Stimulation Artifact Removal Graphical Environment (SARGE)

Practical Guide for Users

The SARGE is a graphical user interface that enables the removal of stimulation artifacts. Full details regarding the SARGE application were published in:
Erez Y, Tischler H, Moran A, Bar-Gad I. (2010). Generalized framework for stimulation artifact removal, Journal of Neuroscience Methods, in press.

The software is available at: http://neurint.ls.biu.ac.il/software/SARGE.
This guide includes practical instructions for the user of the application.

1. Software installation

   Unzip the file 'SARGE_V1.3.zip'. Open Matlab and run 'SARGE' at the command window to open the SARGE application.

2. Loading and displaying data

   1.1 Loading data

   To load a Matlab input data file, use the menu: File → load. All the variables in the file will appear in the drop down list on the upper left corner of the application. Choose the appropriate variable and press the "Open" button. The loaded signal will be displayed in the main graphical view of the continuous signal.

   1.2 Data display

   On the upper right corner, adjust the "sampling rate" parameter to fit your data. It is also possible to adjust the "Time/Window" parameters, which defines the time window (in seconds) to be displayed in the graphical view. To the right of the main graphical view, the "Y max" and "Y min" parameters can be adjusted, defining the signal values of the Y axis.

3. Pre-processing filter (optional)

To filter the signal before starting the artifact removal process, adjust the parameters in the 'Pre-filter' panel at the bottom right corner of the application and press the 'Raw-Filter' button. To view the filtered signal in the main graphical view, check the 'Raw filtered signal' checkbox.

4. Stimulus detection

Below the main graphical view, press the "Detect stimulus" button to detect the stimulus pulses onset. The detection is performed using the method that is chosen in the drop-down list below. Three methods are provided:

(1) "Stim time" – detection is performed according to digital markers of stimulus pulse onset, as appear in a variable named "CStimSync3" in the loaded data file. The name of this variable can be set in the parameters file (ArtParm.m).

(2) "Manual" – detection is performed using threshold, according to the detection parameters that appear on the lower right corner of the screen.
- "Begin" – threshold for detection of pulse beginning.
- "End" – threshold for detection of pulse ending.
- "Min (sec)" – minimal time for detection of pulse ending, relative to pulse beginning.
- "Max (sec)" - maximal time for detection of pulse ending, relative to pulse beginning.
- "Offset" – offset of stimulus detection (in sampling points), if required.

(3) "Sync uniform" – detection is performed according to digital markers of stimulus pulse onset, similarly to the "Stim time" option. However, this option assumes fixed intervals between pulses of a continuous stimulation. The pulses onset is calculated based on the first pulse and the mean interval between pulses. This option is provided to handle cases in which the sampling rate of the digital markers of stimulation is lower than the sampling rate of the recorded signal.

Following the detection of the stimulation pulses onset, the continuous signal is divided into segments, where each segment is the part of the signal from the onset of a pulse, until the onset of the consecutive pulse. The segments are displayed in the graphical view at the lower left corner of the application. The ‘min’ and ‘max’ edit boxes below can be used to adjust the y-axis values of the graph. The scroll to the right can be used to present different segments. Upon checking the ‘Stimulus detections’ checkbox, the detected pulses will be marked on the continuous signal in the main graphical view.

5. <u>Artifact estimation and removal</u>

   To estimate and remove the artifacts, choose the method of estimation in the drop-down list under the ‘Remove artifact’ button, adjust parameters at the lower right corner of the application and press the button.

   Following the removal of artifacts, the estimated artifact (red) will be displayed in the bottom left graphical view, superimposed on the raw segment (blue). The artifact-free segment is displayed at the right bottom graphical view.

6. <u>Signal reconstruction and filtering</u>

   To reconstruct the continuous artifact free signal, press the ‘Reconstruct’ button. To filter the reconstructed signal, adjust the parameters at the ‘Post-filter’ panel on the lower right corner of the application and press the ‘Filter’ button. The result signal can be viewed upon checking the ‘Clean signal’ checkbox.

7. <u>Assessment tools</u>

   Use the scroll of the main graphical view to subjectively assess the quality of the result artifact-free signal. If needed, adjust parameters and repeat the removal process. Note that in case one of the steps was performed again (for example, the artifact removal step), then all the consecutive steps should be performed again as well (for example, the reconstruction and filtering steps), as they are not performed automatically by the SARGE.

   To further assess the quality of the signal, use the ‘Assess’ menu option and choose the required assessment tool. A separate window will be opened, in which the chosen assessment tool will be presented.

8. Exporting data and metadata

Following the completion of the artifact removal, the data and metadata can be exported for further use. The data include the artifact-free signal (exported as either a Matlab data file or a binary file), the stimulation pulses onsets and the FNP of all segments. The metadata include all the parameters used within the SARGE application during the removal process.

9. Parameters initialization file

Some of the parameters used in the SARGE can be initialized using the initialization file ‘ArtParm.m’. This file is called by the SARGE upon opening the application and parameters are initialized accordingly. Initialization parameters for the ‘Multiple segments’ window can be adjusted in the file ‘ArtSegParm.m’.