DOI: 10.3217/978-3-99161-050-2-164

A Brain-Computer Interface Approach to Music and Sound Generation

L. Bianchi[1]*
[1]*Dipartimento di Ingegneria Civile e Ingegneria Informatica, Tor Vergata University, Rome, Italy*
*Via del Politecnico, 1, 00133, Rome, Italy. E-mail: luigi.bianchi@uniroma2.it

Introduction: EEG-based BCI cannot directly provide the required bitrate to play music. However, digital instruments implement features that allow musicians to interact with them with minimal inputs and even generate entire phrases with different styles while requiring a low bandwidth.

Material, Methods and Results: MIDI (Musical Instrument Digital Interface) is a communication protocol that allows electronic musical instruments, computers, and other devices to connect and control each other. It transmits performance data—such as which notes are played, their intensity, timing, and modulation—rather than audio, enabling seamless interaction for music creation, playback, and production. A BCI software used to drive a videogame [1] was adapted to allow the output of MIDI messages.

Due to the low bandwidth provided by non-invasive BCIs, two classical paradigms were used:
1) mu-rhythm control, to deliver MIDI continuous and asynchronous control messages, such as Modulation Wheel, After Touch, Filter Cutoff, and resonance, allowing sound parameters to be modified during a performance. A preliminary calibration phase is required to acquire and compare relax epochs and motor imagery epochs. Differences in their power spectra are computed to train a regressor that will be used to deliver the selected MIDI messages and their corresponding values, which may vary in the range 0-127.

2) SSVEP, synchronized with the MIDI clock, to select notes, musical phrases, and samples or to program and drive a Drum Machine. A system with 16 flashing LEDs is employed. A single musical measure is divided into 8 eighth notes, each of which can be selected via a specific LED. The remaining 8 LEDs allow the selection of the drum instrument (kick, snare, hi-hat open and closed, and crash) to correct a mistake and to increase or decrease the speed of the pattern. This setup enables the selection of the instrument and its temporal placement within the measure, making it possible to construct a drum pattern (Fig. 1). Future implementations will allow the selection of pitched notes from the chromatic scale.

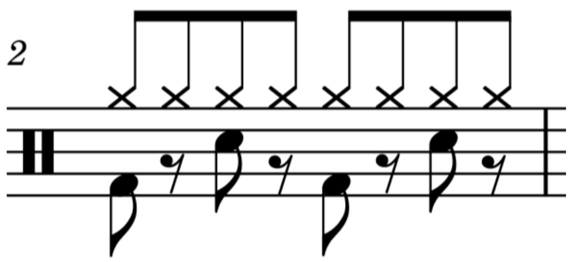

Figure 1: *A drum pattern generated with a BCI-based SSVEP paradigm*

Conclusion: Integrating EEG-based BCIs with MIDI protocols enables effective control of musical instruments with minimal input, overcoming the bandwidth limitations typically associated with non-invasive brain-computer interfaces. Using mu-rhythm control and SSVEP paradigms, musicians can manipulate various sound parameters and construct rhythmic patterns with high precision. These techniques provide a promising foundation for future developments in BCI-driven music performance, including the potential for more complex musical compositions and pitch-based note selection.

Acknowledgments and Disclosures: The authors declare that there is no conflict of interest regarding the publication of this article.

References:
[1] Bianchi, L. (2020). A Videogame Driven by the Mind: Are Motor Acts Necessary to Play?. In: Arai, K., Kapoor, S., Bhatia, R. (eds) Advances in Information and Communication. FICC 2020. Advances in Intelligent Systems and Computing, vol 1129. Springer, Cham. https://doi.org/10.1007/978-3-030-39445-5_5Anderson FA. Impedance plethysmography. In Webster JG (ed.). *Encyclopedia of Medical Devices and Instrumentation*. John Wiley & Sons, New York, 1988.

Published by Verlag der Technischen Universität Graz