Custom Algorithms/Code Used in the Manuscript

The package contains the Matlab codes that implement new/custom algorithms used in the analysis for this manuscript. It also contains sample data and the expected output based on running the code on sample data.

Sample data:
- trace.mat - contains a 2-min long recording of one of the DA neurons from our manuscript. It is a vector containing voltage values in Volts acquired at 20KHz.

Code:
- main.m – main script that loads the sample data and calls other analysis functions and plots the sample data and results.
- detect_spikes.m – function that takes the voltage trace as input and detects spikes within the trace. It also calculates the spike threshold for each detected spike. Detailed description of these algorithms is given below.
- detect_modes.m – function that uses MLE (maximum likelihood estimation) to fit a two-Gaussian mixture to a bimodal Vmin or Vthr distribution. It also calculates the threshold for determining which ISIs are considered part of the second mode. It also plots the resulting MLE estimates.
- /utils – a few utility functions called by the two functions above are provided in this folder.

Detailed description of the algorithms:
- Spike peaks are detected first. Overall, a spike is detected when a high dV/dt value is followed by a high V value and a low dV/dt value. Specifically, a spike peak is detected if these three conditions are met within a 3 ms window following the crossing of a dV/dt threshold (default value=10mV/ms). Firstly, the minimal value of dv/dt must be less than -5mV/ms. Secondly, the maximal value of voltage must be within 30mV of the highest voltage in the whole trace and lastly, the difference between the maximal voltage and the voltage at dV/dt-threshold crossing (spike height, roughly speaking) must be greater than 5mV. All the parameters mentioned here are tunable and were changed to improve spike detection performance in some cells. The performance of the algorithm was verified visually and was found to be highly accurate.

- Detection of spike threshold depends of the dV/dt and d2V/dt2 crossing certain thresholds. To make the algorithm flexible and robust, these thresholds are indexed to the maximal values of first and second voltage derivative for each detected spike. Specifically, the spike threshold is detected when the following conditions are met within a 2ms window ending at the spike peak. Both first and second derivative of voltage cross 5% of their respective within-window maximal values for two consecutive samples. This ensured that spike threshold determination was 'customized' for each spike. The phase of the spike being detected as threshold was visually verified and was found to be very consistent. Similar to previous algorithm, the numeric parameters were tunable.

Miscellaneous

The code above requires MATLAB and has been tested on MATLAB 2018b. The code requires less than one minute to run on a standard desktop computer. There are not non-standard hardware or software requirements.