encevis

AUSTRIAN INSTITUTE OF TECHNOLOGY

Software Manual

encevis 1.8

© AIT Austrian Institute of Technology
Document ID: 1906041515

Errors and omissions excepted

Manufacturer:
AIT - Austrian Institute of Technology GmbH;
Giefinggasse 4; 1210 Vienna; Austria
Date of manufacture: 2019

Notified Body:
DQS Medizinprodukte GmbH; August-Schanz-Straße 2; 60433 Frankfurt am Main; Germany

Caution:
Please read paragraphs marked with this symbol carefully as they contain important safety information.

Issuing date of this document:
2019-06-04

Contents

Warnings and precautions 5
Contraindications 6
Possible adverse effects 6
Quick Start Guide 7
Installation 8
License activation 9
Open EEG file(s) in 5 steps 10
Review EEG 11
Start automatic EEG analysis 12
EpiSpike 13
NeuroTrend 14
encevis EEG viewer 15
Overview 15
Initial configuration 16
Open EEG 17
View EEG 25
Montage editor 31
Markers 39
Settings 43
PureEEG 48
Overview 48
Description of the algorithm methods 49
Using PureEEG 49
EpiScan 50
Overview 50
Description of the algorithm methods 52
EpiSpike 54
Overview 54
Description of the algorithm methods 55
Starting EpiSpike 55
EpiSpike – User Interface 58

© AIT Austrian Institute of Technology

NeuroTrend 62
Overview 62
Description of the algorithm methods 63
Using NeuroTrend 67
NeuroTrend User Interface 67
Navigating in NeuroTrend 73
Distributor 77
Overview 77
Moberg Interface 78
Overview 78

Warnings and precautions

⚠	The modules from encevis for the automatic analysis of EEG cannot replace the examination by the physician. As for any other automatic procedure, there can be inaccuracies during the analysis with encevis. The original EEG still needs to be used for the evaluation and the results of encevis need to be confirmed based on the unaltered raw EEG trace. encevis does not provide any diagnosis or diagnostic recommendation, conclusion or prediction of the patient's state. It remains the responsibility of the physician to decide over the diagnosis or to induce treatment. The use of the software cannot replace the real-time surveillance by medical staff particularly of the vital functions. The patient's safety remains the responsibility of the staff.
⚠	The maximum length for one continuous EEG recording that can be analyzed with encevis is 10 days. If a recording is longer than 10 days encevis will stop processing.
⚠	The EEG-data should be recorded at least with the complete 10/20 set of scalp electrodes.
⚠	encevis PureEEG does not remove all interference and reduces only interference coming from EMG and electrode artifacts. encevis PureEEG can change areas of the EEG that show cerebral activity. PureEEG works only with electrodes from the 10/20 system and additional T1-, T2-, SP1- and SP2-electrodes.
⚠	encevis EpiScan cannot be used as an alarm system, since there may be a delay of several minutes between the clinical onset of a seizure and the display of the detected pattern. Some EEG-events with epileptic seizures that have an electrographic correlate might be missed. For this reason, encevis EpiScan can only support but cannot replace the qualified expert in the real-time monitoring.
⚠	Some EEG-events where spikes occur might not be detected with encevis EpiSpike. The detection of such events with the spike detection encevis EpiSpike cannot replace the analysis by a qualified expert.
⚠	encevis NeuroTrend should not be used as an alarm system, since the visualization of patterns could be delayed by up to several minutes. Some events, where patterns defined in the Standardized Critical Care EEG Terminology of the American Clinical Neurophysiology Society including Burst Suppression Detection

© AIT Austrian Institute of Technology

	are visible in the EEG, might be missed. It can happen that the localization of patterns is not correct. All measures of the module encevis NeuroTrend must be evaluated in combination with the original raw EEG and must not be the only basis for a diagnosis, treatment or change of treatment.

Contraindications

There are no known contraindications for the use of encevis.

Possible adverse effects

There are no known possible adverse effects when using encevis.

encevis

AUSTRIAN INSTITUTE OF TECHNOLOGY

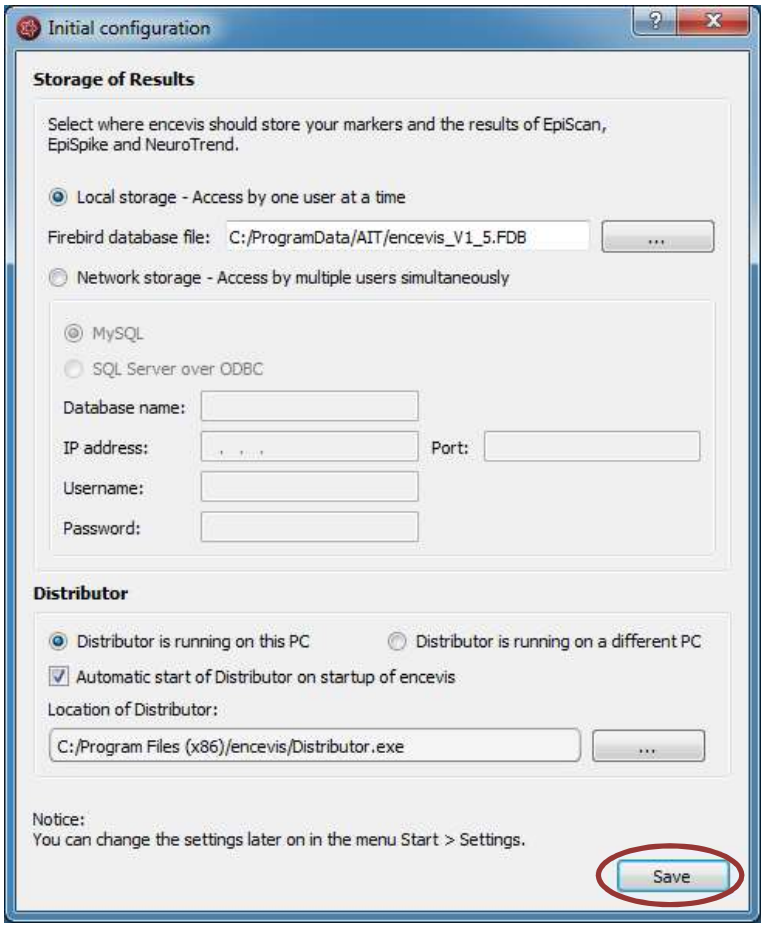
Quick Start Guide

© AIT Austrian Institute of Technology

Installation

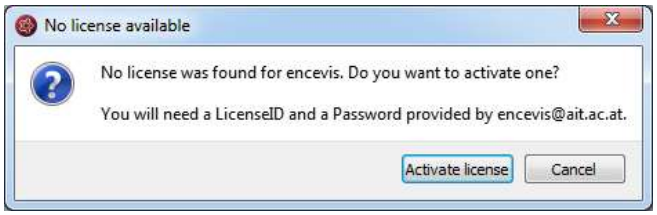
Once you have downloaded **encevis**, continue with the following steps:

1. Start the **encevisInstaller**, this will guide you through the installation process.
2. Start **encevis**.
3. The initial configuration window will pop up.
4. Press "**Save**", to keep the default settings.

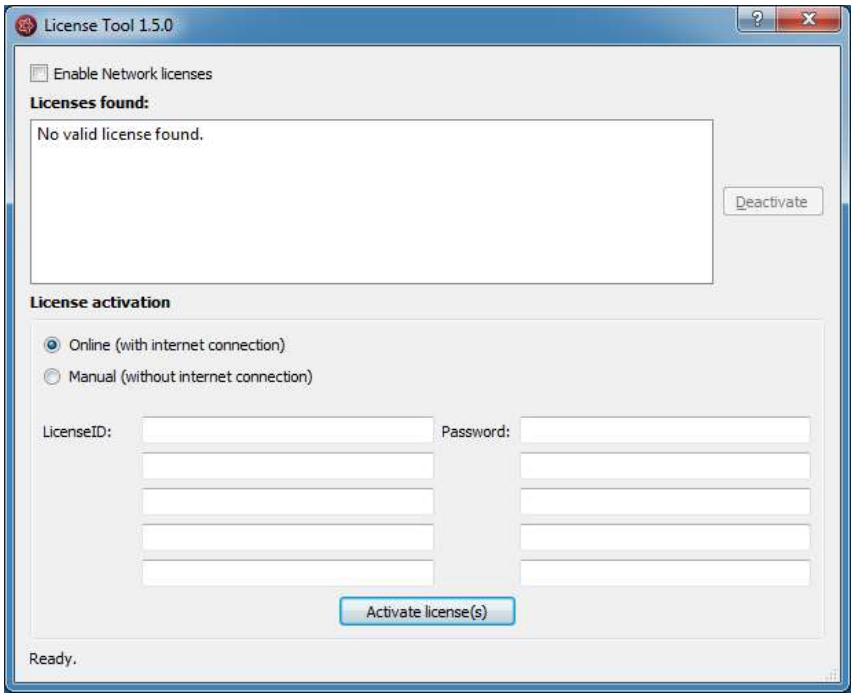


License activation

1. Start **encevis**.
2. Press the button “**Open EEG**”, the following window will pop up:

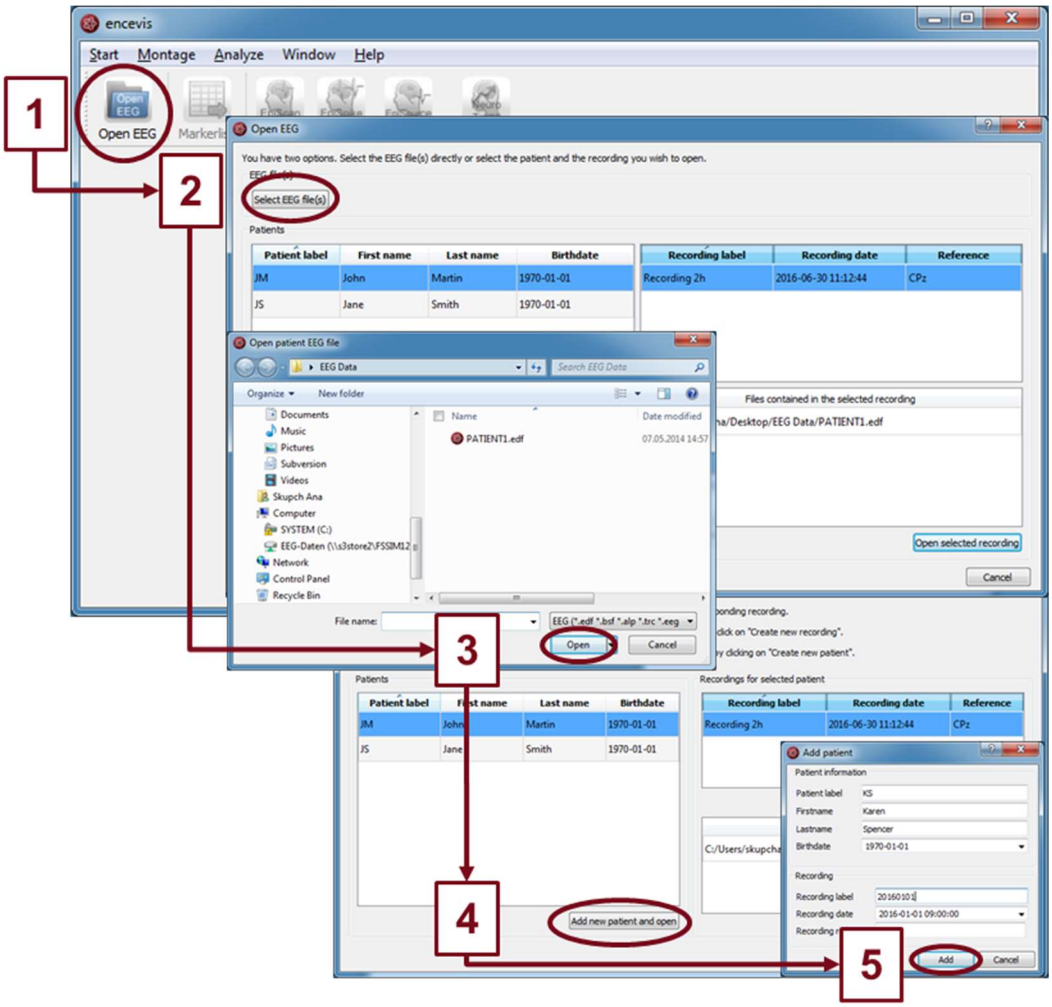


3. Press “**Activate license”**, the License Tool will pop up.



4. If you are connected to the internet, select „**Online**“ as activation mode. Otherwise, select “**Manual**” and contact your distributor in order to get the keys for the manual activation.
5. Enter the LicenseID and Password.
6. Press ”**Activate license(s)**“.

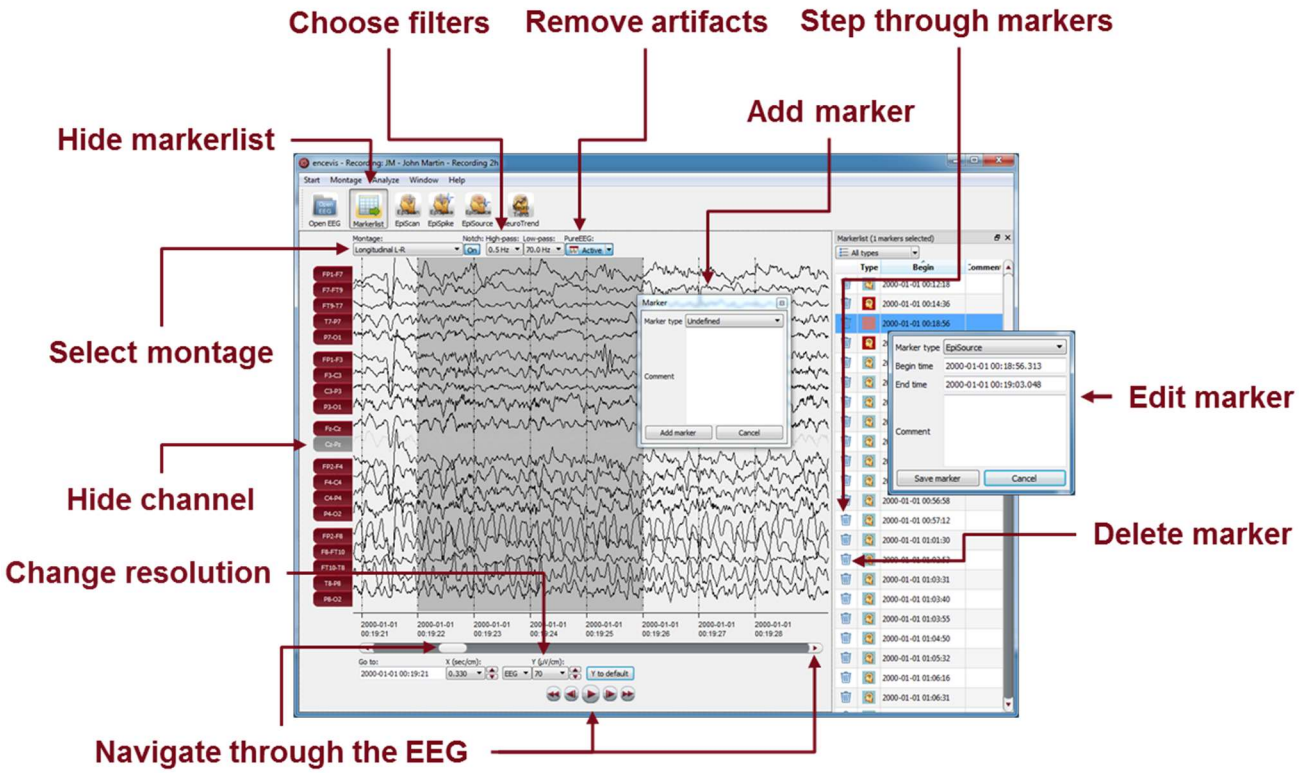
Open EEG file(s) in 5 steps



1. Press “**Open EEG**” or select the menu point **Start > Open EEG.**
2. Press “**Select EEG file(s)**”
3. Select the EEG file(s) that you would like to open.
4. If the file(s) are already registered in the EEG file management they will be opened immediately, otherwise a window will pop up. There, Press "**Add new patient and open**", a new window will pop up.
5. Fill in the fields of the "Patient information". Fill in the recording label and the recording date and the reference used for the EEG recording. Press "**Add**".

© AIT Austrian Institute of Technology

Review EEG

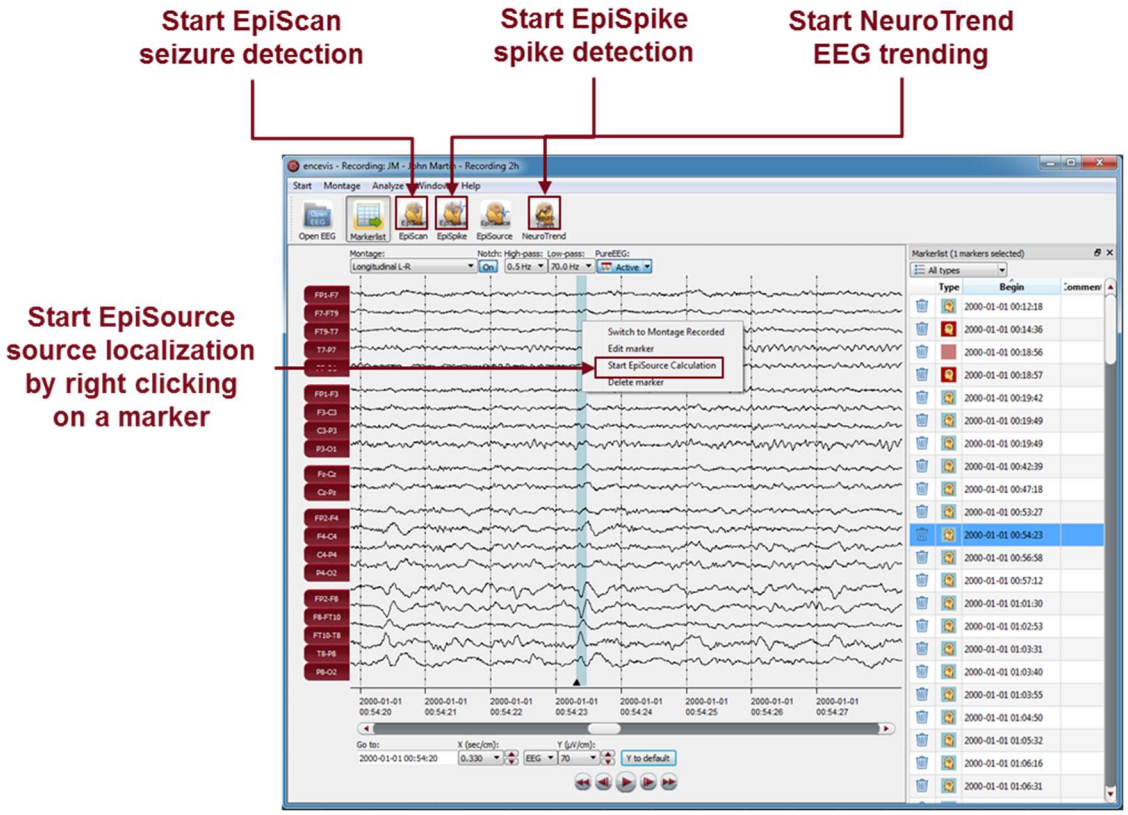


You have now the possibility to use all functionalities of encevis:

- Navigate easily through the EEG.
- Remove artefacts with PureEEG.
- Change the settings of the channels by selecting a montage and hide channels.
- Change the resolution in time and in voltage.
- Select notch, high-pass and low-pass filters.
- Watch the EEG in two windows at the same time.
- Create, review and change markers for special EEG events.
- Markers are saved with the data in the marker list and can be reviewed anytime.
- Start automatic EEG analysis.

© AIT Austrian Institute of Technology

Start automatic EEG analysis

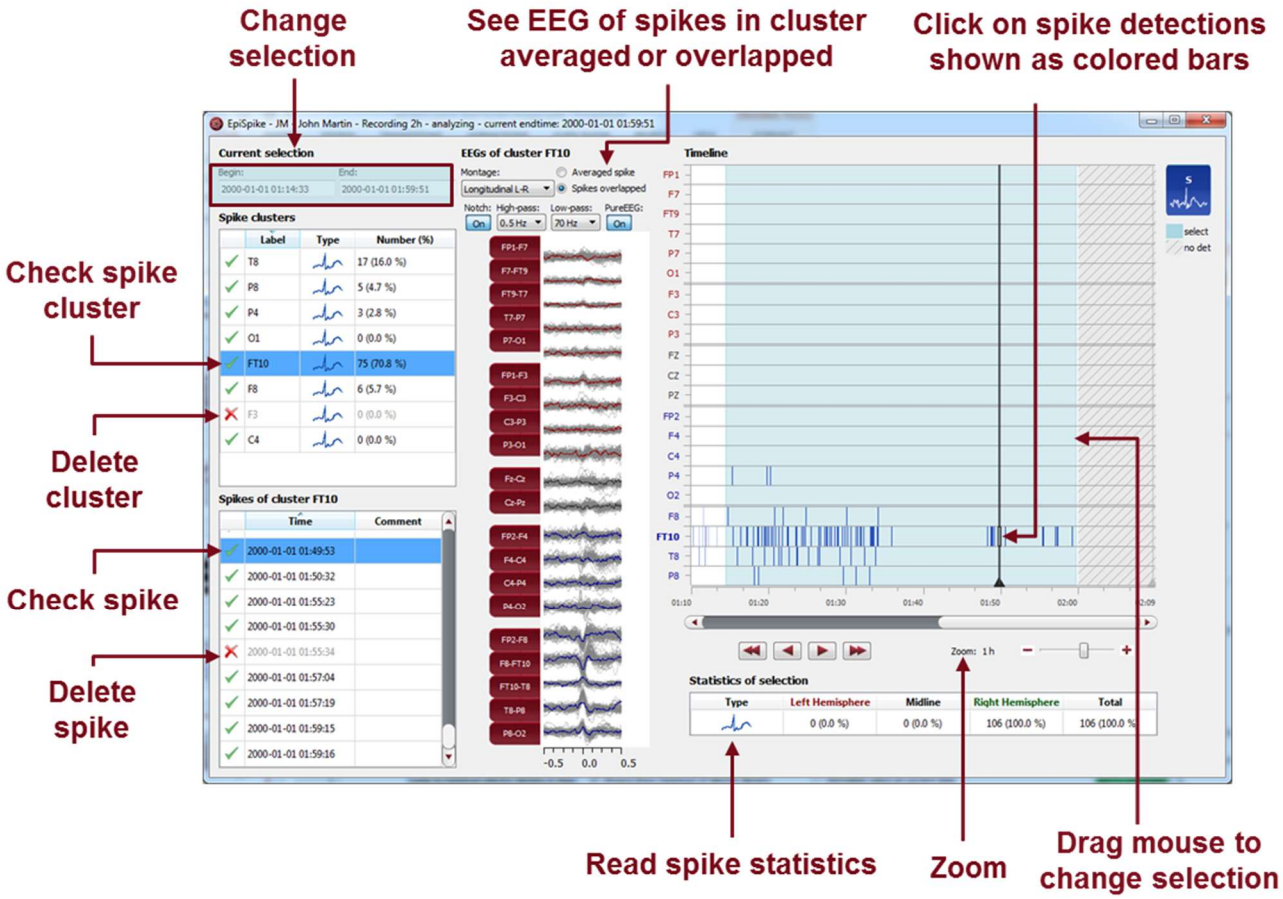


encevis offers you a series of automatic EEG analysis tools:

- EpiScan: the automatic seizure detection generates markers that you can easily review with the marker list.
- EpiSpike: the automatic spike detection detects spikes, clusters them by localization and visualizes the results for easy review.
- EpiSource: you can easily start the source localization on markers inserted manually or automatically. EpiSource has its own easy to use display.
- NeuroTrend: the advanced EEG trending calculates automatic detection of patterns, qEEG, aEEG, the heart rate based on ECG and visualizes the results on a single screen.

© AIT Austrian Institute of Technology

EpiSpike

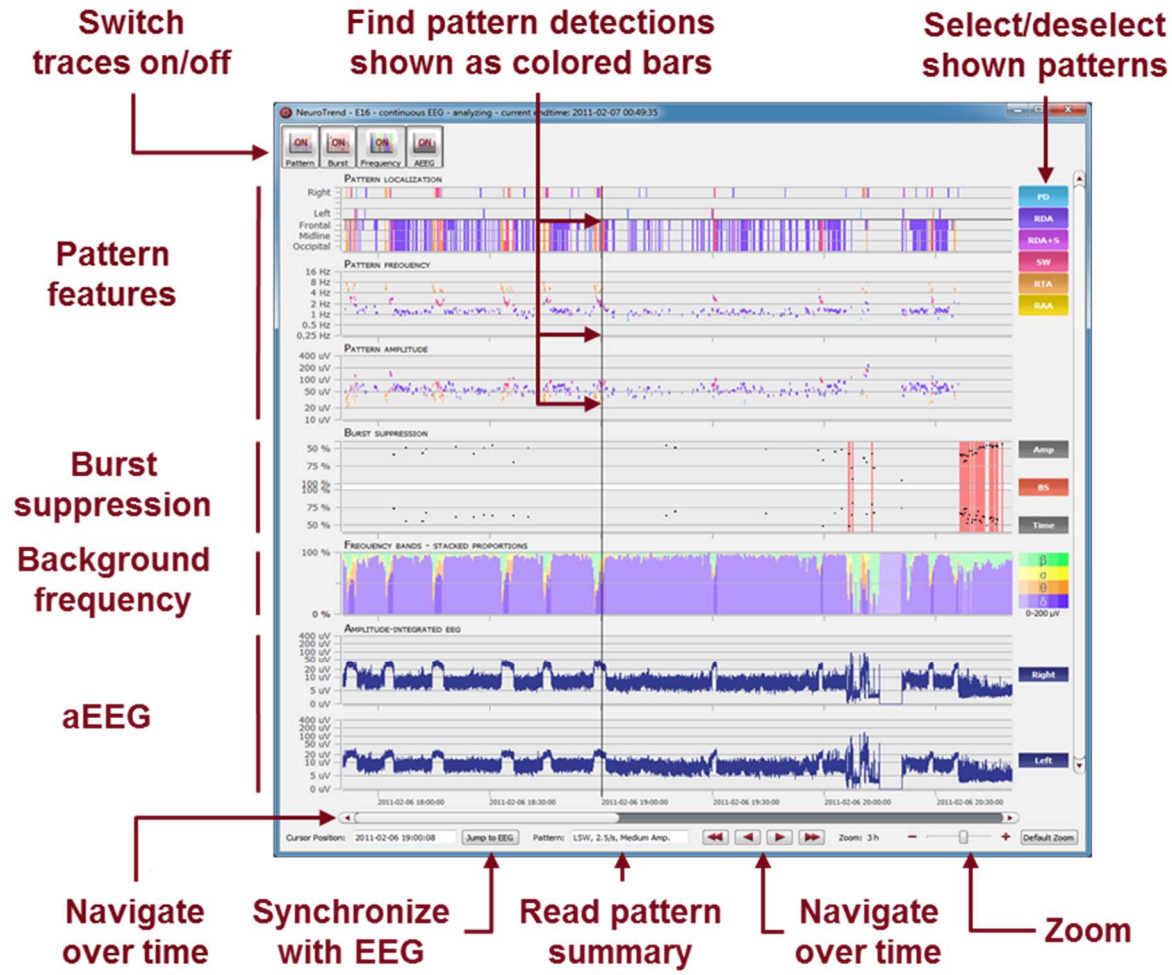


Start EpiSpike and use all its functionalities:

- Start the detection on the complete time range or specify a time segment you are particularly interested in.
- Find the spike detections on a timeline as blue bars clustered and arranged by their localization.
- Zoom in and zoom out of the timeline using the mouse wheel.
- Click on a detection to see its EEG and find it in the spike list.
- Choose if you want to see the average spike EEG of the cluster or all spikes overlapped.
- Go through the lists of spike clusters and their spikes and remove detections you do not want.
- Change time of selection for review and statistics.
- Synchronize with the EEG in the EEG viewer.

© AIT Austrian Institute of Technology

NeuroTrend



Start NeuroTrend and use all its functionalities:

- Find color coded detections of six different patterns.
- Read localization, frequency and amplitude of the detected patterns.
- Find burst suppressions and attenuations.
- See the amplitude-integrated EEG and the proportion of the frequencies as continuous measures.
- Navigate in time.
- Zoom in and zoom out using the mouse wheel.
- Synchronize with the EEG shown in the encevis viewer.
- Select or deselect patterns that you want to have shown or hidden.
- Switch on/off the traces you want to have displayed.

© AIT Austrian Institute of Technology

encevis EEG viewer

Overview

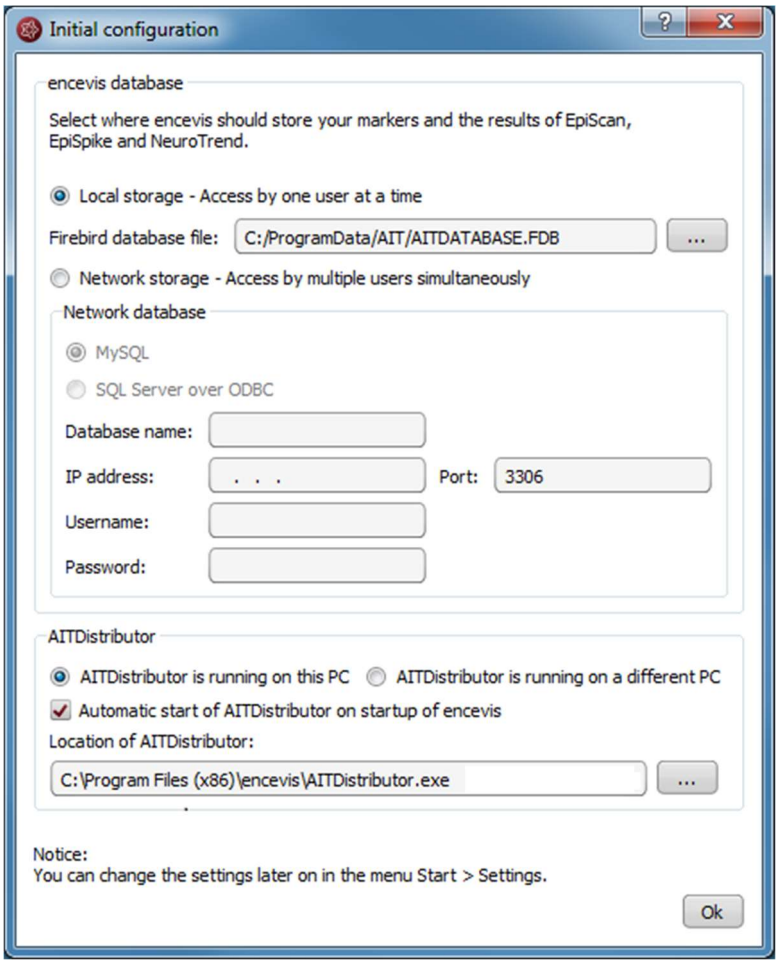
The encevis EEG viewer enables you to view your patients' EEG. It also helps you to have an overview of all your patients, their EEG recordings and the EEG files that correspond to them.

For more details on how to use the encevis EEG viewer see the following sections: Open EEG,

© AIT Austrian Institute of Technology

Initial configuration

The first time you use encevis, you have the possibility to decide in which mode you want to use it.



encevis database

encevis stores your markers and the results of EpiScan, EpiSpike and NeuroTrend in one database. Select where encevis should store it:

Local storage - Access by one user at a time:

This is the best mode, when the results of your review with encevis should only be accessed from your PC. Only one user at a time can then access the results. You can leave the file name specified by default or select a personalized name.

Network storage - Access by multiple users simultaneously:

This is the best mode, when you want to access the results of your review with encevis from several PCs in your network. With this option several users can access the results at the same time. In this case, you need to specify a database where everybody has access to. It can be a MySQL database or a SQL server over ODBC.

© AIT Austrian Institute of Technology

Distributor

Select if the Distributor should run on your PC or on a different one. If the Distributor is running on another PC, you need to specify IP address and Port.

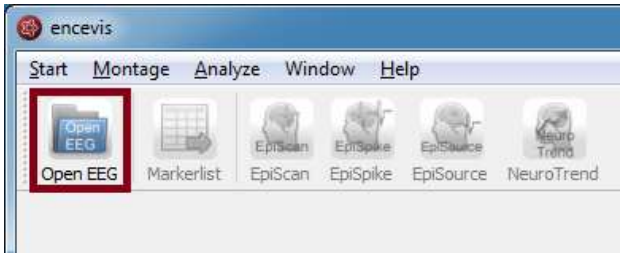
→ For more details, see section

→ Distributor.

These settings can be changed anytime under the sections *encevis database* and *Distributor* in the menu point *Start* > *Settings*. Whenever you change these settings, you need to restart encevis.

Open EEG

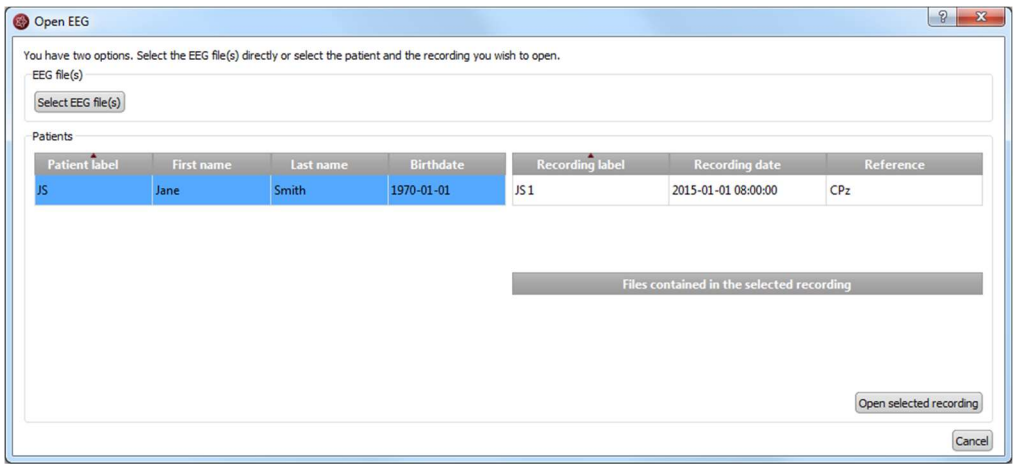
Click on the icon "Open EEG"



The “Open EEG dialogue” will open and show you the contents of the EEG File Management. The EEG File Management includes all the EEG files organized by recording and patient.

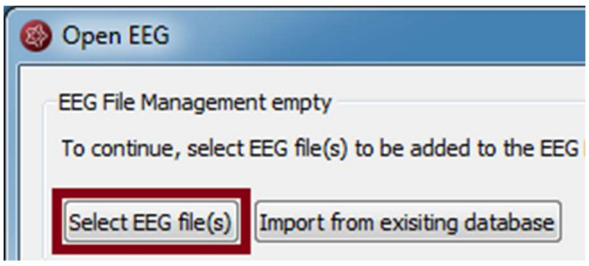
To open the EEG you want to review, you have two possibilities:

- Select EEG file(s) directly or
- Select an entry in the EEG File Management



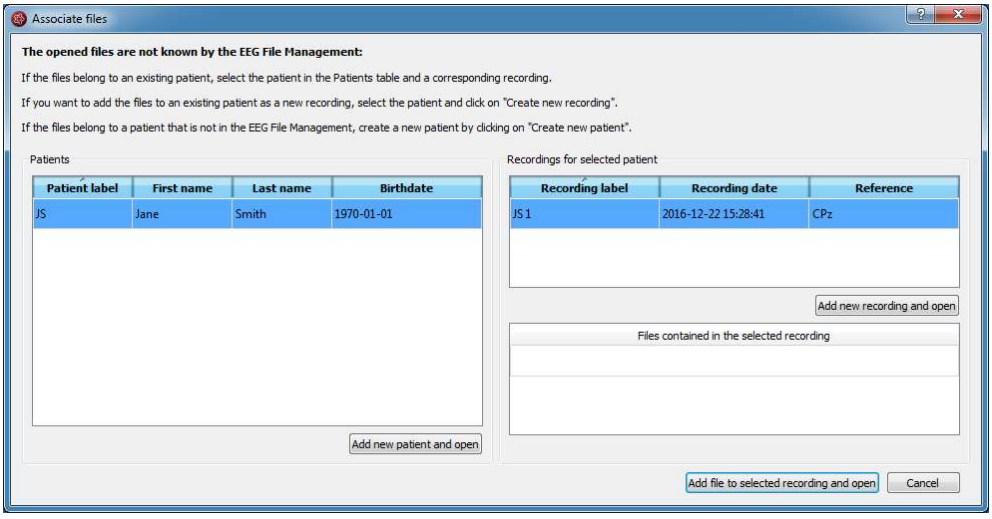
Select EEG file(s)

EEGs are stored in one or several EEG files as EEG recordings. If you want to open EEG files, click on the button “Select EEG file(s)”.



You may now select the EEG files.

- If the file(s) are already registered in the EEG File Management, they will be opened immediately.
- Otherwise, you will need to add them to the EEG File Management. In this case, the following window will open:

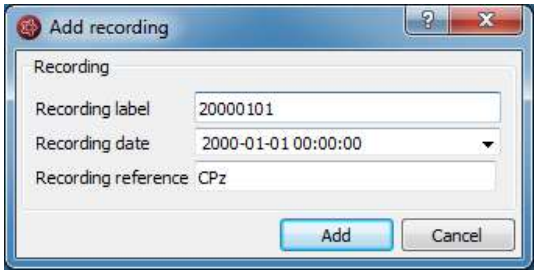


Add the file(s) to an existing recording:

1. Select the patient in the Patients list and the corresponding recording.
2. Click on "Add file to selected Recording and open".

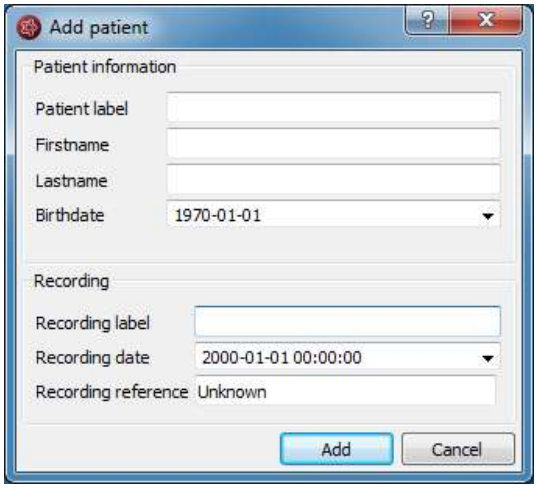
Add the file(s) to an existing patient as a new recording:

1. Select the patient in the Patient list.
2. Click on "Add new recording and open".
3. Fill in the recording label, date and reference.
4. Click on "Add".



Add the file(s) to a new patient:

1. Click on "Add new patient and open".



2. Fill in the fields of the "Patient information".
3. Fill in the recording label, date and reference.
4. Click on "Add".

EEG File Management

All information about the patients' EEG recordings and EEG files is stored in the EEG File Management. You can change the data in the EEG File Management anytime. For this, open the EEG File Management by selecting the menu point *Start > EEG File-Management*

You can easily change the entries by double clicking on the field you want to change.

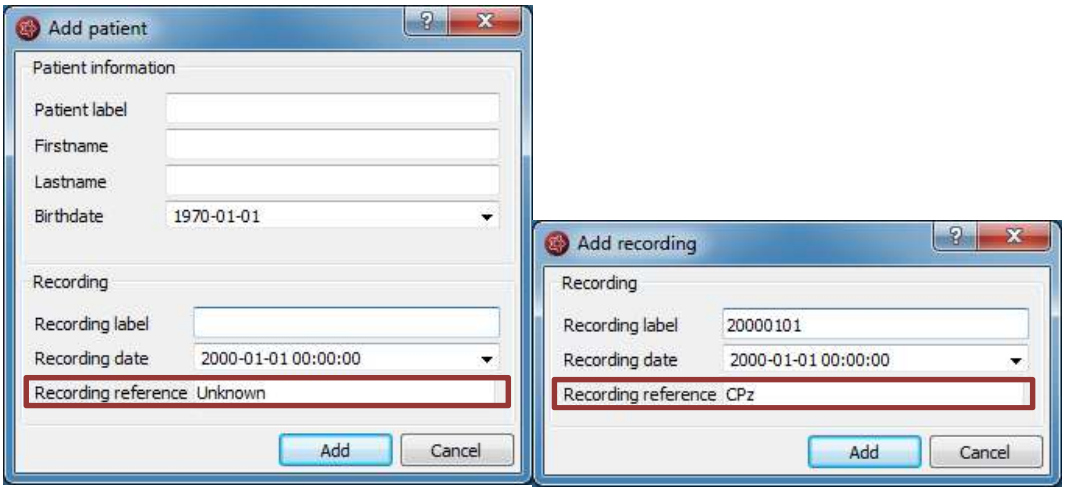
For more information on how to add patient and recording information, see the following chapters:

- Specify reference electrode
- Add a patient
- Add a recording
- Add file(s)

Specify reference electrode

- The location of the reference electrode that was used during the recording of the EEG (*Recording reference*) is used by several encevis components as PureEEG, EpiSpike and NeuroTrend. For the optimal functioning of these tools, it is recommended to fill out the reference correctly.

  You have the possibility to fill out this information in the process of opening the EEG (see Select EEG File(s), Add a patient and Add a recording).

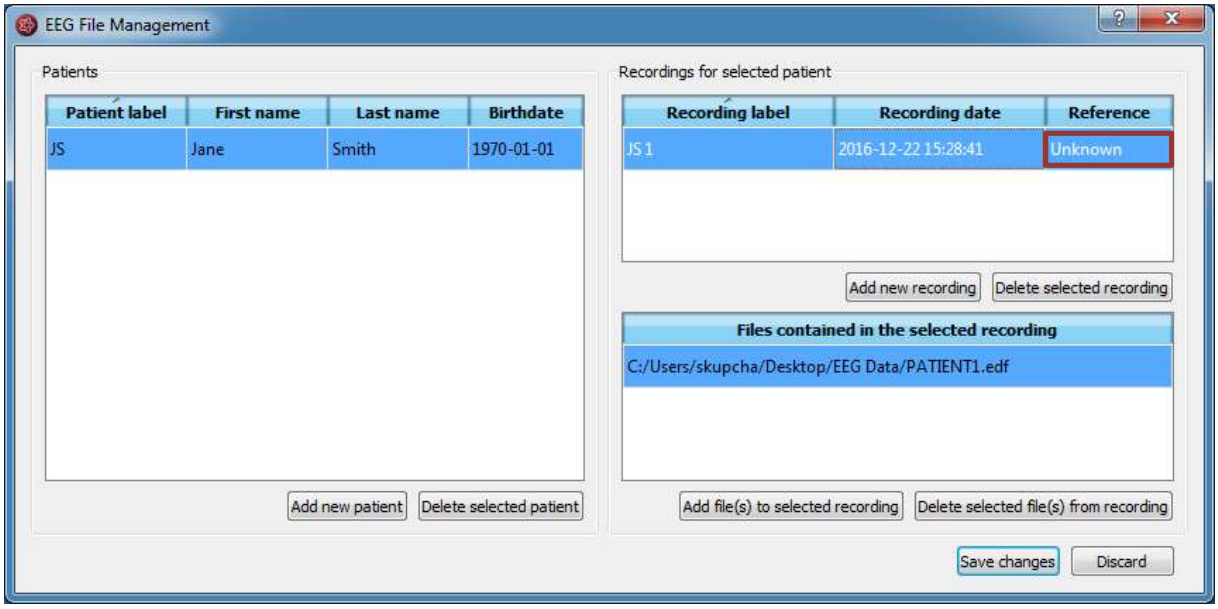


When the reference is stored in the file, encevis reads it out automatically and writes it in the field "Recording reference".

When the reference is not stored in the file, encevis writes "Unknown". You have then the possibility to correct this if you know the location. For this, type in an electrode label from the 10-20 standard.

→ If you don't have the information about the reference, leave it as "Unknown".

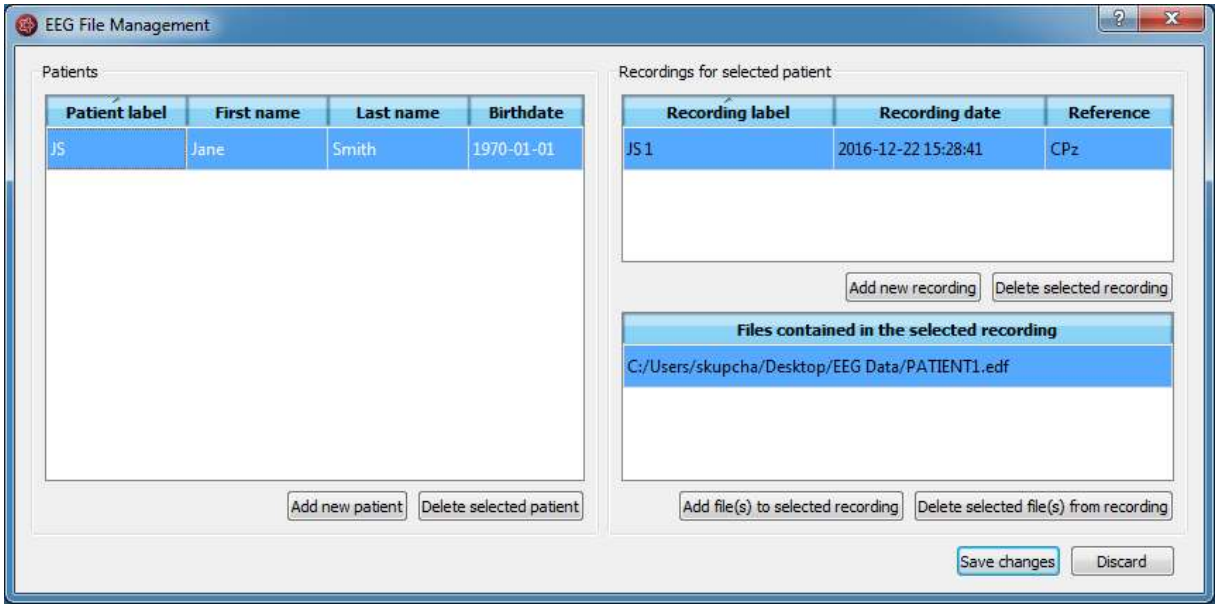
→ If you want to correct the reference later on, change the field in the EEG File Management.



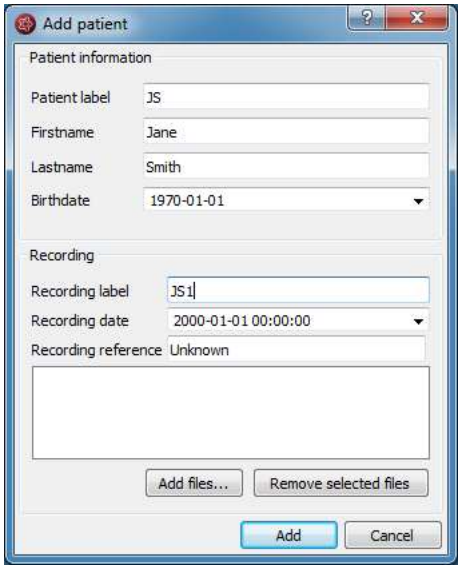
Add a patient

Follow these steps in order to add a new patient to the EEG File Management:

1. Select the menu point *Start* > *EEG File Management*. A window will open:



2. Click on "Add new patient". A form will open.
3. Fill in the fields of the "Patient information".

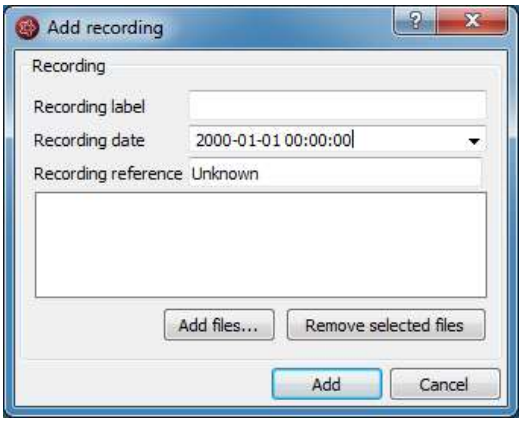


4. Fill in the recording label.
5. Select the recording date.
6. Correct the recording reference if it appears as "Unknown". If you don't know it, leave "Unknown". For more information on the recording reference see section Specify reference electrode.
7. Click on "Add files" and choose the files that belong to the recording.
8. Click on "Add".
9. Click on "Save changes".

Add a recording

If you would like to add a recording to the EEG File Management, select the menu point *Start > EEG File Management*.

1. Select the patient in the Patient list.
2. Click on "Add new recording". A form will open.



3. Fill in the recording label.
4. Select the recording date.

5. Type in the label of the electrode that was used as a reference during the recording. If you don't know it, leave "Unknown".
6. Click on "Add files" and select the files belonging to the recording.
7. Click on "Add".
8. If you need to add files to the recording once finished, then
9. Click on "Add file(s) to selected recording"
10. Choose the additional files that belong to the recording.
11. Click on "Save changes".

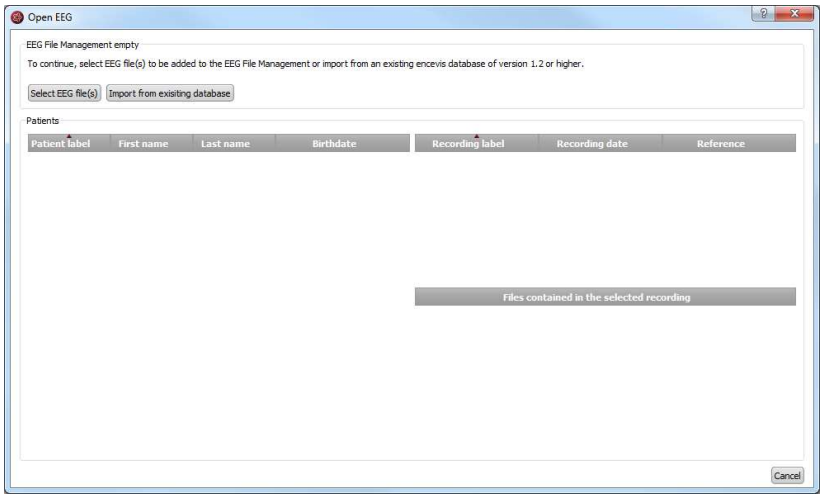
Add file(s)

In order to add new file(s) to the EEG File Management, select the menu point *Start* > *EEG File Management*.

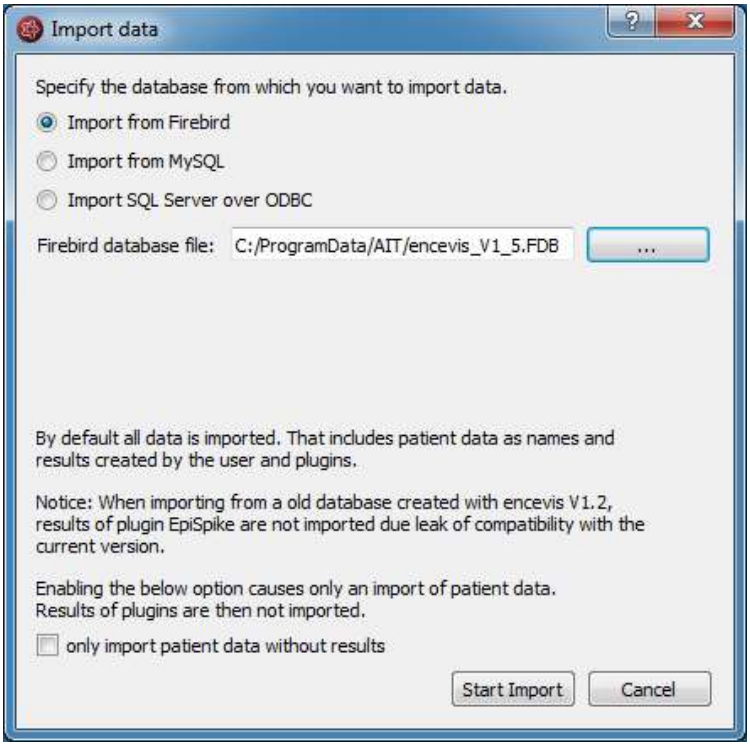
1. Select the patient in the Patient list.
2. Select the recording in the list of Recordings for the selected patient.
3. Click on "Add file(s) to selected recording".
4. Select the file(s) that belong to the recording.
5. Click on "Save changes".

Import from existing database

When the EEG File Management is empty, thus the first time you use a version of encevis or an encevis database, the following window will open:



1. If you want to start on an empty EEG File Management, click on the button "Select EEG file(s)". Further steps are explained in section Select EEG file(s).
2. If you want to reuse patient data saved in an EEG File Management you have used before, you can import it from an existing encevis database from versions 1.2 or higher. For this, click on "Import from existing database".


Import data
Specify the database from which you want to import data.
Import from Firebird
Import from MySQL
Import SQL Server over ODBC
Firebird database file:
C:/ProgramData/AIT/encevis_V1_5.FDB
...
By default all data is imported. That includes patient data as names and results created by the user and plugins.
Notice: When importing from a old database created with encevis V1.2, results of plugin EpiSpike are not imported due leak of compatibility with the current version.
Enabling the below option causes only an import of patient data. Results of plugins are then not imported.
only import patient data without results
Start Import
Cancel

View EEG

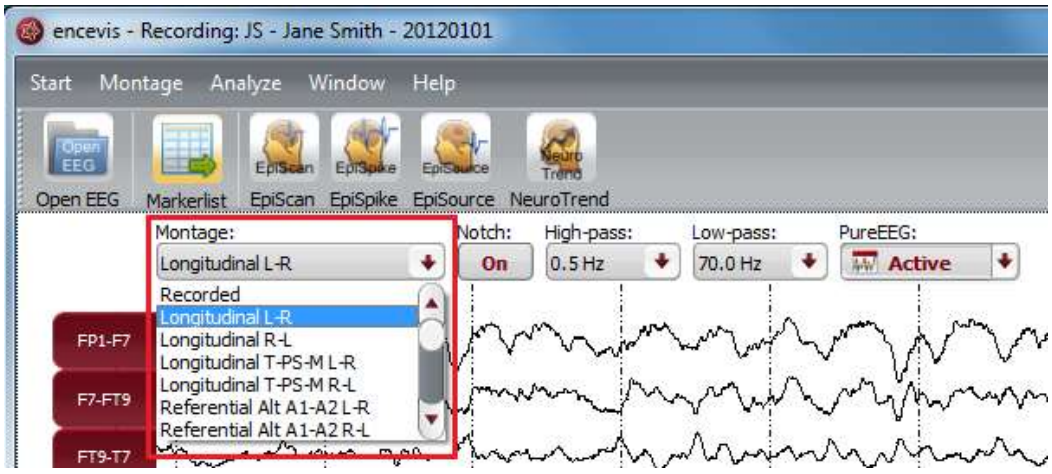
For a better review of the EEG, you have several possibilities:

- Change the montage and the way channels are displayed.
- Edit the montages.
- Navigate in time.
- Change the resolution in time and in voltage.
- Change the filters.
- Watch the EEG in two windows at the same time.
- Add and review markers

Channel and montage settings

Select a montage

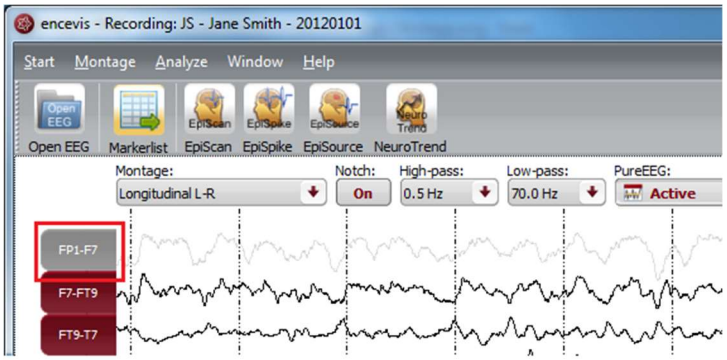
The montage control is in the upper part of the viewer.



You can choose between a variety of montages. There is a default list of montages in encevis. The default list of montages includes referential, longitudinal and transverse montages with several references and order of the channels. You can find details about these montages as well as adapting and adding new ones in the Montage editor. You can find details about these montages as well as adapting and adding new ones in the Montage editor.

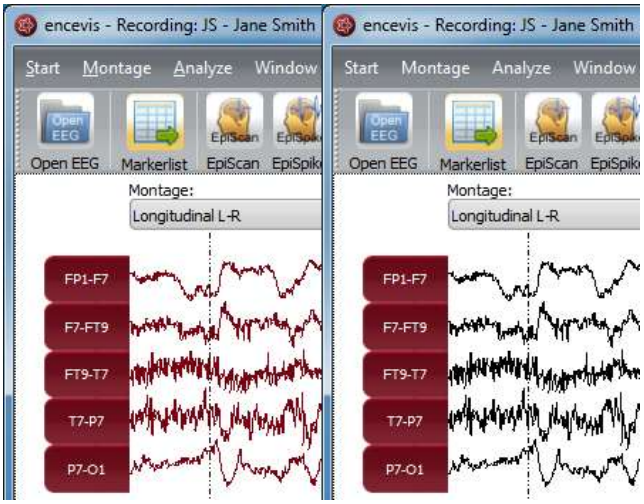
Select and unselect channels

Click on the red box on the left, where the channel name is shown in order to make the EEG of this channel visible or invisible.



Color of the curves

Select if you want to have the channels displayed in color or black

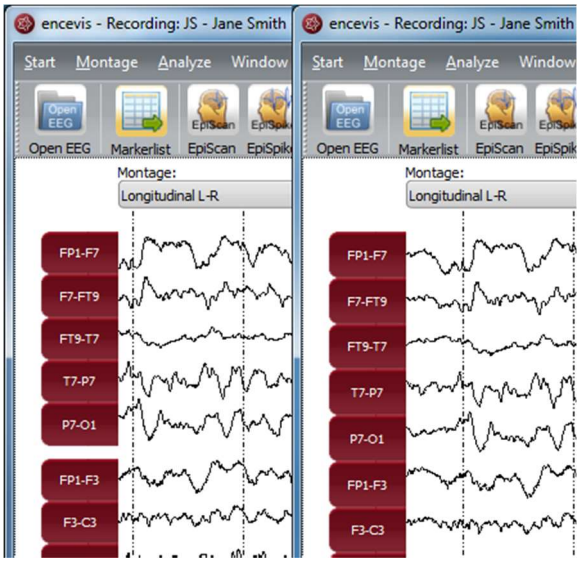


Click on the menu point *Montage* > *Colored curves* to show the channels in color or in black and white.

You can also select the exact color that you want for the curves in the Montage editor, see section Color.

Display the channels grouped

Right side and left side channels can be shown grouped.



Click on the menu point *Montage* > *Grouped curves* to switch on/off the grouping of the channels.

Time navigation

In order to navigate in time through the EEG, you have several possibilities. You can use your mouse wheel or the controls found in the lower part of the viewer.

Scroll in time with your mouse wheel

Click on the EEG and use your mouse wheel up and down to move back and forward in time.

Scroll in time with the slider

- Click on the slider and move it left and right to move back and forward in time.
- Alternatively use the back and forward arrows next to the slider to move back and forward in time.

Fill in the field "Go to:"

© AIT Austrian Institute of Technology

- Click in the field the field "Go to:" under the slider or
- Enter the date you want to start to view the EEG.

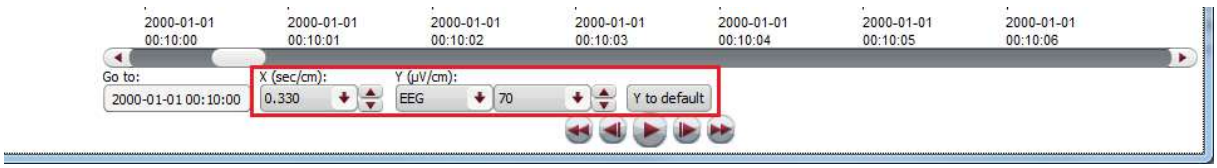
Use the video buttons

- Click on the forward or backward buttons next to the play button and the EEG will move by 1 seconds at a time.
- Click on the forward or backward button and the EEG will move by 5 seconds at a time.
- Click on the play button on the bottom of the viewer and the EEG will be shown as in a movie.
- Click on pause and the movie will pause.

Resolution

For a better review of the EEG, you have the possibility to change the resolution in time and in voltage.

The controls for this are found under lower part of the viewer.



Change time resolution

Click on the drop-down list "X:" on the bottom of the viewer and select the sensitivity you wish in sec/cm.

Change voltage resolution

Click on the drop-down list "Y:" on the bottom of the viewer and select the sensitivity you wish in microVolt/cm.

© AIT Austrian Institute of Technology

Go back to the standard resolution

Click on the button "Y by default" to go back to the standard resolution of 70 microVolt/cm.

Filters

For a better review of the EEG, you have the possibility to use several filters. The controls for this are on the top of the viewer.

Notch filter

Click on the button "Notch:" to switch on/off the notch filter of 50Hz.

High-pass filter

Click on the drop-down list "High-pass" and select the frequency you want for the high-pass filter.

Low-pass filter

Click on the drop-down list "Low-pass" and select the frequency you want for the low-pass filter.

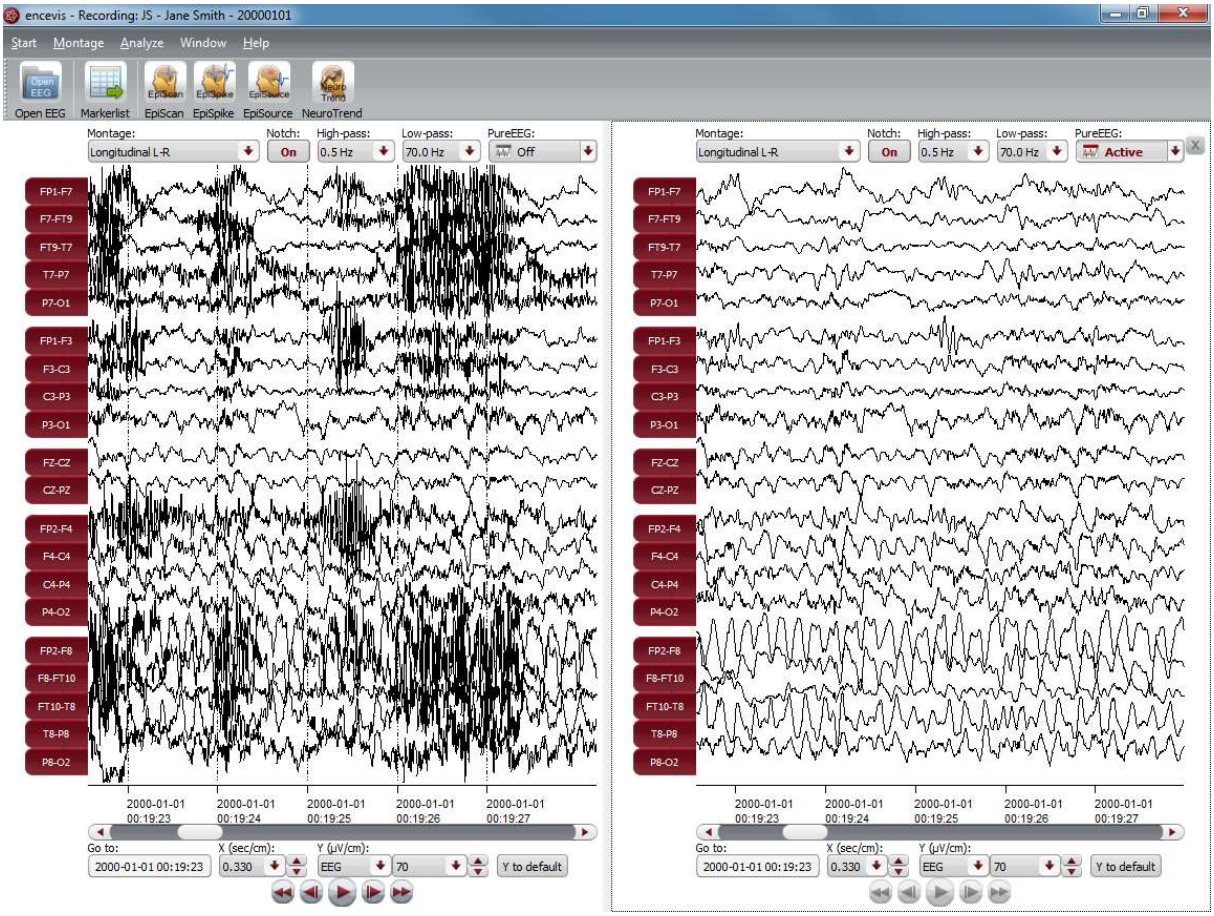
Artifact filter PureEEG

Click on the drop-down list "PureEEG" to switch on/off the artifact reduction filter PureEEG. For more details see PureEEG.

Split window

For a better review of the EEG, you have the possibility to watch your patient's EEG in two windows at the same time. You can use this mode in order to easily compare two different time segments or the EEG in two different settings.

© AIT Austrian Institute of Technology



Select the menu point *Window* > *Split window* and an additional EEG window will open. You can use this window in the same way as the original one.

You can choose to navigate in time synchronously in both windows. In this mode, if you move the time cursor in one window, it will move automatically in the other. Select the menu point *Window* > *Synchronize windows* to switch on/off the synchronous mode.

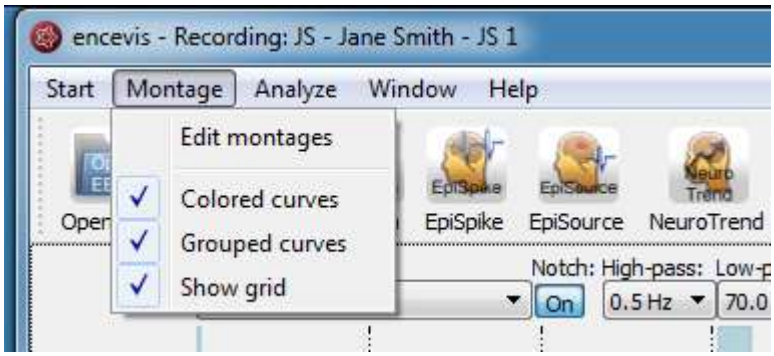
If you want to close the additional plot, just click on the cross icon in the upper right corner of the window or select the menu point *Window* > *Split window*.

© AIT Austrian Institute of Technology

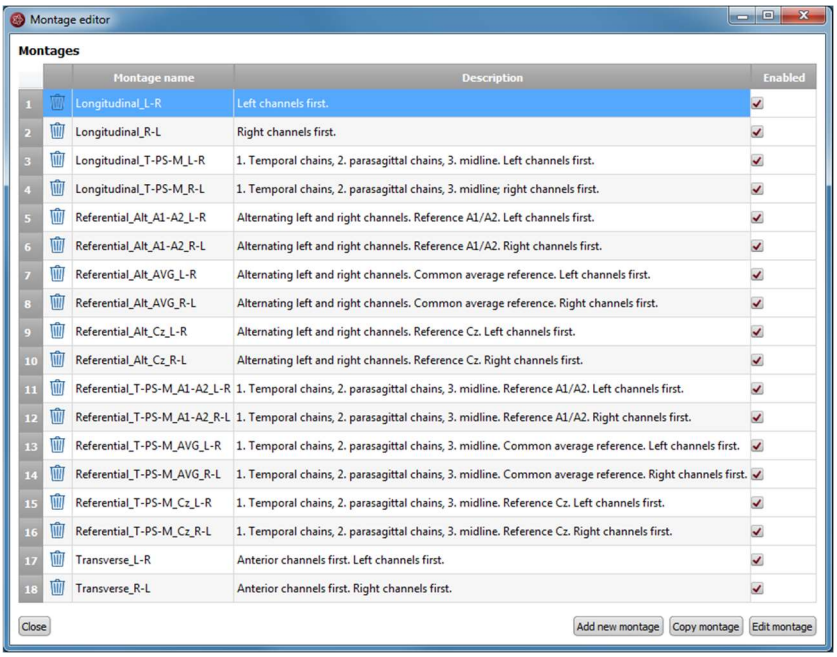
Montage editor

With the Montage editor you can change the montages that are used in the viewer. You can add new montages or edit the existing ones.

To open the montage editor select the menu point *Montage* > *Edit montages*.



The montage editor will open showing the list of montages:



As you can see, a variety of default montages are already defined in the montage editor. They include montages with channels from the 10-20 system. There are standard referential, longitudinal and transverse montages with several orders of the channels and references.

You can decide if you want to have the montages included in the montage drop-down list of the viewer, by selecting or deselecting the check box "Enabled".

A montage is defined by a series of channels grouped to chains.

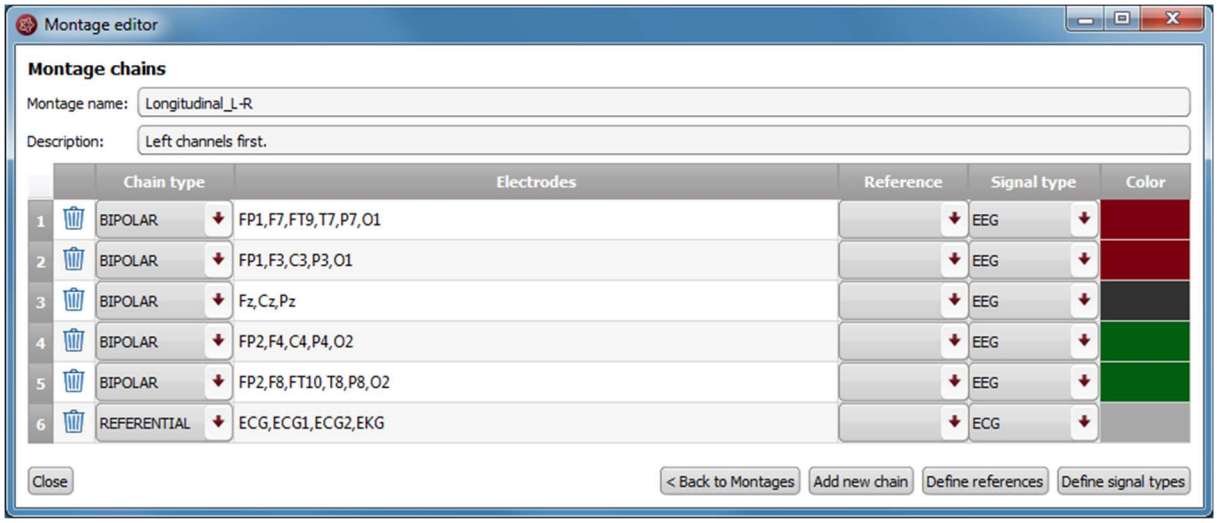
Select a montage in the montage editor and Click on "Edit montage" to see the chains included in it. More details on the montage chains are found in the following section.

© AIT Austrian Institute of Technology

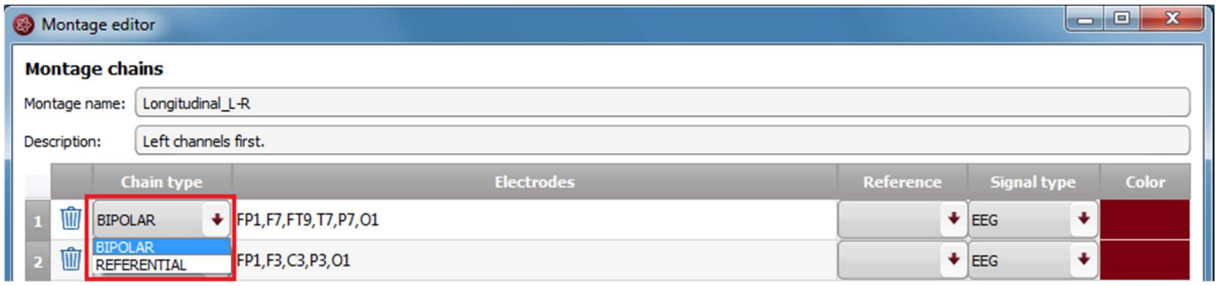
Montage chains

A montage is defined by a series of channels grouped to chains. By editing a montage you can see the chains that are defined in the selected montage.

→ Select a montage and Click on "Edit montage" to see the chains included in it.



There are two types of chains: BIPOLAR and REFERENTIAL.



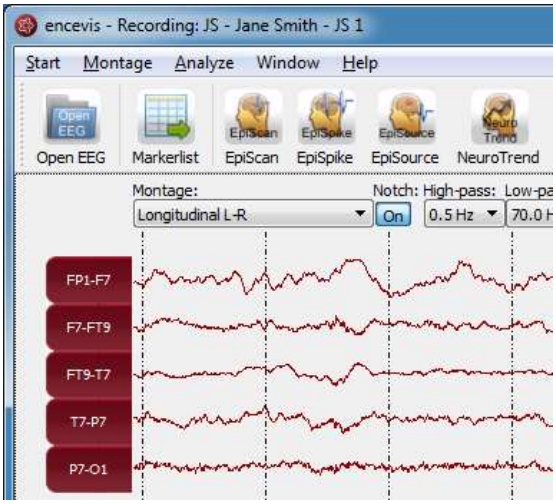
A BIPOLAR chain will result in a group of bipolar channels shown by the viewer.

In the field "Electrodes" are written the positive electrodes included in this group. For a BIPOLAR chain, the field "Reference" needs to be empty.

E.g. the chain including FP1,F7,FT9,T1,T7,P7,O1

will result in the group of channels FP1-F7, F7-FT9, FT9-T7,T7-P7 and P7-O1 when the montage is selected in the viewer.

© AIT Austrian Institute of Technology



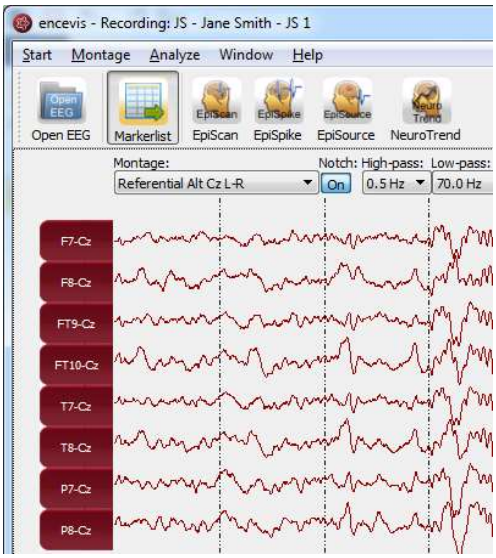
A REFERENTIAL chain will result in group of referential channels shown by the viewer.

In the field "Electrodes" are written the positive electrodes included in this group. For a REFERENTIAL chain, the field "Reference" needs to be filled. It should contain the reference that is whished for this group. On how to select the reference see References.

E.g. the chain including F7, F8, FT9, FT10, T7, T8, P7, P8 with Reference Cz

	Chain type	Electrodes	Reference	Signal type	Color
1	REFERENTIAL	F7, F8, FT9, FT10, T7, T8, P7, P8	Cz	EEG	

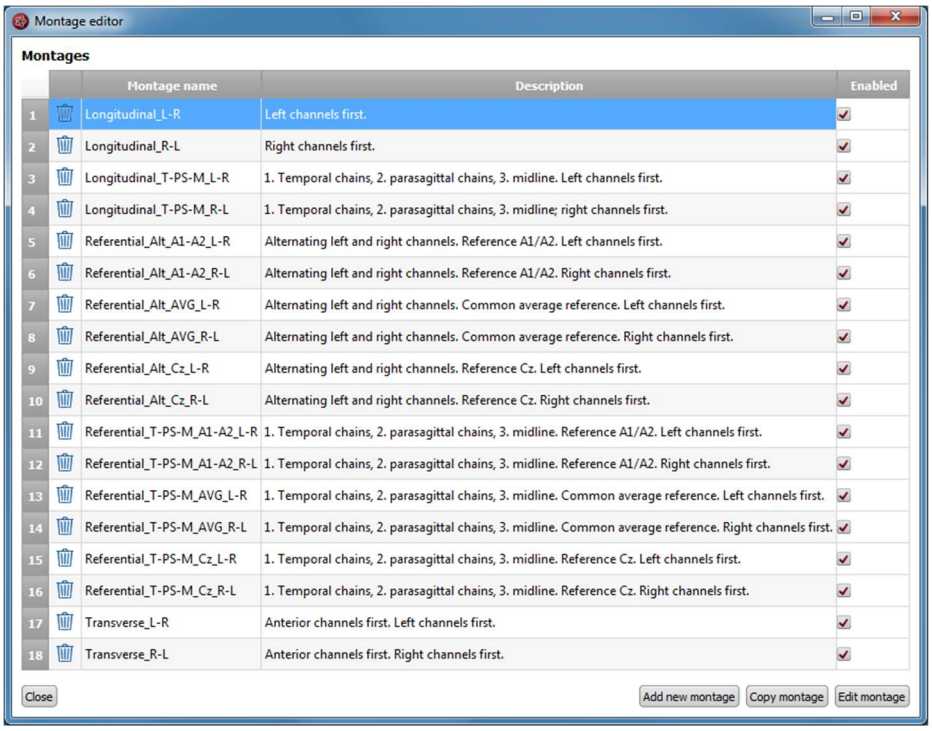
will result in the group of channels: F7-Cz, F8-Cz, FT9-Cz, FT10-Cz, T7-Cz, T8-Cz, P7-Cz, P8-Cz when the montage is selected in the viewer.



For more details on the other fields see the sections Chain references and Signal Types.

Add montage

If you want to add a new montage, first open the montage editor by selecting the menu point *Montage* > *Edit montages*



If you want to add a new montage to the existing ones you have two possibilities:

Add a completely new montage

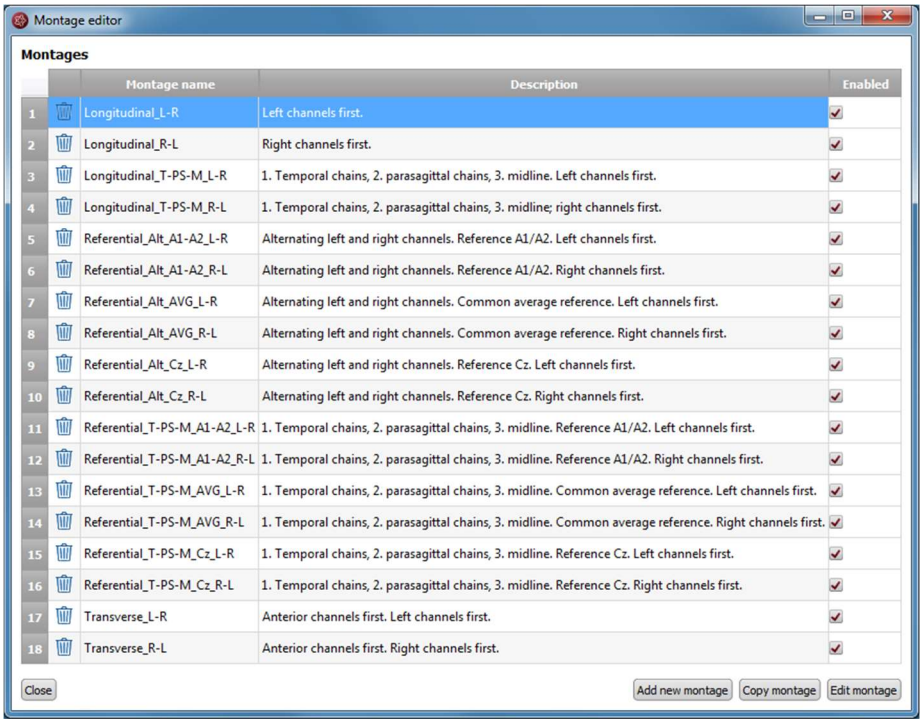
In this case you will need to add new montage chains too. Press the button "Add new montage", then edit the montage. For more details, see Montage chains and Edit montage chains.

Copy an existing montage and edit it

If you find an existing montage that it similar to the one that you want to add you may select and edit it. For this, select the montage and press the button "Copy montage". Then edit the montage. For more details see Edit Montage.

Edit montage

You may want to change an existing montage. For this, open the montage editor.

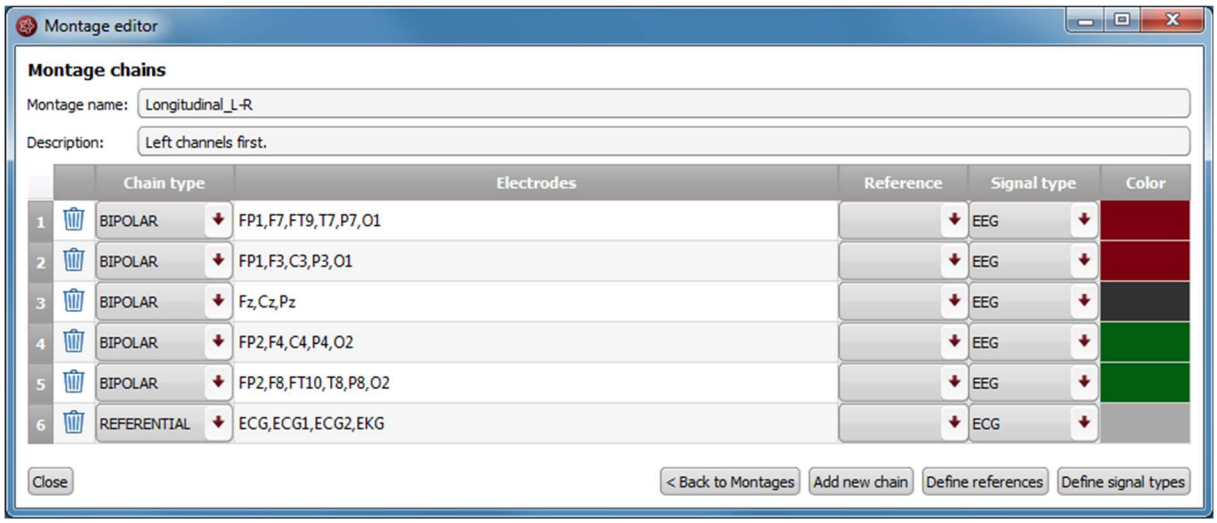


and select the montage you wish to change. Double click on it or click on the button "Edit montage". The window with the montage chains will open.

For details on the changes that can be made in the montage chains, see

Edit montage chains and Montage chains.

Edit montage chains



The following changes can be made in the montage chains:

Montage name

Double click on the field "Montage name" and fill in the name you wish. This is the name that will appear in the drop-down menu Montage of the viewer.

Description

Double click on the field "Description" and fill in the description you wish. This field is for your personal information and not used elsewhere by the viewer.

Chain type

Click on the drop-down menu and select REFERENTIAL or BIPOLAR.

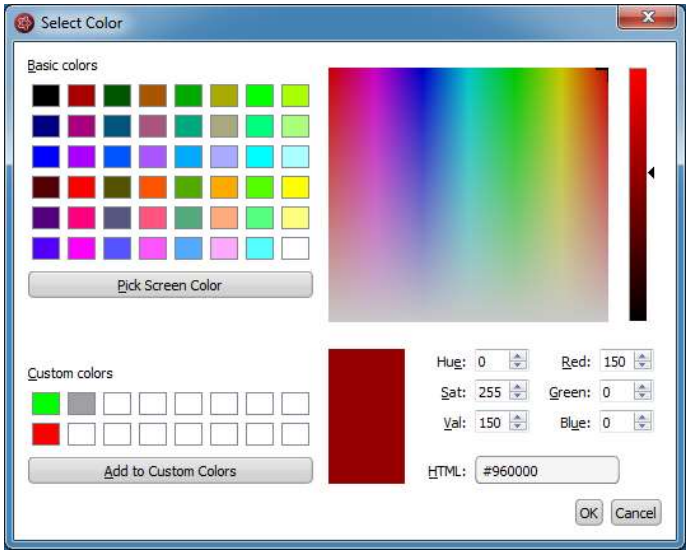
Electrodes

Double click on the field "Electrodes" and fill in the electrodes that should be included in the chain separated by commas.

- Reference: Click on the drop-down menu "Reference" and select an electrode in the list.
- Signal type: Click on the drop-down menu "Signal type" and select a type in the list.

Color

Double click on the field "Color". Select a color in the window and press "OK". This is the color displayed on the curves of the chains in the viewer.



Channel order

Change the order of the channels by changing the order of the electrodes in the field "Electrodes" or by clicking on the number for the chain and dragging and dropping the line where you wish to have it.

Add a new chain

Press the button "Add new chain" and edit the fields as described above.

For more information about the fields, see sections Chain references and Signal Types.

Order of the channels

The order of the channels in the montage chains corresponds to the order of the channels how they are displayed in the viewer when the montage is selected. To change the order of the channels you have two possibilities:

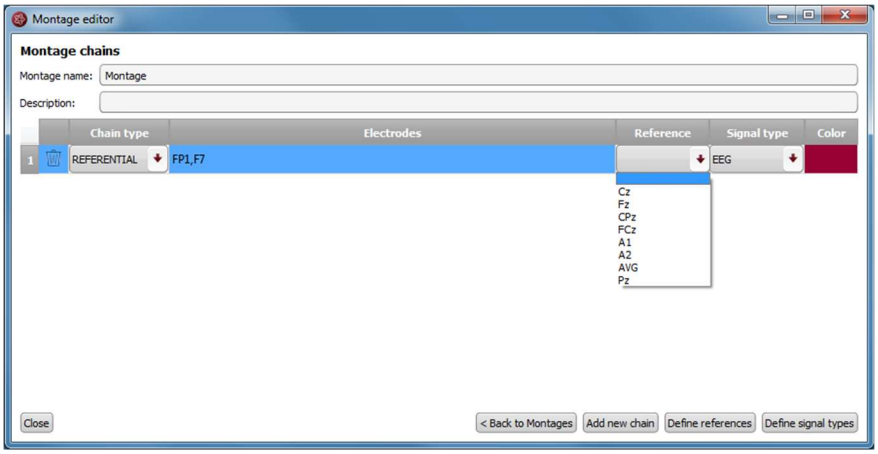
1. Change the order of the electrodes in the field "Electrodes".
2. Change the order of the chains by moving them in the list with drag and drop.

Chain references

A REFERENTIAL chain should always have the field "Reference" filled out.

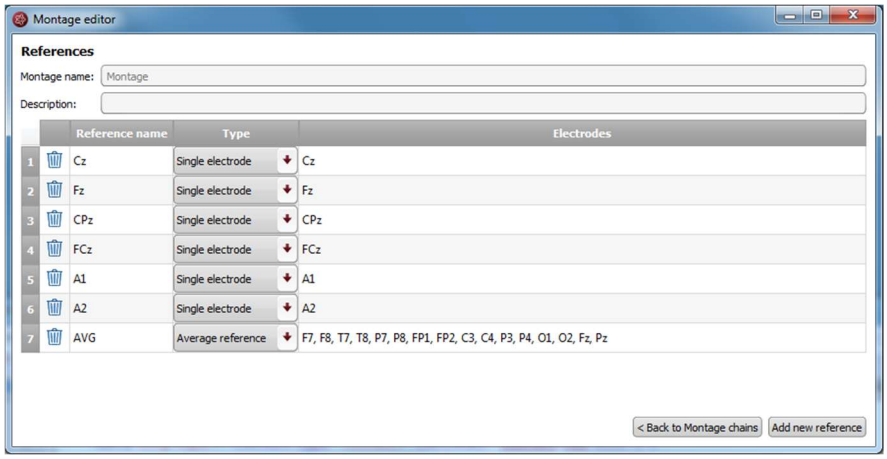
Fill in Reference

In order to fill in the Reference click on the drop-down menu and select an electrode in the list.

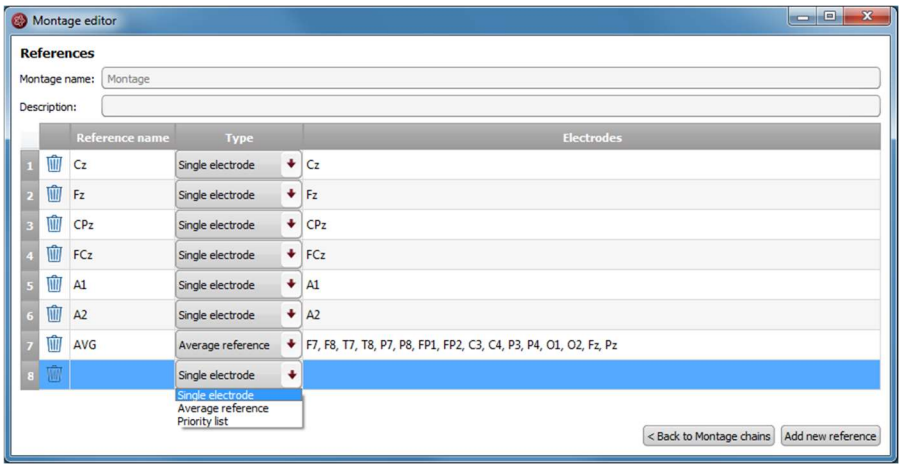


Define new reference

If the whished electrode is not in the list, it can be added by defining a new reference. For this, click on the button "Define references". The following window will open, showing the references already defined:



1. In order to add a new reference click on the button "Add new reference", a new line will be inserted:



2. Fill in the "Reference name".
3. Fill in the field "Type". For this:
    1. Select "Single electrode", when only one individual electrode should be the reference. Fill in the electrode label in the field "Electrodes".
    2. Select "Average reference", when the reference should be an average of several electrodes. Fill in the electrodes that should be included in this average in the field "Electrodes".
4. Click on the button "Back to Montage chains" to continue editing the chains.

Signal Types

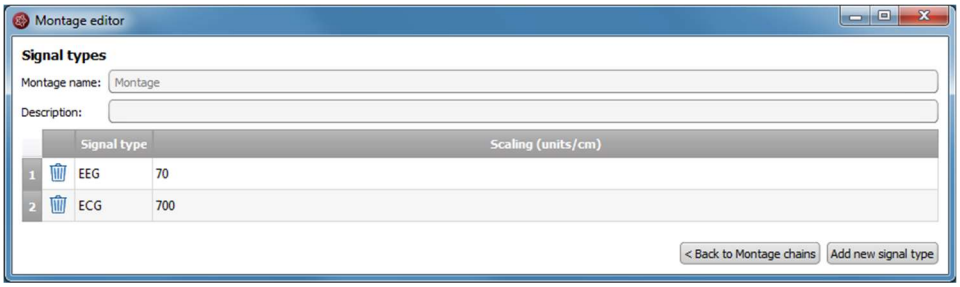
A chain should always have the field "Signal type" filled out.

Fill in signal type

In order to fill in the Signal type click on the drop-down menu and select a type in the list.

Define new signal type

If the whished signal type is not in the list, it can be added by defining a new signal type. For this, click on the button "Define signal types". The following window will open, showing the signal types already defined:



1. In order to add a new signal type click on the button "Add new signal type", a new line will be inserted.
2. Fill in the "Reference name".
3. Fill in the name of the signal type and the scaling in units/cm.
4. Click on the button "Back to Montage chains" to continue editing the chains.

Markers

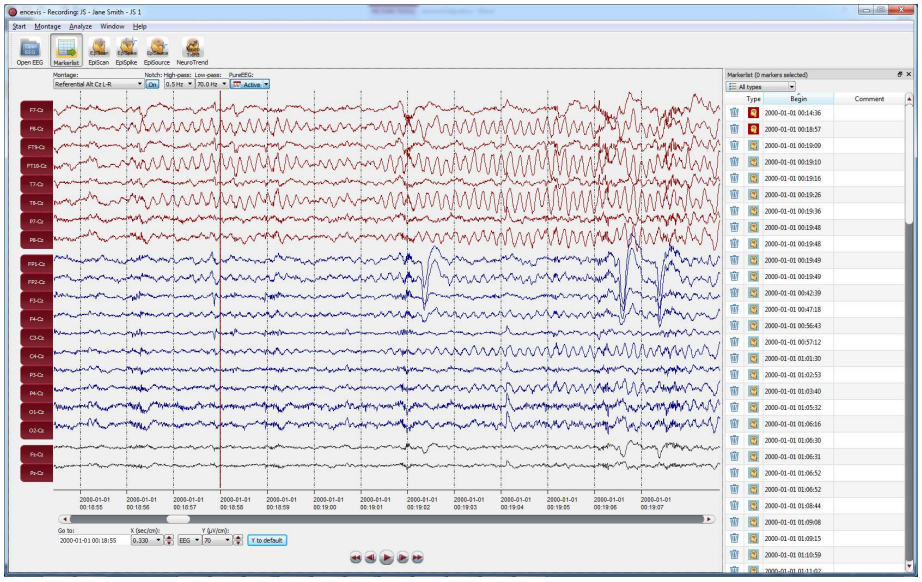
Special EEG events can be stored in the form of a marker. A marker includes the information:

- Type (see the different marker types)
- Begin
- End
- Comment

Markers are saved with the data in the marker list and can be viewed anytime.

In the viewer, the markers can be easily identified because they appear colored. More details on how to use the markers can be found in the following sections.

© AIT Austrian Institute of Technology



Markerlist

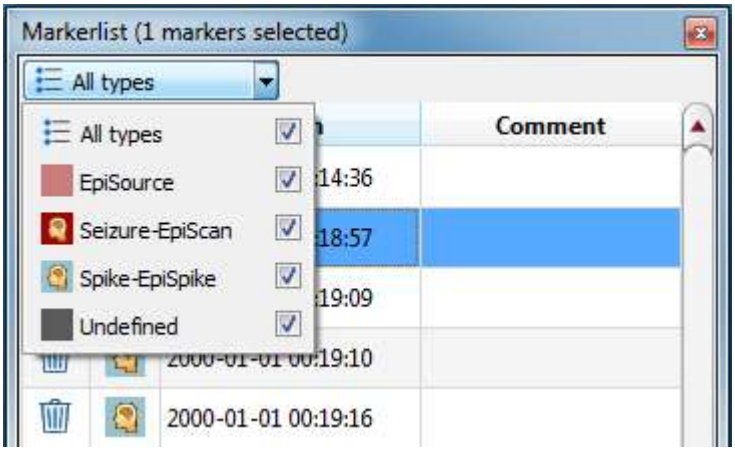
Click on the button "Markerlist" to open the Markerlist or select the menu point *Window* > *Markerlist*.

- Click on the button "Markerlist" to close the Markerlist when it is open.
- Click on a marker in the list. The EEG, starting with the begin of the marker, will be displayed in the viewer.

You can use the list in the following ways:

Select marker type

Select a marker type in the list "All types".



Navigate through the list

Use the keyboard arrows for going up and down the list.

Sort the list

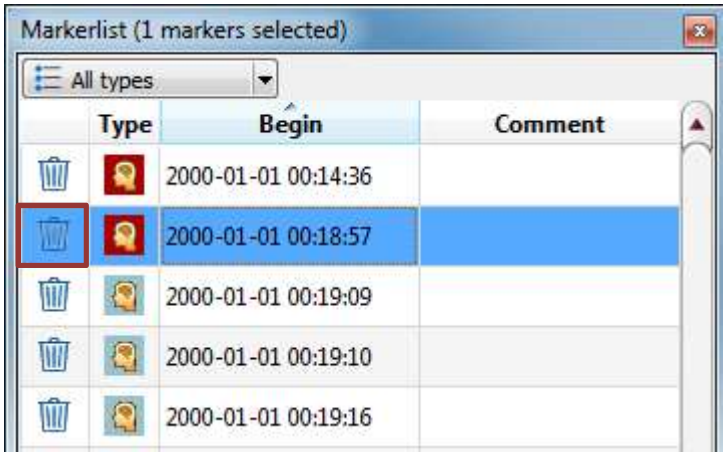
Click on the field you want to sort by.

Change the fields of a marker:

Double click on the marker in the Markerlist or right click on the marker on the screen and select “Edit marker”. Fill in the changes.

Delete marker(s) by moving them to the Recycle Bin:

Click on the recycle bin icon on the left column of the marker or right click on the marker on the screen and select “Delete marker”.



Show/hide deleted markers in the list

You can choose to have the markers that were moved to the recycle bin shown in the Markerlist or hidden.

→ For this, select the menu point *Window* > *Show markers in Recycle Bin*.

If you have chosen this setting, you can easily remove the marker from the recycle bin by clicking on the icon again.

Permanently delete marker(s)

You can choose to permanently delete markers by moving them to the Recycle Bin and emptying the Recycle Bin.

→ For this, select the menu point *Window* > *Empty Recycle Bin*.

Add marker

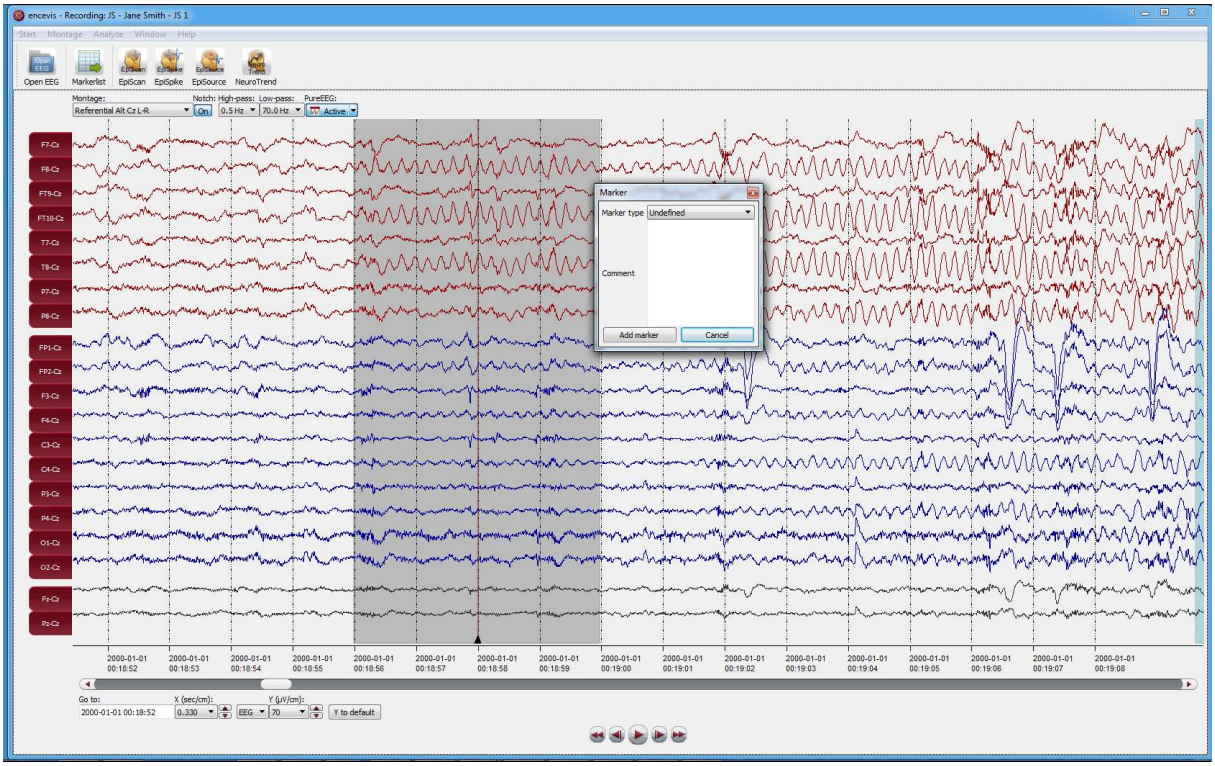
Special EEG-events can be saved in the form of markers.

You can insert a marker in 2 different ways:

Add marker by clicking and dragging the mouse

1. Click on the EEG where the marker should start and leave the mouse pressed.
2. Move the mouse to select the time period for the marker (grey color).
3. Release the mouse and a window will pop-up.

© AIT Austrian Institute of Technology



In this window:

1. Select the Marker type.
2. Fill in the field "Comment" if necessary.
3. Click on "Add marker".

Add marker with right click

Right click on the EEG and select "Add Marker" or double click where the marker should start. A window will pop-up.

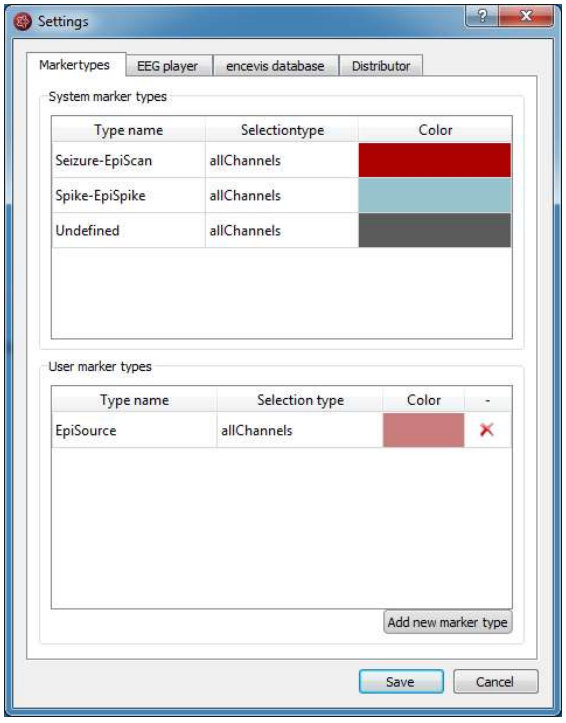
In this window:

1. Select the Marker type.
2. Fill in the field "Comment" if you wish.
3. Click on "Add marker".

Settings

Several settings can be defined in encevis. For this, select the menu point *Start* > *Settings*.

Settings Markertypes



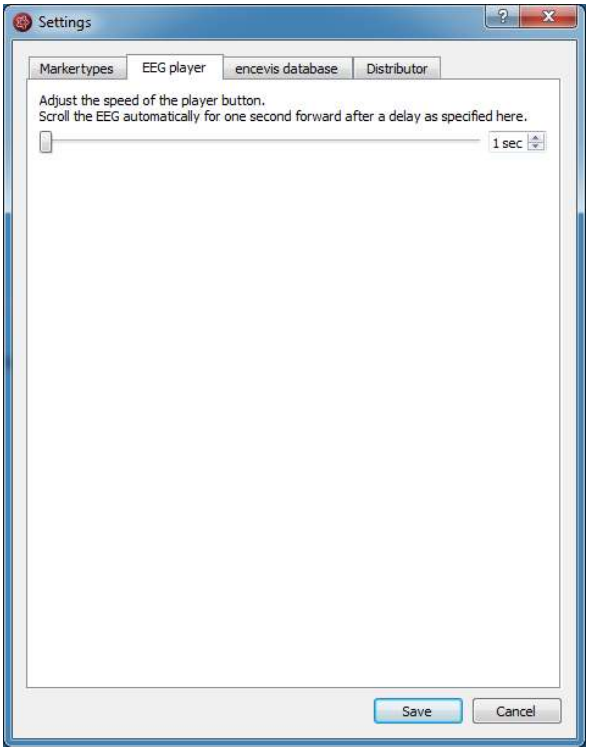
System marker types

System marker types are the default marker types of encevis. You can define their color by just double clicking on the field "Color".

User marker types

User marker types include marker types defined by the user. You can easily define new marker types. Press the button "Add new marker type" and choose a name and a color.

Settings EEG player



The play button in the viewer enables you to view the EEG as in a video. You have here the possibility to set the speed at which the EEG is shown.

Settings encevis database

encevis stores your markers and the results of EpiScan, EpiSpike and NeuroTrend in one database. Select where encevis should store it:

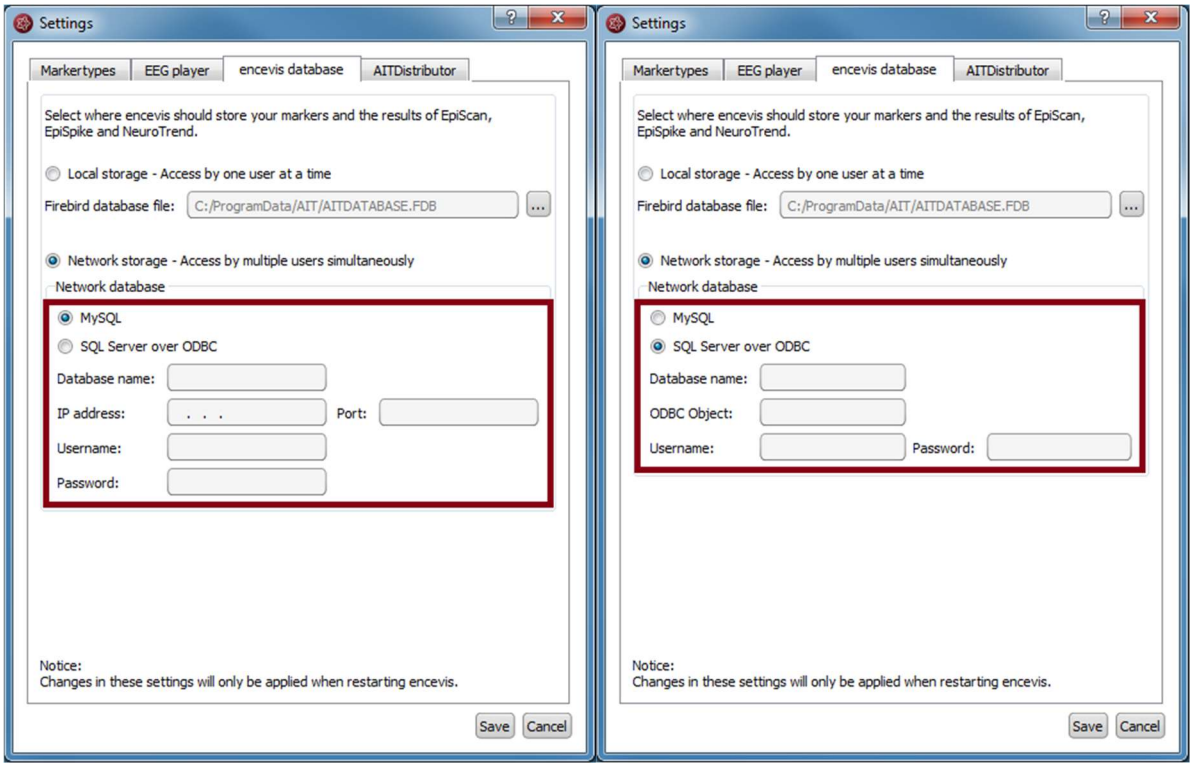
Local storage - Access by one user at a time:

This is the best mode, when the results of your review with encevis should only be accessed from your PC. Only one user at at time can then access the results. You can leave the file name specified by default or select a personalized name.

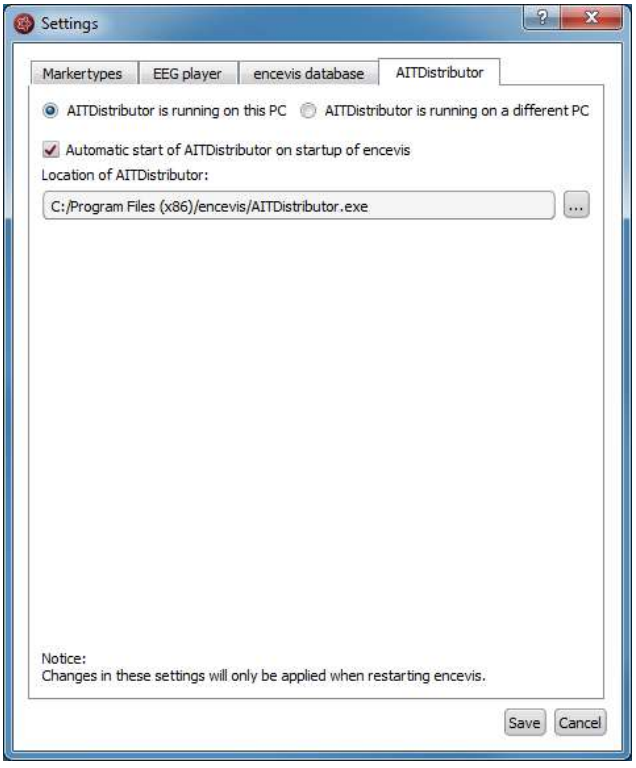
Network storage - Access by multiple users simultaneously:

This is the best mode, when you want to access the results of your review with encevis from several PCs in your network. With this option several users can access the results at the same time. In this case, you need to specify a database where everybody has access to. This database can be MySQL or an SQL server over ODBC.

© AIT Austrian Institute of Technology



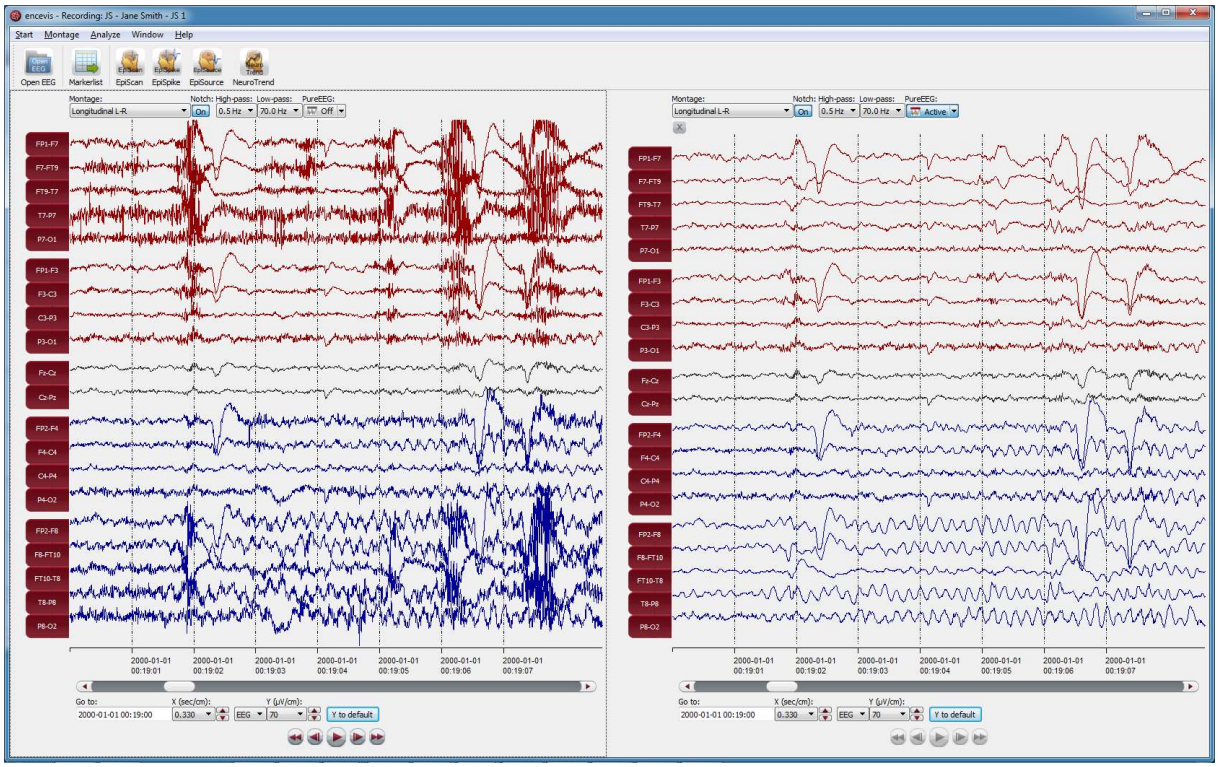
Settings Distributor



Select if the Distributor should run on your PC or on a different one. If the Distributor is

running on another PC, you need to specify IP address and Port. For more details see the section Distributor.

PureEEG



Overview

PureEEG is the automatic artifact reduction from encevis. It removes artifacts from your patient's EEG while the EEG coming from cerebral sources is left unchanged.

User- and data input

PureEEG uses the raw EEG, only. No additional information is necessary to use PureEEG.

User-defined parameters

All parameters are optimized for EEG analysis. There are no parameters that can be change by the user.

Outputs to the user

The output of PureEEG is the artifact reduced EEG. Further processing and interpretation is identical to the processing and interpretation of raw EEG.

Description of the algorithm methods

The “PureEEG-approach” for fully automatic artifact removal supports the visual analysis of long-term EEG recordings. PureEEG rejects numerous types of artifacts that frequently obscure long-term recordings and impede their interpretation. It targets artifacts that do not coincide with a spatio-temporal correlation pattern of an EEG of cerebral origin, which particularly includes artifacts due to myogenic contractions, faulty electrode-to-patient connections and patient movements. The method works fully automatically and without any patient-individual parameter adjustments. The algorithm is based on a neurophysiological signal model which includes one term representing the pure EEG, which originates from cerebral sources only, one term representing ocular artifacts, and one term representing a wide range of artifacts. Details on the algorithm can be found in “Hartmann, M.M., Schindler, K., Gebbink, T.A., Gritsch, G., Kluge, T., “PureEEG: Automatic EEG artifact removal for epilepsy monitoring“, Neurophysiologie Clinique/Clinical Neurophysiology, November 2014.

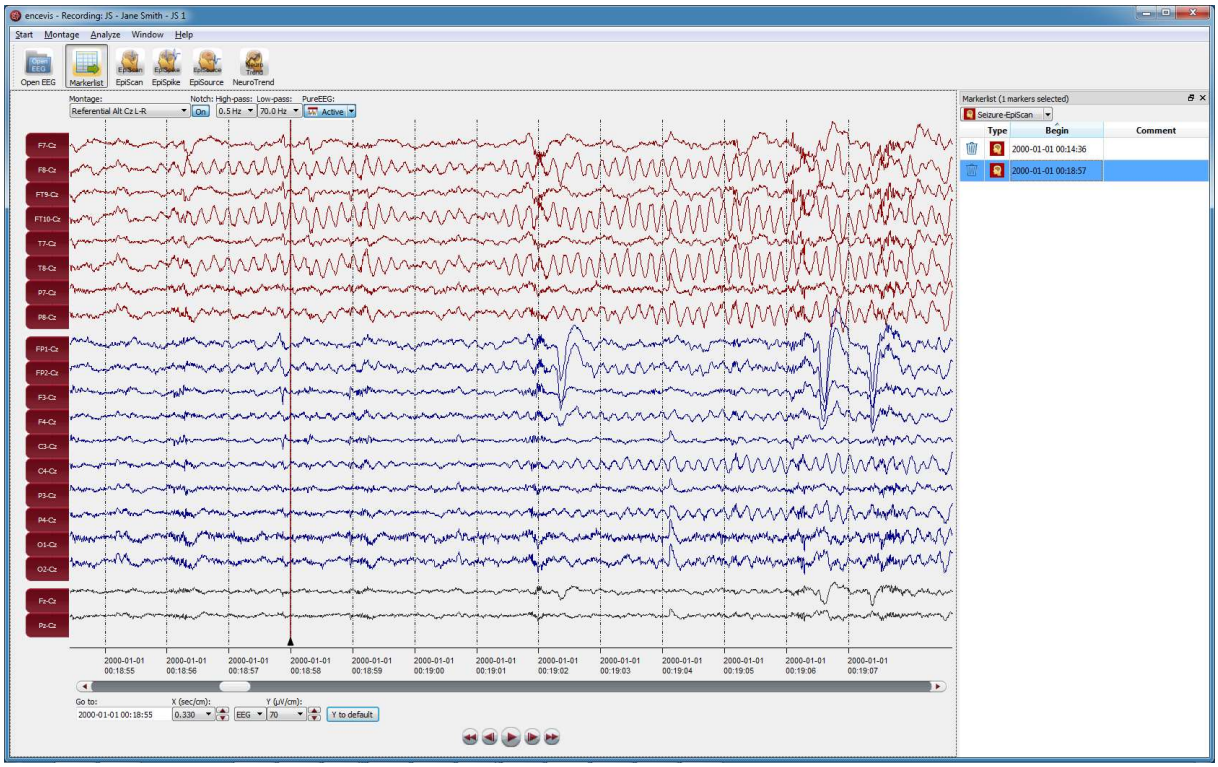
Using PureEEG

Simply click on the button "PureEEG" to switch PureEEG on and off.

The location of the reference electrode used during the recording of the EEG (*Recording reference*) is used by PureEEG. For the optimal functioning of PureEEG, it is recommended to fill out the reference correctly. For more details, see section Specify reference electrode.

© AIT Austrian Institute of Technology

EpiScan



Overview

EpiScan is the automatic seizure detection from encevis. It enables to find seizures EEG-activity in your patient's recording. It creates a list of markers that can be easily reviewed. Markers are created and can be reviewed already during the calculation.

User- and data input

The input to EpiScan is the raw EEG signal only. No video or other data is used by the algorithm. Any settings in the viewer such as filter setting or montages are ignored. There is no user input to EpiScan. The user can only start the processing by clicking the button “EpiScan” in the tool bar of the encevis viewer. The sampling rate of the EEG data is arbitrary but needs to be above or equal 100 Hertz. All channel labels in the digital EEG must be part of the extended international 10-10 electrode system. The channel labels T1, T2,

© AIT Austrian Institute of Technology

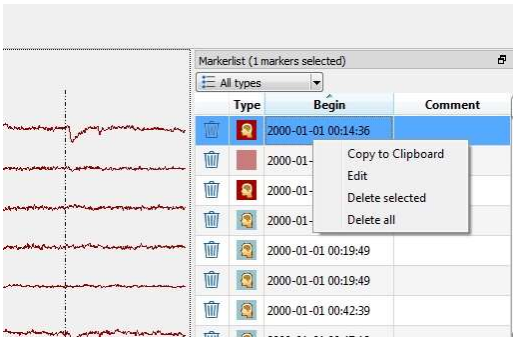
SP1, and SP2 are allowed in addition. Electrode name recognition is case-insensitive. EpiScan can work with data coming from a DC amplifier.

User-defined parameters

All parameters are optimized for EEG seizure detection. There are no parameters that can be change by the user.

Outputs to the user

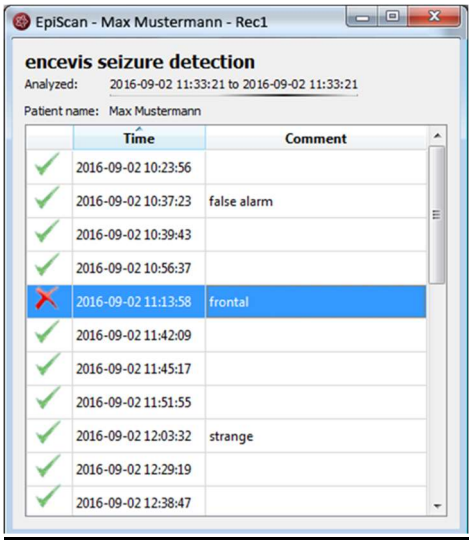
EpiScan makes the results available to the user in form of marker in a marker list shown in the encevis viewer.



The markers are to be interpreted as epochs in the EEG with a high probability of showing an electrographical seizure. Users can click on these markers and the EEG corresponding to these markers will be shown in the EEG viewer. The user can review the raw EEG. If the user decides that the marker represents a false alarm the marker in the marker list can be set as invalid by clicking on the recycle bin symbol on the left side of the marker list. Alternatively, the user can right click on a maker to enter a context menu. The user has now the possibility to copy the marker time to the clipboard, edit the marker (edit the start- and end time and add a comment) and to delete the marker.

If EpiScan is used in combination with the Moberg Vendor Interface, a notification GUI is shown during the recording that shows the results of the calculation to the user. User has the same functionality as described for the marker list in the encevis EEG viewer.

© AIT Austrian Institute of Technology



Description of the algorithm methods

EpiScan is based on a computational method, which automatically detects epileptic seizures in digitized EEG. It is intended to analyze the EEG ad-hoc. The EpiScan method analyses the digital EEG during recording in intervals of a quarter-second. Frequencies below 0.7Hz and above 99Hz are removed by finite impulse response filters. Line noise is removed with notch filters at 50 and 60 Hz. EEG segments with artifacts like i.e. excessive amplitudes or artifacts from loose electrodes are removed automatically and are not used for detection. This will avoid false alarms based on measurement problems. The EEG is then scanned for rhythmic patterns in the time and frequency domain by algorithms called Epileptiform Wave Sequence Analysis (EWS) and Periodic Waveform Analysis (PWA), respectively ([Hartmann MM, Fürbass F, Perko H, Skupch A, Lackmayer K, Baumgartner C, et al. EpiScan: online seizure detection for epilepsy monitoring units. Eng Med Biol Soc 2011 Annu Int Conf IEEE. 2011. p. 6096–9.] [Fürbass F, Hartmann M, Perko H, Skupch A, Dollfuss P, Gritsch G, et al. Combining time series and frequency domain analysis for a automatic seizure detection. In: 2012 Annu Int Conf IEEE Eng Med Biol Soc EMBC. 2012. p. 1020–3]). An energy detector scans for tonic or tonic-clonic seizures with strong muscle artifacts. All extracted features are normalized by a spatio-spectral model of the brain activity that is continuously updated by past information from the EEG. A set of classifiers is used to remove events with physiological origin. The use of these adaption and classification algorithms avoids repeated detections of physiological or pathological patterns that are no seizures and is therefore another important mechanism to avoid excessive false alarms. Further details can be found in [Fürbass et al., “Prospective multi-center study of an automatic online seizure detection system for epilepsy monitoring units “; Clinical Neurophysiology, vol. 126, no. 6, pp. 1124–1131, Jun. 2015].

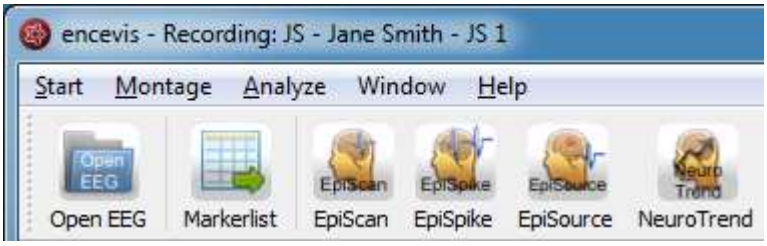
Starting EpiScan

In order to start EpiScan you need to select the recording you want to analyze.

Follow these steps to start EpiScan:

1. Open the EEG that you want to analyze with EpiScan.

2. Click on the "EpiScan" icon under the menu to start the calculation.

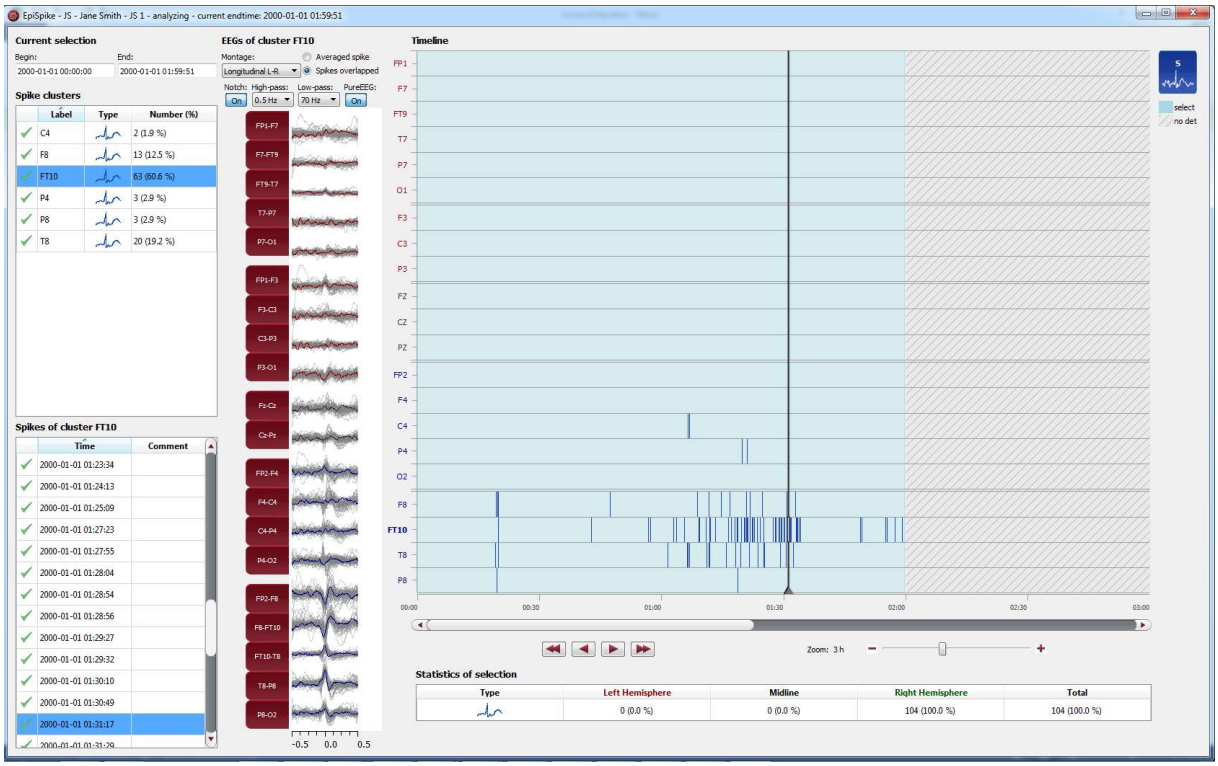


Once the calculation started, the progress will be shown under the icon.

During the calculation, if seizures have been detected, markers will be created and will appear automatically in the marker list.

You can easily view these seizure markers during the calculation. For more details on how to review markers see section Markerlist.

EpiSpike



Overview

EpiSpike is the automatic spike detection from encevis. EpiSpike enables you to find spikes in your patient's recording. Markers are created and can be viewed already during the calculation. A graphical visualization enables you an easy and fast review of the results.

User- and data input

The input to encevis EpiSpike is the raw EEG signal only. No video or other data is used by the algorithm. Any settings in the viewer such as filter setting or montages are not considered. During calculation, there is no user input possible. The user can only start the processing by clicking the button “EpiSpike” in the tool bar of the encevis viewer.

© AIT Austrian Institute of Technology

User-defined parameters

There are no parameters in EpiSpike algorithm that can be changed by the user. During startup of the spike detection, the user can select the time window that EpiSpike should compute. The default value is analyzing the complete EEG file.

Outputs to the user

EpiSpike makes the results available to the user in form of marker. The markers are to be interpreted as epochs in the EEG with a high probability of showing an epileptic spike. The results are presented in a graphical user interface. This user interface is described in detail on the following chapter “EpiSpike – User Interface”.

Description of the algorithm methods

After initial artifact removal, the EEG data stream is divided into temporal segments that correspond to an electrical discharge of groups of neuronal cells. The segments must at least achieve a minimum amplitude and duration. Multiple discharges may occur simultaneously, i.e. the segments can overlap. Positive and negative discharges are evaluated separately and produce separate segments. The algorithm creates a multi-channel representation out of single-channel segments. Single-channels segments describe discharges by their start and end position. In addition the amplitude and waveform is available for each single-channel segment. Out of this information, several single-channel segments are combined that describe the physiological discharge in a unified information entity. By using all single-channel segments of a multi-channel segment as input the average duration and amplitude are derived and stored in the generated multi-channel output markers.

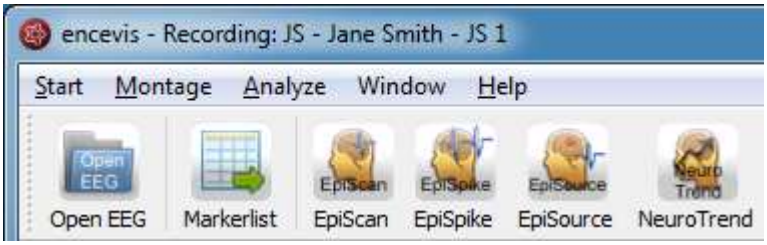
Each segment is then classified as spikes and non-spikes according to their morphology. For this classification task, the morphology and the potential field of the segments are examined. The spike segments are then further evaluated by incorporating the background EEG. The segments are further processed by checking if the spike stands out of the EEG background and detecting the wave if the spike is a spike-wave-complex.

Each detected spike is then assigned to the next electrode to group. The spatial localization of incoming spike segments is calculated and assigned to the most appropriate electrode to allow clustering of the segments. The spatial localization is estimated by the maximum of the interpolated potential field. A standard head model is used for spatial interpolation of the potential field values.

Starting EpiSpike

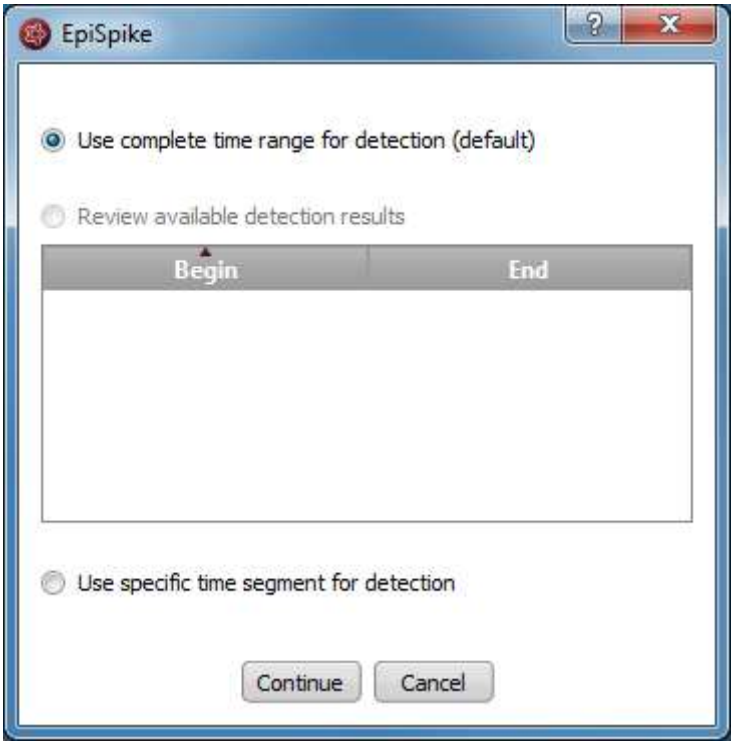
In order to start EpiSpike you need to select the recording you want to analyze. Follow these steps to start EpiSpike:

1. Open the EEG that you want to analyze with EpiSpike.
2. Click on the "EpiSpike" icon under the menu to start the calculation.



Starting EpiSpike for the first time

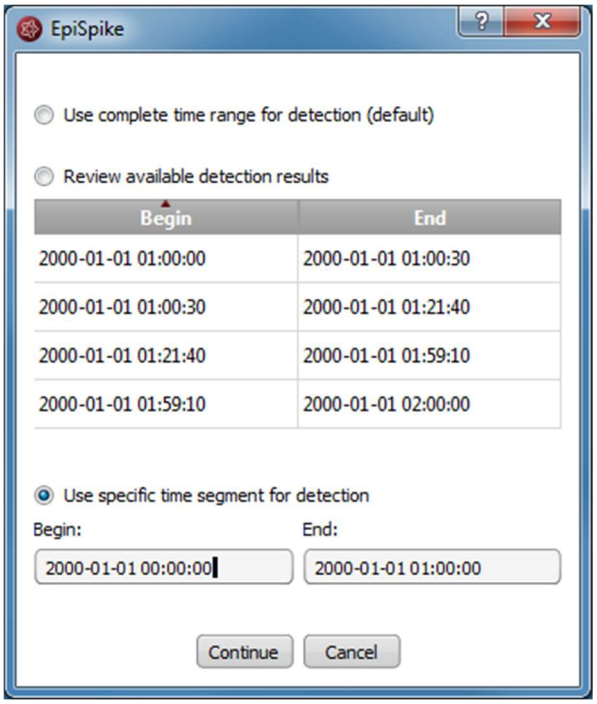
When you start EpiSpike the first time on a recording, the following window will pop-up:



→ Specify if you want to have the detection on the whole time range of the recording or just a segment.

Starting EpiSpike for the second time

When you start EpiSpike again after the first time and the detection was not completed, the following window will appear:



It shows you in which time ranges the detection is already a complete. You have the following possibilities here:

1. If you select *Use complete time range for detection*, EpiSpike will open and the detection will continue where it stopped before.
2. If you select *Review available results* , EpiSpike will open and show available detection results, but it will not start any new detections. This option is recommended, if you don't want any additional program running.
3. If you select *Use specific time range for detection,* EpiSpike will open and start the detection in the time range you specified. This option is recommended, if you are interested only in one specific time period and you want to access results faster.

EpiSpike calculations in progress

Once the calculation started, the progress will be shown lower right corner on the screen.

During the calculation, when spikes have been detected, markers will be created and will appear automatically on the EpiSpike screen.

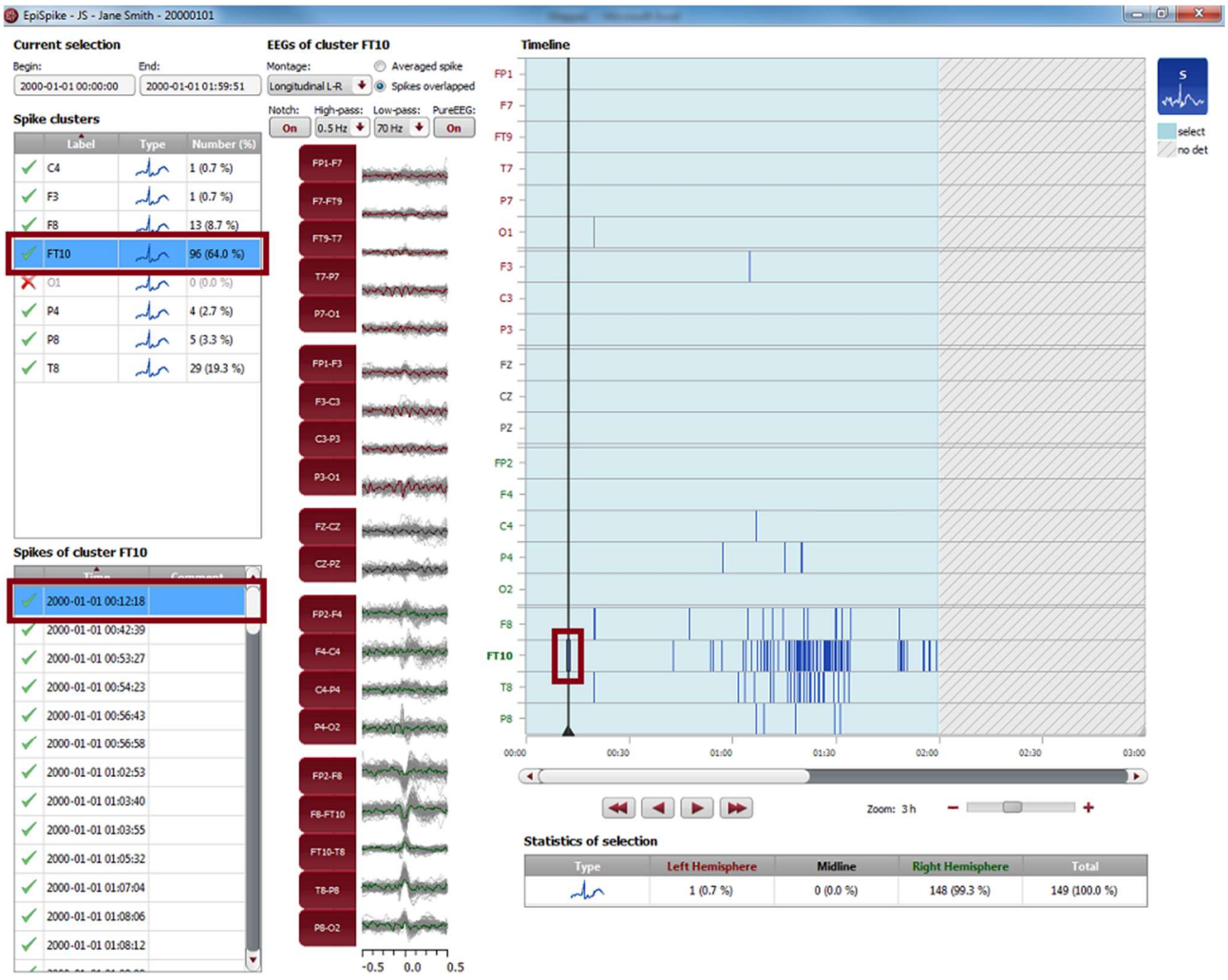
Additionally, the markers will appear automatically in the marker list of the viewer.

You can easily review these detections during the calculation.

- For more details on how to review the detections in the EpiSpike screen, see the section General description.
- For more details on how to review markers see the section Markerlist.

EpiSpike – User Interface

EpiSpike detects single spikes and groups them in spike clusters with respect to their localization. As localization the electrode label is defined, where the maximum of the spike has been detected. Once EpiSpike has been started, the EpiSpike screen opens and shows the results of the detections.



Timeline

Detections are shown as colored bars on the timeline (see right side of the screen). Each line of the timeline shows the detection within a cluster.

→ You can easily navigate through the results using the navigation controls, the zoom and the mouse.

→ The background can have different colors, see section Current selection for more details.

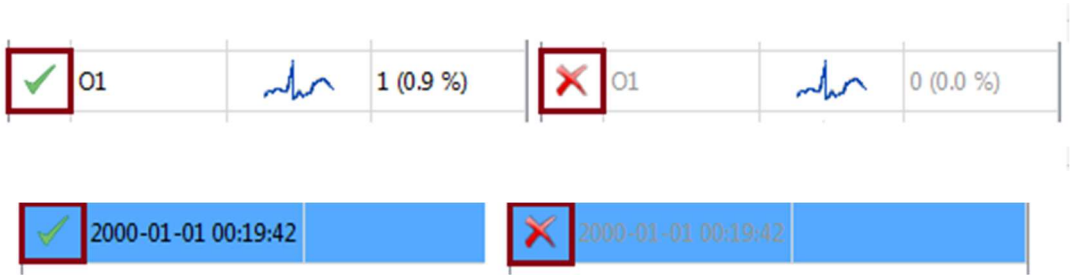
Cluster and spike lists

Additionally, the detections are shown in form of cluster and spike lists (see left side of the screen).

→ Click on a detection on the timeline. The spike and its cluster will be automatically selected in the cluster and spike lists and the EEG is shown (see middle of the screen).

You can delete single spikes or complete clusters.

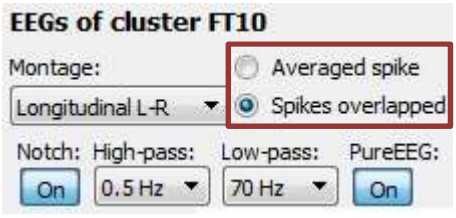
→ Clicking on the check symbol in the corresponding list. A cross will replace the check symbol and the spikes will then appear grey on the timeline.



EEG representation

When a spike is selected, the EEG of its cluster is shown (see middle of the screen).

There are two ways to show the EEG of the cluster:



1. By selecting *Averaged spike*, the EEG of all spikes within the cluster are averaged and the resulting averaged spike is displayed.
2. By selecting *Spikes overlapped*, the EEGs of all spikes are shown overlapped in grey. The EEG of the selected spike is shown in color.

Montage and filters of the EEG can be changed independently of the setting chosen in the EEG viewer.

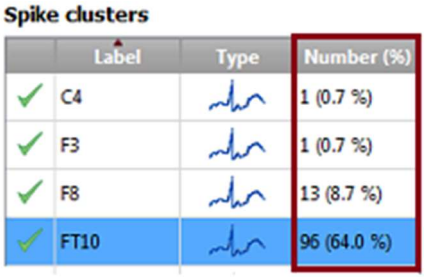
© AIT Austrian Institute of Technology

Synchronization with the EEG viewer

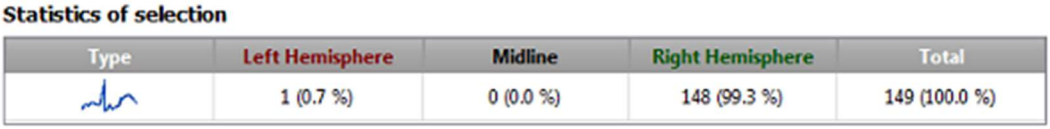
When a spike is selected on the EpiSpike screen, the EEG viewer shows automatically the spike on the main screen. In the same way, when you click on the spike marker in the EEG viewer, this spike will be automatically selected in the EpiSpike screen.

Counting of spikes and statistics

For each cluster, the spikes are counted. The numbers are shown in the spike list:



Additionally, statistics over all clusters are calculated. (see lower part of the screen).



Note that the counting is done in the current selection corresponding to the light blue area on the timeline.

Current selection

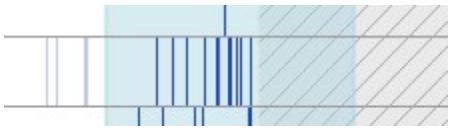
The current selection is the time range that can be selected to have the spikes displayed and counted. It is shown in light blue on the time line.

The selection can be changed in two ways:

1. Using the mouse on the timeline. The edges of the light blue area, which marks the selection, can be dragged and moved as wanted. The detections that are not in the current selection are not counted and appear as grey bars on a white background.
2. Entering Begin and End (see upper left corner).

© AIT Austrian Institute of Technology

Depending on how the current selection is set, the background of the timeline can have different appearances:



White

White shows that the time range is not in the current selection, but detection results are available. Therefore, detections are not shown in the lists and appear on the timeline as grey bars on white background.

Light blue

Light blue shows that the time range part is part of the current selection and that detection results are available. Therefore, detections are shown in the lists and appear as blue bars on light blue background.

Light blue with hatching

Light blue with hatching shows that the time range is part of the current selection, but detection results are not available. This appears when the detection is not finished or when the time range has not been selected for review before starting EpiSpike.

Grey with hatching

Grey with hatching shows that the time range is not in the current selection and detection results are not available. This appears when the detection is not finished or when no EEG data is available in this time range.

© AIT Austrian Institute of Technology

NeuroTrend

Overview

NeuroTrend is the encevis EEG trending software for the automatic analysis and trending of continuous EEG from EMU and critically ill patients at the ICU. NeuroTrend classifies epochs according to the ACNS's Standardized Critical Care EEG Terminology. It provides a condensed graphical representation based on the new standard that helps you assess all the information about trends in the functional state of your patient's brain within a very short time.

User- and data input

The input to encevis NeuroTrend is the raw EEG signal only. No video or other data is used by the algorithm. Any settings in the viewer such as filter setting or montages are not

© AIT Austrian Institute of Technology

considered. During calculation, there is no user input possible. The user can only start the processing by clicking the button “NeuroTrend” in the tool bar of the encevis viewer.

User-defined parameters

There are no parameters in the NeuroTrend algorithm that can be changed by the user.

Outputs to the user

NeuroTrend makes the results available to the user in form of different type of markers as a function of time. The markers are to be interpreted as epochs in the EEG with a high probability of having a certain signal characteristic. The results are presented in a graphical user interface. This user interface is described in detail on the following chapter “NeuroTrend User Interface”.

Description of the algorithm methods

encevis rhythmic and periodic patterns

encevis rhythmic and periodic patterns is a feature for the analysis of EEG-recordings. It automatically detects EEG-patterns defined in the Standardized Critical Care EEG Terminology of the American Clinical Neurophysiology Society (CCET) (Hirsch, L.J., et al., 2013. American Clinical Neurophysiology Society’s Standardized Critical Care EEG Terminology: 2012 version. J. Clin. Neurophysiol. 30, 1–27) and graphically presents the results to the user. Pattern locations and pattern types are defined for all detections in a time interval of a few seconds. In addition, rhythmic patterns with frequencies of more than 4 Hertz are detected. NeuroTrend serves as a support during the examination of EEG-recordings. This post-hoc analysis can take place in parallel to the recording or after the recording finished.

Main term 1 of the CCET defines several categories for the localization of EEG patterns. First of all, rhythmic and periodic patterns can be generalized (G) or lateralized (L). In addition predominant areas can be specified. The implementation of recognition of the main term 1 in our detection algorithm supports generalized (G) and lateralized (L) pattern. A pattern qualifies as lateralized (L), if the maximum amplitude of the pattern in one hemisphere is at least 50% higher than in the contralateral hemisphere, based on bipolar transverse and longitudinal montages only. If not qualified as lateralized, the pattern is generalized. If a generalized pattern has 50% higher amplitude in the frontal, midline, or occipital area compared to a contralateral or bilateral reference area, the pattern is predominant. Frontally, midline, and occipital predominant patterns are therefore detected according to the CCET definition except that again only bipolar longitudinal and bipolar transverse montages are used.

The CCET defines various types of rhythmic and periodic patterns in main term 2. These pattern types are periodic discharges (PD), rhythmic delta activity (RDA), and repetitive spike-and-wave or sharp-and-wave (SW) patterns. PDs are defined as uniform discharges repeating in regular intervals with a clear inter-discharge interval (IDI). Only discharges with waveforms having less than 4 crossings of the baseline are allowed in order to distinguish periodic from burst suppression patterns. The average frequency allowed for PDs ranges

© AIT Austrian Institute of Technology

from 0.2 to 3Hz. The so-called ‘‘relative amplitude’’ is defined as the average discharge amplitude divided by the average amplitude between the discharges. The value of the relative amplitude of a periodic pattern has to be above 1.6 to be detected. Rhythmic delta activity (RDA) is defined as repeating discharges with uniform morphology without an inter-discharge interval. The computational detection of RDA conforms to this definition. Several modifiers to the main term 2 pattern types are defined in the standardized terminology that describes variants in the morphology. The modifier ‘‘+S’’ is defined as a pattern with frequent intermixed sharp waves/spikes or a sharply contoured pattern and is only applicable to patterns of type RDA. These ‘‘RDA + S’’ patterns are detected if at least one unequivocal spike is included in a RDA pattern or the pattern has a sharply contoured morphology. Spike-and-wave or sharp-and-wave (SW) patterns are defined as polyspike, spike or sharp wave consistently followed by a slow wave in a regularly repeating and alternating pattern. The automatic detection of SW is based on detected RDA + S patterns and requires in addition that 20% of the discharges in the RDA + S pattern coincide with unequivocal spike-and-waves or sharp-and-waves. Finally, a frequency up to 4Hertz is allowed to qualify for SW in our method. The detection of rhythmic theta and rhythmic alpha patterns (RTA, RAA) is logically equivalent to the RDA detection but requires more than 6 successive discharges and frequencies between 4—7.5 or 7.5—12 Hertz, respectively. The modifier ‘‘amplitude’’ is defined as the average amplitude of all discharges in the pattern. The discharge amplitude is defined as the minimum of the two peak-to-peak voltages measured from the start of the discharge to the maximum and from the maximum to the end of the discharge. The modifier ‘‘frequency’’ is determined as the average distance between consecutive discharges in a pattern.

The following is a brief description of how the detection algorithm processes EEG data. At the beginning, EEG artifacts are removed using the PureEEG algorithm. The PureEEG algorithm is based on a neurophysiological model and utilizes an iterative Bayesian estimation scheme to remove typical scalp EEG artifacts like movement, muscle, line noise, and loose electrode artifacts. The output of the PureEEG algorithm is a clean EEG signal that is solely used for further analysis. This approach assumes that all following pattern detections are of cerebral origin. Frequencies below 0.4Hertz and above 70 Hertz are then removed by a finite impulse response filter. Bipolar longitudinal and transverse montages are created according to ACNS’ proposal for clinical EEG montages. The signal in each bipolar channel is divided into segments that represent spikes, waves, or any other discharge item with durations between 40 milliseconds and 1.5seconds and amplitudes above 20microvolts. The wave segmentation procedure scans the EEG signal in the time domain for arbitrary peaks with more than 20mV. Each peak is then extended on both sides as long as the waveform lies above two projection lines that start at the borders of the starting peak and have 20% reduced slope value. All resulting wave segments below 40milliseconds and above 1.5seconds are dropped. These single-channel segments are then combined over several channels to build multi-channel segments. The spatial distribution of potentials within multi-channel segments is checked and segments with non-cerebral origin are discarded. All multi-channel segments are then marked as spike, sharp wave, or non-spike segment by a spike-detection algorithm. The multi-channel segments are also used to build groups of representing RDA, RDA + S, SW, RTA, RAA, and PD segments as described above. Whether a pattern meets minimal requirements for duration and the number of discharges is checked and patterns that do not meet criteria are discarded. The spatial location of all

© AIT Austrian Institute of Technology

detected patterns is analyzed and a main term 1 definition is assigned. Finally, segments of equal pattern type are concatenated to groups with a maximal duration of 30 seconds. These groups are displayed in the main term 1 and 2 plot of the graphical user interface.

More details of the algorithm can be found in [F. Fürbass, M.M. Hartmann, J.J. Halford, J. Koren, J. Herta, A. Gruber, C. Baumgartner, T. Kluge; "Automatic detection of rhythmic and periodic patterns in critical care EEG based on American Clinical NeurophysiologySociety (ACNS) standardized terminology", Clinical Neurophysiology, 45 (3), September 2015, Pages 203-213].

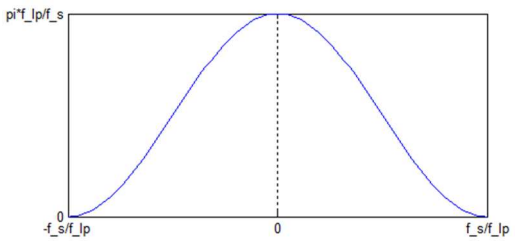
encevis aEEG

Encevis aEEG calculate and visualize a continuous measure that describes the EEG by showing the aEEG as defined in "Zhang, D., Ding, H., 2013. Calculation of compact amplitude-integrated EEG tracing and upper and lower margins using raw EEG data. Health (N. Y.) 05, 885–891", http://dx.doi.org/10.4236/health.2013.55116). The method describes an algorithm to calculate aEEG for single EEG channels. The encevis NeuroTrend implementation follows the algorithm for channel-wise aEEG calculation and then extents it for the use of multi-channel EEG signals.

Channel-wise calculation of aEEG starts by applying the asymmetrical filter to the EEG channel following the description given in Section 2.1 "Asymmetrical Filtering" of Zhang et al 2013. The frequency response of Figure 1 (a) in Zhang et al 2013 is approximated using a finite impulse response filter that implements the specified 12 dB per decade increasing filter response in the range of 2 to 20 Hz. The filtered signal is called x_{bp}. Then, the envelope detection of the filtered time series data (Section 2.3 "Envelope Detection" in Zhang et al 2013) is implemented by applying a low pass filter h_{lp} to the signal.

$$x_{lp}(t) = \left(\left|x_{bp}(t)\right|\right) * h_{lp}$$

The filter impulse h_{lp} is a raised cosine window of length $2\ f_s/f_{lp}$, where f_s is the sampling frequency, f_{lp} is the cutoff frequency of the lowpass. In our implementation $f_{lp} = 2$. The impulse response is shown in the following figure:



Impulse response of the aEEG

This implementation will result is a smoothened line which will be sub sequentially used as amplitude feature y_{AEEG}.

After smoothening, non-overlapping segments of 0.5 seconds with the index i are defined and the maximum and minimum value of each segment is calculated.

Then the average value of the maximum and minimum segment values over all channels belonging to the right and left hemisphere are calculated respectively resulting in values aEEG_right_max(i), aEEG_right_min(i), aEEG_left_min(i), aEEG_left_max(i). The amplitude-integrated EEG plot of encevis NeuroTrend visualizes these average values by drawing a line between aEEG_right/left_max(i) and aEEG_right/left_min(i) as well as connection line between them.

encevis frequency bands

encevis frequency band feature calculates and visualizes a continuous measure that describes the EEG by showing the frequency distribution of the EEG. The relative proportions of the four Berger frequency bands delta (< 4Hz), theta (4-7.5 Hz), alpha (7.5-12.5Hz), and beta (>12.5 Hz) are shown. The intensity of the colors corresponds to the amplitudes in these four frequency bands.

For the calculation of the frequency band measures, the input signals are divided into segments of three seconds duration. Then the dominant frequency band for each segment is determined, i.e., delta, theta, alpha or beta. The relative frequency of the dominant Berger-bands is calculated within windows of 15 seconds. The amplitude for each Berger frequency band is determined as an average over all segments that have been assigned to that frequency band respectively. The amplitudes for each Berger band, which directly correspond to the power levels in a conventional spectrogram, are indicated by color intensities in the encevis frequency band graph: high amplitudes are indicated by high intensities and vice versa.

Example: In a 20-channel EEG, if exactly 4 channels clearly show dominant alpha, then the relative frequency of alpha is 20%. The alpha amplitude is determined as an average amplitude over the 4 alpha channels. In the graph, the width of the green alpha bar would be 20% of the total height, the intensity would be indicated by the intensity of the green bars.

encevis Burst Suppression

Encevis burst suppression feature calculates and visualizes suppression rate and suppression time in percent. It calculates periods of burst suppression in the EEG and marks them by vertical bars with red color. The definition of burst suppression patterns follows the guidelines of the American Clinical Neurophysiology Society ICU EEG Terminology (Hirsch, L.J., LaRoche, S.M., Gaspard, N., Gerard, E., Svoronos, A., Herman, S.T., Mani, R., Arif, H., Jette, N., Minazad, Y., Kerrigan, J.F., Vespa, P., Hantus, S., Claassen, J., Young, G.B., So, E., Kaplan, P.W., Nuwer, M.R., Fountain, N.B., Drislane, F.W., 2013. American Clinical Neurophysiology Society's Standardized Critical Care EEG Terminology: 2012 version. J. Clin. Neurophysiol. 30, 1–27. doi:10.1097/WNP.0b013e3182784729).

First, the EEG is segmented into consecutive and non-overlapping detection segments of 15 seconds. All further processing is based on these detection segments. Scalp EEG artifacts are removed using the PureEEG method. The EEG channels are converted to bipolar longitudinal and transversal montages following ACNS recommendations.

Next, a channel-wise detection of burst suppression events is performed. In each EEG channel x_t the peak-to-peak amplitude is measured by subtracting the minimum from the maximum digital value in non-overlapping chunks of 0.4 seconds. Only EEG samples of the

© AIT Austrian Institute of Technology

current detection segment are used. A chunk is defined as part of a suppression event if either a chunk with double amplitude follows in 1.5 seconds or if a chunk with double amplitude precedes with 1.5 seconds distance. All remaining chunks in the detection segment are part of a suppression event if their amplitude is below the amplitude of the initially detected suppression chunk. All chunks that are not marked as part of a suppression event at this processing step are part of a burst event if the peak-to-peak amplitude is higher than double amplitude of the surrounding suppression chunks.

The channel-wise detection information is then used as input to a hierarchical cluster algorithm to find spatial groups of the same activity type. The resulting clusters represent burst or suppression detections that span several EEG channels and extend over a certain time period. In this method clusters need to span at least 40% of the cortical area covered by electrodes to be further used in the detection procedure. The minimum coverage value of 40% was determined empirically and serves as a sensitivity parameter of the method.

Detection segments are marked as a burst suppression pattern if two conditions apply: First, at least one suppression cluster was detected with $\mathrm{A_{IBI}} \leq 10\,\mu\mathrm{V}$ and $\tau_{IBI} \geq 1.5$ seconds. Second, one burst cluster with $\mathrm{A_{BURST}}$ of more than two times the lowest suppression cluster amplitude and $\tau_{\mathrm{BURST}} \geq 0.5$ seconds was found in the detection segment. The quantity of these parameters follow the definitions in the ACNS' critical care EEG terminology. An exception is the value of 1.5 seconds for τ_{IBI} which was found empirically through extensive manual evaluation of BSP during algorithm development.

A detailed description of the algorithms can be found in [F. Fürbass, J. Herta, J. Koren, M. B. Westover, M. Hartmann, A. Gruber, C. Baumgartner, T. Kluge; "Monitoring burst suppression in critically ill patients: Multi-centric evaluation of a novel method", Clinical Neurophysiology, April 2016].

Using NeuroTrend

Follow these steps to start NeuroTrend:

1. Open the EEG that you want to analyze with NeuroTrend.
2. Click on the "NeuroTrend" icon under the menu to start the calculation.

Once the calculation started, the progress will be shown under the icon. The NeuroTrend screen will pop-up and show the results of the calculations.

NeuroTrend User Interface

NeuroTrend includes five traces. The traces can be switched on and off in the button bar.

The first two traces show the detections of Traces “PATTERN” - rhythmic and periodic patterns based on the ACNS's Standardized Critical Care EEG Terminology. Detected patterns are shown as lines with a color code. The next trace shows detections of

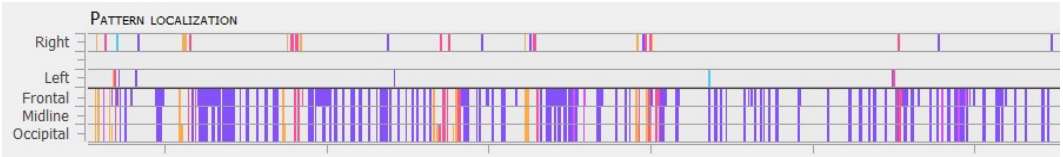
Trace „BURST SUPPRESSION“. The two last traces show the Trace „FREQUENCY BANDS- STACKED PROPORTIONS” and the Trace „AMPLITUDE-INTEGRATED EEG“.

Traces “PATTERN” - rhythmic and periodic patterns

The first two traces show the detections of rhythmic and periodic EEG patterns based on the ACNS's Standardized Critical Care EEG Terminology. Time is displayed on the x-axis. Each colored line is to be interpreted as an epoche in the EEG with a high probability of showing a pattern according to its color code. The algorithm is explained in chapter “encevis rhythmic and periodic patterns”. Detected patterns are shown with the following color code

PD	Periodic discharges
RDA	Rhythmic delta activity
RDA+S	Rhythmic delta activity + superimposed sharp waves Sharply contoured rhythmic delta activity
SW	Rhythmic spike and wave Rhythmic sharp and slow wave Rhythmic polyspike and wave
RTA	Rhythmic theta activity
RAA	Rhythmic alpha activity

Trace „PATTERN LOCALIZATION”



In the first trace the localization of the patterns is displayed. Time is displayed on the x-axis. For each detected pattern the localization or dominance with the highest probability is shown. The color code is as defined in section “Traces “PATTERN” - rhythmic and periodic patterns”. The upper part shows, when the pattern was lateralized:

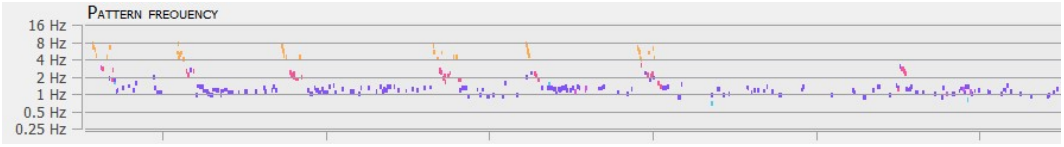
- Right or
- Left

When no lateralization is recognized, then the lower part shows the dominance:

- Frontally predominant or
- Midline predominant or
- Occipitally predominant or

- Generalized, when the line covers Frontal, Midline and Occipital.

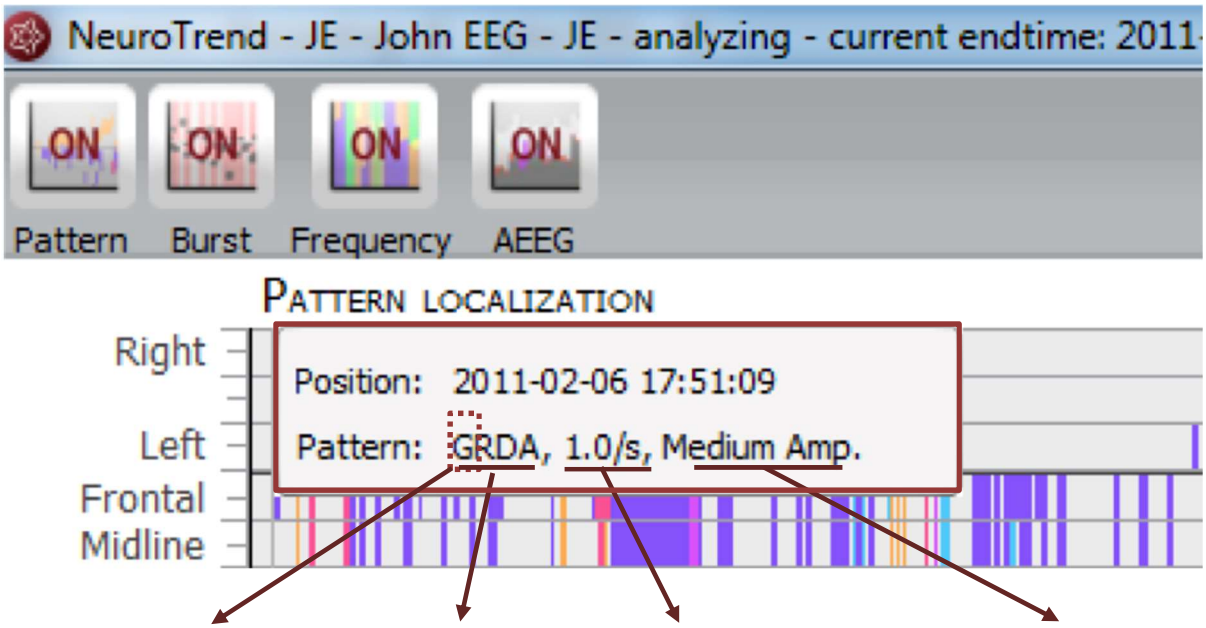
Trace „PATTERN FREQUENCY“



For each detected pattern the frequency is shown on a logarithmic scale in the range from 0.25-16Hz. Time is displayed on the x-axis. The color code is as defined in section “Traces “PATTERN” - rhythmic and periodic patterns”.

Cursor text box

The cursor text box that appears when you move with the mouse includes the following summarized information:



Pattern localization	Pattern type	Frequency range	Amplitude range
L: Lateralized	PD	<0.5 /s	<20 µV (“very low”)
G: Generalized	RDA	0.5 /s	20-49 µV (“low”)
	RDA+S	1 /s	50-199 µV (“medium”)
	SW	1.5 /s	>200 µV (“high”)
	RTA	2 /s	
	RAA	2.5 /s	
		3 /s	
		3.5 /s	
		>= 4 /s	

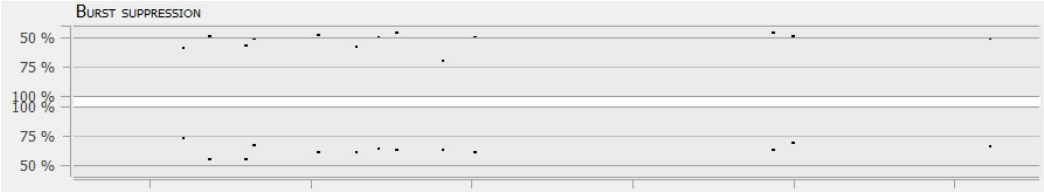
Position refers to the time point where the pattern was detected.

Pattern includes the summarized information on the pattern as described in the ACNS's Standardized Critical Care EEG Terminology

The Pattern information can also be found in the bottom of the screen.

© AIT Austrian Institute of Technology

Trace „BURST SUPPRESSION“



In this trace, red lines show high probability for the detection of burst suppressions and black dots show two quantitative values related to the discontinuity of the EEG as a function of time. Time is displayed on the x-axis. In the upper part, the user can read off the relative amplitude attenuation in [%] of the amplitude between burst and suppression period on the y-axis. E.g., a value of 50% corresponds to an amplitude reduction during suppression period of 50% relative to the burst period before. In the lower part, the suppression time in the range of 50-100% is shown on the y-axis. Values close to 100% suppression time mean that the length of the suppression period nearly covers all of the EEG segment, a value of 50% mean that burst and suppression periods have equal duration. When the user clicks in the trace, the raw EEG for this time point is shown in encevis viewer. No further user interaction is possible.

Trace „FREQUENCY BANDS- STACKED PROPORTIONS”

encevis frequency band feature calculates and visualizes a continuous measure that describes the EEG by showing the frequency distribution of the EEG. The relative proportions of the four Berger frequency bands delta (< 4Hz), theta (4-7.5 Hz), alpha (7.5-12.5Hz), and beta (>12.5 Hz) are shown in the range between 0-100% as a function of time. The intensity of the colors corresponds to the amplitudes in these four frequency bands. The amplitudes for each Berger band, which directly correspond to the power levels in a conventional spectrogram, are indicated by color intensities in the encevis frequency band graph: high amplitudes are indicated by high intensities and vice versa.

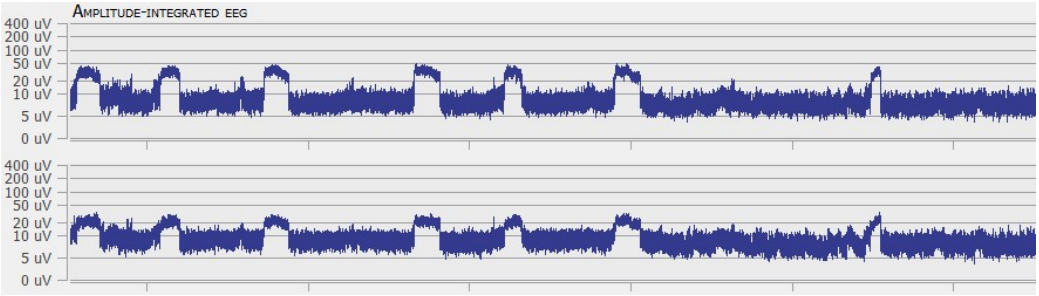
β Beta-Band

α Alpha-Band

θ Theta-Band

δ Delta-Band

Trace „AMPLITUDE-INTEGRATED EEG“



The aEEG trend displays the amplitude characteristics of a filtered, rectified representation of the EEG signal as a function of time. Time is displayed on the x-axis and the aEEG amplitude measure on the y-axis. The amplitude integrated EEG is shown on two traces. The upper one shows the aEEG of the right hemisphere and the lower one the aEEG of the left hemisphere on a combined linear and logarithmic scale in the range: 0-400 µV as defined in Zhan et al. When you click in the trace, the raw EEG at this time point is shown in encevis viewer. The aEEG trend provides a simplified depiction of amplitude characteristics of the EEG signal, and is intended to be used in conjunction with other EEG trends, and with the original EEG waveforms, for analysis of the EEG.

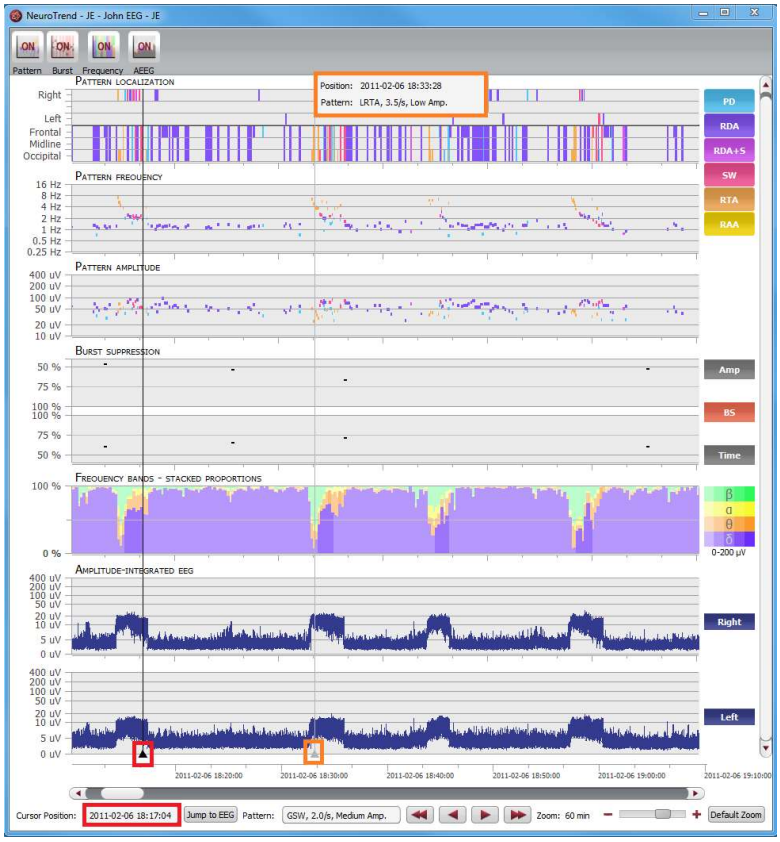
Navigating in NeuroTrend

NeuroTrend provides a graphical user interface that makes navigation through the results very easy. The detection of the EEG patterns can be synchronized with the EEG at any time. You can navigate using your mouse and mouse wheel and by using the buttons on the bottom of the screen.

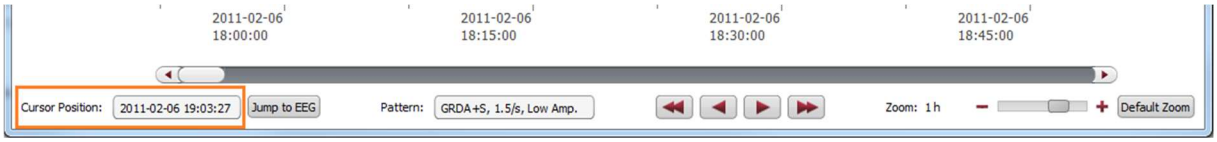
Cursor

- Move the mouse on the screen, a cursor will appear with a text box with the time position and the pattern detected (orange).
- Click on the screen and the cursor will be set on that position (red). On the bottom of the screen you will find the related Cursor Position and Pattern.

© AIT Austrian Institute of Technology

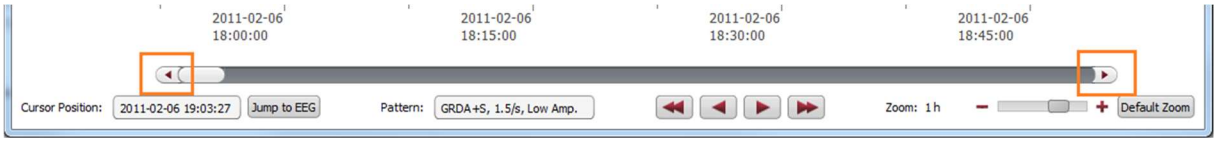


- Type in the exact time in the field "Cursor position"

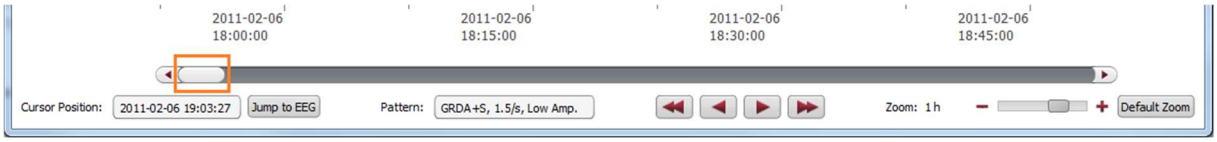


Move forward and backwards in time

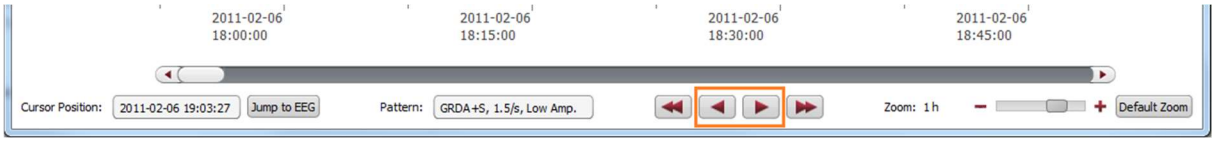
Click on the arrows of the scroll bar,



or use the slider,



or click on the simple buttons to move stepwise,



or click on the double buttons to move pagewise.

Zoom

You can zoom in and out and thus show more or less results on one screen.

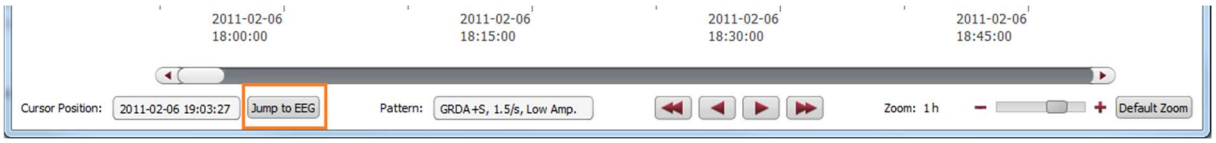
1. The easiest way to zoom is by clicking on the NeuroTrend screen and scrolling the mouse wheel.
2. You can also click on the symbols - and +. The resolution shows which time range is shown on the screen.

3. Clicking on "Default Zoom" gets you back to the initial zoom of 3h per screen.

Synchronize with EEG

The NeuroTrend screen can always be synchronized with the EEG viewer. You have two possibilities for that:

1. Click with the mouse on the screen, the EEG on the selected time point will be shown in the EEG viewer.
2. Click on the button „Jump to EEG", the EEG where the cursor is set will be automatically shown.



The synchronization works both ways. Additionally, when you click with on the screen of the EEG viewer, the cursor will automatically be set on that time point in the NeuroTrend screen.

Select pattern types

You can select and deselect patterns that will be displayed on the screen

→ Click on the icon on the upper right side of the screen

© AIT Austrian Institute of Technology

PD
RDA
RDA+S
SW
RTA
RAA

Distributor

Overview

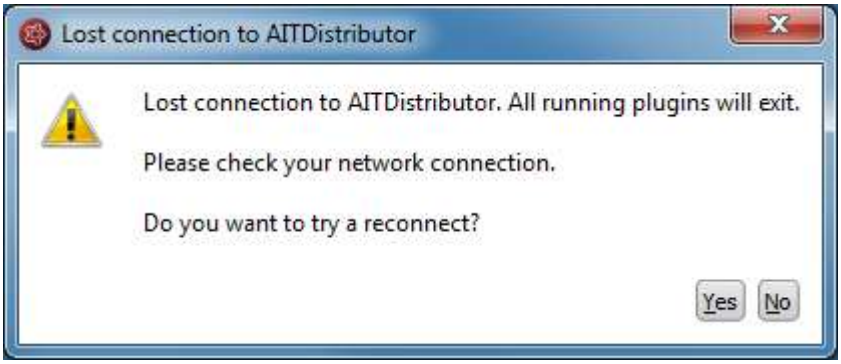
The Distributor is the tool that connects the EEG analysis tools as encevis EpiScan, EpiSpike, EpiSource and NeuroTrend to the encevis viewer. The Distributor needs to be running and connected, if you want to use the analysis tools.

Automatic start of Distributor

Usually, encevis starts automatically the Distributor when it is opened. This setting can be changed under the menu point *Start* > *Settings* > *Distributor*.

Manual start of Distributor

If you get the following error message when starting the plug-in:



→ Start the executable *Distributor.exe* and connect to the Distributor again.

Moberg Interface

Overview

The Moberg interface enables you to use encevis in an "online" mode, together with the Moberg CNS Monitor. You can have the plugins EpiScan, EpiSpike and NeuroTrend running and processing data while you are recording an EEG with a CNS Monitor. Once set up, the Moberg interface scans automatically if an EEG recording is being performed with the CNS Monitor and starts the plugins that you want. When an EEG recording of a new patient is started, the Moberg interface adds the patient's data automatically in the encevis EEG File Management. The calculation results of the plugins can then be reviewed.

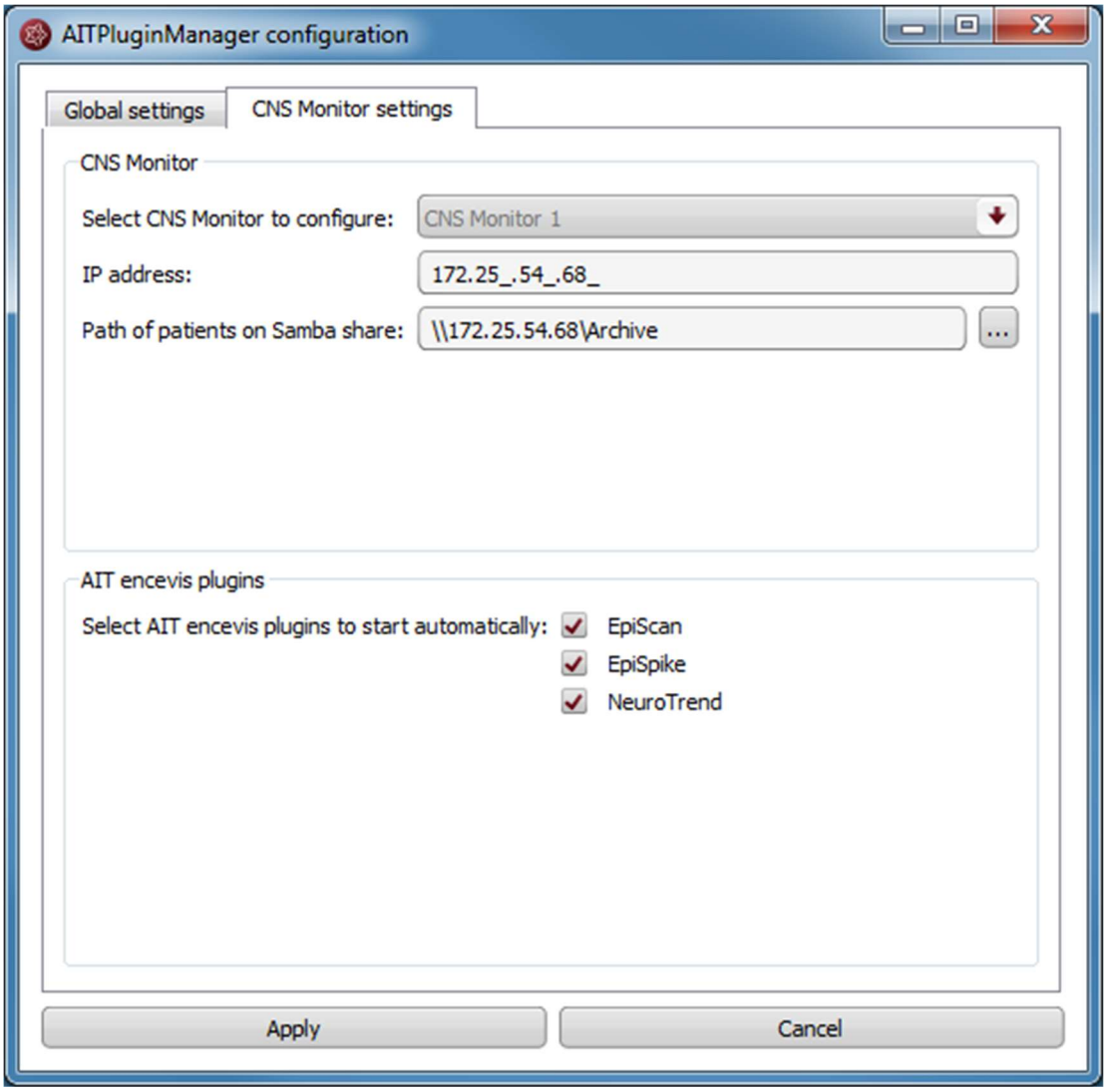
Moberg interface configuration

Start the executable *MobergInterface.exe*, the configuration will open.

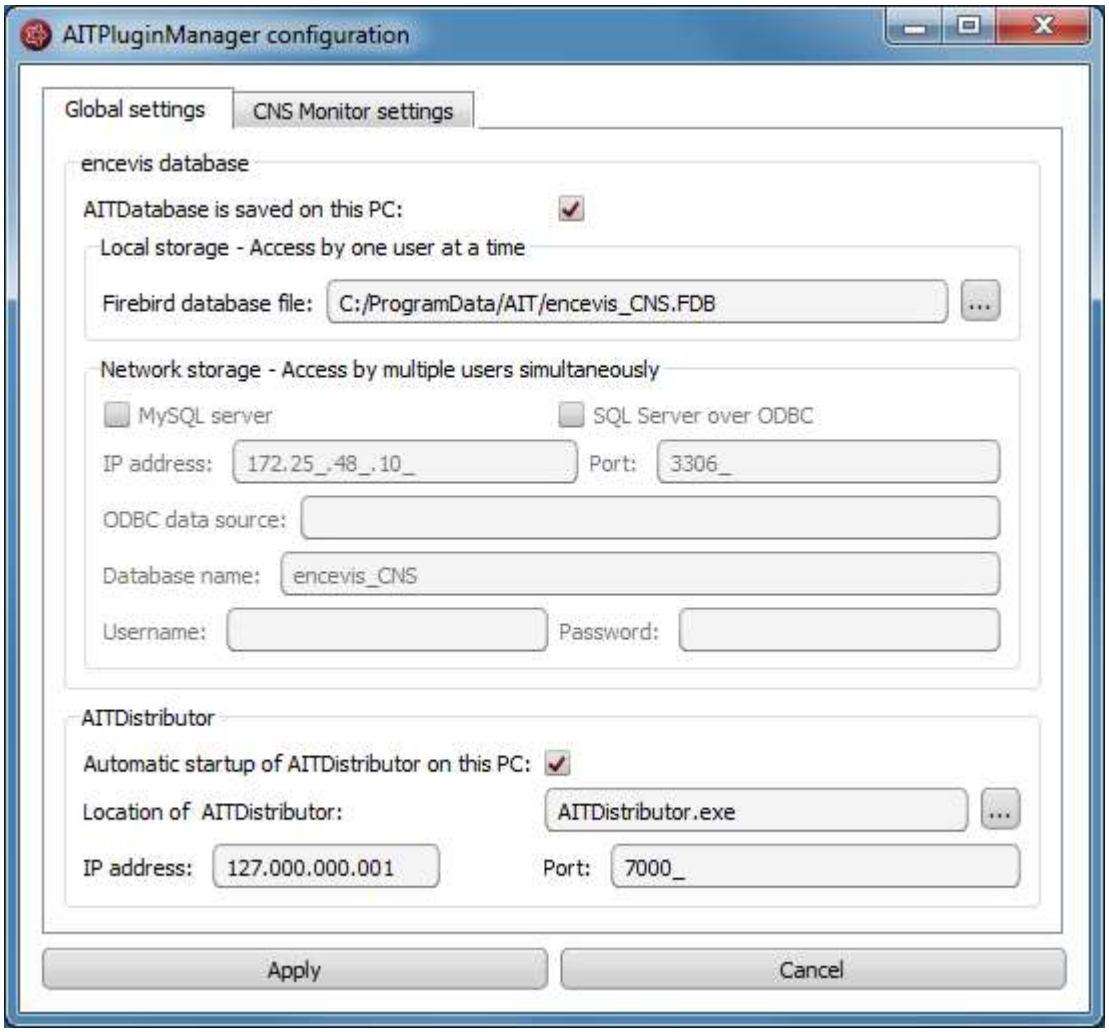
Section *CNS Monitor settings*

- Fill out the IP address of the CNS Monitor and the path where the patients' data are stored.
- Select the plugins that should be started automatically. EpiScan, EpiSpike and NeuroTrend can run at the same time.
- Click on "Apply".

© AIT Austrian Institute of Technology


AITPluginManager configuration
Global settings
CNS Monitor settings
CNS Monitor
Select CNS Monitor to configure:
CNS Monitor 1
IP address:
172.25_.54_.68_
Path of patients on Samba share:
\\172.25.54.68\Archive
...
AIT encevis plugins
Select AIT encevis plugins to start automatically:
EpiScan
EpiSpike
NeuroTrend
Apply
Cancel

Section *Global settings*



Fill out the fields of *encevis database*

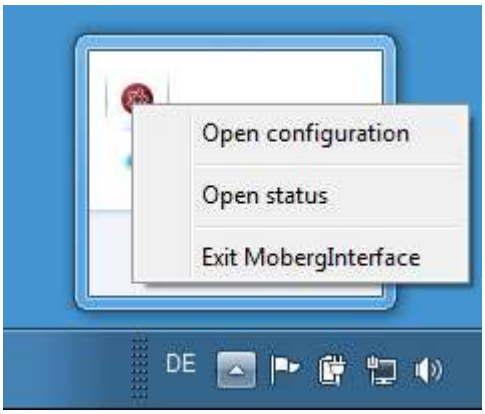
- Local storage - Access by one user at a time:
  This is the best mode, when the results of your review with encevis should only be accessed from your PC. Only one user at at time can then access the results. You can leave the file name specified by default or select a personalized name.
- Network storage - Access by multiple users simultaneously:
  This is the best mode, when you want to access the results of your review with encevis from several PCs in your network. With this option several users can access the results at the same time. In this case, you need to specify a database where everybody has access to. This database can be MySQL or an SQL server over ODBC.

Fill out the fields of *Distributor*

- Select if the Distributor should run on your PC or on a different one. If the Distributor is running on another PC, you need to specify IP address and Port. For more details on the Distributor see Distributor.
- Click on "Apply".

Access Moberg interface

Once it has been started, the AITPluginManager runs in the background. You can access it by clicking on the tray in the lower right corner of your screen and right clicking on the encevis icon.

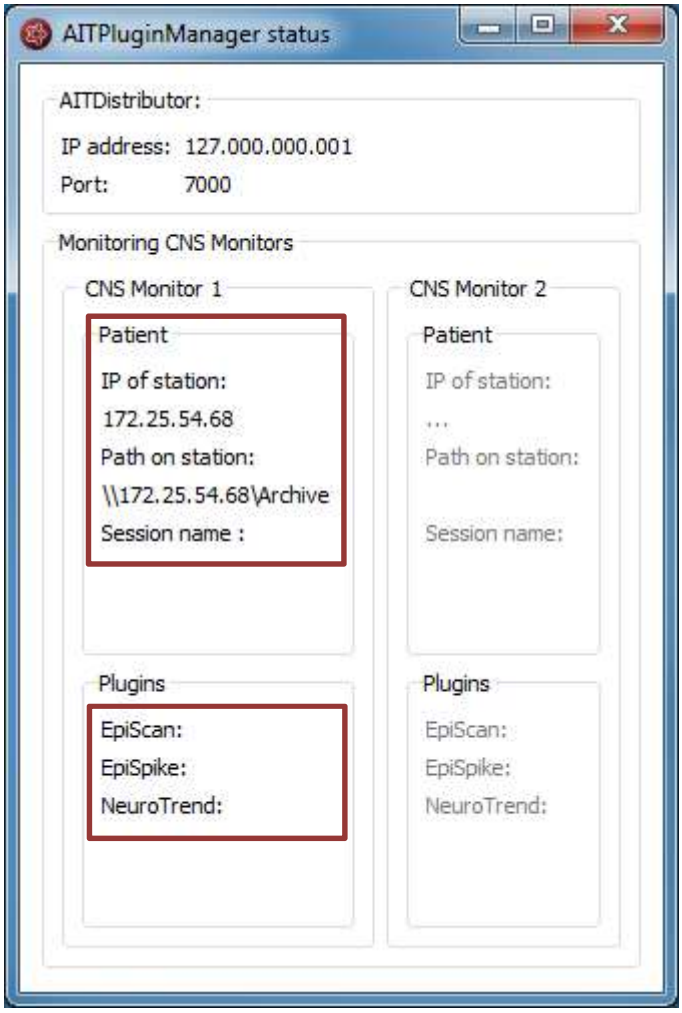


-

Moberg Interface status

No EEG data is being recorded

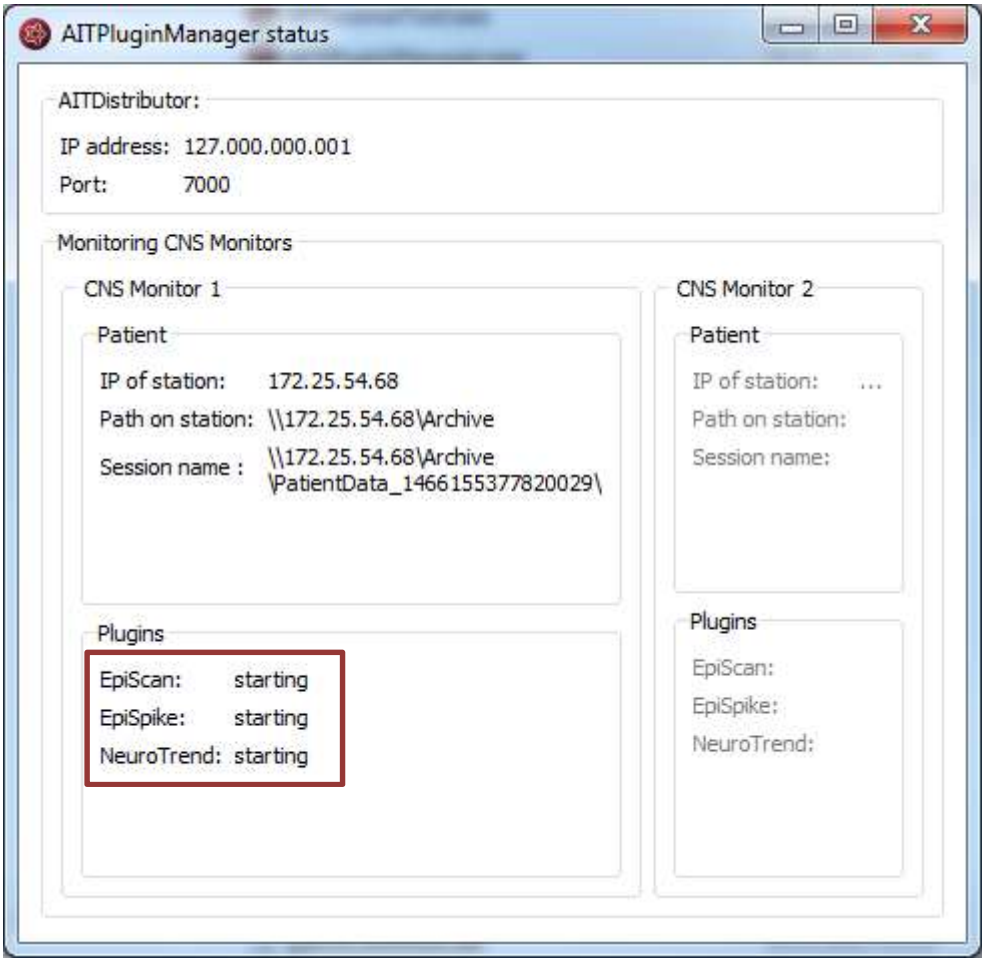
When no EEG data is being recorded by the CNS monitor, this is shown in the status window:



EEG recording starting in CNS Monitor

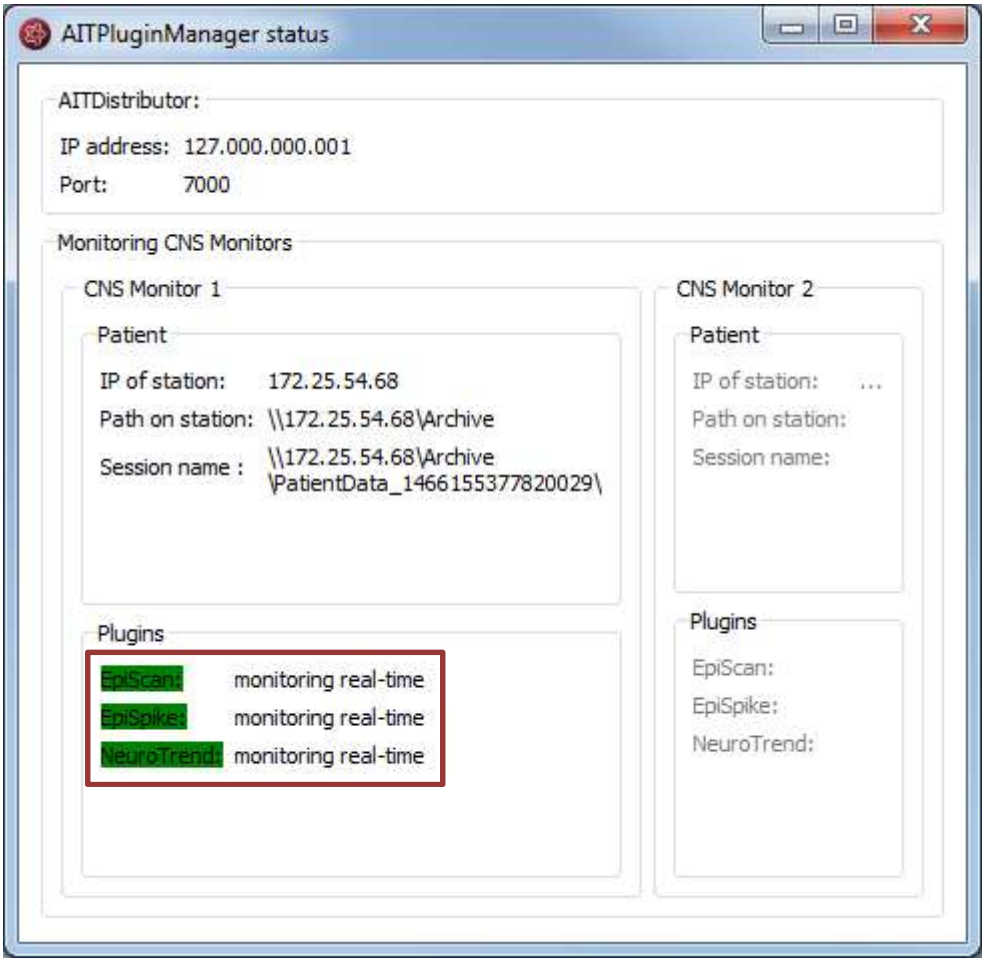
Start a recording with the CNS Monitor. Note, that In order to use EpiScan, you should make sure, that the Pz electrode is being used.

When a recording is being started in the CNS Monitor, this is shown in the status window:



EEG recording running in the CNS Monitor

When an EEG is being recorded with the CNS Monitor, this is shown in the status window:



The following color code can be read on the screen:

- green: everything is well, monitoring is done in real time.
- yellow: attention, monitoring is not in real time anymore.
- red: error.