

Development Report:

Unobtrusive Tremor Detection While Gesture Controlling a Robotic Arm

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A light weight robotic arm (Jaco) has been interfaced with a novel gesture detection sensor (Leap Motion Controller), substituting complicated conventional input devices, i.e., joysticks and pads. Due to the enhanced precision and high throughput capabilities of the Leap Motion Controller, the unobtrusive measurement of physiological tremor can be extracted. An algorithm was developed to constantly detect and indicate potential user hand tremor patterns in real-time. Additionally a calibration algorithm was developed to allow an optimum mapping between the user hand movement, tracked by the Leap Motion Controller, and the Jaco arm, by filtering unwanted oscillations, allowing for a more natural human-computer interaction.

Keywords: Fourier analysis, tremor detection, leap motion controller, ageing diseases

In Parkinson’s disease, people suffer apart from the tremor, also from rigidity and bradykinesia, mostly essential, but also posture. One main symptom of this disease is the tremor. It is of great interest to be able detect this symptom, because even simple muscle fatigue, and also other nerve disease can cause a tremor, e.g., dystonia, strokes, cancer, multiple sclerosis, etc. The Leap Motion Controller can be used to validate and quantify tremor and bradykinesia, once it is possible to calculate acceleration in all axes, with enhanced accuracy (sub-millimeter), and more importantly in real-time, due to its enhanced throughput rate (up to 300 fps) [1]. While the Jaco robotic arm is controlled using the Leap Motion Controller, the pathological, and also the physiological tremor of the user palm can be detected and measured. In order to do this an algorithm based on Fourier-Analysis has been developed. By gesture controlling the robotic arm (Fig. 1), using the user palm, raw data can be recorded (Fig. 2). Particularly the position over time in all x , y , z axes and roll, pitch, and yaw angles (in cm/s), are recorded, which are used to calculate the acceleration over time (cm/s^2). By using the following Fourier transformation on the acceleration data the corresponding frequencies can be retrieved (Fig. 3):

$$\bar{x} = \left| F \left(\frac{\Delta^2 x}{\Delta t^2} \right) \right| \dots \dots \dots \bar{x} \quad (1)$$

where \bar{x} represents the Fourier-transformed result, x the

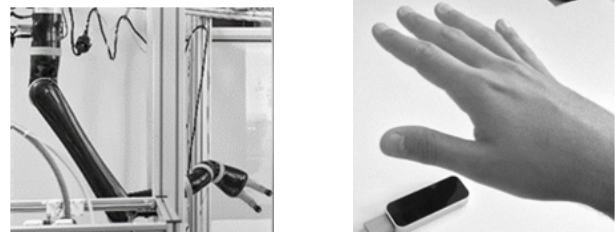


Fig. 1. Robotic arm (left), leap motion controller (right).

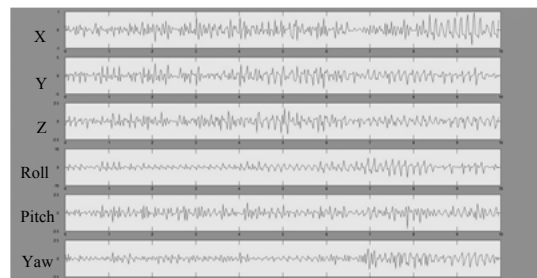


Fig. 2. Recorded raw data [cm/s]: x , y , z , roll, pitch, yaw.

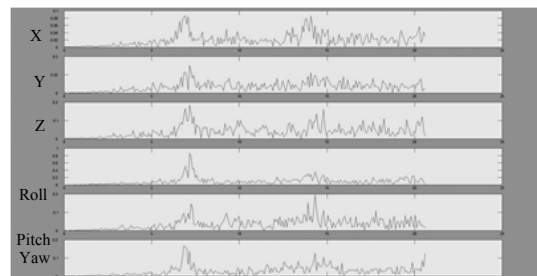


Fig. 3. Frequencies (0–20 Hz) in the data from Fig. 2.

measured raw data in cm, and t the time in seconds (where a time window of 10 secs was used). Tremor patterns up to 8 Hz, where observed during experiments. Thereby it is possible to visualize the tremor by the filtered disordering frequencies, Fig. 4. Depending on the environment conditions, the physiological tremor (7–12 Hz) can be evaluated. In future implementations the authors will attempt to also detect muscle fatigue, when using this innovative controlling scheme.

Additionally a calibration algorithm was developed [2], to filter unwanted oscillations due to hand tremor and allow a smooth operation of the arm. This was performed by initially applying a Simple Moving Average fil-

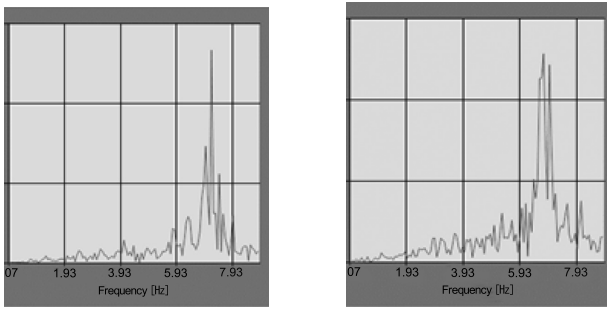


Fig. 4. Filtered signals pitch (left) and roll (right).

ter (SMA) on the derivative (instantaneous rate of change, over a period of 10 secs) of the raw data input for each x , y , z and roll, pitch, yaw data streams. Adaptive threshold values for each stream could thus be extracted by measuring the difference between the current max and min values of the SMA resulting arrays. Once these thresholds are calculated they are used to neglect extreme peaks on the recorded user palm and orientation data.

References:

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