Detecting event bursts in Spike2 using Poisson Surprise

Spike2 contains routines that group events into bursts following simple rules based on spike separation, however this is not the only method.

If we model our event data as a background event rate (assumed to be a Poisson process) with higher frequency bursts of activity, and if we know the mean background event rate, we can ask the question of any sequence of events, “What is the chance of this set of events being part of the background Poisson process?”

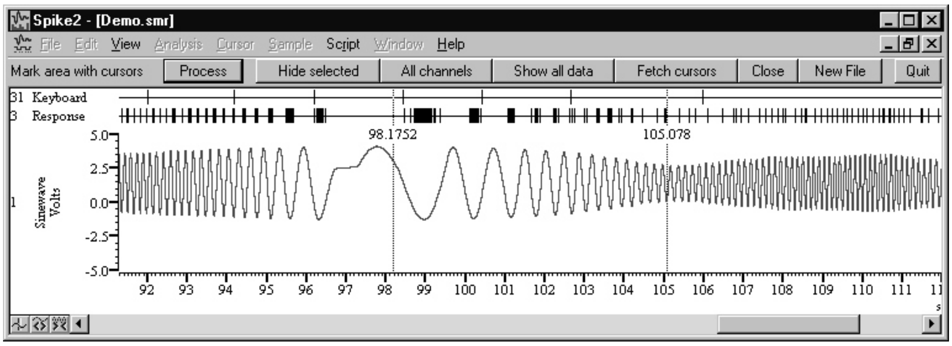
Given a calculable measure of the probability (Poisson Surprise - see the box below), and a threshold level above which a group of events is to be considered too unlikely to occur by chance, we can construct a list of regions where the events are unlikely to belong to the background process. In other words, a list of event bursts.

A Spike2 script that does this is available from our Web site (`surprise.s2s`). It works on any Spike2 data file holding channels of event data and will produce new channels showing the bursts and the Poisson Surprise values for each burst.

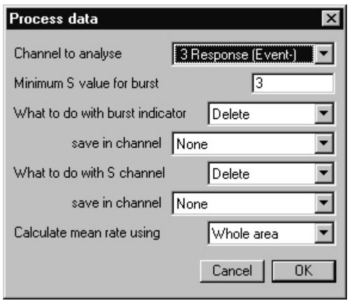
It turns out that the most difficult problem to solve from a script writer’s point of view is to calculate the Poisson Surprise value. The function is always in grave danger of mathematical overflow or underflow, leading to nonsensical results. Also, it takes a while to compute (summing a series to infinity can be time consuming). However, with a little mathematical *leger de main*, it is possible to write functions that do the job.

Using the script

When you run the script it checks in memory to see if a suitable file is present, otherwise you are prompted to choose a data file. Once you have a file open, you can select a channel and an area of the file to analyse. The toolbar lets you hide selected channels (click on the channel number to select a channel) or show



all channels in the data file. You can also zoom in and out either with the standard view controls or using the toolbar button to display the whole file. Place the cursors around the area of the file to process and then click the Process button.



The first field in the dialog sets the channel to analyse. The Minimum S value for burst field determines how unlikely a group of events must be when compared to the mean rate before they are considered a burst. A value between 3 and 10 is usually appropriate. The lower the value, the more bursts you will get.

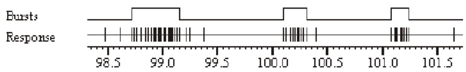
When the analysis is done, a level event channel is produced that marks the bursts. The What to do with burst indicator field sets how we treat this channel when we have finished the analysis. The three settings are: Delete, Keep in memory and Make permanent. If you choose to make it permanent, you must use the next field to set the channel in which to save the data.

The analysis also produces a RealMark channel that holds the calculated Surprise values for each burst. You can also choose what happens to this channel.

Finally you must choose the method to set the expected mean rate. You can choose between Whole area (the mean rate over the area to be processed), Select area (you can then select an area with the cursors), or User (you must type in a rate). If you type in a rate you are offered the mean event rate of the area to be analysed as a guide to a likely mean rate.

Output

Click the OK button and the data will be processed. This can take some time if you have selected a large number of events. A typical section of the output is shown below:



You can save the results to a text file if you wish. The first few lines of a typical output file are displayed below.

```
Poisson Surprise analysis of:
C:\SPIKE2\DATA\Demo.smr
Channel #:3, Title:Response
Created
Comment for file
      Time    Duration   n     S
  98.7141     0.43314   22  15.8
 100.0931     0.21624    9   6.0
 101.0806     0.15584    8   6.7
```

`Time` is the time of the first event in the burst, `Duration` is the burst length in seconds, `n` is the number of intervals in the burst (that is the number of events minus 1) and `S` is the Poisson Surprise factor for the burst.

Exactly the same type of analysis can be done with histograms and correlations (although the script does not contain the code for this).

This article was featured in the June 1998 CED Newsletter

Poisson processes and Poisson Surprise

A Poisson process is one in which the chance of finding an event in any time interval t is constant, or put another way, the probability of an interval t not containing an event is e^{-rt} where r is the mean event rate. The cumulative Poisson probability function gives us the probability that given a mean event rate r, a time interval t will contain n or more events, and this is given by P_n where:

$$P_n = e^{-rt} {}_{i=n} (rt)^i/i!$$

Given a P_n as calculated above, the Poisson Surprise is defined as $-\ln(P_n)$ where ln() is the natural logarithm function. The bigger the Surprise, the more unlikely it is that the event sequence would occur by chance. For example, a Surprise value of 3 is a 1 in 20 chance, and Surprises of 4, 5, 6 and 7 correspond to chances of 1 in 55, 148, 403 and 1097. You can find further details in Legéndy and Salcman, J. Neurophysiol. 53: 926-939, 1985.