Spike2

Life sciences data acquisition & analysis system

Data processing

Spike2 contains advanced features for processing waveform and timestamp data. Waveforms can be modified and information passed between channel types, for example marking times of detected waveform features or converting event data to waveform for analysis of frequency content.

Channel processes

A channel process is an operation applied dynamically to waveform data. Although the original data is not changed in any way, the user sees the processed data. Multiple processes can be applied and removed at any time.

- Processes include rectify, smooth, DC remove, slope, time shift, downsample, interpolate, match channel sample rate, median filter and RMS amplitude
- Apply processes on-line or off-line
- Duplicate channels for simultaneous display of raw and processed data

EMG data with duplicated channels showing rectification and smoothing
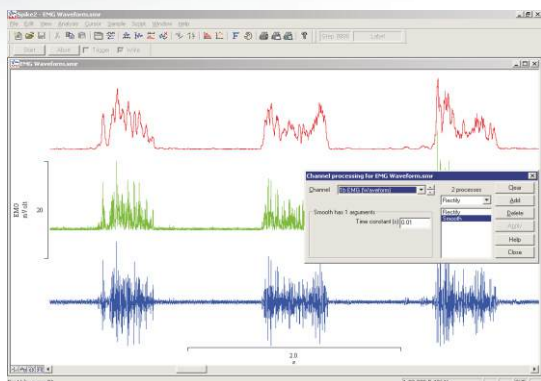
Virtual channels

Virtual channels hold waveforms calculated from existing channels, as defined by user-supplied expressions. Calculations can be simple sums, products, differences or ratios of channels, or use mathematical functions. Like channel processes, they are applied dynamically both on-line and off-line.

- Define data using arithmetic operations and values
- Manually enter expressions or create using drop down menus
- Display results of multi-channel waveform arithmetic
- Cubic spline interpolation used if channels have different sample rates
- Generate waveform display of event frequencies using smoothing by Gaussians, sinusoids, triangles or rectangles, or interpolation of instantaneous frequency
- Create evenly sampled data derived from unevenly sampled measurements
- Apply arithmetic functions e.g square, square root, cube, absolute values, half-wave rectification and trig functions (sin, cos, tan, arc tan)
- Waveform generation: sine, square, triangle, sawtooth, envelope

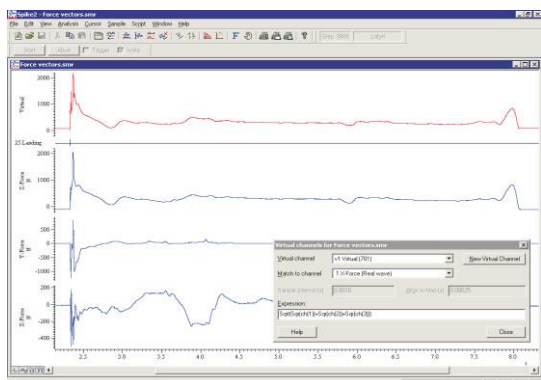*A virtual channel used to calculate the magnitude of 3 perpendicular forces*

Memory channels

Memory channels are temporary versions of any type of Spike2 data channel. The data they contain is held in computer memory for fast access and modification. The information held can be copies of channels, detected waveform features or user-entered information. These channels are lost when the file is closed down, but can be written permanently to the file at any time, if you wish to keep them.
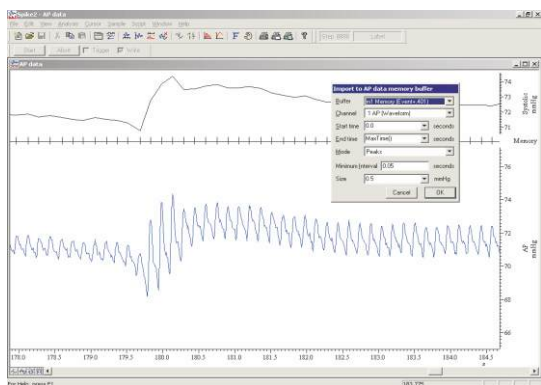
- Create up to 300 memory channels in a data file
- Import compatible data between channel types
- Import times of peaks, troughs or threshold crossings from waveform data
- Extract waveform sections based around markers and times
- Manually add and delete data
- Complete control available through the built-in script language

Import of arterial pressure peaks to memory channel

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Digital filtering

Digital FIR (Finite impulse response) and IIR (Infinite impulse response) filters can be applied to waveform data. Both types are set up using interactive dialogs with the following functions.

- View filter response and preview effect before applying filter
- Save and restore filters for later use
- Drag filter features or edit filter values

FIR filter types include high pass, low pass, band pass and band stop (1, 1 ½ and 2 bands) and differentiators with control of band edges and steepness of cutoff. FIR filters are unconditionally stable and impose no phase delay, so peaks and troughs do not move when data is filtered.

IIR filter types include notch and resonator filters plus low pass, high pass, band pass and band stop, modelled on Butterworth, Bessel and Chebyshev analogue filters. IIR filters allow steeper edges and narrower notches than FIR filters for the same computational effort.
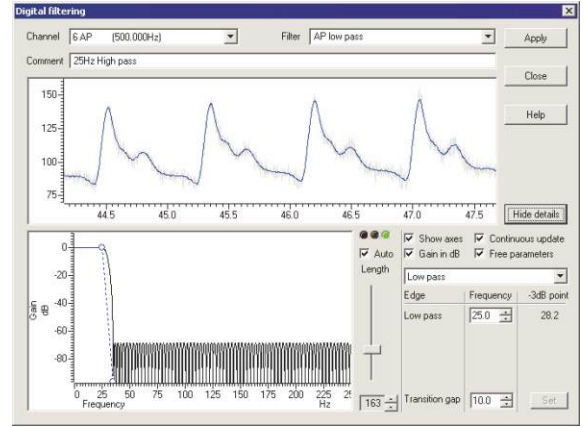
Digital FIR filtering
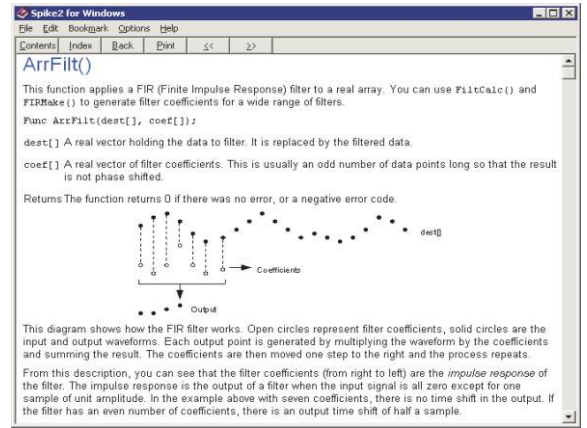
Data processing using the script language

As well as commands for implementing all the built-in data processing functions described above, the Spike2 script language has full access to the data as arrays of waveform values or marker times. Within the script language there are many commands and mathematical functions for use with arrays, matrices and individual values. Results may then be placed back into a data file, or to another type of view, or output for further analysis. Typical commands include:

|	
`ChanData()`	Fill an array with a waveform or event times
`ChanMeasure()`	Take specified measurements from a channel
`ArrFFT()`	Perform spectral analysis on result views, or data array
`ArrFilt()`	Applies a FIR filter to an array
`ArrSort()`	Sort an array and optionally order others in the same way
`ArrSpline()`	Interpolate one array to another using cubic splines
`MATDet()`	Calculate the determinant of a matrix
`MATSolve()`	Solve a set of linear equations
`MATTrans()`	Transpose a matrix
`PCA()`	Principal component analysis (singular value decomposition)
`Exp()`	Exponential function of a number or array
`Log()`	Logarithm to base 10 of a number or array

The script language also contains a function for converting events to waveform format. Although similar functionality is available through the use of virtual channels, the `EventToWaveform()` command gives the added benefit of allowing the resultant waveform to be smoothed with a user-defined shape which may be asymmetrical.

Example script command help page

CED hardware

On-line processing in Spike2 requires the data to be recorded using one of the 1401 family of laboratory interfaces. The 1401 and Spike2 system can capture data continuously whilst simultaneously processing and analysing this data as well as controlling the experiment and generating output stimuli.
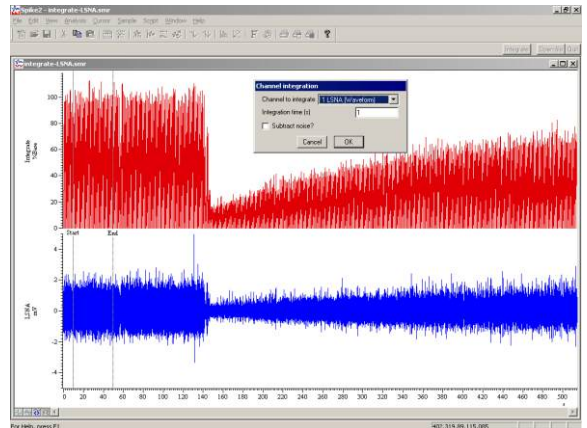
Script driven waveform processing. Integration of nerve activity normalised to baseline

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