

User manual for Delphos in AnyWave

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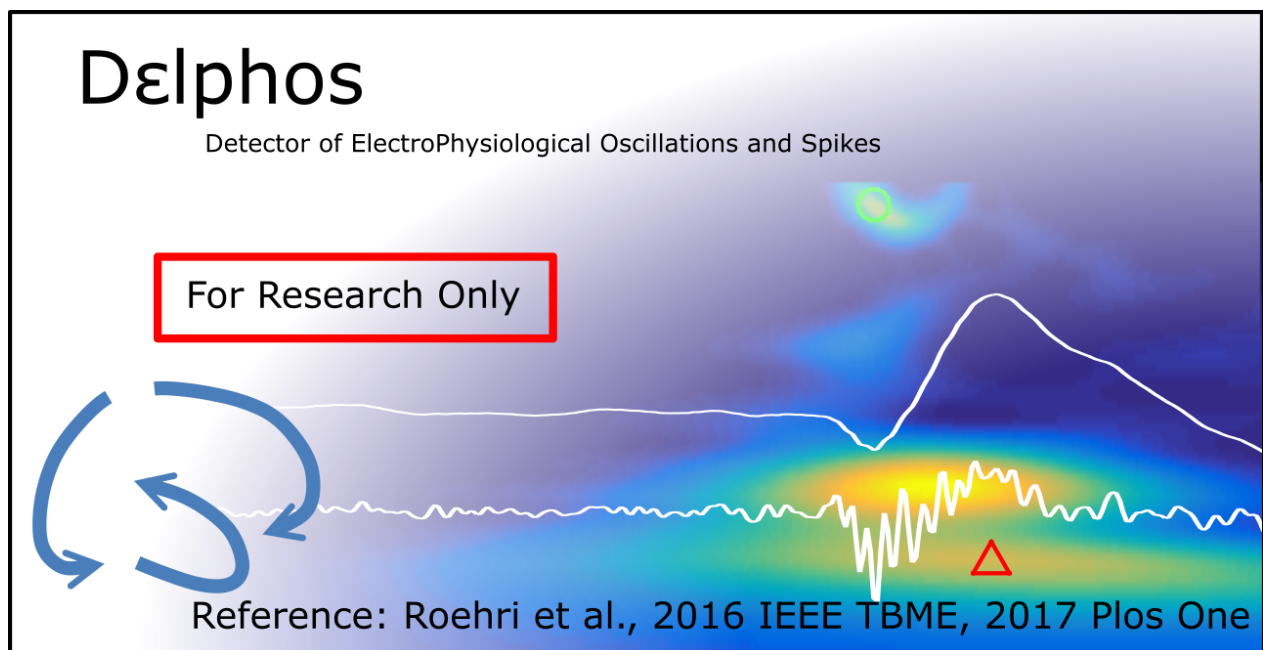


Figure 1: Delphos splash screen

1 Preamble

Delphos, standing for **D**etector of **E**lectro**P**hysiological **O**scillations and **S**pikes, is a detector based on the ZH0-normalization of the wavelet transform described in [Roehri et al., 2016]. As its name suggests, Delphos was designed to detect both oscillations and spikes. Moreover, because the detection happens in the time-frequency plane, the oscillations are not restrain to a frequency band. Two separate interfaces were developed: *Delphos* and *Delphos Viewer*, the multi-channel detection algorithm and the single channel re-viewer, respectively. This manual is for the Delphos 1.0.

Note that Delphos should be run on **stationary background** (e.g. not on seizure or transition from REM to NREM) and on **artefact free period** as muscle artefact increases the number of false detection. Also, it is recommended to re-reference the montage in bipolar.

2 How to cite

Please cite Delphos using [Roehri et al., 2016] for the method and [Roehri et al., 2017] for the validation.

3 Requirements

- Delphos.zip: Zip folder containing Delphos plugin and required components,
- MCR_R2018b_win64_installer.exe: Matlab Runtime Executable 2018b.

Delphos.zip must be unzip in C:\Documents\AnyWave\Plugins\Matlab\Delphos.

MCR_R2018b_win64_installer will install a Matlab engine to run compiled code such as Delphos.

4 Usage

1. From AnyWave, click on the **Process** tab and then on **Matlab** and finally on **Delphos** (Fig. 2).

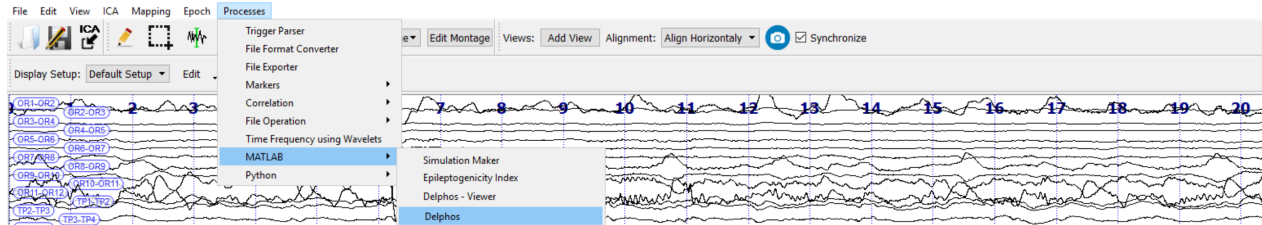


Figure 2: AnyWave Processes tab

Note that AnyWave continues running while Delphos is in use, this means AnyWave can be used normally and other calculations can be launched.

2. A splash screen (Fig. 1) pops up when AnyWave launches Delphos. The main interface (Fig. 3) should appear shortly after.

Contoured in red, you have a list of buttons to modify the parameters of the analysis.

- **Select Channel(s):** select channels from your preselection from AnyWave. By default, Delphos select all channels of either the previously selected lines/channels or the current montage.
- **Duration:** set the beginning and duration (in seconds) of the section to be analysed. By default, Delphos analyses 5 minutes (duration = 300s) – or the duration of the file if shorter than 5 minutes – starting from the beginning (start = 0s). To tell Delphos to analyse the whole section you have to set start at 0 and write *all* in duration.
- **Wavelet Settings:**
 - the number of voices corresponds to the resolution of the time-frequency plane (similar to the frequency step in linear scale but in log-scale). Lowering the number of voices speeds up the analysis but lower the sensitivity of the detection.
 - the vanishing moment controls the time and frequency resolution of the wavelet. The greater, the higher the frequency resolution but the lower the time resolution.
- **Detection Settings:**
 - Threshold corresponds to the level in the ZH0 time-frequency image separating the background from an event of interest. Default is set to 40.
 - Osc width thr is the lowest time width defining an *oscillation*,
 - Osc freq spread thr is the highest frequency spread defining an *oscillation*,
 - Spk width thr is the highest time width defining a *spike*,
 - Spk freq spread is the lowest frequency spread defining a *spike*,

Fig. 4 illustrates the time width ratio and the frequency spread.

The default settings correspond to the ones which were validated and used in [Roehri et al., 2017, Roehri et al., 2018], respectively.

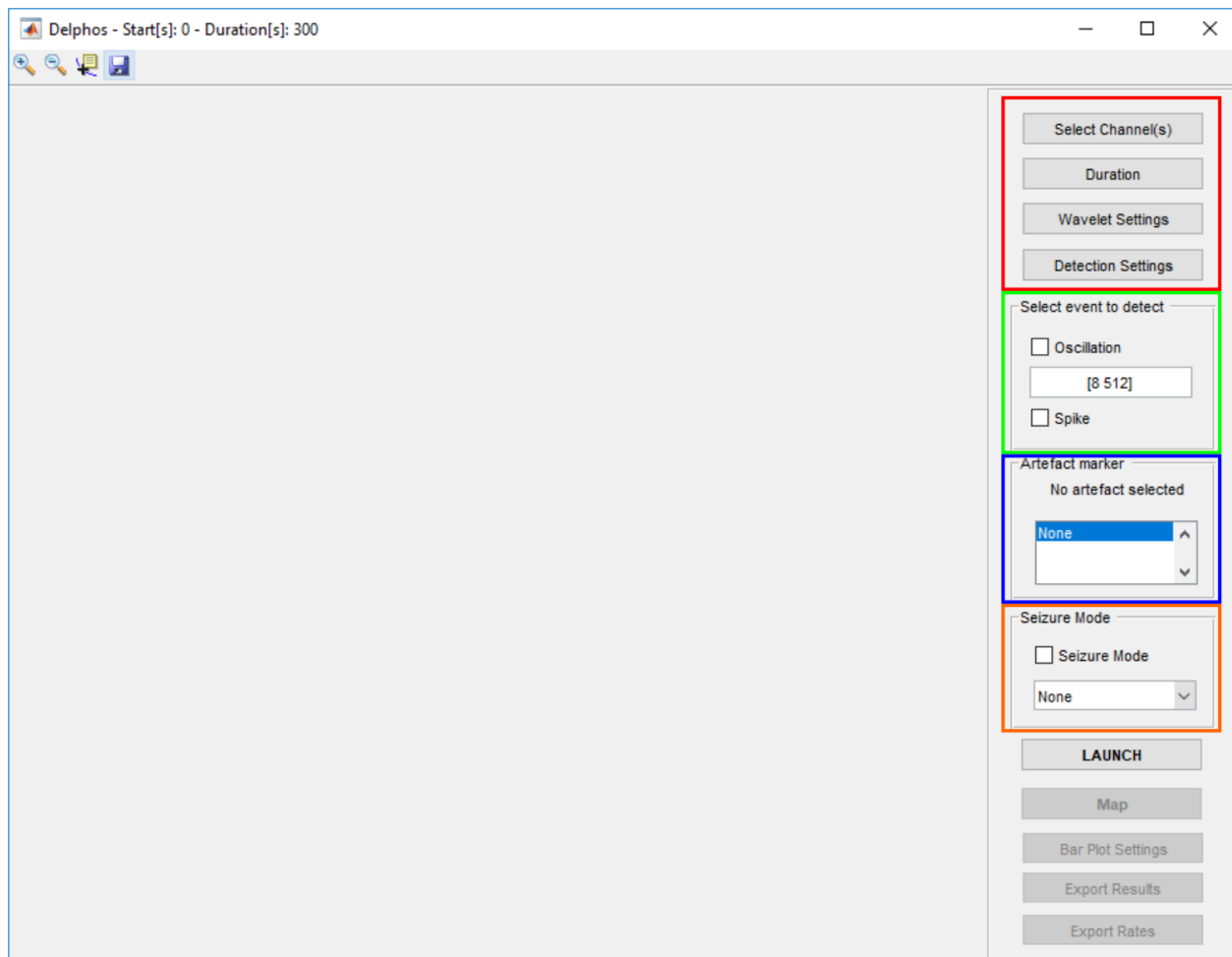


Figure 3: Delphos main interface

From the panel contoured in green, you can choose the type of events you want to detect and the limits of the frequency band for the oscillations. In the installation folder of Delphos (C:\Documents\AnyWave\Plugins\Matlab\Delphos), there is a file named *default_freqband.txt* where default settings of the oscillations markers are set (label, color and frequency bands) in a semicolon separated file. The first column corresponds to the label of the oscillation, the second and third columns to its lower and higher limits of its frequency band respectively, and the last column to the color of the

marker in hexadecimal. An example is given below:

```
%Oscillation name;lower frequency;higher frequency
Very Fast Osc;500;Inf;#ff00ff
Fast Ripple;250;500;#ff0000
Ripple;80;250;#ff8000
Gamma;24;80;#800000
Beta;12.4;24;#00b000
Alpha;7.4;12.4;#00b0b0
Theta;3.5;7.4;#0070ff
Delta;1;3.5;#0000ff
Infra slow;0;1;#000090
```

The *Artefact marker* panel in blue gives you the possibility to select *Global Markers* from AnyWave as artefact markers. Delphos will skip the sections corresponding to these markers.

The *Seizure Mode* panel in orange enables you to detect events of interest during seizures. To do so, you have to check the *Seizure Mode* box and select a *Global Marker* from AnyWave targeting a seizure. Delphos uses 60s- baseline prior to the marker onset to normalised the ictal time-frequency.

3. Once all the parameters have been set press **LAUNCH**. A bar progress will pop up reading consecutively *Initializing Parallel Computing*, *Detection on chunk 1/n* and *Sending markers to AnyWave*. Finally, a bar plot of the rate of the detected events is displayed on Delphos' main interface (Fig. 5) and the markers appears in AnyWave.

The button **Bar plot settings** is now active and allows you to modify the frequency band of the oscillation rate you want to display. To change the bands, you have to give the limit of the bands of interest

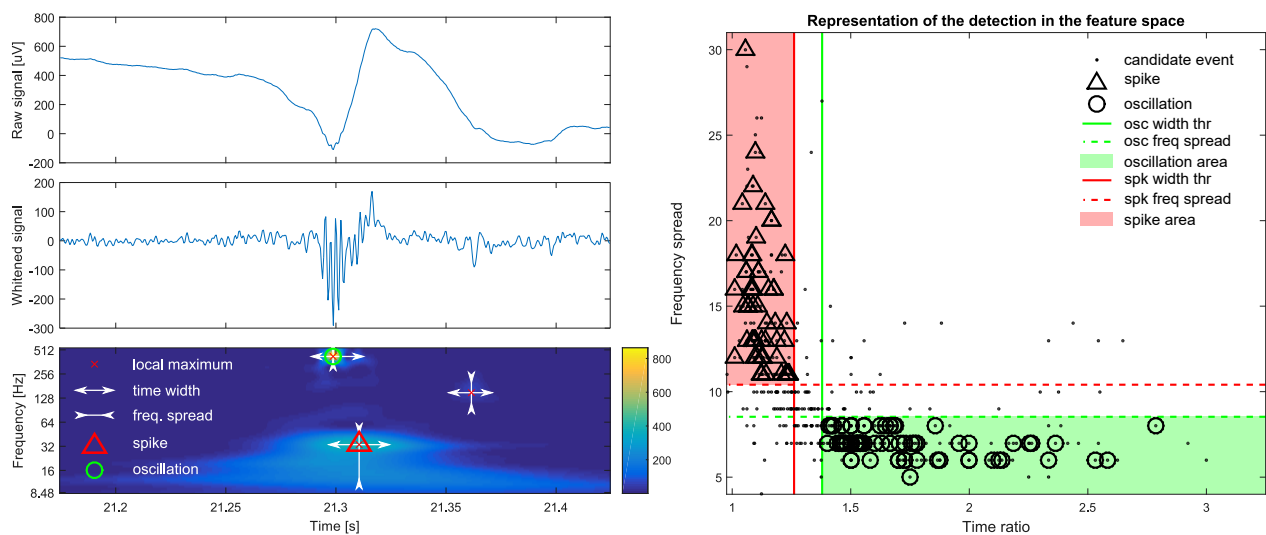


Figure 4: Right panel: Example of a fast ripple occurring during a spike. Left panel: Feature space used to differentiate oscillations (high time width ratio, low frequency spread) and sharp transients (low time width ratio, high frequency spread).

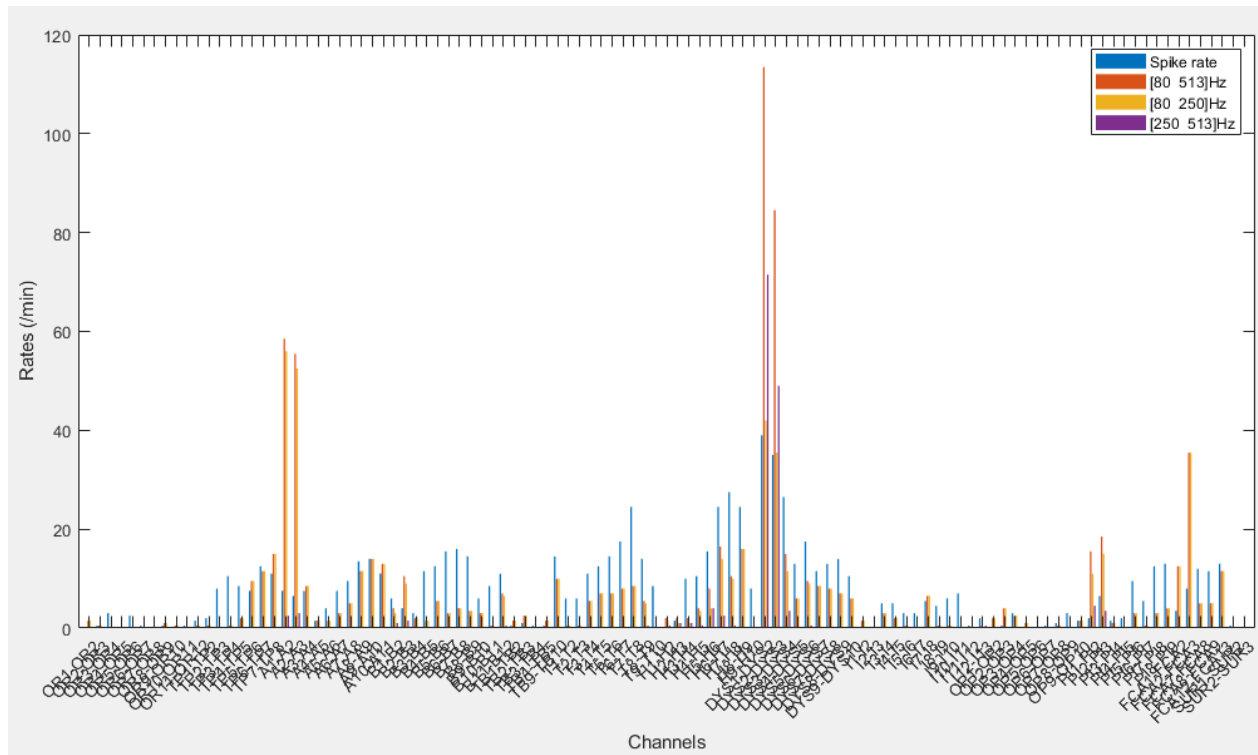


Figure 5: Bar plot showing the rates of the different markers for each channels. In the interface, there is also a second panel showing the cross-rate from [Roehri et al., 2018], i.e. the square root of the geometric mean of the rate of the spikes and the rate of any oscillation rate.

in bracket and separated by a semi-colon (e.g. [10 18; 30 80; 80 500])

The button **Map** is also active and permits you to visualise the occurrence of the markers over time for all channels (Fig. 6). You can modify the output by changing:

- the window width which is used to smooth the image,
 - the decimation factor which reduce the time resolution,
 - the frequency of interest (as above in bracket, e.g. [80 250] to see the occurrence of ripples).
4. You can save the results in either a Matlab file or an Excel file. The Matlab contains all information concerning the detected events. The Excel file stores the rates and counts of the markers (controlled by **Bar plot settings**) and information about the parameter used.
 5. Once you have finished, you can close Delphos. You have to click **Ok** in the External Calculation window (Fig. 2) to see the detections as markers in AnyWave interface.

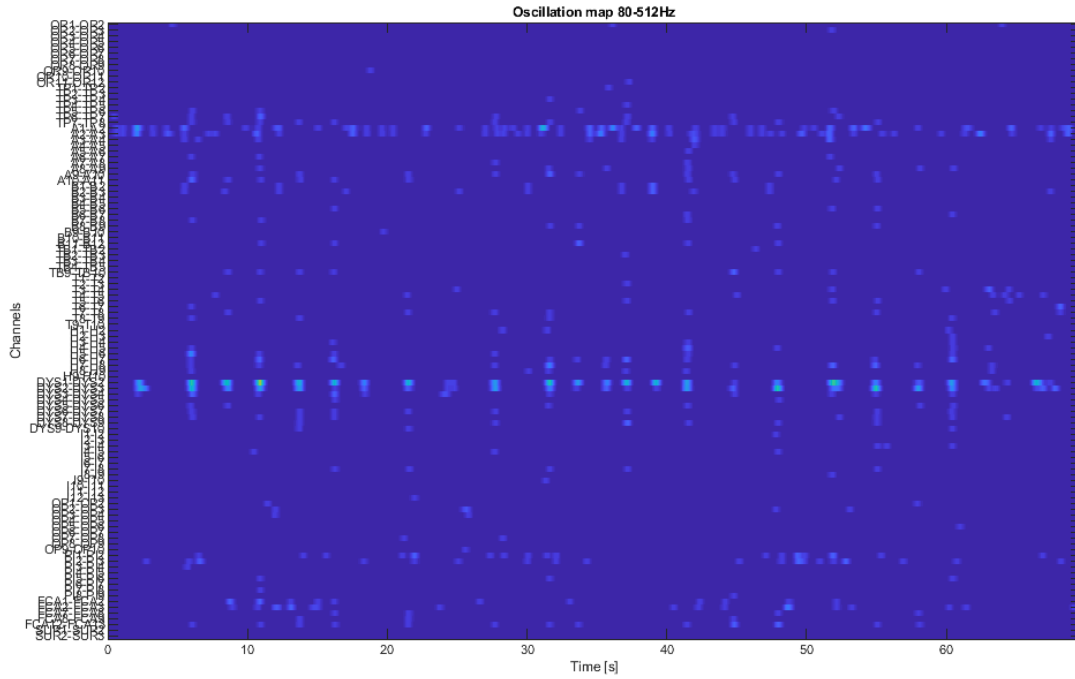


Figure 6: Map of the detection over time (in case of a focal cortical dysplasia).

References

- [Roehri et al., 2016] Roehri, N., Lina, J.-M., Mosher, J. C., Bartolomei, F., and Bénar, C.-G. (2016). Time-frequency strategies for increasing high frequency oscillation detectability in intracerebral. *IEEE Transactions on Biomedical Engineering*, 63(12):2595–2606.
- [Roehri et al., 2017] Roehri, N., Pizzo, F., Bartolomei, F., Wendling, F., and Bénar, C.-G. (2017). What are the assets and weaknesses of HFO detectors? A benchmark framework based on realistic simulations. *PLoS ONE*, 12(4).
- [Roehri et al., 2018] Roehri, N., Pizzo, F., Lagarde, S., Lambert, I., Nica, A., McGonigal, A., Giusiano, B., Bartolomei, F., and Bénar, C.-G. (2018). High-frequency oscillations are not better biomarkers of epileptogenic tissues than spikes. *Annals of Neurology*, 83:84–97.