

Manual to NeurOne: A Digital Motor Unit Interface for the Paralyzed

Introduction:

NeurOne is an application developed with Python 3.10 and compiled to an executable file for Windows. NeurOne is designed to interface with a multichannel EMG recording system (Quattrocento, OT Bioelettronica, Italy) to identify individual motor units in the forearm of people with upper limb paralysis. After the motor units have been identified in an offline phase, online decomposition of these motor units is possible. By computing a smooth neural feedback based on the activity of the motor units, users can follow the presented ramp trajectories with high accuracy.

We provide here a step-by-step protocol to facilitate the implementation of NeurOne in any experimental setting.

Before starting the experiment:

Hardware setup

NeurOne is currently only connected to the multi-channel EMG recording system developed by OT Bioelettronica: Quattrocento using the included OT Biolab Light software. OT Biolab Light opens the communication between NeurOne and the Quattrocento via TCP/IP communication.

To establish a connection between the multichannel amplifier and NeurOne, you will need:

- An Ethernet cable to connect the Quattrocento to the computer.
- Up to six grids with 64 surface electrodes (e.g. GR04MM1305, GR08MM1305, GR10MM0808) with the appropriate adhesive foams to stick the grids to the skin.
- Up to six preamplifiers
- Up to six cables to connect the preamplifiers to the input channels on the front of the Quattrocento (Note: Only multiple inputs 1-4 support 64 channels. If all six electrodes are to be used, a splitter from 1x64 to 4x16 is required for the top row).
- Patient reference cable and electrode
- Connecting cable between each preamplifier and the reference electrode.

After you have successfully connected all electrodes and cables, open OT Biolab Light on the instrument using NeurOne. Make sure that... (cf. Figure 1)

1. the device is set to "QUATTROCENTO"
2. the frequency is set to "2048" and the update frequency is set to "32"
3. the IP address is set to "169.254.1.10" (Note: Compare this IP address with the IP address printed on the display).

Note: If a connection fails, try to connect to the webpage of the Quattrocento by typing its IP address in your browser. If this doesn't work too, turn off and unplug the Quattrocento from power supply. Afterwards, reconnect the ethernet cable and plug the Quattrocento back to power supply and turn it on.

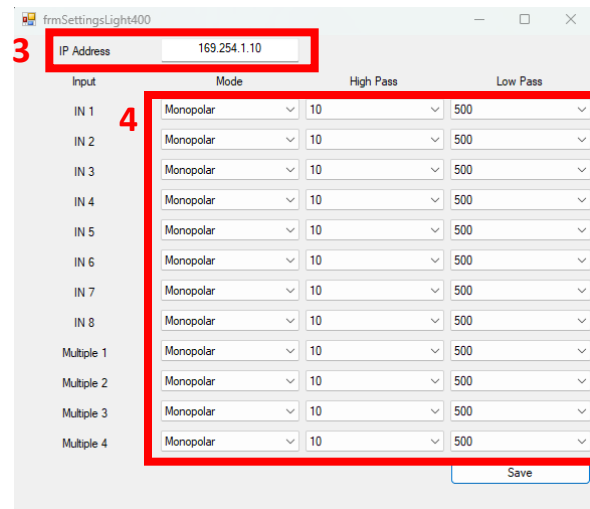
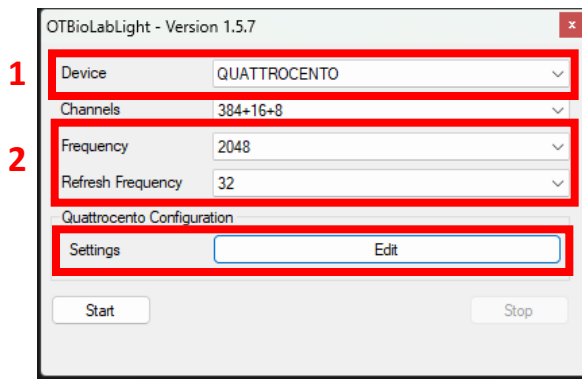


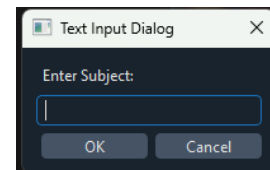
Figure 1: Settings for OT Biolab Light.

NeurOne setup

Make sure you have installed the latest version of NeurOne from the Github repository.

After the connection to the Quattrocento has been successfully established, the connection to the OT Biolab Light must be opened via NeurOne. To do this ...

1. start the NeurOne.exe (location -> bin -> dist -> NeurOne.exe).
2. a dialog window opens and asks for the name of the subject. This name is important because all files will be stored in a folder associated with this name.
3. click on "Connect EMG" to connect to the OT Biolab Light and receive the streamed HD-sEMG signals. An overview of NeurOne can be found in Figure 2.



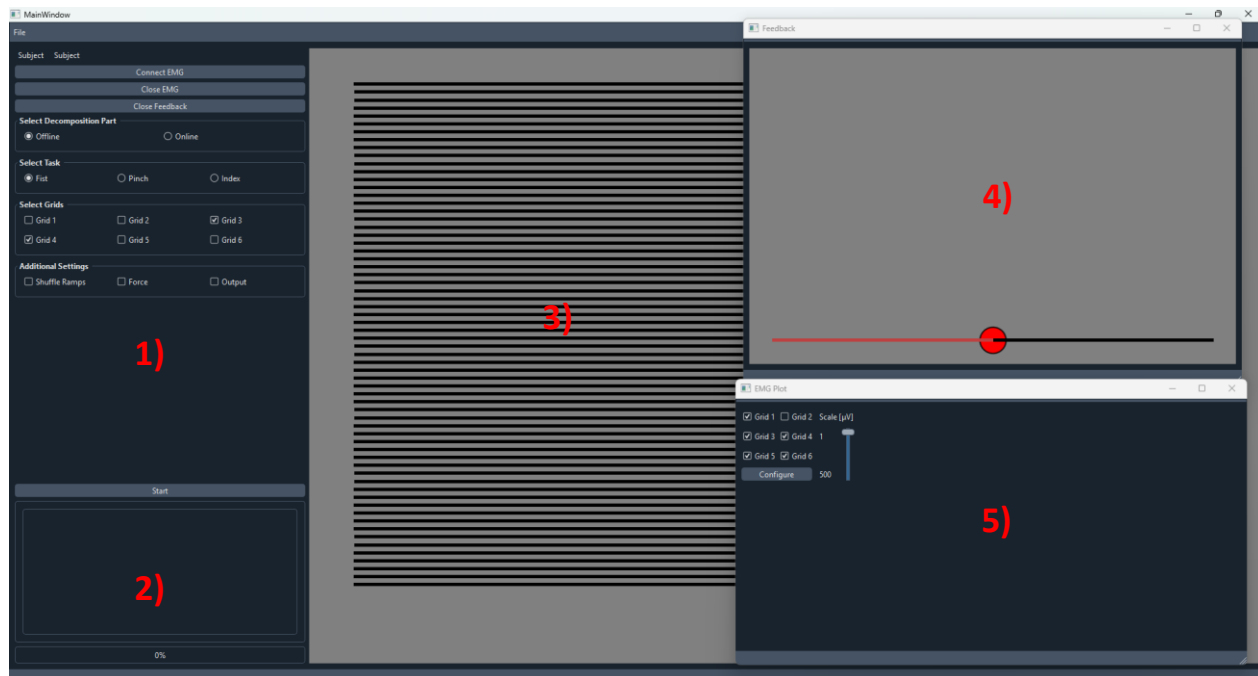


Figure 2: Overview of NeurOne. 1) GUI to control NeurOne. 5) Software log. 3) Spike Train Plot during online decomposition. 4) Feedback Plot during online decomposition. 5) EMG Plot to display streamed channels.

How to use NeurOne

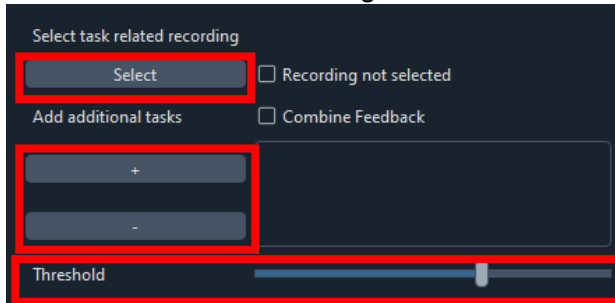
Offline

1. select "Offline" as the decomposition part.
2. select the task you want your subject to perform: Fist, pinch, or index finger.
3. select the electrode grids that are connected to the quattroceto.
Note: Grid 1 = top left splitter (IN 1-4), Grid 2 = top right splitter (IN 5-8), Grid 3-6 = multiple inputs #1-4.
4. Click start to record 20 seconds of HD-sEMG
Note: In paralyzed subjects, it was best to try dynamic rather than isometric contractions. In healthy subjects, low forces were preferable. FDI and TA in particular work very well.
5. After offline recording, it takes a few minutes to complete the decomposition. There is a notification in the software log (number 2) in Figure 2).

Online

1. select "Online" as the decomposition part.
Note: Online can only be executed after at least one offline recording has been decomposed for this part and the selected task
2. Select the task that you want your subject to complete.
Note: The main task corresponds to the selected task. Make sure that the main task has a previous successful offline decomposition'
3. Select the electrode networks that are connected to the Quattroceto.
Note: Make sure that the electrode configuration matches the offline recording.

4. Select offline recording for main and subtasks. You can select the main task by pressing "Select". A file dialog opens where you can select your file. After successfully loading a valid offline recording, the name of the task will be displayed next to the checkbox. To add subtasks that will be displayed in the Spike Train widget, click "+". Another file dialog will then open, allowing you to select all of your subject's offline recordings. Note: To remove a recording, select the recording and click "-".



5. Open the feedback plot window and place it in front of your subject. 6.
6. Click on "Start" to start the online decomposition.
Note: The threshold value for the noise level is determined in the first frame of the online recording. Therefore, make sure that your subject is at rest before you start!
7. Adjust the threshold if too many or too few spikes are detected.