**TDT Analysis of Electrically Stimulated Potentials (version 3)**

Written by: Jeremy Ford copyright 2023, GNU Public License v3.0

This software will import data gathered using TDT (Tucker Davis Technologies) hardware and Synapse software and allow the user to name channels of interest, define analysis windows, and run calculations over the windows of interest. Information can be saved throughout this process, and can be loaded in the future to re-analyze without importing or to apply the same channel names and analysis windows across mice. This interface is guided so that the user only has access to the next section in the analysis process, and the GUI updates these sections along the way.

**Getting started**:

Start the GUI by running TDTAnalysisGUI.m.

**Load Data Tab**:

* **Total Number of Channels**: Define the number of channels in the TDT recording: Default is 16
* **Number of Stimulations**: Define the number of electrical stimulation amplitudes used: Default is 10
* **Number of Sweeps**: Define the number of per recording: Default is 9
* **Chopped Window Duration**: Define the window surrounding the electrical stimulation artifact. The window will be defined so that 5% of the window occurs before the artifact and 95% of the window occurs after the artifact. Default is 1 second.
* **Electrode Spacing**: Define the distance between each adjacent electrode channel in the multielectrode array. This assumes a single line of electrodes with uniform spacing. Default is 0.1 mm
* **Stim Values**: Define the electrical stimulation amplitudes. This should be a comma separated list. The number of stimulation amplitudes should match the value defined in the Number of Stimulations field. Default is “10,20,50,100,200,300,400,500,600”
* **Detect Outliers checkbox**: Select the Detect Outliers box to automatically detect sweeps with artifacts and broken channels
  + Outlier sweeps: This is detected by two methods. First, the average of all sweeps is calculated, and the sum of differences between each individual sweep and the mean is calculated. This distribution of the sum of difference from the mean is assessed for outliers based on sweeps that are more than 7 standard deviations. Second, each sweep is assessed for a progressively changing baseline offset by fitting a best fit line to the data prior to the stimulation artifact and at the last 5% of the sweep. The distribution of slopes for all sweeps is assessed for outliers based on a slope more than 7 standard deviations away from the average slope. This is performed for all channels and all stimulations.

Broken channels are detected using the total variation of each channel. The standard deviation across all sweeps is calculated for each time point in the sweep. This standard deviation is then summed over the entire sweep time. This is performed for each channel at each stimulation strength. The total deviation across sweeps is then averaged over all stimulations for each channel. This average total deviation of sweeps is then plotted for each channel, and outlier/broken channels are detected by a threshold value. The default threshold is 1.

* **Filter checkbox**: Check the box to filter the data when it is imported. Fields to define the filter cutoffs will appear.
  + **High Pass Cutoff:** Define the lower end of the filter’s passband
  + **Low Pass Cutoff:** Define the higher end of the filter’s passband
* **Known “Bad” Channels? Checkbox**: Select this box to manually define channels that are known to be broken/bad or need to be removed. Removed channels will be excluded for analysis and the data will instead be interpolated in an attempt to recover the information in the excluded channel.
  + **Bad Channels field**: Enter a comma separated list of the channels to be excluded, no spaces between adjacent entries.
* **Select Data To Import**: Use this button to select the TDT data to import. A dialog box will appear. Use this box to select the folder with the data containing the first stimulation, typically named “Block-1”. Once selected, the TDT data will be scanned to determine the data streams present in the acquired data. These data streams will appear in the list below the “Select Data To Import” button. **Note**: Import assumes that the Block folders are named in sequential order where each subsequent folder contains the data from the next stimulation amplitude in the comma separated string entered into the “Stim Values” box. Import also assumes that the value entered in the “Number of Stimulations” box represents the number of these folders.
  + **Data Stream check boxes:** Once complete, the data streams in the acquired data will appear as check boxes. Select the check boxes that you wish to import.
* (Optional) **Specify Save Location**: By default, a folder named “AnalysisGUIResults” is created in the TDT Tank storing the raw data. Selecting this button will allow the user to manually define where this folder is created.
* **Import Data**: Clicking this button initiates reading data directly from the TDT tanks into MATLAB. During importing, data will be loaded into MATLAB from the TDT files, filtered (if selected), used to detect outlier sweeps and broken channels (if selected), and used to calculate the Current Source Density (CSD) from information in adjacent electrode channels using the “Electrode Spacing” value. If changes need to be made to any of these calculations, the data must be re-imported. The importing process creates a folder within the parent directory (the folder containing all of the Block folders). In this folder will be all data and images generated by this code. The first piece of data will be a .mat file containing all imported data, “ImportedData.mat”, which can be loaded upon future analysis sessions instead of importing the data again. After importing, the Select Windows and Export Plots tabs will become selectable.
* **Load Data**: Load Data will allow the user to analyze data previously imported using this analysis code. A dialog box will pop up and the user should select the ImportedData.mat file generated during a previous session. the Select Windows and Export Plots tabs will become selectable.

**Batch Processes (not update for v3 yet)**:

* **Batch Import**: Clicking the Batch Import button will launch a new window to import multiple experiments at once. The import process can take time, and importing multiple data streams and performing filtering and outlier detection can be resource intensive. The benefit of batch importing is that multiple experiments with the same import parameters can be queued to import so that the user does not need to be present during the process. The user can then relaunch the GUI at a later date and load the experiment of choice for analysis.
  + **Recording Parameters Panel**: Information about these settings can be found in the Setting Recording Parameters section of the documentation.
  + **Additional Options Panel**: Information about these settings can be found in the Additional Options section of the documentation.
  + **Import Path List**: This is the list of TDT tank paths that will be imported. Paths within this list can be selected for removal.
  + **Add Path**: Clicking this button will open a dialog box to select the folder to add to the import list. Use this box to select the folder with the data containing the first stimulation, typically named “Block-1”. Import assumes that the Block folders are named in sequential order where each subsequent folder contains the data from the next stimulation amplitude in the comma separated string entered into the “Stim Values” box. Once the path is selected, the path will appear in the Import Path List.
  + **Remove Selected Path**: The highlighted path in the Import Path List will be removed.
  + **Batch Import Selected Files**: Clicking this button will start the import process. All .mat files with the imported data will be written into the folder “AnalysisGUIResults” which will be created in each path.
* **Batch Analysis**: Will be added in a future version

**Select Windows Tab**:

Use this tab to define the analysis windows of interest. Users can define any number of windows across all data streams and variables (LFPs or CSDs) and view all windows created for each channel. Window definition requires the user to select a data stream, variable, and channel, and define a window name, window start time, window end time, peak polarity, and area polarity. When working in the Select Windows tab, adjusting the data stream, variable, channel, window extents, or already defined window will cause the plot to automatically update.

* **Data Stream Radio buttons**: Choose which imported data stream to work with. Only imported variables will be visible for selection.
* **Variable Radio buttons**: Choose which imported variable to plot. Only imported variables will be visible for selection.
  + **LFPs**: Raw local field potentials.
  + **CSDs**: Calculated current source density.
* **Plot Filtered Checkbox**: Visible if data was filtered upon import. Selecting will plot the filtered data.
* **Override Y Axis Checkbox**: Selecting will allow the user to override the default y-axis limits on the plot. When the box is selected, boxes to define the y-axis minimum and maximum limits will appear.
  + **Min**: Define the minimum extent of the y-axis
  + **Max**: Define the maximum extent of the y-axis
* **Channel Dropdown List**: The list of channels for the selected Variable will appear here. Clicking on a channel will update the plot.
* **Window Name**: Define the name of the current analysis window.
* **Window Start field**: Define the start of the window for the currently highlighted channel of interest. The plot will automatically adjust.
* **Window End field**: Define the end of the window for the currently highlighted channel of interest. The plot will automatically adjust.
* **Peak Value Toggle**: Use this toggle switch to adjust the polarity of the peak value in the analysis window (positive or negative).
* **Area Calculation Knob**: Define if the area to be calculated should only be over the Positive values, Negative values, or Total area (Positive area - Negative area).
* **Accept Window Button**: Clicking this button will save thecurrently defined information in the Channel Name box, Window Extents, Peak Value switch, and Area Calculation knob for the currently highlighted channel in the Channel Dropdown List and selected Data Stream. This will be saved as an analysis window, which will then appear in the Defined Windows dropdown list.
* **Defined Windows Dropdown List**: All currently defined analysis windows for the selected Data Stream, Variable, and Channel will appear here. To view the information of any defined analysis window, select it from the dropdown list. To view all defined windows, select “All”. To view the plot with none of the defined Windows, select “Select Window”.
* **Delete Selected Window Button**: Clicking this button will delete the currently highlighted analysis window in the Defined Windows dropdown list.
* **Save Window Information**: Clicking this button will write all analysis window information to a .mat file. This .mat file can be loaded in the future to continue previously initiated analysis or to apply the same channel information to a different experiment.
* **Load Window Information**: Load a previously saved set of analysis windows.

**Analyze Tab (yet to be updated for v3):**

* **Streams Buttons**: Select which data streams to analyze
* **Data To Analyze Buttons**: Select which variables to analyze (LFPs or CSDs)
* **Quantifications**: Select which parameters to calculate
  + **Peak**: The maximum deflection is calculated. If PeakIsNegative is selected for the channel, the maximum negative peak of the window of interest is calculated.
  + **Area**: The area under the curve is calculated. If AreaIsPositive is selected for the channel, only the positive area over the window of interest is calculated. If AreaIsNegative is selected for the channel, only the negative area over the window of interest is calculated.
  + **Maximum 1st Derivative**: The first derivative of the data is calculated and the maximum value is extracted. By default, the time window (dt in dV/dt) is set to 1 ms. If PeakIsNegative is defined for a window of interest, then the minimum (maximum negative) value is taken. Otherwise, the positive maximum is taken.
  + **Maximum 2nd Derivative**: The second derivative of the data is calculated and the maximum value is extracted. By default, the time window (dt in dV/dt) is set to 1 ms. If PeakIsNegative is defined for a window of interest, then the maximum value is taken. Otherwise, the minimum (maximum negative) is taken.
* **Analyze Filtered Data**: Visible if data was filtered upon importing. Calculates quantifications on the filtered data if imported data was filtered.
* **Run**: Quantifications will be calculated for all channels of interest using the specified parameters. Upon completion, a .mat file will be written with the results, a .mat file will be written with all GUI parameters used, and a .csv file will be written with all channels of interest and their corresponding results.

**Plotting Panel:**

The plotting panel allows users to plot the imported data to visualize all LFP or CSD channels at once and write these plots to .png and/or .svg files. Writing to .svg requires the plot2svg.m package available through:. All LFP of CSD channels are plotted on one set of axes with a user defined offset between each plot. A plot is created for LFPS, LFPs with the area under the curve filled in (red=positive, blue=negative), CSDs, and CSDs with the area filled in. The panel has been superseded by the Preview Plots button (located at the bottom of the GUI) which launches a separate GUI window. This new window allows the user to play with the plots and export these once a preferred figure has been generated.

* **Stream**: Select which data stream to plot. Only data streams that were imported are visible
* **Minimum Time**: Define the minimum time plotted in the figure.
* **Maximum Time**: Define the maximum time plotted in the figure.
* **LFP Plot Offset:** Define the y distance between each LFP trace.
* **LFP Area Offset:** Define the y distance between each LFP trace in the filled in area figure.
* **CSD Plot Offset:** Define the y distance between each CSD trace in both the trace and filled in trace plots.
* **Plot Filtered:** If the data was filtered upon import, this will plot the filtered version of the data stream.
* **.png checkbox:** Save the figures as .png format
* **.svg checkbox:** Save the figures as .svg format
* **plot:** Click this button to initiate the plotting