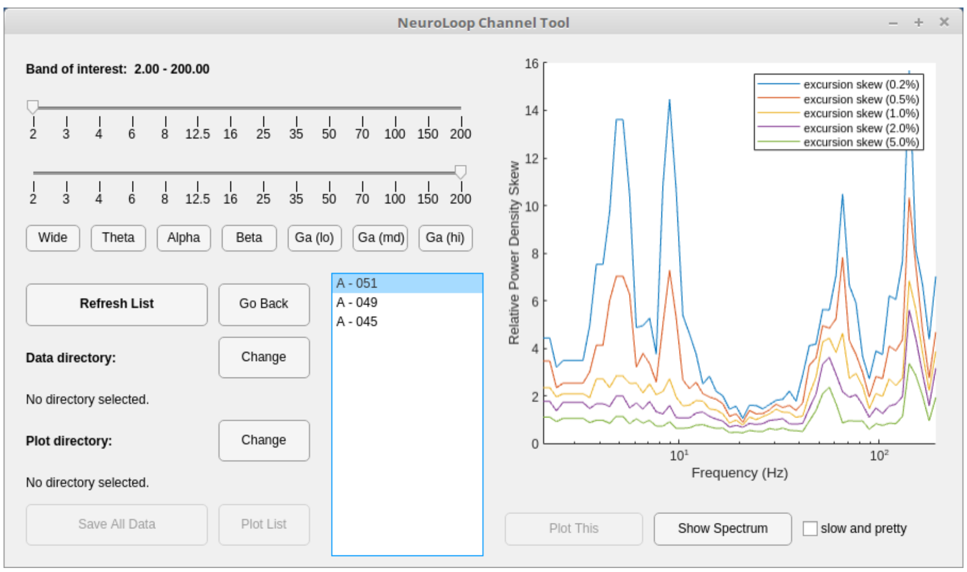
NeuroLoop Channel Tool – User Guide

Written by Christopher Thomas – January 4, 2024.



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Chapter 1

Overview

The “NeuroLoop Channel Tool” is a GUI application that looks at folders containing neural recordings and identifies channels that have spikes and channels that have LFP bursts.

The intended use of this tool is for examining high-channel-count recordings to identify channels that have interesting behavior without a human having to manually examine each channel. The tool is designed to do this quickly enough that it may be used during experiments (analyzing a short initial recording to identify channels of interest in the primary experiment).

Chapter 2 gives a walk-through of how to use the Channel Tool.

FIXME: Stub content.

Chapter 2

Walk-Through

2.1 Installation

The NeuroLoop Channel Tool consists of a single Matlab script (`nloop_channeltool.m`) that makes use of the NeuroLoop utility libraries.

To install the tool, first make sure that the NeuroLoop utility libraries are on path, then make sure that the Channel Tool script is on path, and finally type “`nloop_channeltool`” in Matlab to launch the tool.

2.2 Data Selection Screen

When the Channel Tool is launched, it shows the data selection dialog (Figure 2.1). To use this dialog:

- Click the “Select Data Directory” button. This brings up a file browser window.
- Navigate to the directory containing your data.
- Click “open” in the file browser window.

After selecting a directory, the Channel Tool will attempt to read metadata. If successful, it will enable reference selection and processing (Figure 2.2). **Make sure to finish configuration before clicking “process”:**

- For each detected bank of channels, select a channel in that bank to use as the reference. This removes common-mode noise from the channels.
- If there are known artifacts at the beginning or end of the signal, edit the “trim” times to remove the specified number of seconds from the start and end.
- If you want to adjust the settings used when loading and filtering the data, click the “Edit Processing Config” button.

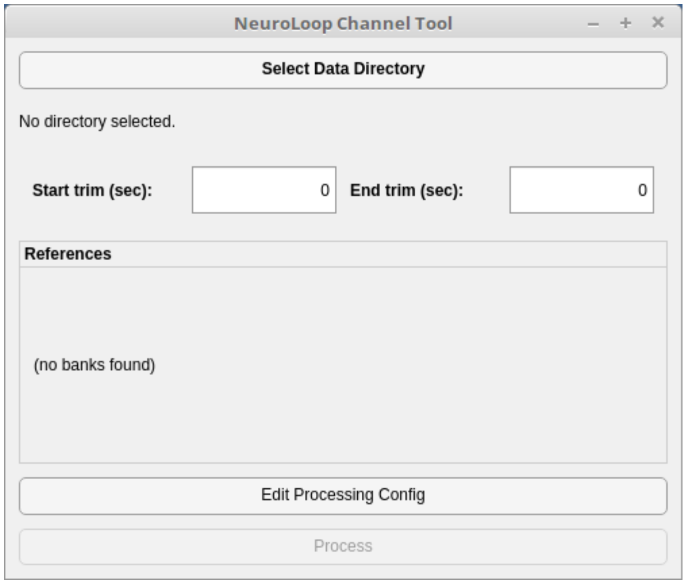

Figure 2.1: Data selection dialog on startup.

- **After all of that is done**, click “Process”.

You can go back to the setup dialog later to adjust configuration and re-read the data (or to read a different data set). The problem is that loading and filtering the data takes a long time, so you only want to do it when it’s necessary.

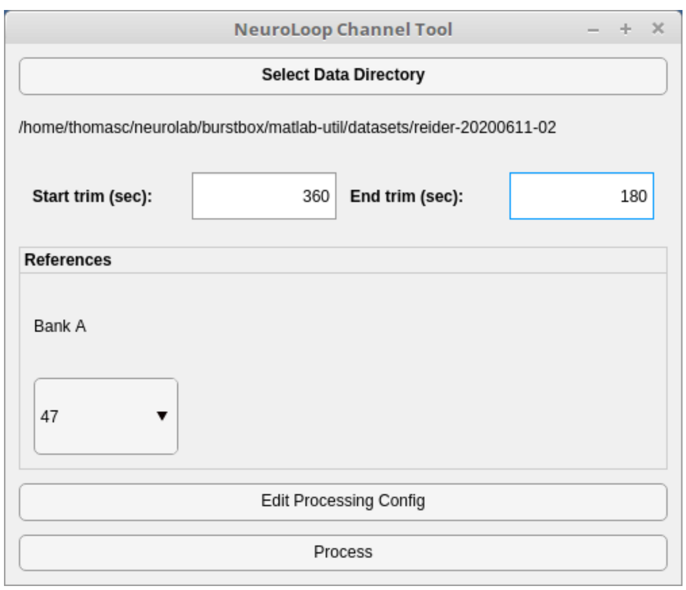

Figure 2.2: Data selection dialog after choosing a directory.

2.3 Processing Configuration Dialog

The processing configuration dialog (Figure 2.3) lets you adjust the filtering and artifact-rejection settings used when loading and processing channels.

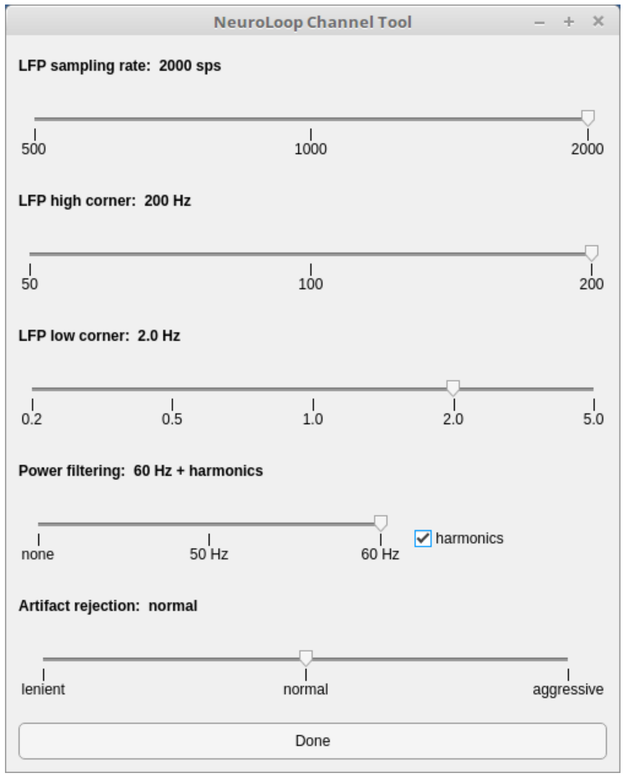

Figure 2.3: Processing configuration dialog.

Artifact rejection is performed first, and then filtering is used to separate the signal into a spiking component (high frequencies) and a local field potential component (low frequencies).

Artifact rejection works by looking for large excursions in either the unfiltered signal itself (typically large voltage transients) or in the signal's derivative (typically impulse or stepwise changes in the signal). The artifact rejection slider adjusts how large an excursion has to be in order to count as an artifact. Artifact regions are removed and interpolated. Channels that have significant numbers of artifacts are discarded.

Filtering uses infinite impulse response filters that are run forwards and backwards in time to cancel phase shifts. The LFP filters take about 1 period of their respective frequencies to stabilize, and the power line notch filter takes about half a second to stabilize. For best results, set the LFP corner frequencies a factor of two higher or lower than the highest and lowest frequencies of interest (respectively), and set the LFP sampling rate ten times higher than the highest frequency of interest.

Power line filtering has the option of removing the second and third harmonic of the power line frequency as well as the fundamental frequency. These frequently appear in recorded signals, but removing them causes filtering to take considerably longer.

2.4 Processing Dialog

When the processing dialog is launched, most controls will be disabled while processing is happening. The status message at the top of the window shows the progress of processing (Figure 2.4). This will take a while. When processing is finished, the display updates with graphs and controls are enabled (Figure 2.5).

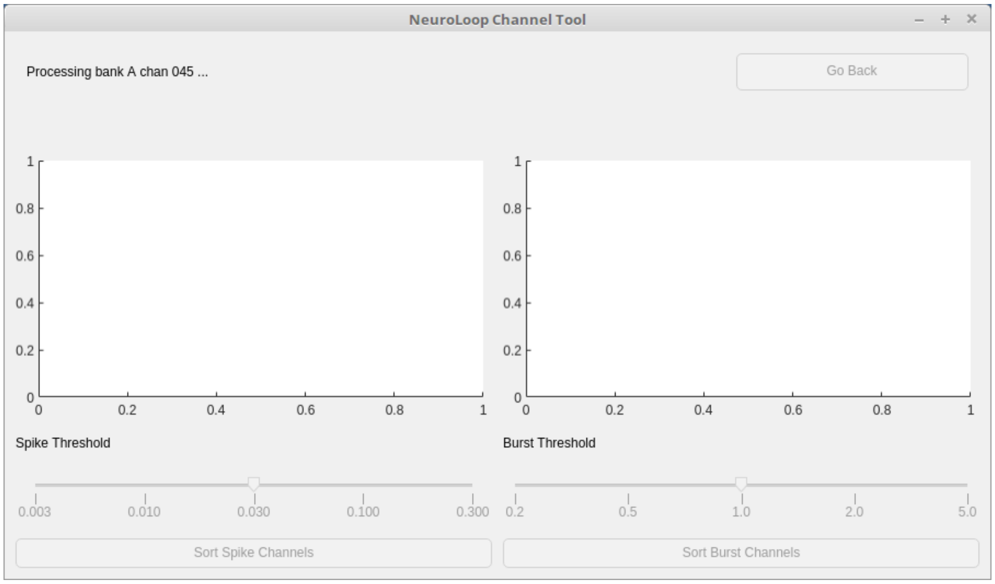

Figure 2.4: Processing dialog while processing is running. Only the status bar is active.

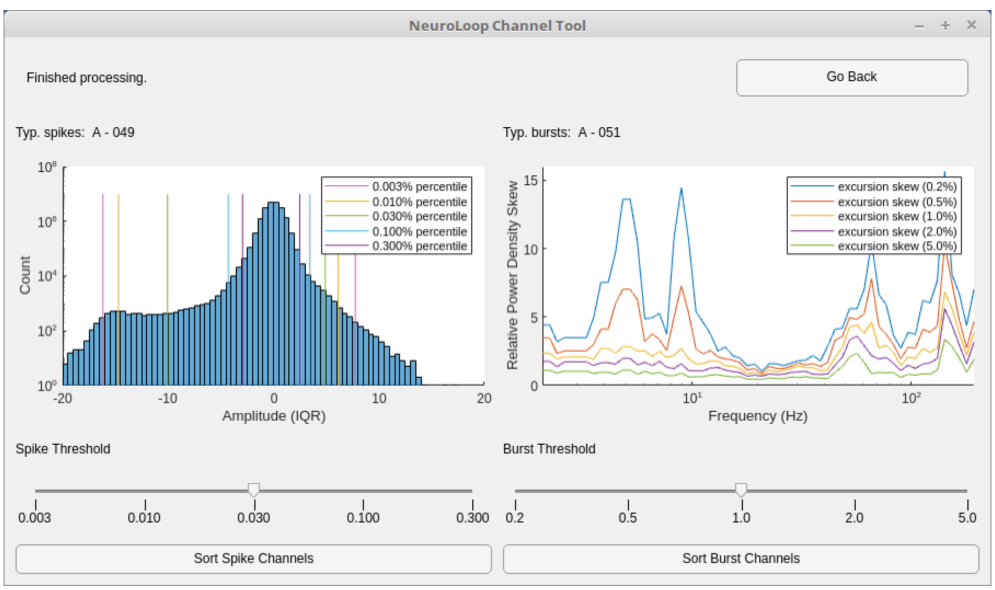

Figure 2.5: Processing dialog after processing is finished, showing results and controls.

Spikes and bursts are identified by looking for negative excursions in amplitude and positive excursions in the power spectrum, respectively. "Excursions" are identified by making a histogram of these respective quantities and finding where the Nth percentile tails of the probability distribution are. The "skew" is computed by looking at the point half-way between the tails (the "midsummary") and seeing if that is displaced with respect to the median. Negative skew in the amplitude distribution indicates spikes, and positive skew in LFP power spectrum frequency bins indicates transient LFP oscillations ("oscillatory bursts").

The left graph in Figure 2.5 shows a histogram of amplitudes in the high-pass-filtered signal. The tails of the distribution are asymmetrical, with the plateau indicating significant spiking activity. The vertical bars indicate where various tail percentiles are. The "spike threshold" slider may be adjusted to select bars where the leftmost bar intersects the plateau.

The right graph in Figure 2.5 shows skew in the power spectrum as a function of frequency. Peaks indicate the presence of transient LFP oscillations. The different curves use different tail percentile values. Lower percentile values give greater sensitivity to outlier events. The "burst threshold" slider may be adjusted to pick a curve to use when identifying channels with oscillatory bursts.

The "sort spike channels" button brings up a dialog that ranks channels by spiking activity, and the "sort burst channels" button brings up a dialog that ranks channels by LFP oscillation activity. These operations are cheap, so those two dialogs may be entered and left without worry. The "go back" button leaves the processing dialog – discarding the results – and returns to the data selection dialog.

2.5 Spike Channel Sorting Dialog

FIXME: This dialog is not yet implemented.

2.6 Burst Channel Sorting Dialog

The burst channel sorting dialog ranks channels by the amount of LFP transient oscillation activity. This is evaluated by skew in the probability distribution of power spectrum frequency bin contents over time, per Section 2.4. On entering the dialog, select a frequency band using the frequency buttons or sliders, and click "refresh list" to get a ranked list of channels. The result looks like Figure 2.6.

Channels in the results list are ranked by the amount of in-band skew, with the channel with the highest amount at the top of the list. To examine the spectrum of a given channel, click that channel's name in the list. The plotting area updates to show the amount of skew at each frequency, per Figure 2.7. To see excursions overlaid on the power spectrum, click the "show spectrum" button. This gives a plot like the one shown in Figure 2.8. To see a persistence spectrum without skew, click the "slow and pretty" checkbox. This gives a plot like the one in Figure 2.9. To return to the excursion plot, click "Show Excursions".

Plots for the selected signal can be saved by clicking the "plot this" button after a plot directory has been set. Plots for all channels in the results list can be generated by clicking the "plot list" button. The raw statistical data used to generate these plots can be saved by clicking "save all data" after a data directory has been set. The "go back" button returns to the processing dialog.

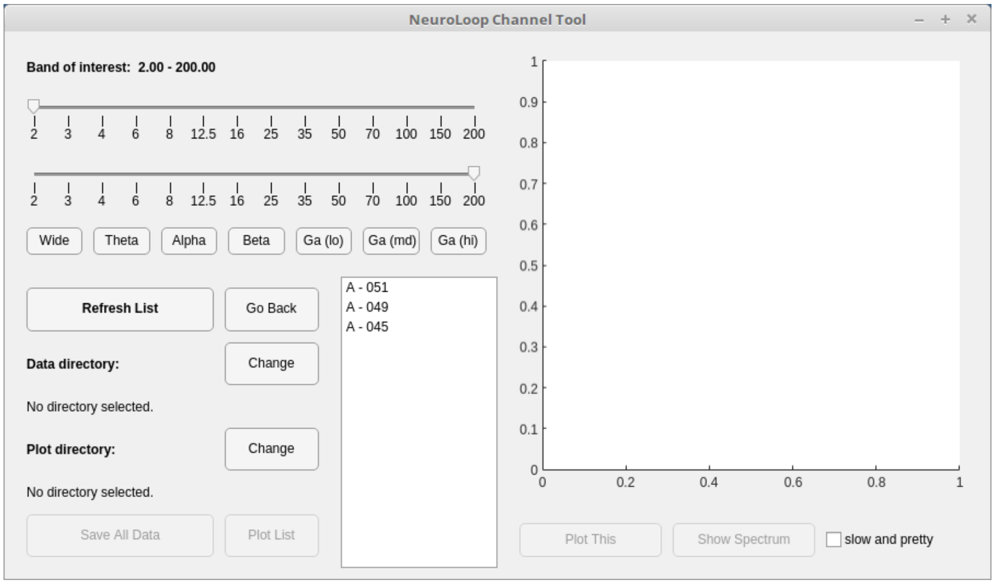

Figure 2.6: Burst channel sorting dialog after clicking “refresh list”.

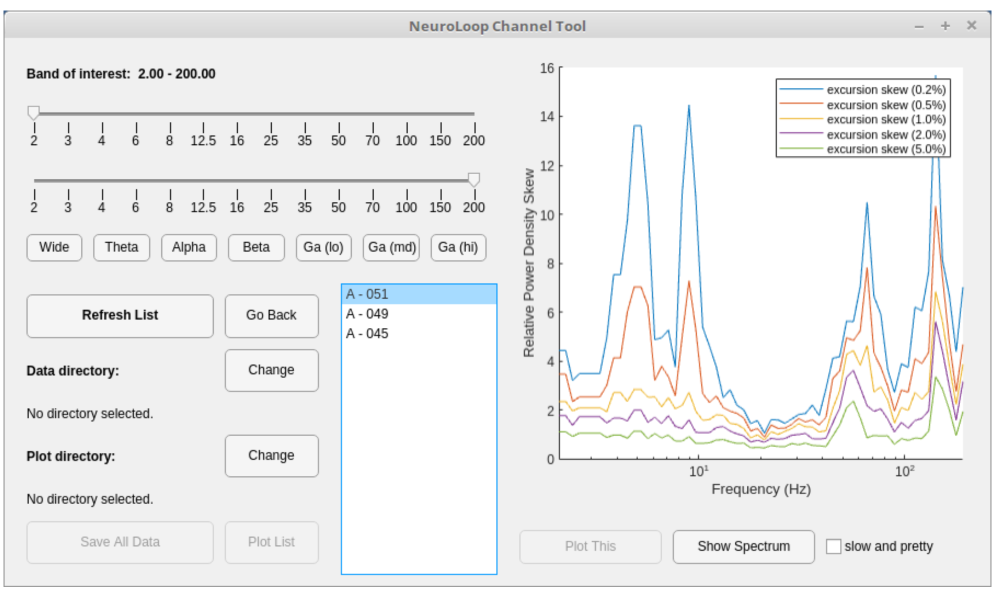

Figure 2.7: Spectrum skew plot for channel “A - 051”.

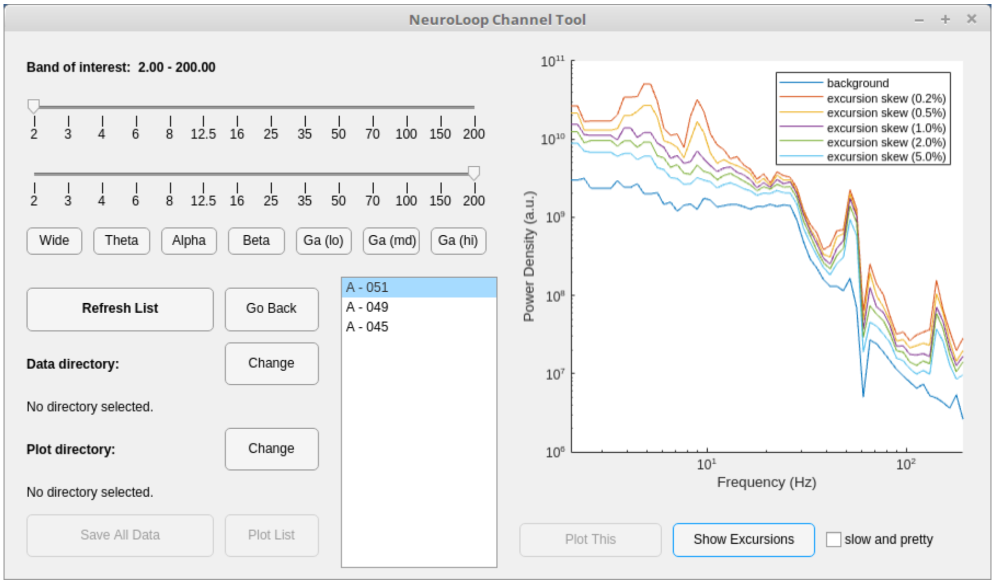

Figure 2.8: Power spectrum plot for channel “A - 051”.

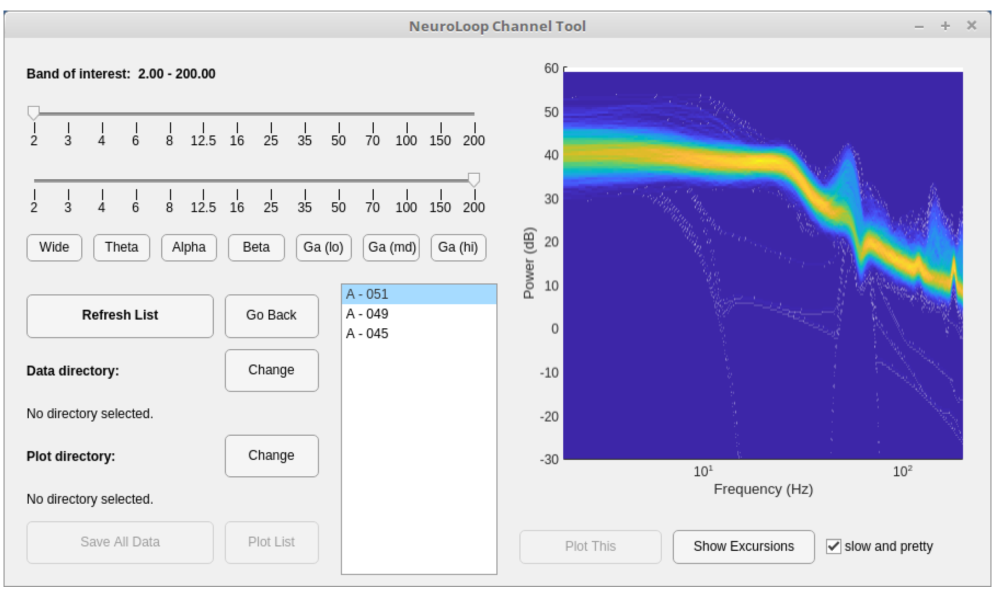

Figure 2.9: Persistence spectrum plot for channel “A - 051”.