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Controlling UAVs with a SSVEP-Based BCI

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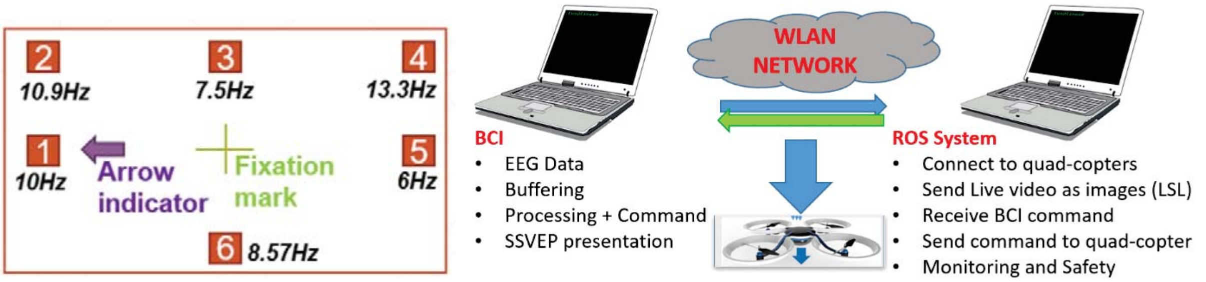
Introduction: The rapid advancement of technology and innovative multi-disciplinary approaches allows the freedom to use BCIs for a wide range of medical, commercial, military and even entertainment applications. Our focus is to design and implement a non-invasive BCI based on Steady State Visual Evoked Potentials (SSVEP) for controlling Quad-copters based on Electroencephalography (EEG) signals. Unlike motor imagery-based BCIs, SSVEP does not require training. This SSVEP approach has demonstrated to be robust and efficient for BCI control.

Material, Methods and Results: An SSVEP presentation program was developed to present participants with 6 3x3cm flickering visual stimulus changing color from white to black. Flickering frequencies and position arrangements are presented on Figure 1A. EEG recordings are acquired at a 256Hz sampling rate using the BioSemi Active Two system and 12 electrodes located at Pz, POz, PO3, PO4, Oz, O1, O2, P3, P4, PO7, and PO8 on the 10/20 international system. A quick pre-processing is then applied consisting of a 1 – 40Hz band-pass filter, a digital re-referencing to averaged mastoids, and a single-epoch baseline removal where multiple epoch lengths from 2.0 to 5.0 seconds were investigated. Canonical Correlation Analysis (CCA) is used for SSVEP frequency detection. An experiment was conducted to measure the robustness of detection performance of the SSVEP frequencies. 36 individuals (25 male) ranging from 18 to 45 years old participated in the experiment that requires them to look at each flickers clockwise for periods of 7 seconds. An approximate 90% accuracy was obtained across all frequencies. Frequencies encode commands which are send to a ROS system on the same network using the lab streaming library as presented on Figure 1B. Available commands are move up, move down, move forward, move back, move left, and move right. When using multiple quad-copters up/down movement is replaced by the scatter and gather commands.



A B

Figure 1. *A) Frequency and position of 6 flickering visual stimulus on the SSVEP presentation program.* ***B.)*** *Diagram of BCI implementation to control a quad-copter. All 3 devices share a WLAN network. Lab streaming layer is used for messaging and data transfer.*

Discussion: We proposed a novel SSVEP-based UAV control system. SSVEP flickering detection is based on the CCA approaches. The test results demonstrated fair accuracy and high robustness across multiple participants. It is required to correctly calibrate monitor position and distance if the participant is visually impaired. Flickering observations should be a natural gaze, rather than an intense focus to prevent visual fatigue during prolonged use.

Significance: This BCI offers great flexibility to add more commands easily. Patrolling, surveillance and complex tasks distributed across multiple quad-copters are being adapted to be integrated on this BCI. The system has a high-speed deployment: after connection and quick checking the BCI can be used immediately without training. The implementation of a quad-copter and web-cam video feedback system is an innovative feature that enhances the practical application of this BCI.

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