Brain-computer interfaces: Controlling a game with your brain

With the help of electrodes placed on your head, and sophisticated signal processing, it is possible to interface your brain with a computer, and extract and use brain waves to control applications. The technology is generally called Brain-Computer Interface (BCI), and this thesis investigates and implements such a system.

BCI systems are attempting to connect your brain to the computer. One approach is to put electrodes on the user's scalp and measure the brain activity, this is called electroencephalography (EEG). These EEG signals can then be used to play video games, control quad-copters, and more!

However, there is a lot of processing going on between the raw signal present on the electrodes on the user's head, and controlling a game. First the signal needs to be collected, filtered, and processed in different ways, and then categorized. Categorization here roughly means taking an EEG signal and making sense of it. What does the user want to control when he or she is thinking in a certain way?

Categorization can be hard, and we sometimes let Artificial Intelligence (AI) do the work for us. However, similar to us humans, the AI needs to first learn what to detect. A so-called labeled data set for previously collected EEG signals can be used to train the AI to understand the user's thoughts, this is referred to as supervised learning, and it can be seen as calibration of the BCI system.

To simplify not only the categorization but also filtering, EEG acquisition, calibration and other processing methods, this thesis presents a library for constructing BCI systems easily. The library consists of "blocks" containing different functionalities which can be linked together to create chains of data pipelines—similar to as you would build with Lego blocks. If the particular BCI project finds that one or two more types of blocks are missing, the library allows the researchers to build their own blocks containing their own functionality.

During the thesis a demonstration BCI system was also constructed. This demonstration consisted of a small game which the user could control using eye-blinks and jaw clenching. Eye-blinks and jaw clenching are generally considered artefacts in the BCI community due to their non-neural origin, and the fact that these signals are generally of great magnitude compared to other neural EEG signals. However, these signals only act as place holders in the demonstration, and can easily be changed later.

During the demonstration two pipelines were built using appropriate blocks mentioned before. After the calibration phase the user can control the player in the game by blinking (turn right) or biting teeth together slightly (turn left). Note that everything here happens in real time! The voltage fluctuations generated by these actions are registered and sent to the first block in the pipeline which processes the data and sends the data to the next block. When the data has been processed and classified game commands are sent to the game to control it.

The library was written in 100% Python, compared to for example OpenVibe—another BCI platform for constructing BCI systems—which also makes modifying the core behaviour of the library easy!