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MappEMG: Supporting Musical Expression with Vibrotactile Feedback by Capturing Gestural Features through Electromyography

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Music performance involves continuous muscle activity of different body parts. Activity of more distal body segments which directly interact with the instrument usually relates to the actual production of sound. However, muscle activations of more proximal segments, including the trunk, might relate to the expressive content of the musical idea being communicated by the performer due to an embodiment process. This demo paper presents a work-in-progress implementation of an integrated set-up, the MappEMG, to produce a vibrotactile feedback based on surface electromyography data of pianists' abdominal muscle activations. The main objective of the work is to make perceptible through haptic stimuli a rather non-visible dimension of pianists' gestures (i.e. their 'physiological tension') linked to their expressive intentions in terms of musical tension, a key feature of musical structure in western tonal music. We envision to adapt the set-up presented to both live musical performances and pedagogical contexts.

INTRODUCTION

Gestures are an essential element of the creative work of the performer. They represent the physical means of translating a musical idea into actual sound and, at the same time, they actively help the performer give shape and clarify this idea. Musicians use then their body movements while performing to both produce sound and embody the expressive intention contained in the musical discourse [1]. Musical expectancy is associated with tension-relaxation relations embedded in the musical discourse. Therefore, musical tension is usually considered as one of the stepping-stones of the expressive content of Western tonal music [2]. This demo paper presents the work of an ongoing project aiming to use haptic stimuli to make perceptible through vibrations a rather non-visible feature of pianists' gestures: muscle activations not related to the motion of body segments but to the embodiment of musical tension. Specifically, our objective is to produce a vibrotactile feedback for the audience based on the activity of pianists' abdominal muscles while performing.

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MAPP-EMG

MappEMG consists of a data pipeline that uses muscle activity signals captured through electromyography (EMG) to produce a vibrotactile feedback. Based on our preliminary results of a case study on the relationship between trunk muscle activity and pianists' expressive intentions in terms of musical tension, only the activations of the right and left external abdominal oblique muscle (collected during the performance of several piano excerpts) were used to produce the vibrotactile stimuli. Muscle activity was collected using surface EMG (Delsys Trigno™ Wireless system). Processing of EMG data included filtering (2nd order Butterworth band-pass filter), computation of the envelope of the signal using a sliding root mean square, and normalization of the computed envelope with respect to the maximum voluntary contraction (MVC) of the targeted muscles (MVC data was collected before the beginning of the recorded performances). In relation with the gestural component called 'effort' in Laban movement theory [3], the normalized EMG envelope was used as a reference of the intensity of the musical tension and, therefore, as the input signal to control the amplitude of the vibration. Two Vibropixels [4] (a wireless vibrotactile prototype developed at the Input Devices and Music Interaction Lab equipped with cylindrical and coin cell eccentric rotating mass actuators) were used to produce the vibrations. The normalized EMG envelope was mapped using a specifically designed software for Vibropixels programmed in Max/MSP [4] to define the strength (continuous and gradual attacks and decays) of the vibrotactile stimuli applied on the listener.

CONTRIBUTIONS

Previous research has addressed the use of EMG signals for both control of digital musical instruments applications [4] and generation of a vibrotactile feedback intended to improve motor control in pianists [5] and in patients suffering from movement disorders [6]. This research-creation work allows us to make perceptible through haptic stimuli the embodiment of structural musical features, such as musical tension levels, by performer gestures. We intend to adapt the current MappEMG set-up for real-time operation to be used in live musical performances and in the context of instrumental lessons.

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REFERENCES

- [1] Godoy, R. I. Postures and Motion Shaping Musical Experience. In M. Lesaffre, P.-J. Maes, and M. Leman (Ed.), *The Routledge companion to embodied music interaction* (p. 113- 121). New York: Routledge, 2017.
- [2] Bigand, E., Parncutt, R., and Lerdahl, F. (1996). Perception of musical tension in short chord sequences: The influence of harmonic function, sensory dissonance, horizontal motion, and musical training. *Perception & Psychophysics*, 58(1), 1996.
- [3] Tanaka, A. Intention, Effort, Restraint: The EMG in Musical Performance. *Leonardo*, 48(3), 2015.
- [4] Hattwick, I., Franco, I., and Wanderley, M. M. (2017). The Vibopixels: a scalable wireless tactile display system. In *Proceedings of the International Conference on Human Interface and the Management of Information*, 2017.
- [5] Oku, T., and Furuya, S. A Novel Vibrotactile Biofeedback Device for Optimizing Neuromuscular Control in Piano Playing. *IEEE Conference on Virtual Reality and 3D User Interfaces, (VR)*, 2019, 1554-1555.
- [6] Casellato, C., Pedrocchi, A., Zorzi, G., Vernisse, L., Ferrigno, G., and Nardocci, N. EMG-Based Visual-Haptic Biofeedback: A Tool to Improve Motor Control in Children with Primary Dystonia. *IEEE Transactions on Neural Systems and Rehabilitation Engineering*, 21(3), 2013.