Dreamento user manual

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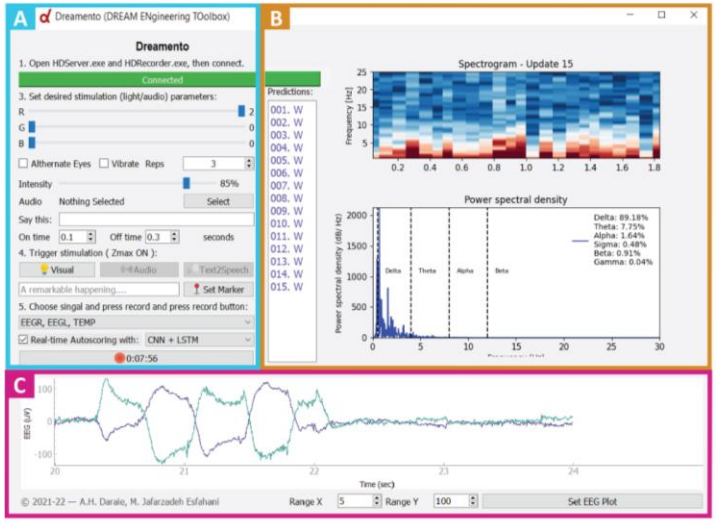
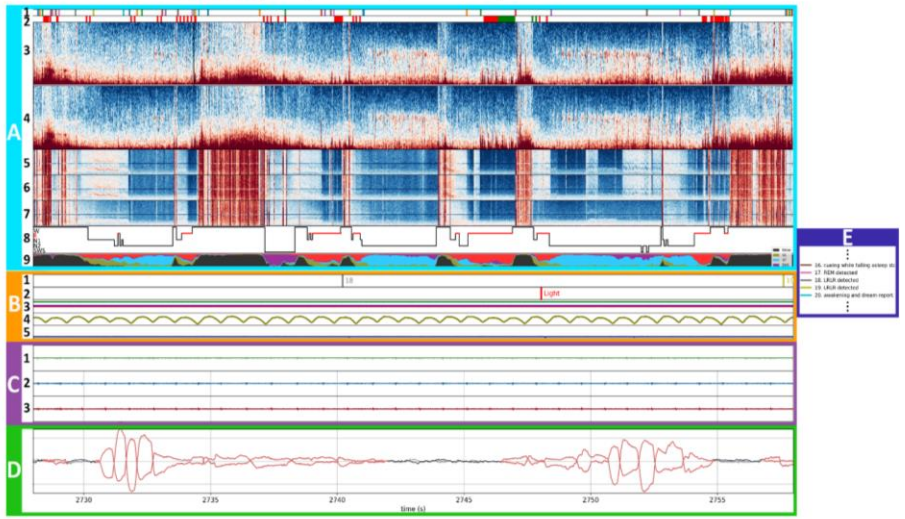
1. Introduction

Dreamento (DREAM ENgineering Toolbox)
an open-source Python package for:

1) Real-time recording, monitoring, analysis, and sensory stimulation



2) Offline post-processing of the acquired data



(A) Recording and stimulation panel:
Recording physiological signals (e.g., EEG, acceleration, PPG, etc)
Sensory stimulation (light, audio, vibration, text2speech)
Annotations:

(B) Analysis panel:
online sleep staging
online time-frequency representation (TFR)
online power-spectrum analysis

(C) Data representation panel:
Two-channel real-time EEG representation
Scalable time (x-axis), and amplitude (y-axis)

(A) Entire recording representation of:
(1) Manual annotations
(2) Automatic annotations (sensory stimuli)
(3 - 4) TFR of EEG channels
(5 - 7) TFR of EMG channels
(8) Automatic sleep staging
(9) Hypnodenisty (probability of sleep stages)

(B) The selected epoch representation of:
(1) Manual annotations
(2) Automatic annotations (sensory stimuli)
(3) Triaxial acceleration data
(4) photoplethysmograph (PPG)
(5) ambient noise

(C) (1-3) The selected epoch EMG data

(D) EEG data (2 channels)

(E) The list of annotations

- Dreamento is currently only available for MS Windows.
- Dreamento is mainly developed for EEG wearables, and ZMax Hypnodyne in particular.

1.1 Which Dreamento do you need?

- If you need to monitor (and record) **real-time** representation of data along with enabling real-time sensory stimulation and analysis, **real-time Dreamento** is the appropriate choice.
- If your intention is to **post-process** the acquired data (the data that has been collected either using real-time Dreamento or collected on ZMax sd card), you will specifically require **offline Dreamento**.
- If both, simply you need both!

Therefore, the initial factor to take into account is whether you need real-time, offline, or both Dreamento, as the installation and usage procedures for each would vary.

1.2 Prerequisites

To be able to install and use Dreamento (either offline or real-time Dreamento), you need to install two software:

I. **Anaconda:** this is the virtual environment manager we need for Dreamento. Download through https://www.anaconda.com/download. The installation is straightforward – you don't have to change anything in the default options while installing the software.
II. **Git:** Git is a distributed version control system. Download through https://git-scm.com/downloads. The installation is straightforward – you don't have to change anything in the default options while installing the software.
III. **ZMax Hypnodyne software suite** *(for ZMax users only)***:** Download from https://hypnodynecorp.com/downloads.php and install the package.

2 Cloning the repository

Dreamento repository is maintained on GitHub: https://github.com/dreamento/dreamento. To clone the repository, we highly recommend you cloning through Git (see below), rather than downloading the .zip repository. Then updating Dreamento would be much easier *(Dreamento is continuously being update with new features).*

To clone, first, you need to specify where you want to store Dreamento, e.g., `C:/Dreamento/`. So, first, create the desired directory in your local pc. Then open the Anaconda prompt (open the start menu and search for Anaconda prompt). In Anaconda prompt console, you need to change the current directory, to where you want to install Dreamento, so, type: `cd C:/Dreamento/` and hit enter. Now, it's time to clone the repository. Type: `git clone https://github.com/dreamento/dreamento.git` and hit enter. It may take a few mins to clone the repository!

3 Updating Dreamento

Whenever you want to use Dreamento, first check if there is any update available. For this, you need to go to the directory where you installed Dreamento (e.g., `cd C:/Dreamento/`) and extract the content of "AutomaticDreamentoUpdate.zip" in the same folder(e.g., `cd C:/Dreamento/`) as other Dreamento files are located. Then you just need to double-click on "AutomaticDreamentoUpdate.exe" before each use and you will automatically receive the updates.

4 Installation (first-time use only)

Please note that the installation of Offline and real-time is different, and thus two different virtual environments are required as follows. So, install the one you need (or both, if you need both!):

- ***Real-time Dreamento*:** (A complete video tutorial on how to install real-time Dreamento can be found HERE.)
  a. Open anaconda prompt (from the start menu).
  b. Change direction into where Dreamento is installed (e.g., `cd C:/Dreamento/`).
  c. Create all the required packages on a virtual environment with the following syntax :
  ```
  conda env create --name dreamento --file dreamento.yml
  ```

- ***Offline Dreamento*:** (A complete video tutorial on how to install Offline Dreamento is provided HERE.)
  a. Open anaconda prompt.
  b. Change direction into where Dreamento is installed (e.g., `cd C:/Dreamento/`).
  c. Create all the required packages on a virtual environment with the following syntax:
  ```
  conda env create --name offlinedreamento --file offlinedreamento.yml
  ```

N.B.1. If you get any errors during this process, make sure your directory is changed to where Dreamento main folder from GitHub is cloned. This folder should contain both `dreamento.yml` and `offlinedreamento.yml` files.

N.B.2. After installation, whenever you need to use Dreamento you should activate the corresponding environment. How? See the next section!

5. Using real-time and offline Dreamento

Make sure you have already installed the required virtual environment. If not, see the previous section!

The very first thing to do is to “activate” the virtual environment so that you can use the toolbox.

If you want to use real-time Dreamento, do the following:

- When you have real-time Dreamento and Hypndoyne software suite installed, follow the following steps.
- Connect the USB dongle to your pc.
- Run “HDServer.exe” from Hypndoyne software suite.
- Run “HDRecorder.exe” from Hypndoyne software suite and click on "connect".
- Open the Anaconda prompt, change the directory to where you installed Dreamento

```
cd directory/to/Dreamento
```

(e.g., `cd C:/Dreamento/`).

- Activate the virtual environment you made in the previous section

```
conda activate dreamento
```

- Run Dreamento through “mainWindow.py”:

```
python mainwindow.py
```

When Dreamento's GUI is started, click on "connect". By clicking on the "record" button, the recording will be started!

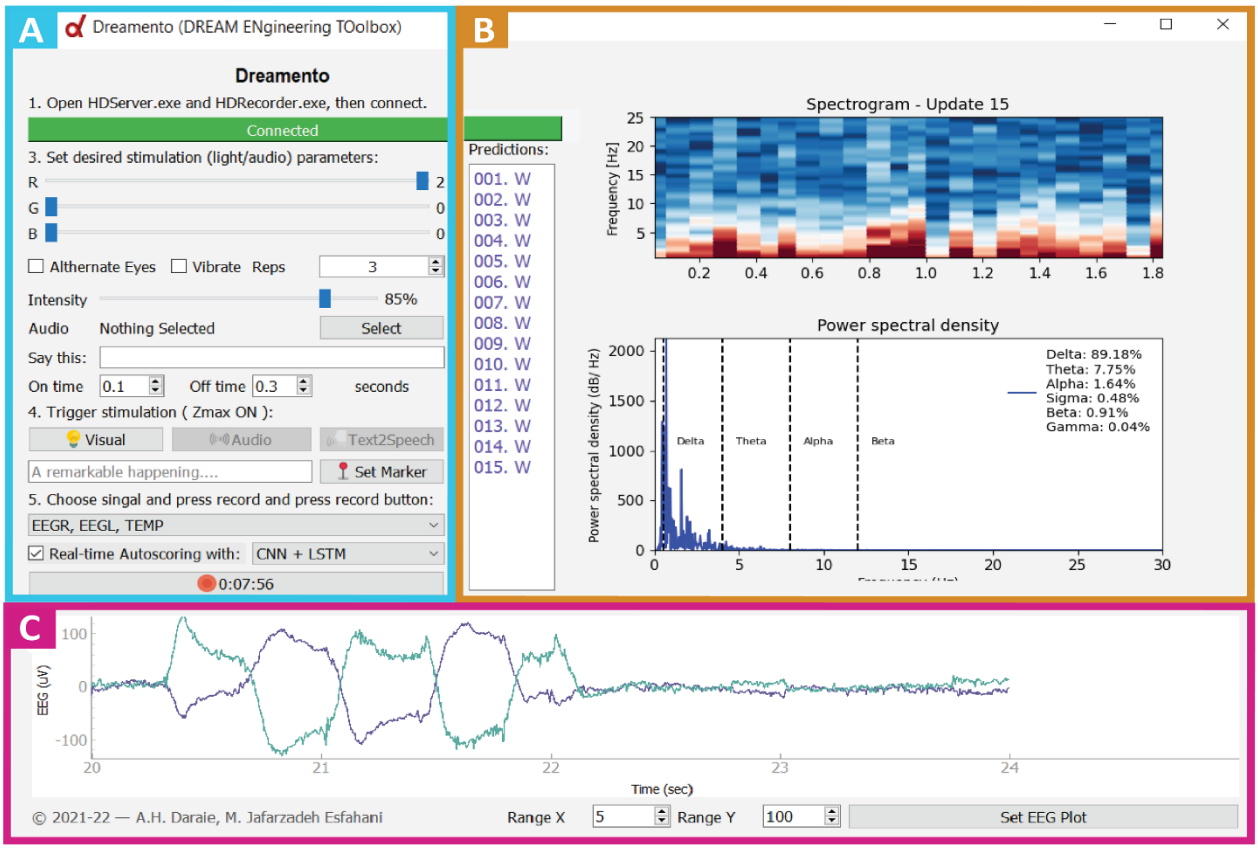
If you want to use **offline Dreamento**, do the following:

- Open Anaconda prompt and activate the virtual environment

```
conda activate offlinedreamento
```

- Then type “spyder” in the anaconda prompt and hit “enter” button.
- In the spyder software, open the “OfflineDreamento.py” from where you stored Dreamento files (e.g., `cd C:/Dreamento/`). If you open it once, it will always stay in spyder as long as you don’t close it intentionally. Run the code with the green play button on top and enjoy your data analysis!

6. Real-time Dreamento Features



In real-time Dreamento you are presented with 3 main sub-panels: **(A) Recording and stimulation panel**, **(B) analysis panel**, **(C) data representation panel**.

(A) Recording and stimulation panel: in this panel, the user has the features to record the desired set of signals, apply sensory stimulation, and set markers. To start the recording, first, Dreamento should be connected to the server. This can be done by clicking on the "connect" button on top of the panel (this requires HDRecorder and HDServer to be already running). Then by hitting the "record" button at the bottom, data collection would start. Dreamento has the features to apply visual, auditory (either through a pre-recorded audio or using a text-to-speech feature), and tactile stimuli. The features of the stimuli (e.g., the color of light, stimulus on/off duration, number of repetitions, etc) can be specified in this panel.

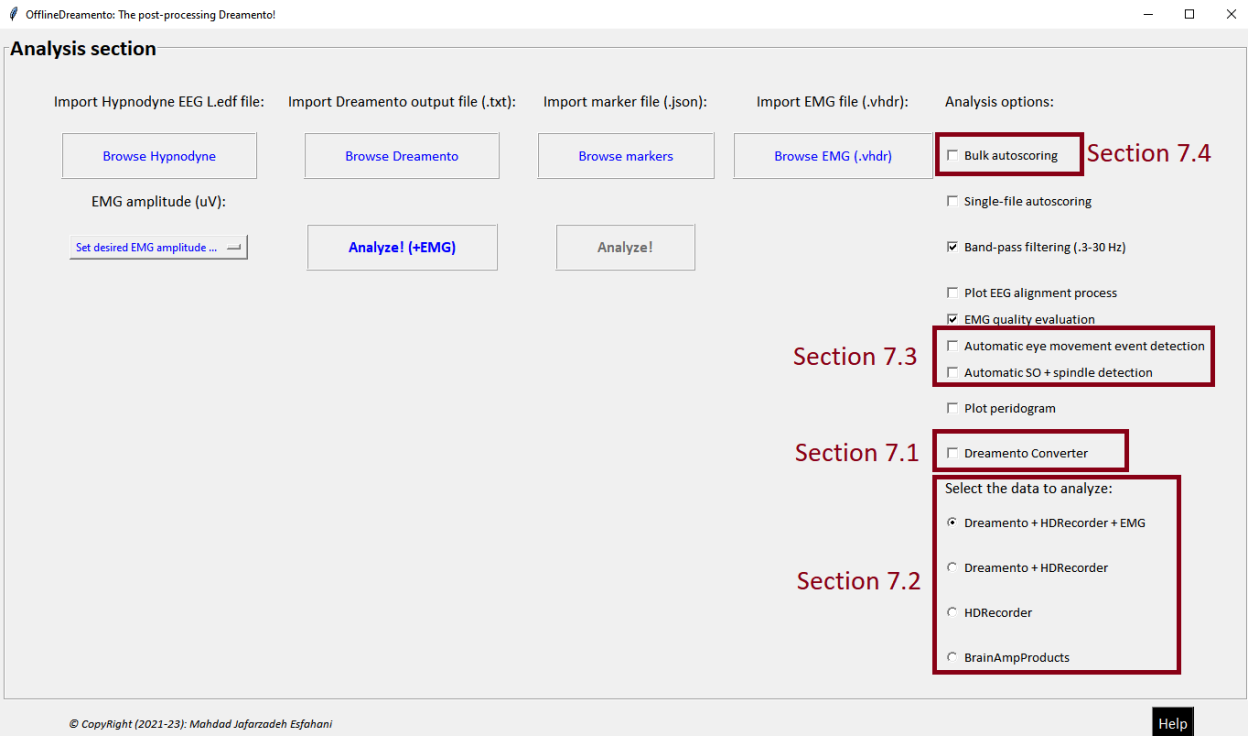
(B) analysis panel: in this panel, at the end of each 30-second epoch, the data will be analyzed. This will be done through automatic sleep scoring of the last 30 s, creating a time-frequency representation (spectrogram), and plotting the power spectral density. The Spectrogram is capable of keeping results from the last ~ 2 mins for the experimenter to have a better overview of the recent sleep stage transitions.

(C) data representation panel: the real-time data stream is presented here. The x- and y-axis limits can be modified at any time.

7. Offline Dreamento Features

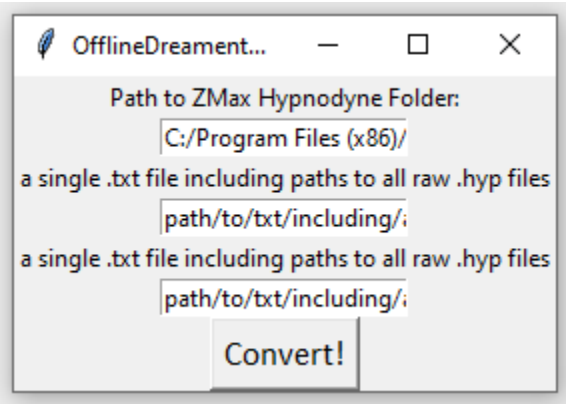
Here you see the main window of OfflineDreamento.py. With OfflineDreamento, you can:

- Convert ZMax raw .hyp files into .edf (especially if you need to convert several .hyp files all at once) *(section 8.1)*
- Analyze four types of data can be analyzed through offline Dreamento: **(1)** ZMax data collected on SD card, **(2)** ZMax data collected in real-time through HDRecorder + real-time Dreamento, **(3)** ZMax data collected in real-time through HDRecorder + real-time Dreamento + another measurement modality such as BrainProducts, **(4)** BrainProducts data (see "select the data to analyze" section in the figure below) *(section 8.2)*
- Automatic non-REM and REM features identification (*section 8.3)*
- And bulk automatic sleep staging, i.e, scoring several data all at once. *(section 8.4)*

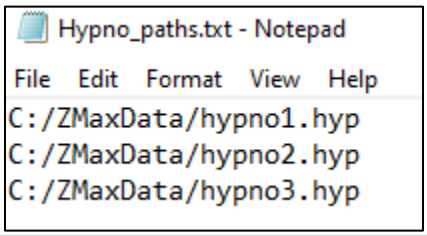


7.1. Dreamento Converter

If you had a recording through ZMax sd card, first make sure you have converted the recorded ".hyp" files into edf. You can do this either using "HDRecorder.exe" or DreamentoConverter. The latter is recommended when you want to convert several ".hyp" files into edf at once. When you run OfflineDreamento.py (see section 6, second table), you should check "DreamentoCoverter" checkbox. Then you are presented with another window, where you should specify three paths:

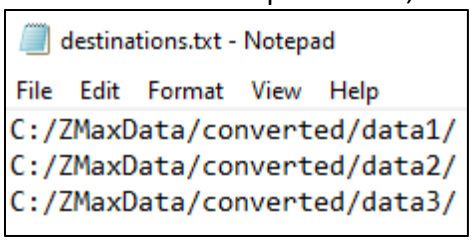


- In the **first entry**, you should specifiy the path to ZMax Hypnpodyne software suite. If you haven't changed the default settings while installing thr suite, it should typically be: `C:/Program Files (x86)/Hypnodyne/ZMax/`
- The **second entry** should be the path to a single .txt file, where the path to all the files you want to convert is stored. This path, can be anywhere, for instance, create a .txt file in `C:/DreamentoConverterFiles/Hypno_paths.txt` and type the path to each .hyp file to be converted in a separate line, for instance:



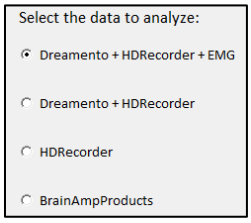
Then the path to this file, `C:/DreamentoConverterFiles/Hypno_paths.txt`, should be entered to the second entry of DreamentoConverter.

- The **third entry** should be the path to a single .txt file, where the path to all the destination of the converted files is stored. This path, can be anywhere, for instance, create a .txt file in `C:/DreamentoConverterFiles/Converted/destionations.txt` and type the path to each destination folder in a separate line, for instance:



7.2. Select the type of data analysis

Depending on the type of data you have, you should select the required option. Then the necessary "browse" buttons for files you need to load will be activated. The analysis types include: **(a)** ZMax data collected on SD card or in real-time through HDRecorder, **(b)** ZMax data collected in real-time through both HDRecorder + real-time Dreamento, **(c)** ZMax data collected in real-time through HDRecorder + real-time Dreamento + another measurement modality such as BrainProducts EMG, **(d)** BrainProducts data.

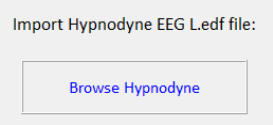


After selecting the data type to analyze, you can activate different features from the "analysis options".

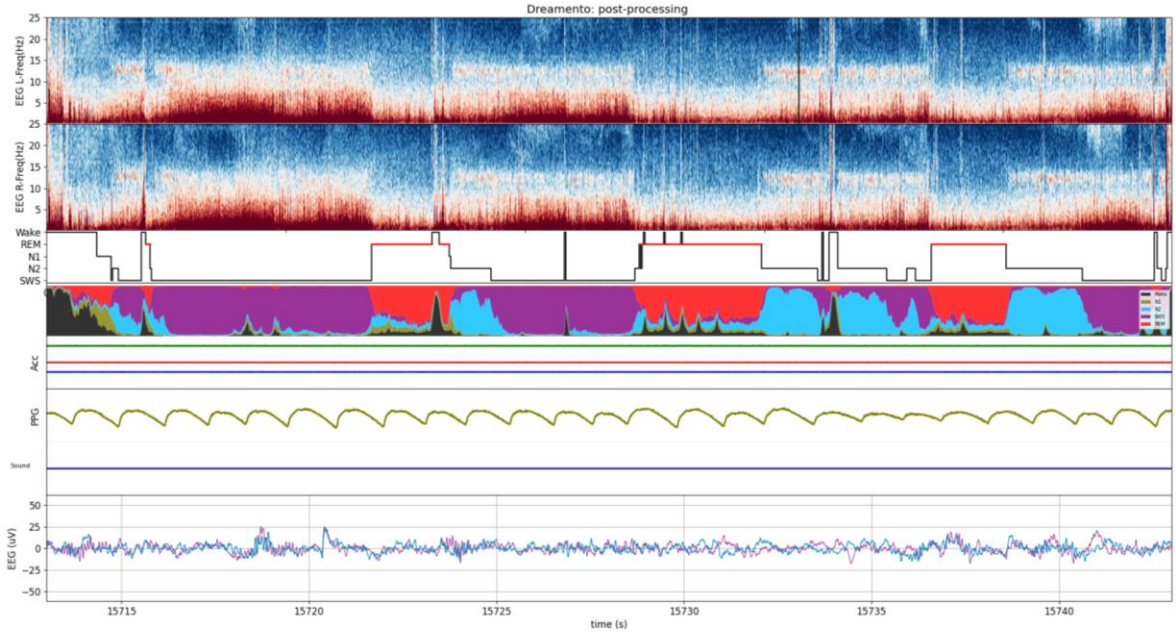
- Activating "single-file autoscoring" would result in autoscoring of the results. For the ZMax data autoscoring DreamentoScorer model will be used, whereas YASA will autoscore the BrainProducts data.
- Using "band-pass filtering (.3-30 Hz) is recommended in the majority of the cases."Plot EEG alignment process" is only applicable if you have a simultaneous HDRecorder and Dreamento recording so that you can ensure the automatic alignment was succeeded.
- "EMG quality evaluation" is only applicable if you have a data of type **(C)**: ZMax data collected in real-time through HDRecorder + real-time Dreamento + another measurement modality such as BrainProducts. In this case the spectrograms of the EMG channels will be added to the final plot which helps with the EMG quality evaluation throughout the recording.
- "Automatic eye movement detection" and "automatic SO + spindle detection" will activate automatic algorithms to detect these events throughout the data. Once these checkboxes are activated, the user is presented with a new window from which various detection parameters can be specified. If "single-file autoscoring" is activated, the "Automatic eye movement detection" will only be applied to the epochs determined as REM sleep and "automatic SO + spindle detection" will be applied to the epochs determined as N1, N2, N3 sleep, otherwise, event detections will be applied throughout the data.
- "Plot periodogram" creates the periodogram of the EEG data.
- Depending on the type of the data you want to analyze, some features may get activated/deactivated.

a. **HDRecorder option:**

ZMax data collected on SD card or in real-time through HDRecorder only. You just need to load “EEG L.edf” file, and the rest of files, (e.g, EEG R, acceleration etc) will be automatically detected.

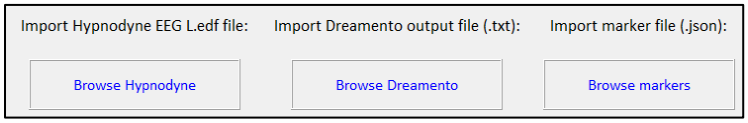


You will have options for “single-file autoscoring”, “Band-pass filtering (.3 – 30 Hz)”, “Automatic eye movement event detection” and “Automatic SO + spindle detection”. Depending on your choice, you will get an output similar to the following:

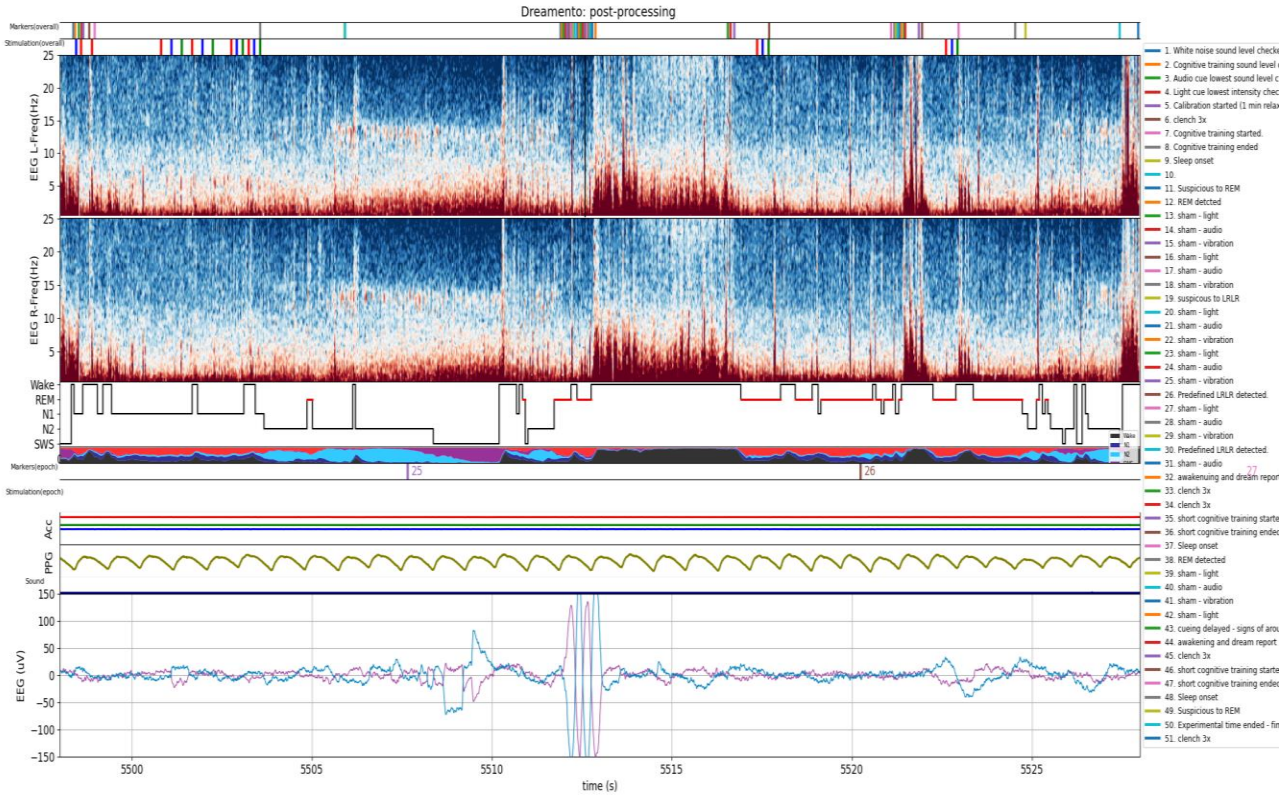


b. Dreamento + HDRecorder:

ZMax data collected in real-time through both HDRecorder + real-time Dreamento. You need to load “EEG L.edf” file from ZMax recording, complete recording file from Dreamento, and the markers/annotations file.

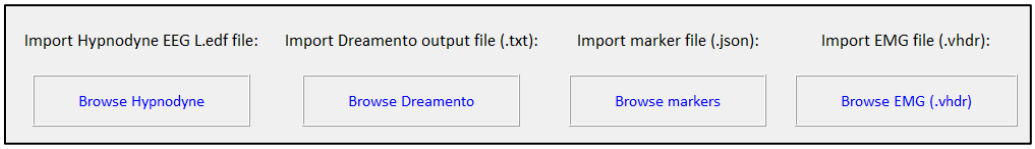


Then you’ll get something like the following:

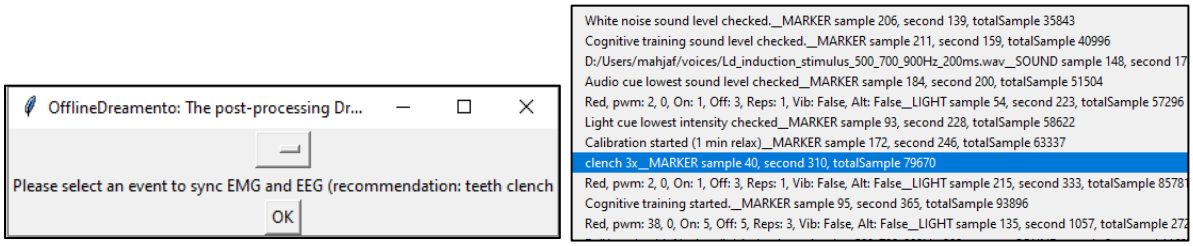


c. Dreamento + HDRecorder + EMG:

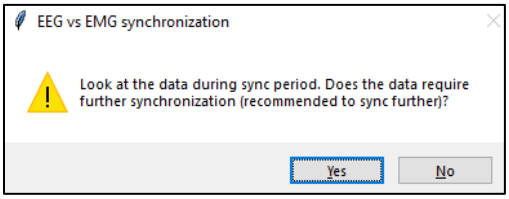
Here we present an example of analyzing a data of type (C) ZMax data collected in real-time through HDRecorder + real-time Dreamento + another measurement modality such as BrainProducts. To start the analysis, you need to load “EEG L.edf” file from ZMax recording, complete recording file from Dreamento, the markers/annotations file, and the .vhdr file from BrainProducts or .edf from g.tech.



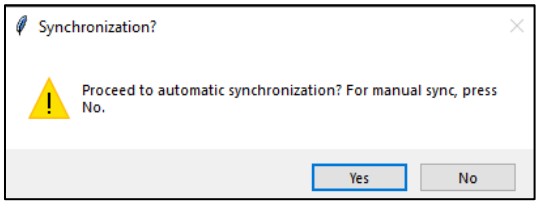
When you import these files and select the “desired EMG amplitude” scale, you can hit “Analyze! (+EMG)” button. Then you are presented with the “annotations” window, where you should select one of the markers which have been set during the data collection to synchronize EMG data with all ZMax recordings.



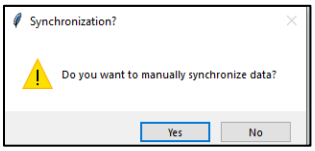
A jaw clenching event is ideal as it creates similar high-frequency noise on both EEG and EMG. After clicking on OK, Dreamento will load the EEG and EMG data in the vicinity of the selected marker and gives the following message:



Look at the figure that Dreamento presents. Does the EEG and EMG event look to be synced? If so, click on “no” and go on with the analysis. If it needs synchorinaztion, click on “yes”. Then you are presented with the sync options:

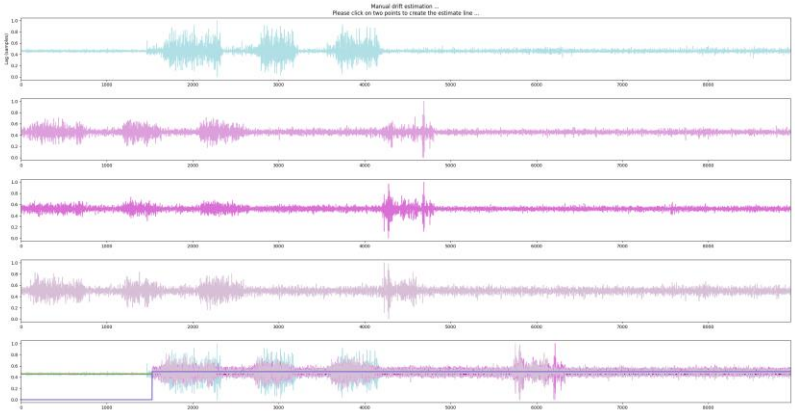


If you intend to use “automatic” sync, then the baseline noise should be relatively low. Otherwise. The algorithm may get confused. If you intend to syn the data “manually”, you should select “no”. And then “yes” to the following question:

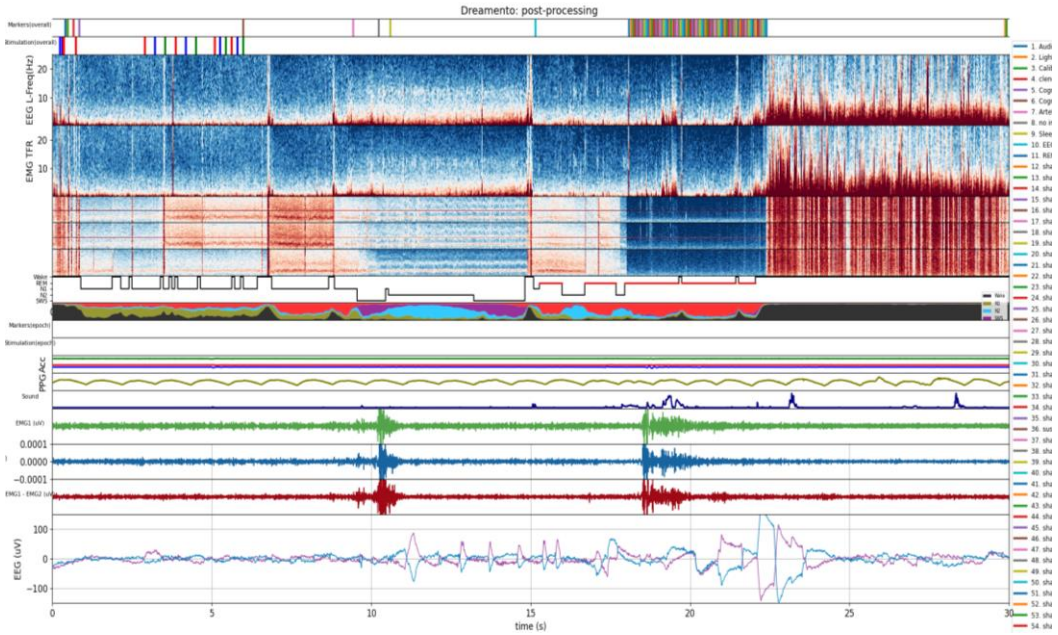


Then you’ll be asked to click on the starting point of an event on the top plot (EEG), and then the starting point of the same event in any of the EMG signals. Then you will see the result of the synchronization in the bottom:

In any case, in the end of either automatic or manual sync, you’ll be asked if the results are satisfying, if not you can redo the synchronization.



If the results of sync are satisfactory, then you can wait for Dreamento to present the output:

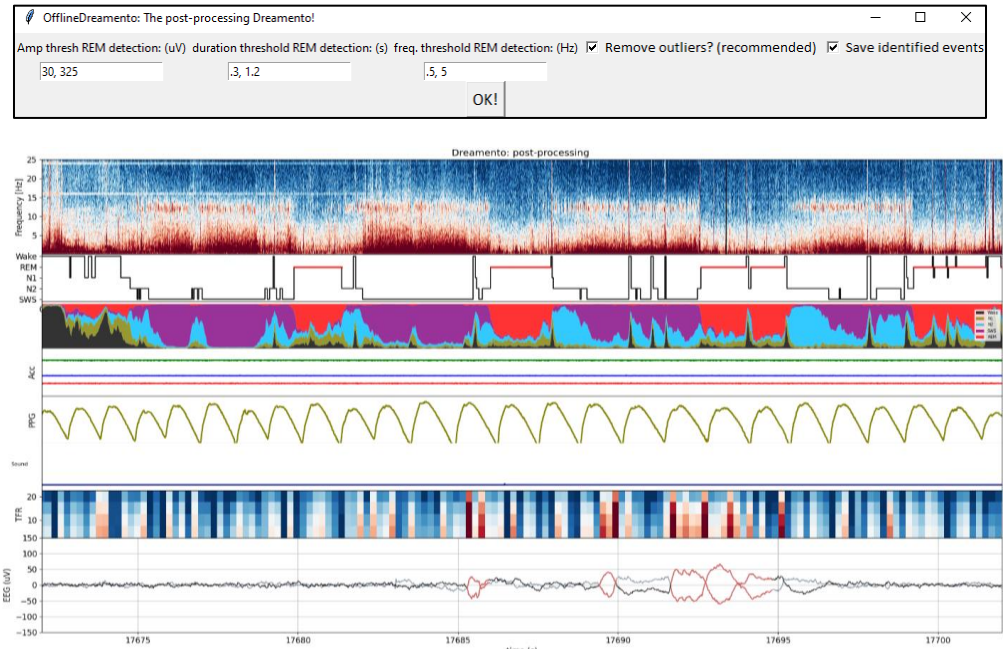


7.3 Automatic sleep event detection

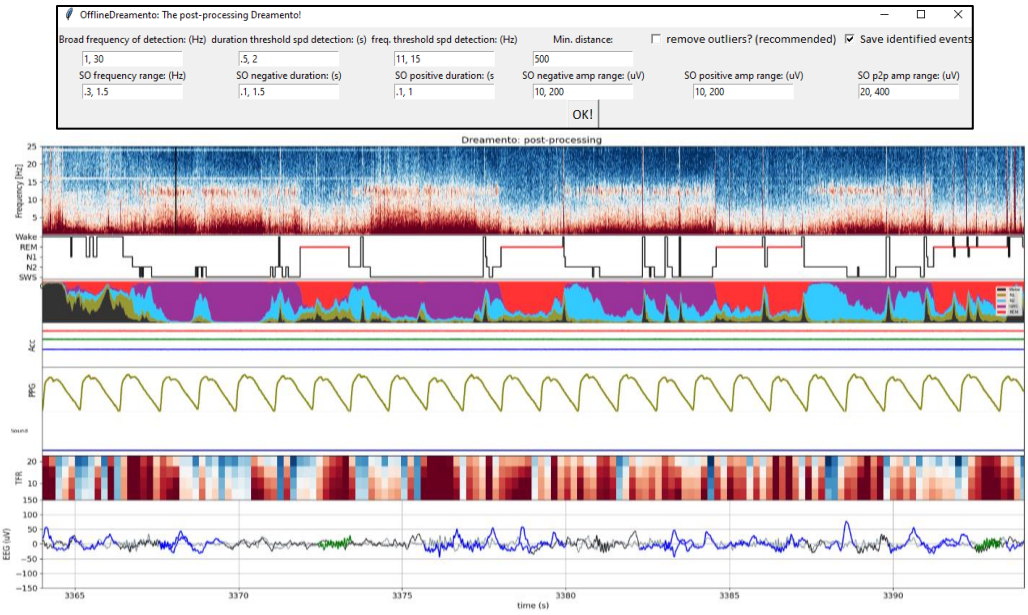
The microstructural features of non-REM sleep such as spindles and slow-oscillations (SO) could be automatically detected in ZMax thanks to the algorithm developed in YASA. When you activate each of the options, you need to specify the parameters for event detection:

If the user intends to, the results will be also stored in the same location as the loaded data. Below you can see the example of event detection + the resulting output (REM events are detected in red, spindles in green, and SOs in blue).

REM:

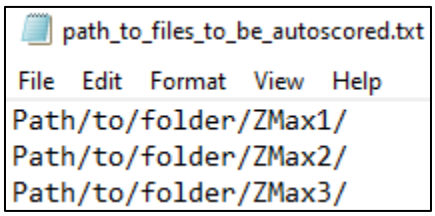


SO + spindles:

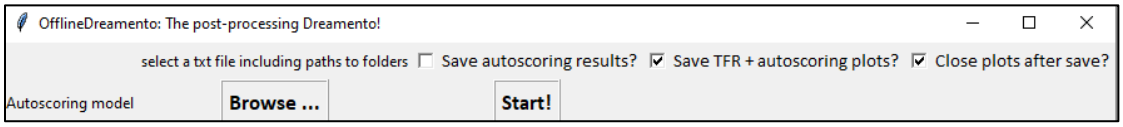


7.4 Bulk autoscoring

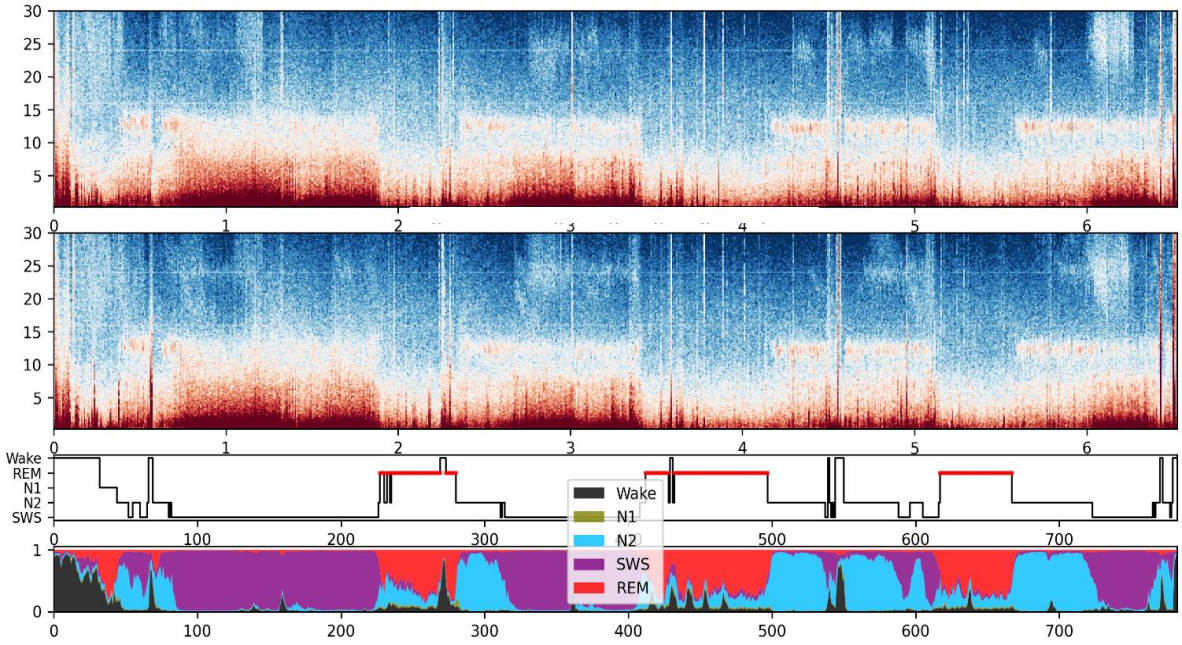
If you intend to autoscore several ZMax data at once, you may activate the "bulk autoscoring" feature. To provide Dreamento with the files that it needs to autoscore, you need to create a single .txt file including the paths to the folders (and not files!) that need to be autoscored (e.g., `C:/ZMax/path_to_files_to_be_autoscored.txt`). These folders should include all the .edf files that either HDRecorder or DreamentoConverter has created. Here is an example of a .txt file including the paths:



Then this file, should be imported into Dreamento, after checking the "bulk autoscoring" checkbox.



You may also activate whether you want the resulting sleep stages and figures to be saved or not. If you choose to save these, the subjective results including sleep quality assessment metrics such as sleep efficiency, duration of each sleep stage, etc will be stored in the same path as the original files and you will find an .xlsx file `(Dreamento_all_sleep_stats.xlsx)` containing the results for all the assessed data stacked together in the same location as the initial .txt file that contained the paths was located. The resulting figures would look like the following:



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- Tech for dreaming: link
- Dream x Engineering seminars 2023: link

Citation

For any use of Dreamento, please cite:

Jafarzadeh Esfahani, M., Daraie, A. H., Weber, F. D., & Dresler, M. (2022). Dreamento: an open-source dream engineering toolbox for sleep EEG wearables. arXiv e-prints, arXiv-2207. https://doi.org/10.48550/arXiv.2207.03977

if you intend to cite DreamentoScorer validity, you should also cite:

Jafarzadeh Esfahani, M., D. Weber, F., Boon, M., Anthes, S., Almazova, T., van Hal, M., ... & Dresler, M. (2023). Validation of the sleep EEG headband ZMax. bioRxiv, 2023-08. https://doi.org/10.1101/2023.08.18.553744