ARRIVET

CONTROLLING OF A DRONE USING EEG AND EMG TECHNOLOGY WITH AN OPENBCI MACHINE

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DOI: 10.56007/arrivet.v1i2.45

ABSTRACT:

This article presents the development of a system combining EEG (electroencephalography) and EMG (electromyography) signals to control a drone, with a particular focus on using EEG to monitor the user's concentration. The project, conducted within TKNIKA's Brain-Computer Interface (BCI) area of specialization, leverages the OpenBCI Ultracortex Mark IV headset and Cyton board to acquire neural and muscular data, enabling the drone's operation and safety mechanisms. The primary objective is to assess concentration levels and automatically disengage the drone if the user loses focus. This integration of brain and muscle signals not only showcases a possible approach to human-drone interaction but also explores the practical implications of using EEG-based control for enhancing user safety and performance in any human controlled machine. The article discusses the key technical challenges and innovations involved in synchronizing EEG and EMG data streams to ensure reliable control and safety features for real-time machine operation.

Keywords: **BCI; EEG;EMG.**

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STATE OF THE ART

Brain-Computer Interfaces (BCI) have rapidly evolved over the past few decades (Nam et al.,2018), opening up new possibilities for human-computer interaction across various domains, including healthcare (Chang et al., 2022), communication, and robotics, focusing on developing innovative solutions that bridge the gap between human neural signals and machine control (X. Gu *et al.,* 2021). One of the most exciting applications of BCI technology is its integration with different kinds of machinery, which allows users to, for example, control drones through neural and muscular inputs.

SOLUTION PROPOSAL

In this context, the combination of EEG (electroencephalography) and EMG (electromyography) signals presents a unique opportunity to improve the safety and performance of machine operations. While EEG is used to monitor the user's concentration and cognitive state, EMG provides insights into muscular control, enabling a more intuitive interaction with the machine. This article explores the development of a system that uses the OpenBCI Ultracortex Mark IV and Cyton board to simultaneously measure EEG and EMG data for controlling a drone (OpenBCI. (n.d.),2025) . A key innovation of this system is the ability to disengage the drone automatically if the user loses focus, ensuring enhanced safety and preventing accidents caused by lapses in concentration.

The integration of these signals in real-time poses several technical challenges, ranging from signal processing to the seamless synchronization of EEG and EMG inputs. By addressing these challenges, this research aims to demonstrate the potential of using neural signals not just as a control mechanism, but also as a safety feature in high-stakes environments like drone operation.

METHODOLOGY

The solution is structured in different phases: design, programming and analysis of results and improvements. In the design phase, the following aspects are considered: Selection of the number of channels to be dedicated to EEG and EMG from which the data to control the drone will be taken, selection of the technology to communicate the data from OpenBCI GUI, as different options must be evaluated, selection of the programming language through which the data will be processed and transmitted to the drone and the selection of the drone.

Taking the initial trials as reference, it was determined that a minimum of 8 EEG channels are required for a stable and reliable reading of concentration data. Additionally, 2 EMG channels were selected for the solution, as only two movements are needed to control the drone's forward and backward movements.

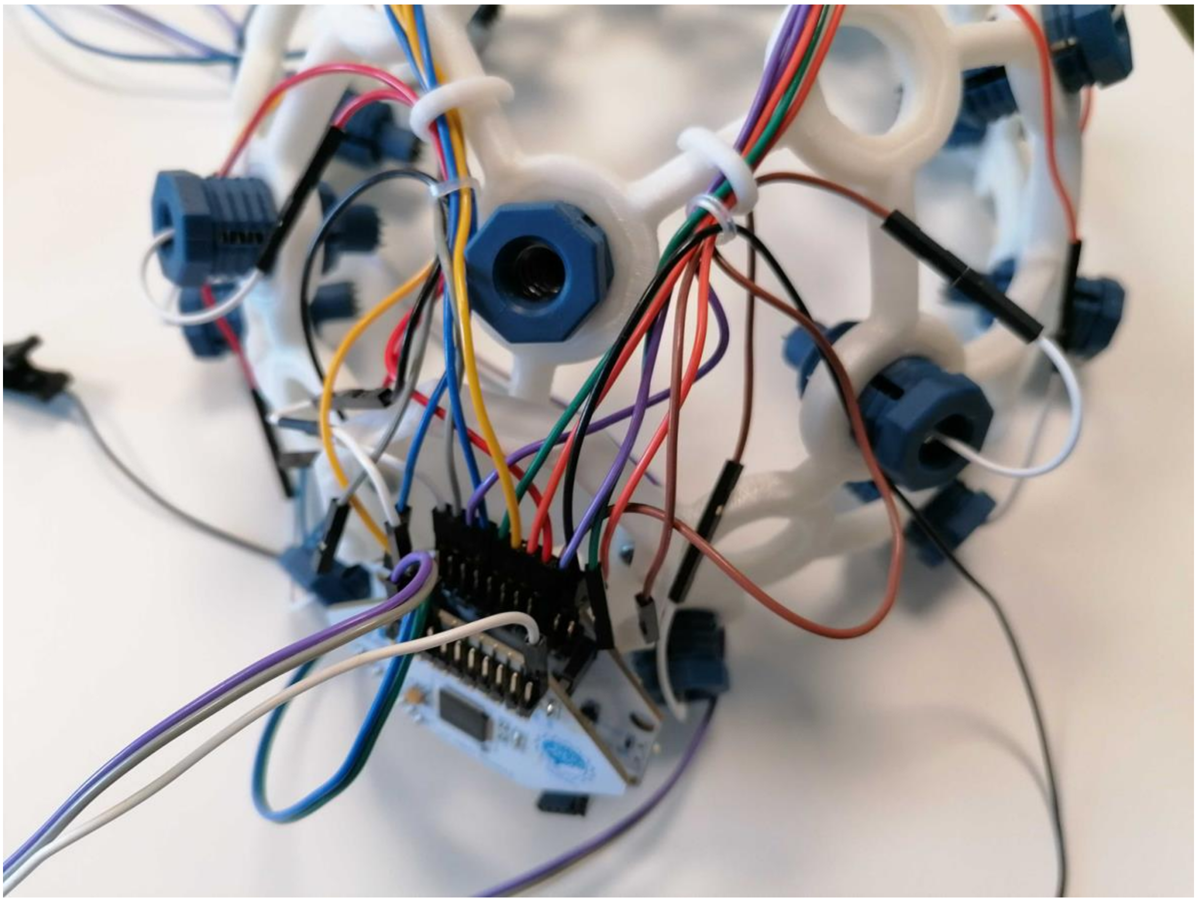

Image 1: OpenBCI Ultracortex Mark IV setup with Cyton board. The conections used for EEG are the 8 from the inner board, while the 2 from the expansion board are the ones used for EMG.

For communication of the data from the OpenBCI GUI, **OSC** was chosen due to its readability, scalability, and low latency, which are essential for building a real-time application. The Python programming language was selected for its readability, wide usage, and strong ecosystem, while a **TELLO** drone was chosen for its suitability in indoor testing environments.

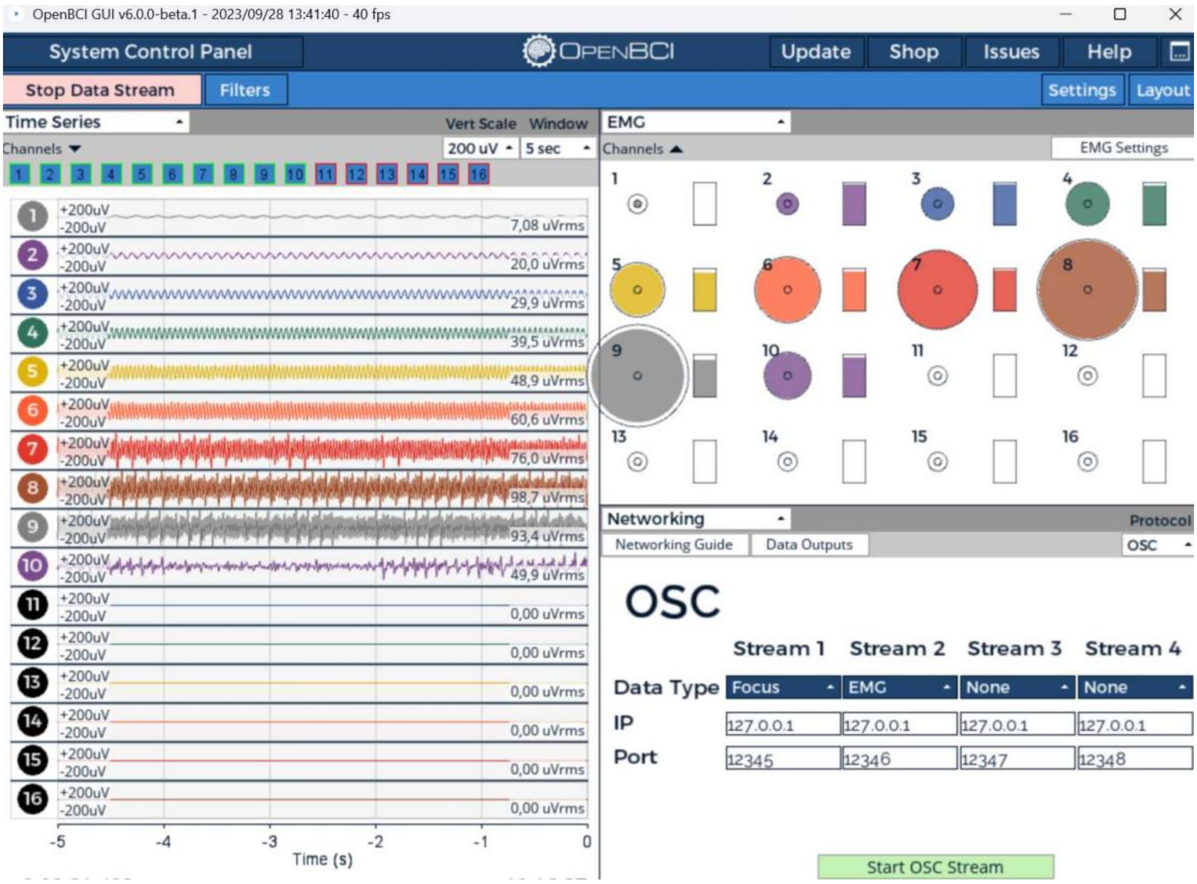

Image 2: OpenBCI GUI screen.

In the second phase, an OSC server was built with python. Three endpoints were created. The first to handle the concentration data sent by the OpenBCI GUI, identified as /openbci/focus. The other two, /openbci/emg/8 and /openbci/emg/9, were used to handle the drone moving forward and backward respectively. It is important to note that the channel numbering starts from 0, meaning the mentioned channels are the 9th and 10th respectively, reserving the firs 8 for measuring concentration with EEG.

Different situations had to be considered to ensure the proper functioning of the application. First, focus handling was prioritized: the drone is commanded to take off only if the user is focused, and if focus is lost, the drone lands and does not respond to any other commands until focus is regained. This is managed by monitoring the concentration level received via OSC, and a debounce mechanism is employed to prevent false triggers caused by rapid fluctuations in the signal. A similar debounce mechanism is also applied when processing EMG data, ensuring that rapid repetitive movements are avoided when the user flexes the monitored muscle(s).

RESULTS

The integration of EEG and EMG signals for controlling machines, such as drones, has shown significant promise in improving the interaction between operators and complex machinery. The system's successful use of brain and muscle signals for controlling the drone demonstrates a viable approach for operating heavy machinery and other robotic systems. By monitoring the user's concentration and muscle movements in real time, the system allows for safer control, which is crucial in environments where a small mistake can cause heavy losses.

The primary result of this approach is the ability to command a machine to take off, land, or perform movements based on the operator's focus and physical actions, such as muscle flexion. This provides an enhanced layer of safety and efficiency, particularly in high-stakes environments like construction, manufacturing, and industrial robot operations. The system employs a debounce mechanism to ensure reliable detection of control inputs, preventing false triggers from rapid fluctuations in EEG or EMG signals. Additionally, the automatic landing feature, triggered by the loss of focus, offers an added layer of security for operators working in high-risk or complex settings.

BENEFITS

The benefits go beyond increased safety. In controlling heavy-machinery, for example, concentration could also be used in phases, meaning higher levels of concentration could allow riskier movements while lower levels of concentration are more restrictive. Similarly, EMG signals could be used to manage robotic systems for specialized tasks, such as lifting, moving, or assembly operations, where precise muscle movements would serve as commands.

Moreover, this approach offers significant potential for improving operator safety and reducing fatigue. By enabling hands-free control of machinery, operators could avoid repetitive physical movements, reducing the risk of strain or injury. In high-risk industries, such as mining, oil extraction, and construction, this could enhance both productivity and safety, as operators could remotely manage heavy equipment or robots, with fewer chances for human error. Future advancements could further extend this concept to incorporate more complex machinery and robotic systems, enhancing real-time control, adaptability, and automation in diverse industrial settings.

For education, the benefits may vary depending on the application. For starters, could be used to create more immersive and engaging learning experiences, particularly in STEM fields, increasing the motivation of students. In fields like aviation, robotics, or remote operations these systems could be used to simulate high-stakes environments where the students need to remain focused and react quickly to prevent accidents or mistakes. In addition to the mentioned applications, educators could design activities where students must control drones or robots based on their concentration levels, fostering improved concentration, mindfulness, and self-regulation skills.

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