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Sensor-embedded percussion stick: an innovative motion capture tool

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1. Introduction

A musician produces music with an instrument using specific gestures. These movements mobilize the neuro-musculoskeletal system – as in sports – and require high repeatability (Jensenus et al. 2010). Since music teaching is mainly empirical (Lafon 2011, Ancillao et al. 2017), a musician has to find a way to achieve a performance based on sound production quality and accuracy. They potentially become an expert which is assumed to have found an efficient musculoskeletal strategy. The case of stick percussion is a relevant model (Mutio et al. 2017), the stick being both an extension of the percussionist arm and the interface between the drum and the musician.

To better understand music performance, difference in movement strategies between a beginner and an expert are investigated. For this purpose, we propose a new tool based on a sensor-embedded stick which allowed to propose an innovative way to perform motion capture and analysis.

2. Methods

A stick was built based on a standard stick (Resta-Jay, France). It comprises of a hollow aluminium handle, a hard felt head and an optional polymer grip (see Figure 1). A 3-axis accelerometer is added at the end of the handle, inside the head (sampling rate 800Hz, $\pm 16g$ range for each of the 3 axes).

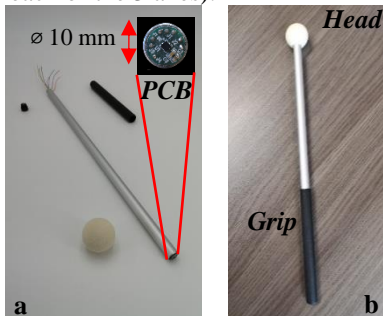


Figure 1: Disassembled stick (a); assembled stick (b)

The stick was tested on timpani by three people: two neophytes (subjects 1 and 2) and one with 6 years of self-taught percussion (subject 3). The subjects play

one stroke to start, 4 strokes with 60 bpm metronome directly followed by 8 strokes without metronome.

3. Results and discussion

The data obtained for one subject (subject 2) are presented in Figure 2. Figure 3 gives a visual comparison of the behaviour between the strokes for the three subjects. Table 1 gathers: the coefficient of multiple correlation (CMC) of the acceleration magnitude in-between strokes; the average time between two strokes without metronome.

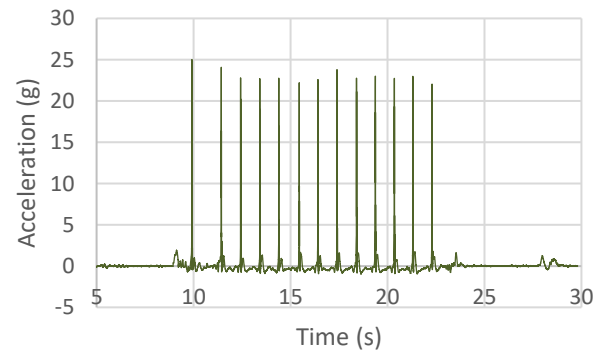


Figure 2: Acceleration magnitude for a series of 13 forte strokes at 60 bpm

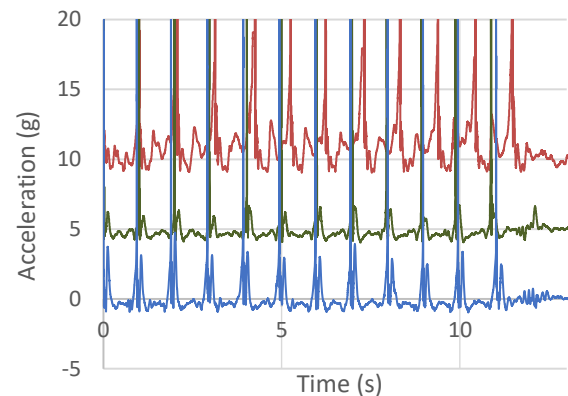


Figure 3: Acceleration magnitude of the three subjects: red subject 1; green subject 2; blue subject 3

	Subject 1	Subject 2	Subject 3
CMC	0.79	0.72	0.71
Average time between strokes (ms)	1043	989	1013
Standard deviation of time between strokes (ms)	46	32	31

Table 1: CMC of the acceleration magnitude in-between strokes and average time between two strokes

The most regular pattern is noticed for subject 1, whereas subjects 2 and 3 display a similar CMC. The less precise is subject 1, with an average error of 4.3%, whereas subjects 2 and 3 display an error of 1.14% and 1.25%, respectively. The less regularity in time between strokes is observed for subject 1, whereas subjects 2 and 3 have a similar standard deviation.

4. Conclusions

The embedded motion capture stick quantified rhythmic precision and repeatability of the movement. This preliminary study didn't clearly demonstrate a relationship between skill level and motion parameters. We noticed sensors saturation with 16g often reached for at least one out of three accelerometers. This makes analyses of strokes accelerations or patterns impossible, but in-between strokes values are still useable. Furthermore, it would be interesting to analyse the three components of acceleration separately (calibration and stick not rotating in hand hypothesis are required) to obtain a 3D understanding of the movement.

To conclude, this embedded motion capture stick offered innovative opportunity to perform motion capture in ecological situation. Further investigation will focus on refining sensor post-processing and investigating a sample of musicians with certified practice level.

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