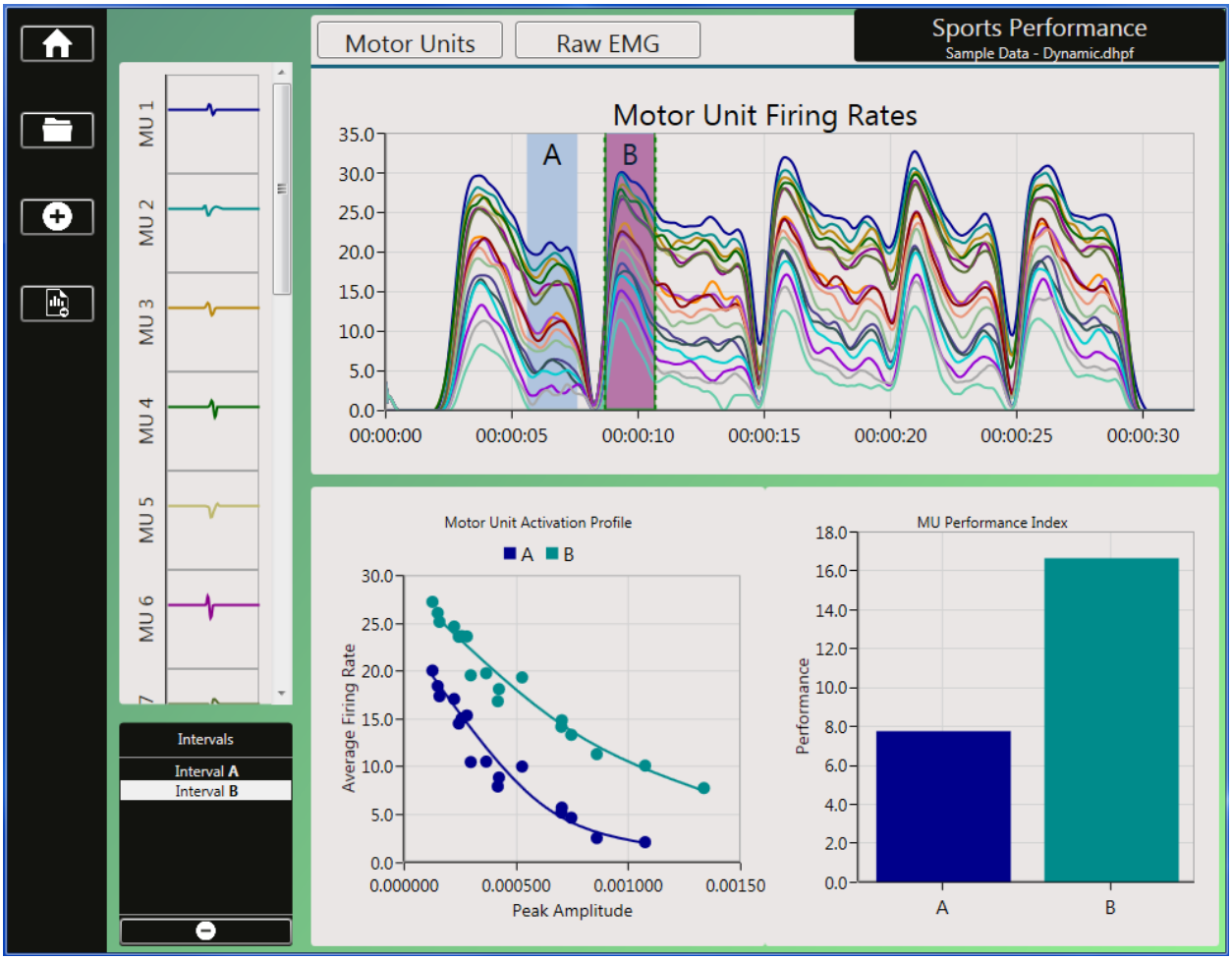


Generate MU Reports

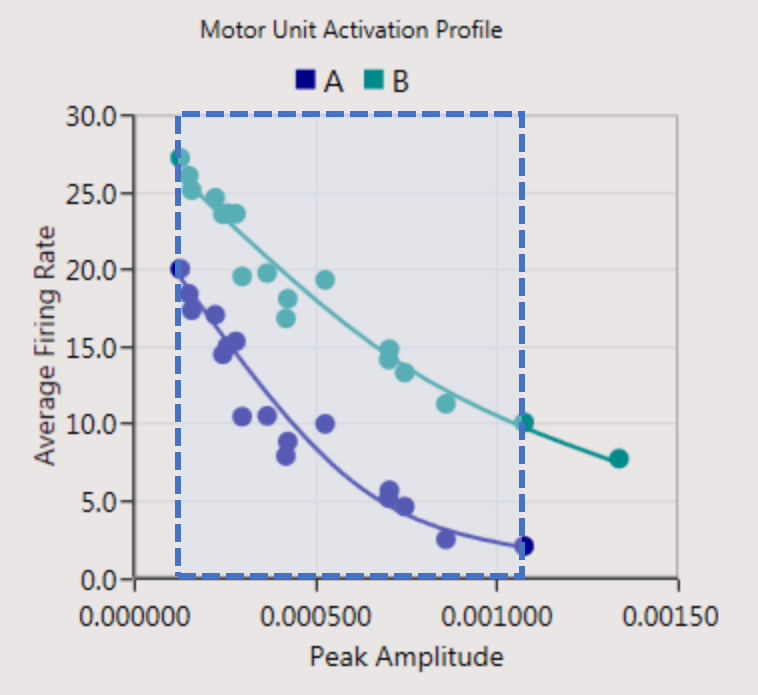
Preview report

Locking an analysis interval generates a report preview for that time interval. The particular plots & metrics displayed depend on the chosen report module:

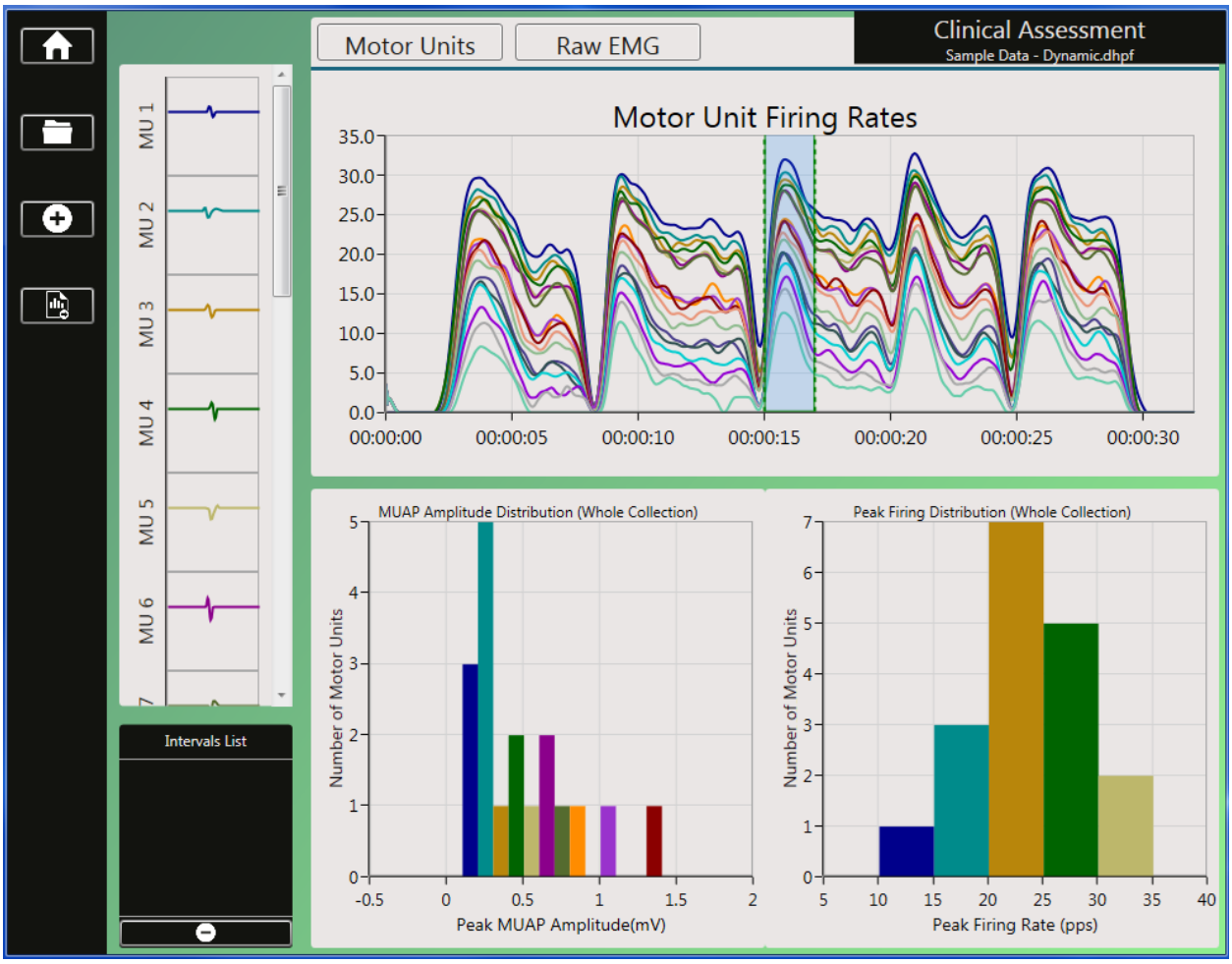
Sports Performance calculates a regression comparing Peak MUAP Amplitude (x-axis) vs. Average MU Firing Rate (y-axis), an approach used in the literature to characterize motor unit firing behavior (see *Applications* section of References).



It also computes the “MU Performance Index” for each analysis interval, which is the average firing rate of the MUs that fall within a common amplitude range. For instance, the common amplitude range between the two analysis intervals in the image above looks like this:

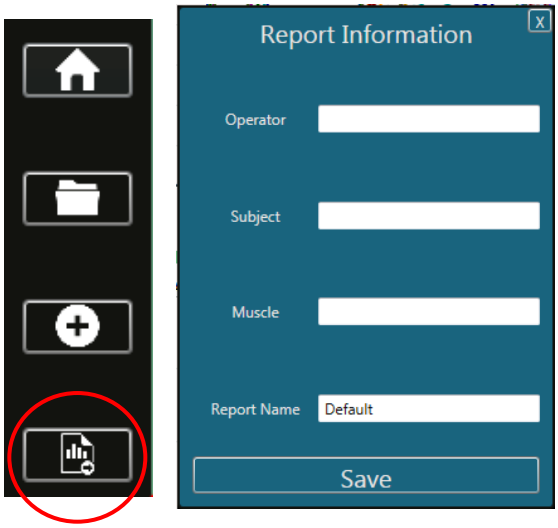


Clinical Assessment offers a quick way to characterize the pool of active MUs. It calculates two histograms for each analysis interval which display 1) the distribution of peak MUAP amplitudes, and 2) the distribution of peak MU firing rates.



Generate PDF report

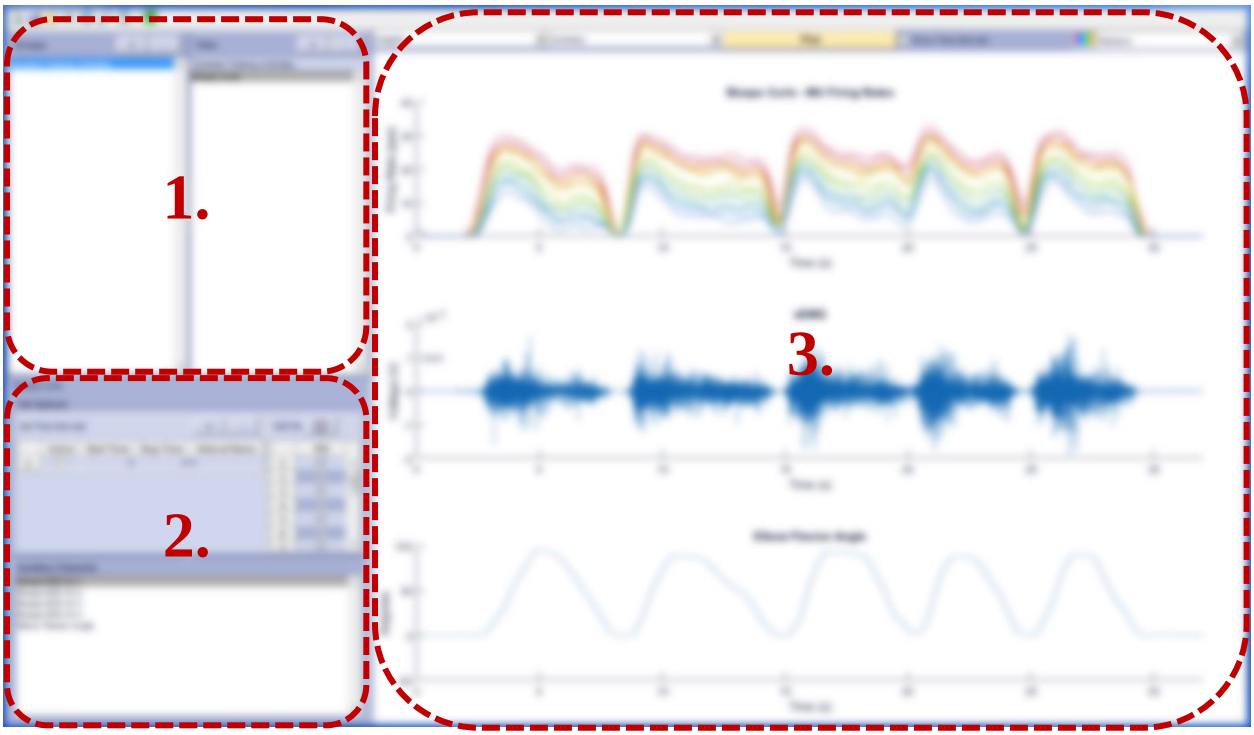
After locking your desired analysis intervals, click the Generate Report button in the toolbar to create a full report in PDF format. Enter any file-specific information that you would like reported in the Report Information window and click “Save.”



NeuroMap Explorer

User Interface

NeuroMap Explorer is an application for viewing and analyzing motor unit data acquired using the NeuroMap system. The user interface is divided into 3 panels:



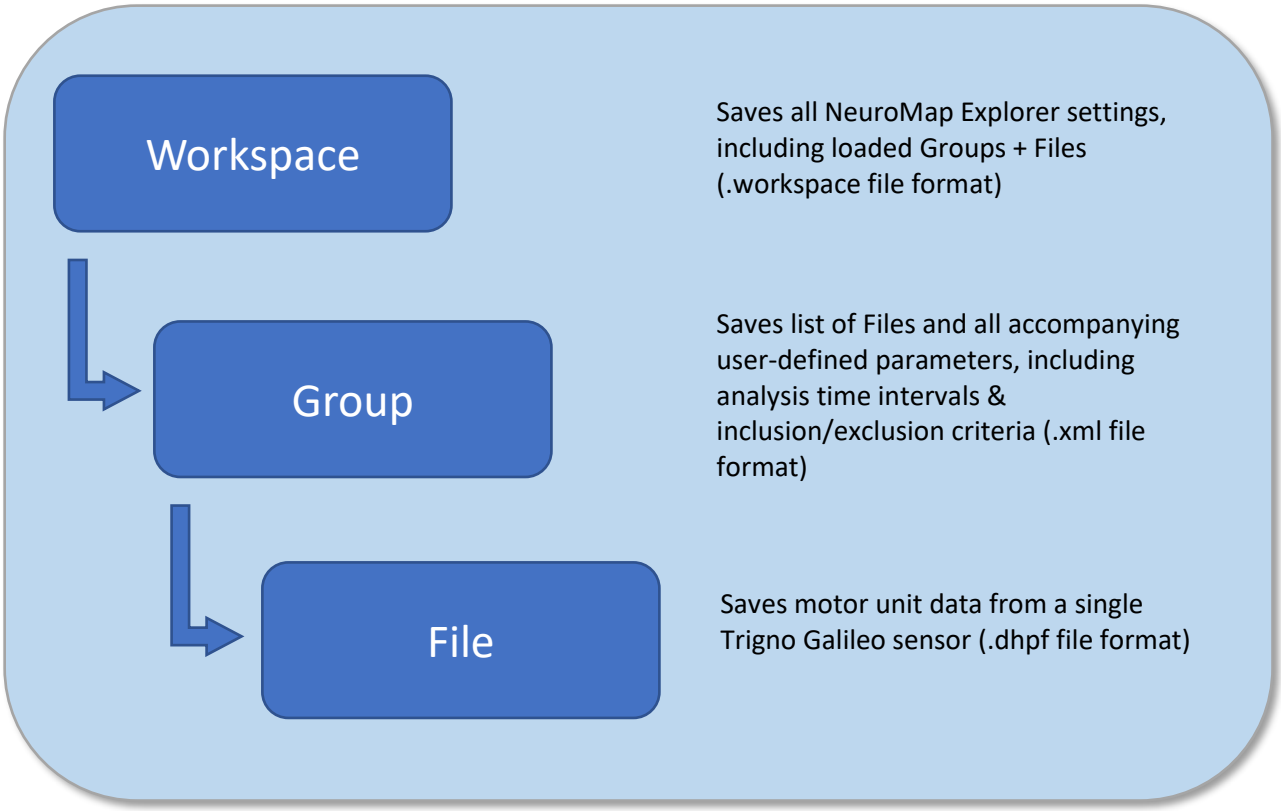
1. **Groups and Files:** Here, you can load and group motor unit data files (DHPF files) into your workspace.

2. **File Information Panel:** Create and edit specific analysis criteria here. Choose which motor units to display, which time intervals to analyze, and more.

3. **Plot Panel:** Choose which plot type to display.

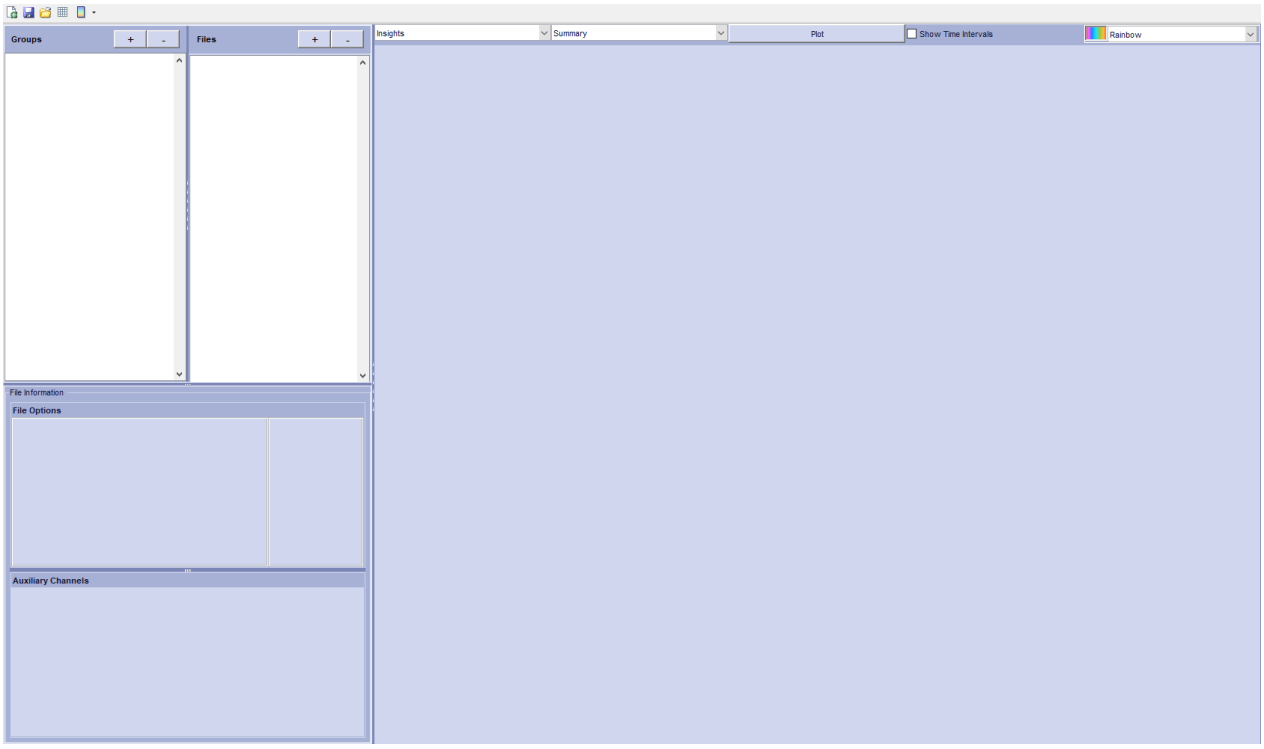
Data Management

NeuroMap Explorer uses a hierarchical approach for data organization. All data is referenced and organized without disrupting your local file structure.

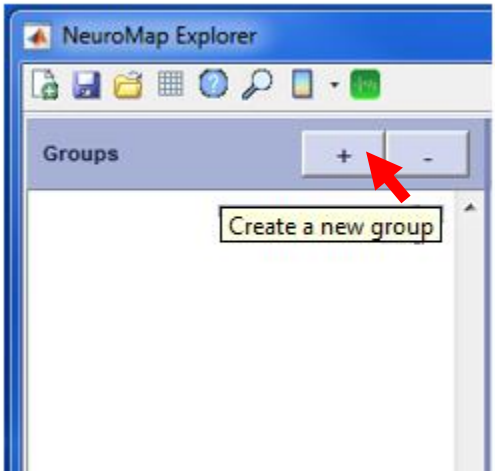


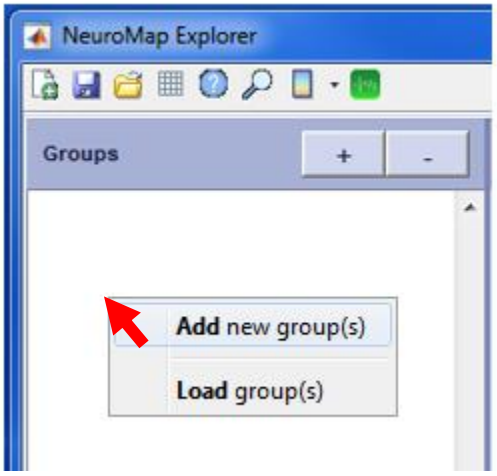
Creating Groups

Upon entering NeuroMap Explorer you will see the landing page:



From here, create a new group either by clicking on the '+' button in the Groups panel, or by right clicking in the Groups panel and selecting "Add New Group:"

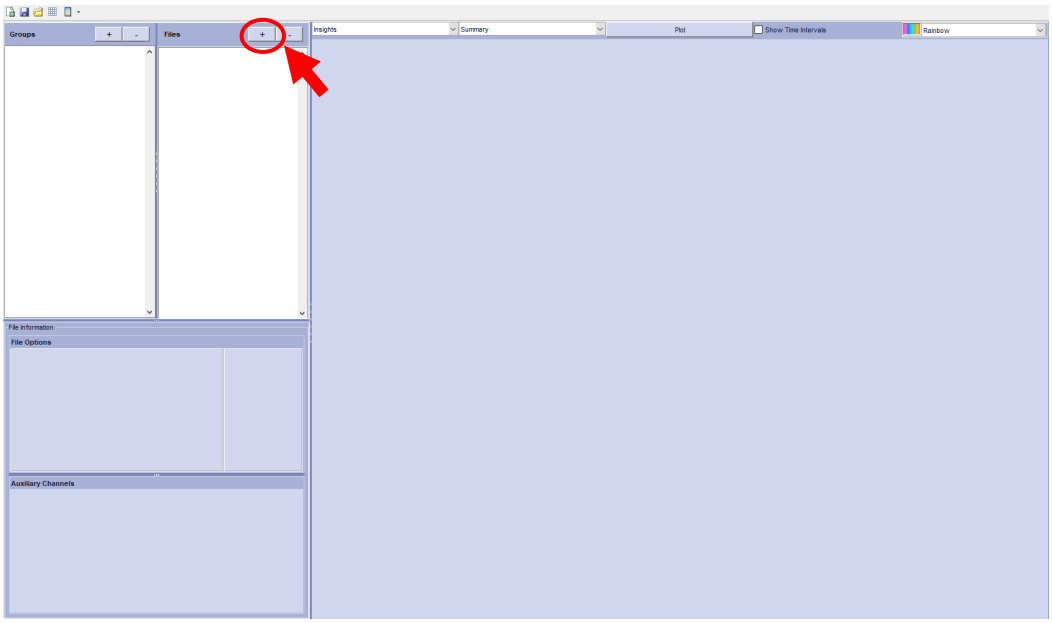




Adding Files to Groups

Once you have created a new group, you can then add files to your newly created group. Click the '+' button in the file panel, or right-click inside the file panel and select "Add New File(s)".

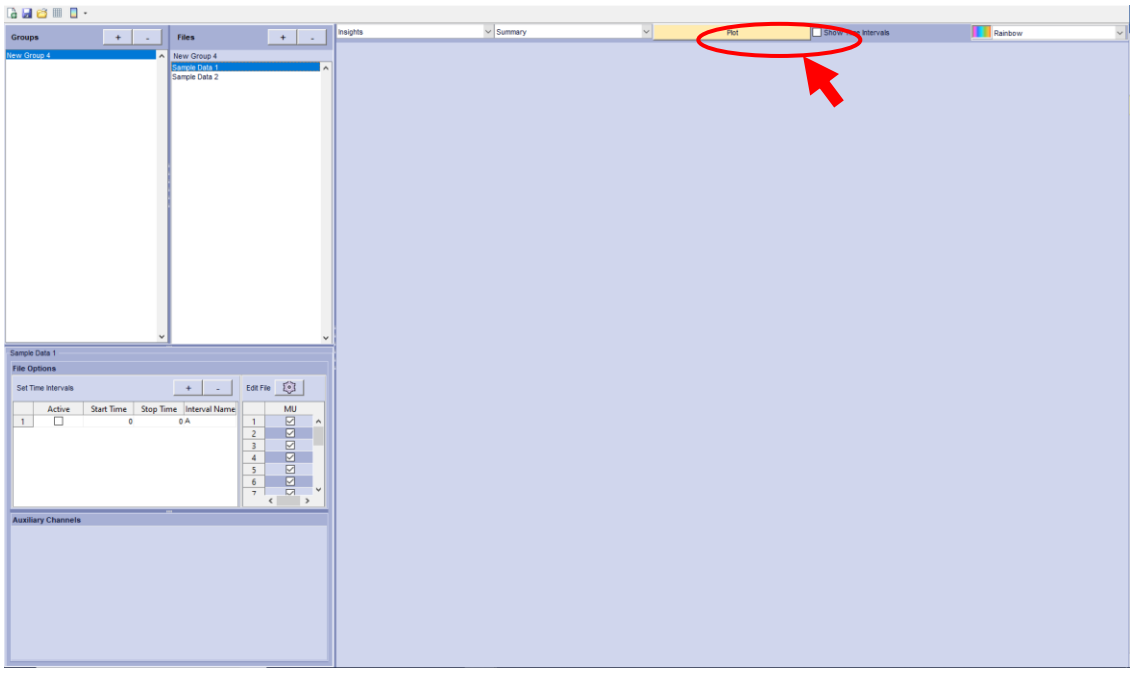
Note: NeuroMap Explorer only accepts DHPF files; raw HPF files can be visualized & analyzed in EMGworks Analysis.


Groups
Files
Insights
Summary
Plot
Show Time Intervals
Rainbow
File Information
File Options
Auxiliary Channels

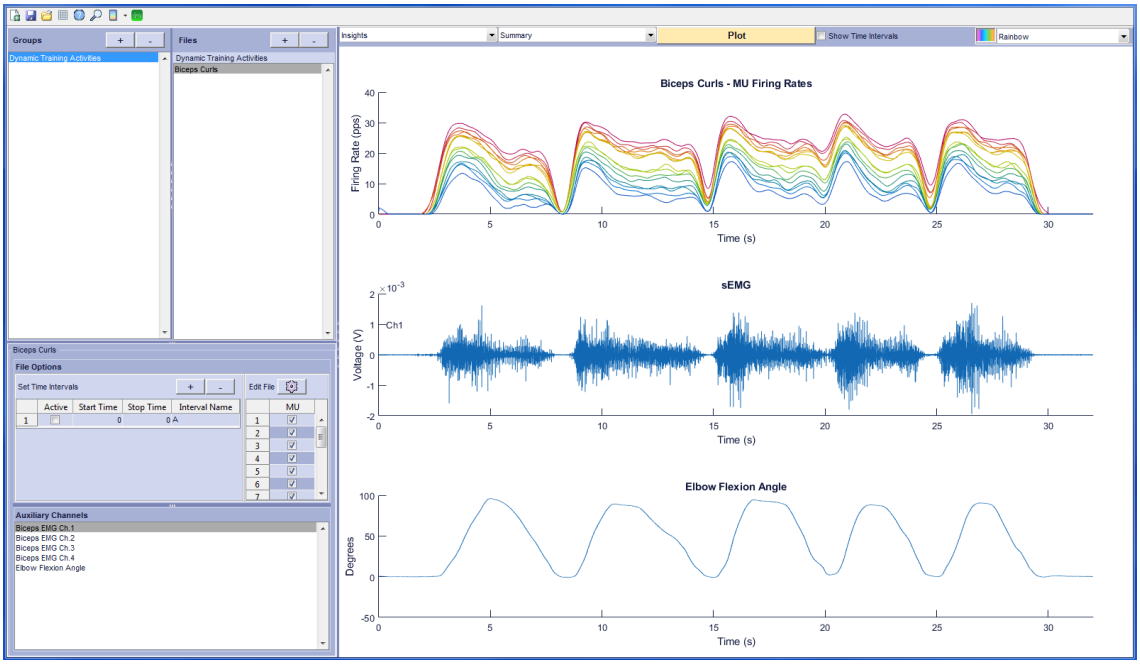
Data Visualization:

In the NeuroMap Explorer software, there are many different analysis options for the user to visualize, calculate, and compare different representations of their collected EMG signals.

Once files have been loaded into the group to analyze, the plot button will change to a bright yellow color. This indicates that plotting is now enabled.



After clicking on the plot button, the software plots the data from the selected file:

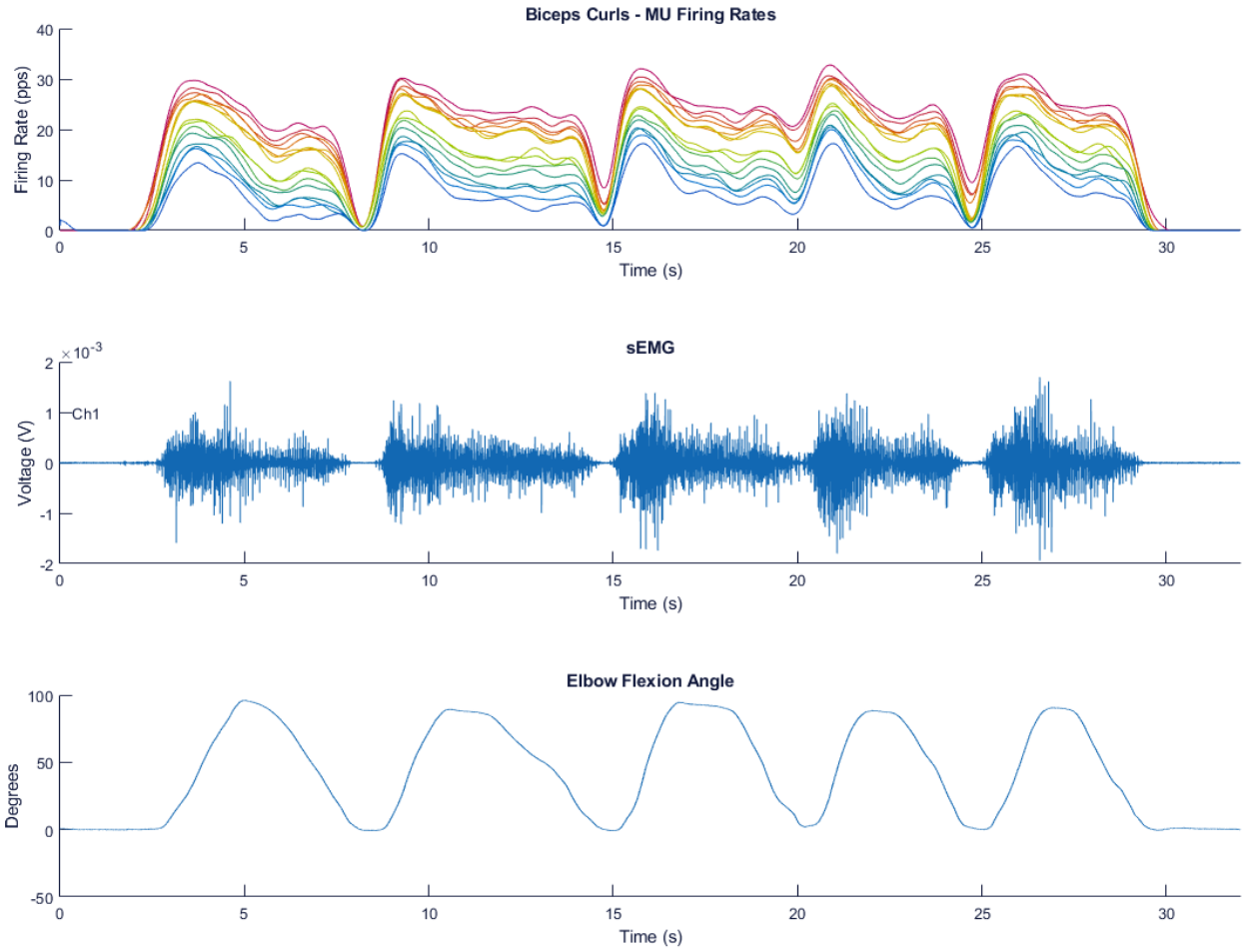


Insights

Summary

The *Summary* plot provides an overview of the selected MU data file. It displays three plots:

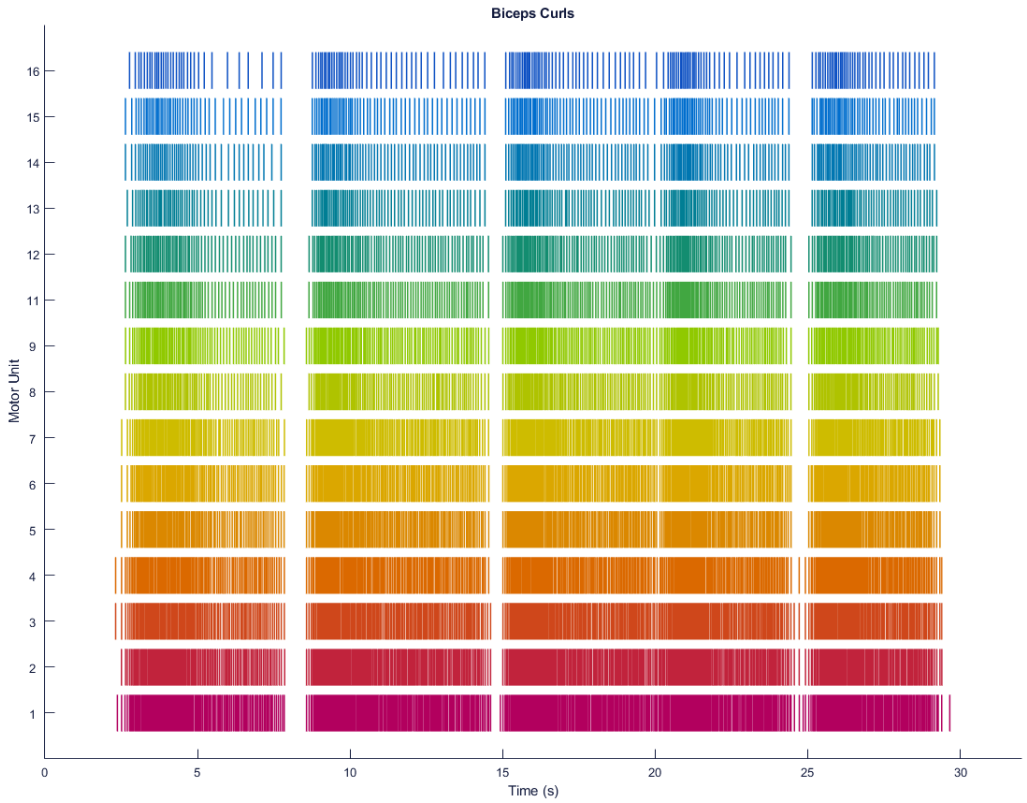
1) Mean firing rates of active motor units
2) One channel of the raw EMG data
3) A selected auxiliary channel (if applicable)



Explore Data:

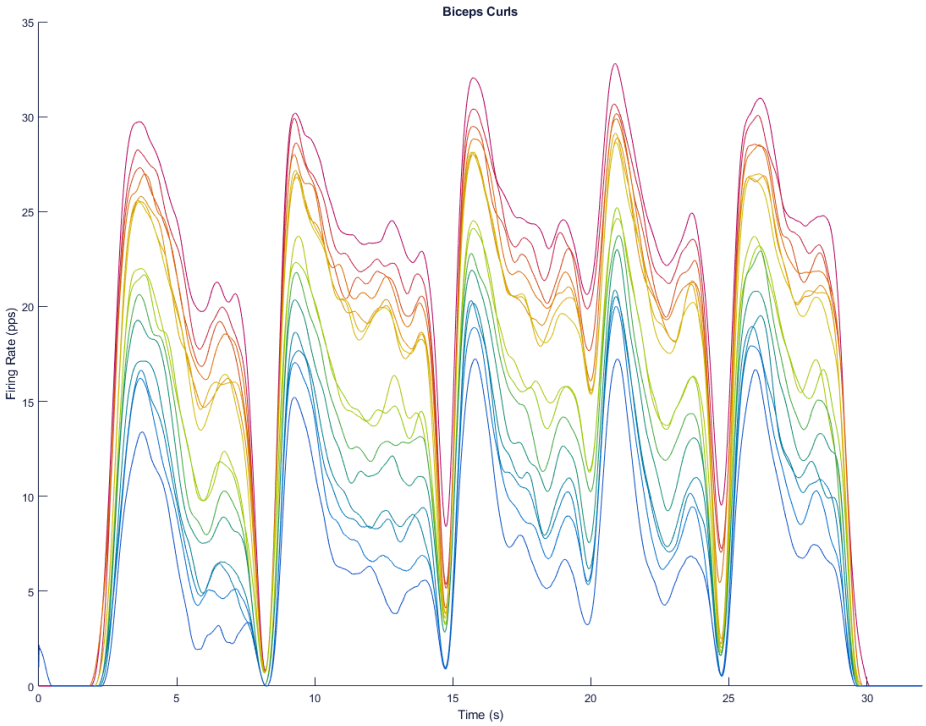
Motor Unit Firings

The *MU Firings* plot shows the firing times for each identified motor unit. Each MU is presented on a separate row, and each firing is represented as a vertical bar:



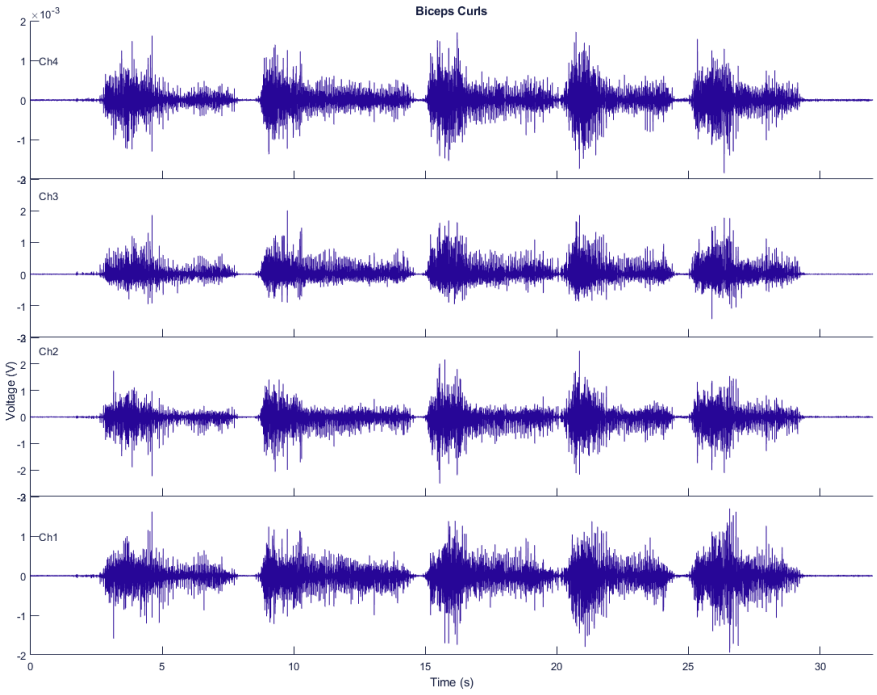
Motor Unit Firing Rates

The *MU Firing Rates* plot shows the mean firing rates for each identified motor unit. The mean firing rate of a single MU is calculated by passing its firing instances through a Hann window; as firings occur more or less frequently, the mean firing rate rises or falls accordingly.



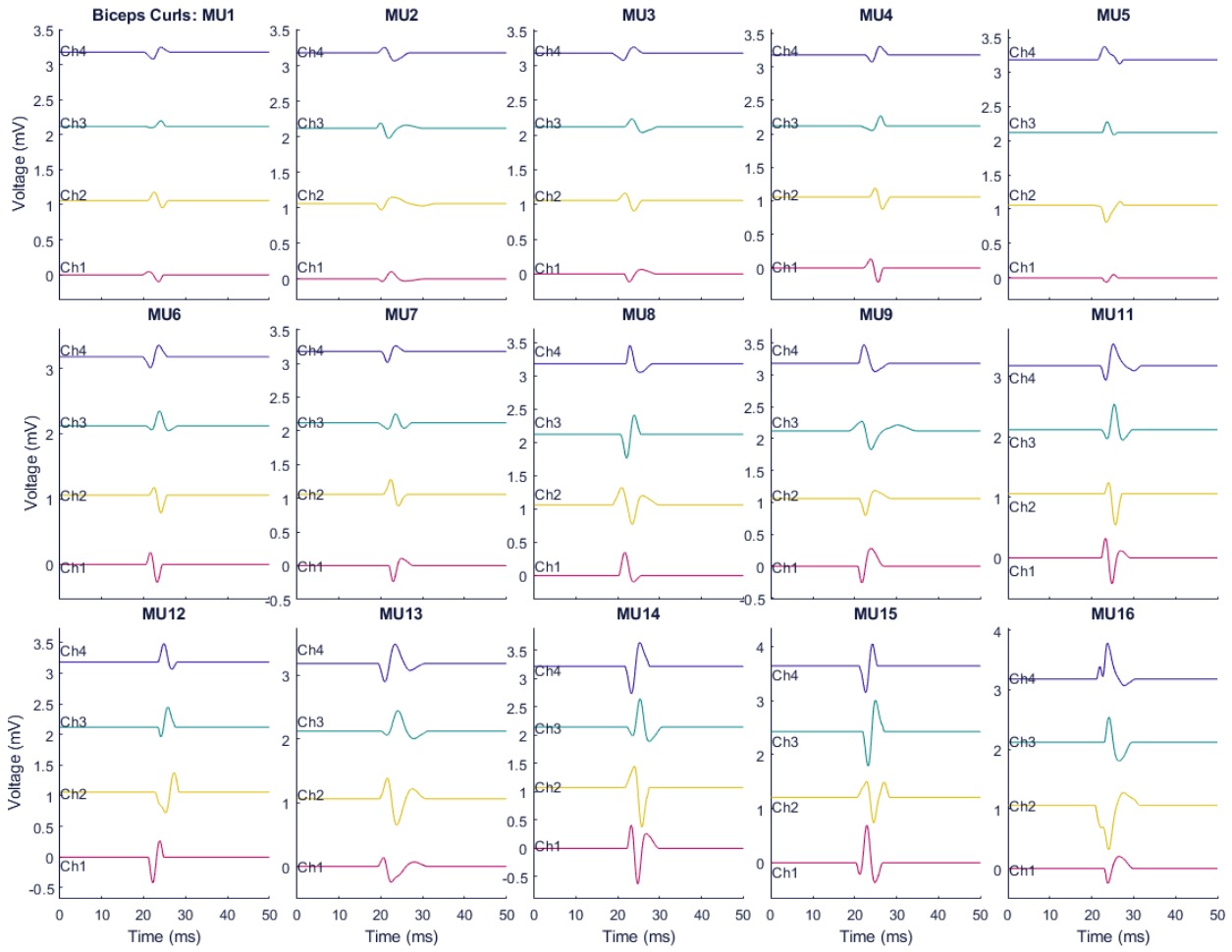
sEMG

The *sEMG* plot presents the four raw EMG signals from the selected file. Additional EMG analysis options are available in EMGworks® Analysis software.



MUAP

The *MUAP* plot shows the unique motor unit action potential shapes found throughout the signal during decomposition. Each identified motor unit has four MUAP waveforms, representing its action potential shape in each of the four EMG channels recorded by the Trigno Galileo sensor.

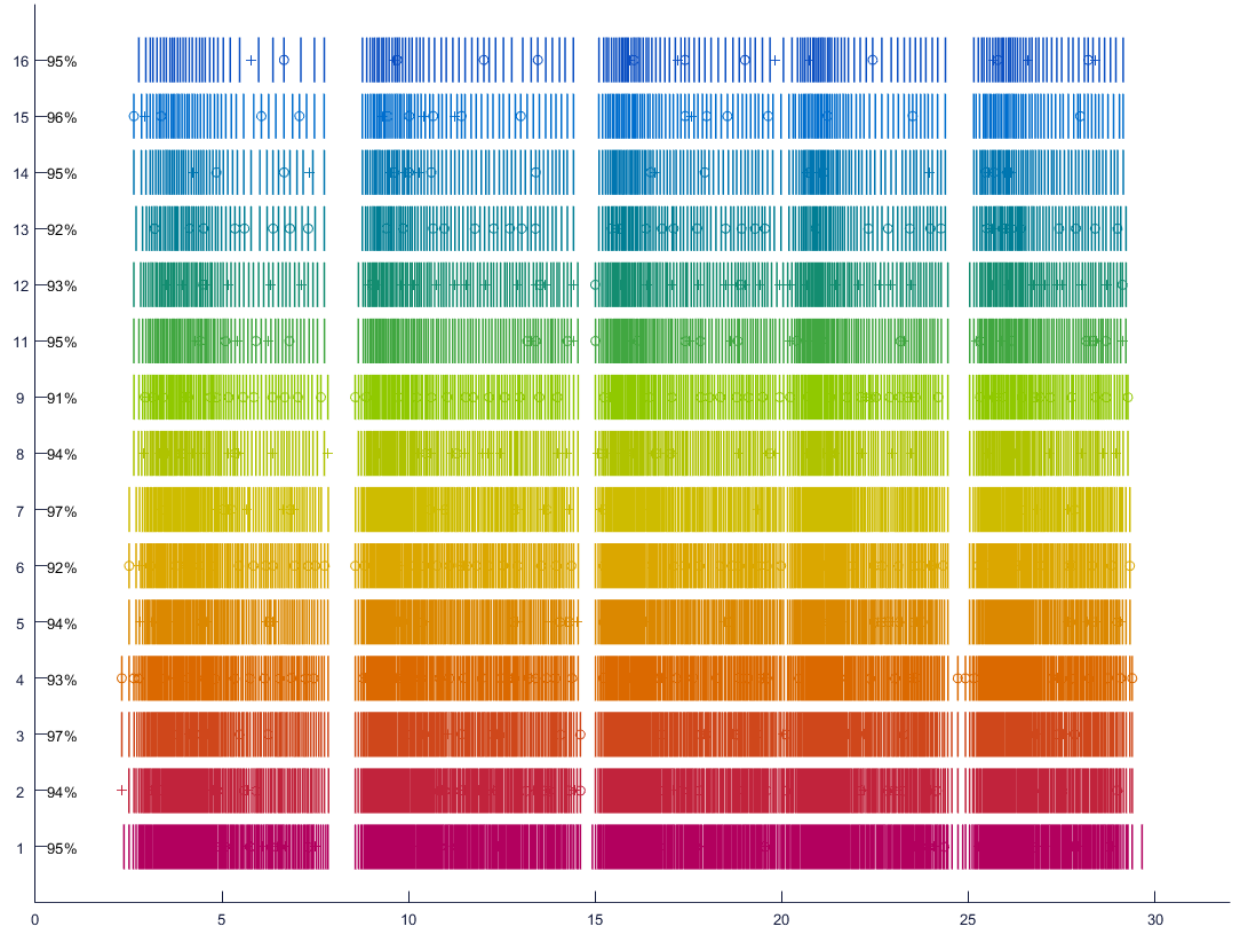


MU Firings – Accuracy

The *MU Firings - Accuracy* plot provides a summary of all MUs obtained from sEMG decomposition. The accuracy (Equation 1) is calculated as 1 minus the sum of false positives (FP, addition symbols), and false negatives (FN, circles), divided by the sum of true positives (TP) and true negatives (TN) for all firings of each MU.

$$(1)\ Accuracy\ (\%) = 1 - \frac{FP+FN}{TP+TN}$$

You may exclude MUs with lower accuracy by setting a threshold in the Analysis and Plot Options panel.

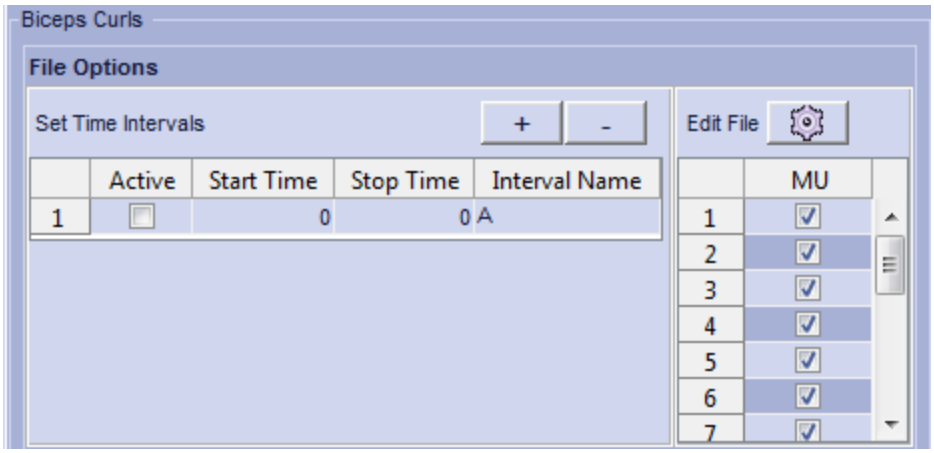


Note: for more information on the accuracy validation, refer to the EMG Decomposition section of the References.

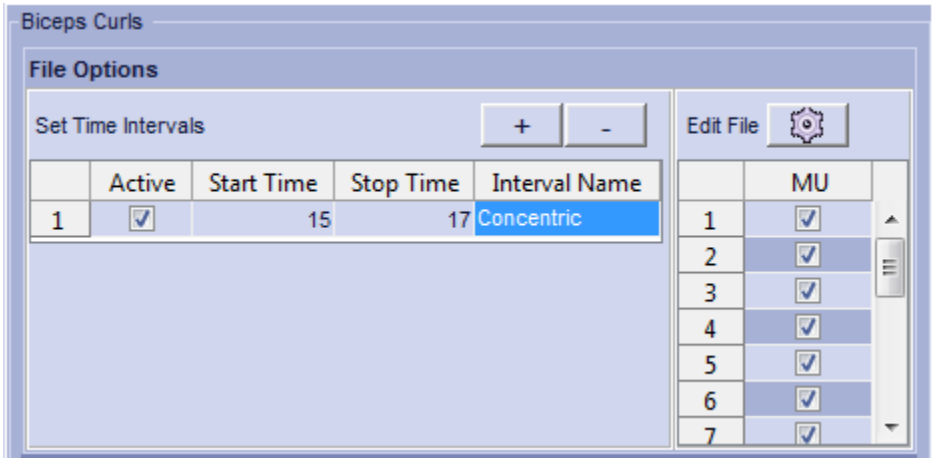
Statistics

Time Intervals

From the File Information panel, you add or modify time intervals that can be used any Statistical plot type to analyze time-dependent features in your MU data.

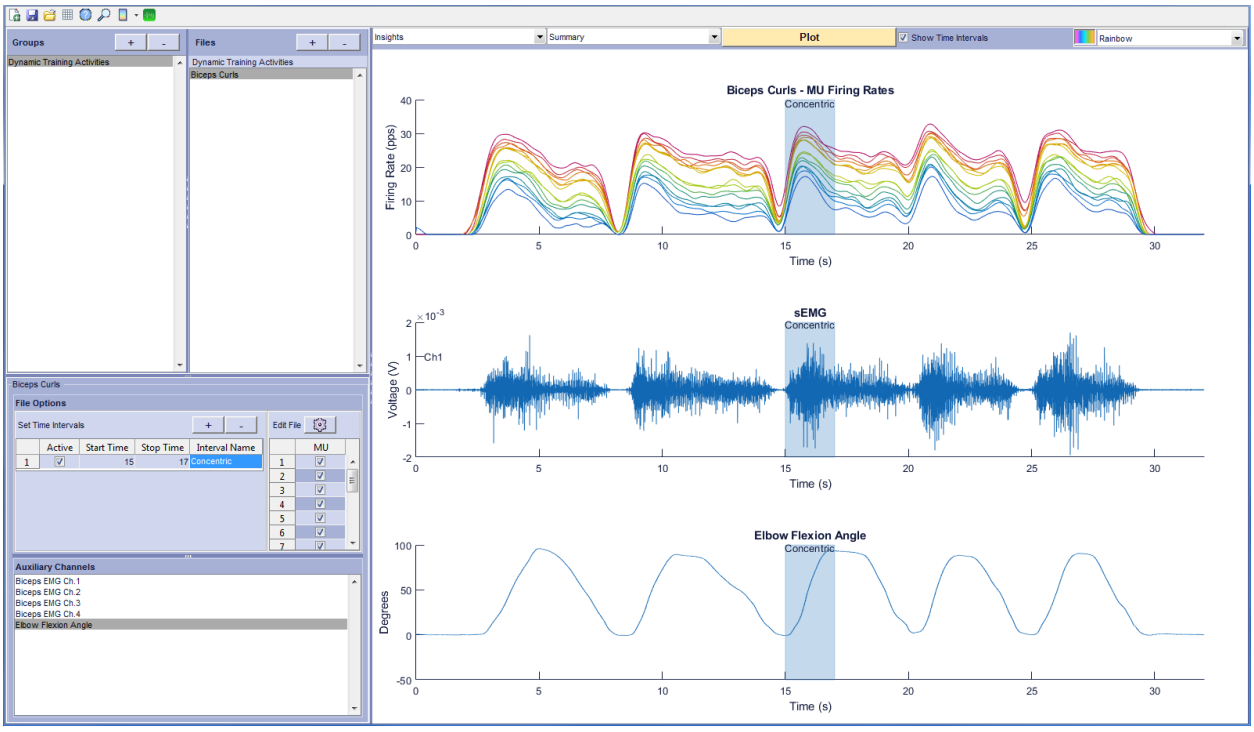


To change the time intervals of a specific file, you can edit the "Set Time Interval" table directly. To add or subtract rows from the table, click on the "+" and "-" buttons. Only active time intervals will be displayed.



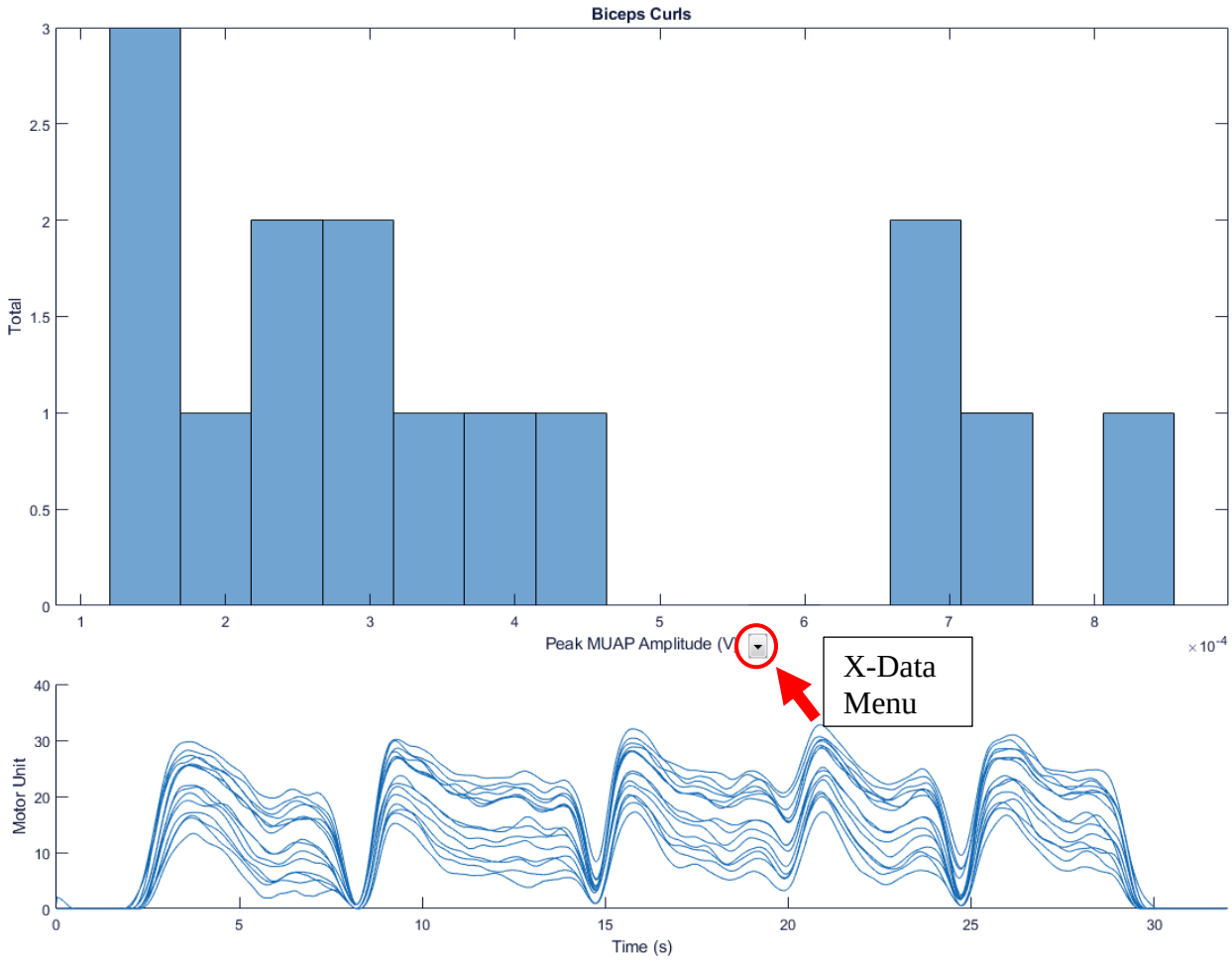
Once you have created a time interval and set it to be active, you can display in on the plot by checking the "Show Time Intervals" checkbox on the plot bar and then clicking the "Plot" Button.

The new time interval displays on the chosen plot as a translucent patch:



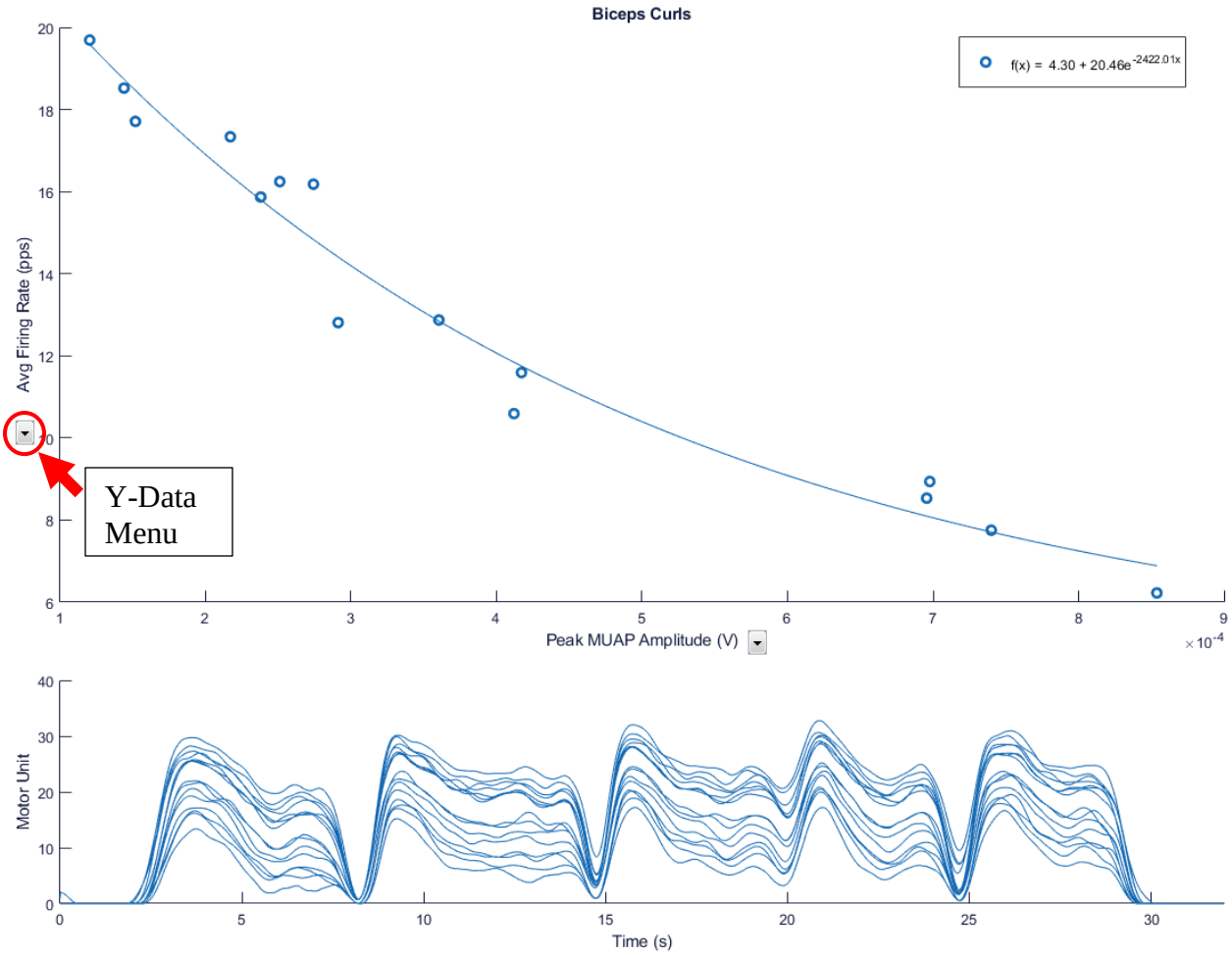
Histogram

The *Histogram* plot displays the distribution of different statistical variables specified by the X-Data dropdown menu.



Regression

The *Regression* plot displays the multi-variable regression specified by the X Data and Y Data dropdown menus:



Note: the default regression is Peak MUAP Amplitude (X-Data) vs. Peak MU Firing Rate (Y-Data)

Statistics Variables

Peak Firing Rate provides a histogram of the peak firing rate of the MU. It is calculated from the inverse of the max inter-pulse interval (IPI) of all MU firing instances within the specified time interval. Each IPI is a measure of the interval between adjacent MU firing instances.

Average Firing Rate provides a histogram of the average firing rate of the MU. It is calculated from the inverse of the average IPI of all MU firing instances within the specified time interval. Each IPI is a measure of the interval between adjacent MU firing instances.

Peak MUAP Amplitude provides a histogram of the peak MUAP amplitudes, calculated as the maximum across all channels of the maximum value of the rectified MUAP waveforms.

Average MUAP Amplitude provides a histogram of the average MUAP amplitudes, calculated as the mean across all channels of the maximum value of the rectified MUAP waveforms.

IPI Average provides a histogram of the average IPI of all MU firing instances within the specified time interval. Each IPI is a measure of the interval between adjacent MU firing instances.

IPI Standard Deviation provides a histogram of the standard deviation of the IPIs of all MU firing instances within the specified time interval. Each IPI is a measure of the interval between adjacent MU firing instances.

IPI Coefficient of Variation provides a histogram of the coefficient of variation of the IPIs of all MU firing instances within the specified time interval. Each IPI is a measure of the interval between adjacent MU firing instances.

List of Abbreviations

IPI	Inter-Pulse Interval
MU	Motor Unit
MUAP	Motor Unit Action Potential
MFR	Mean Firing Rate

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EMG Decomposition

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