A Wearable Brain-Computer Interface Controlled Robot

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Abstract

Brain-computer interface (BCI) controlled systems hold great potential for clinical applications especially in assisting neurologically disabled patients to improve their communication processes [1]. Wearable electroencephalogram devices (EEG) are non-intrusive, meaning they do not require insertion of electrodes into the patient's brain, and are available "off the shelf" with consumer-grade devices such as the MindWave [2]. While such EEG devices do not possess the same high resolution EEG capabilities of medical grade devices, their affordability does make the technology accessible to new applications, such as robotics control and mood deduction [3], and their wearable nature negates the need for invasive surgery. Campbell et al. [4] investigated the potential for wearable consumer grade EEG in creating a BCI. Their aim was to implement a BCI for simple mobile phone operation, which found that a simple task, winking, could be deduced from raw data with a relatively high accuracy, and with processing being performed on a smartphone device [4]. In doing this several limitations were highlighted with EEG devices, including a poor signal-to-noise ratio, which requires further processing to deduce useful information from raw data. Millan et al. achieved relatively sophisticated control of a mobile robot in a simulated environment with a non-intrusive BCI interface [5]. Combining machine learning with subject-device training, they were able to achieve "almost as efficient as manual control".

The primary objective of our project was to build a prototype hardware system to establish the proof of concept of controlling a robotic system by using a wearable EEG device. A very low-cost Arduino [6] based integrated electronics platform was used to implement the BCI controlled robot. The Arduino platform possesses several advantages, such as their affordability, and the large amount of open source hardware and software modules available. Combining MindWave [2] as the off-the-shelf EEG device with the Arduino platform enabled successful processing of wearer's attention and mediation levels to be used as commands to control the robot. The levels of attention and mediation were calculated within the Mindwave device and transmitted to Arduino through Bluetooth as serial asynchronous data packets. Successful processing of these packets within Arduino eventually translated raw BCI data into useful commands. At the end, the project could demonstrate a priority based robust BCI control protocol, with further integration of sensor signals to the system.

References:

1. F. Deravi, C. S. Ang, M. A. H. B. Azhar, A. Al-Wabil,M. Philips and M. Sakel, "Usability and Performance Measure of a Consumer-grade Brain Computer Interface System for Environmental Control by Neurological Patients", International Journal of Engineering and Technology Innovation (IJETI), vol. 5, no. 3, pp.165-177, 2015.
2. MindWave EEG Headset, Available online: http://store.neurosky.com/pages/mindwave [Retrieved September 2016].
3. W. Salabun, "Processing and spectral analysis of raw EEG signal from the MindWave," Przeglad Elektrotechniczny, 90(2), pp.169-174.
4. A. T. Campbell, T. Choudhury, S. Hu, H. Lu, M. Rabbi, R. D. S. Raizada, "NeuroPhone: Brain-Mobile Phone Interface using a Wireless EEG Headset," MobiHeld 2, 3-8.
5. J. R. Millan, F. Renkens, J. Mourino, W. Gerstner, "Noninvasive Brain-Actuated Control of a Mobile Robot by Human EEG," IEEE transactions on biomedical engineering, Vol. 51, No. 6, June 2004
6. Arduino, Available online: https://www.arduino.cc/ [Retreived September 2016].

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