Investigation of Parkinsonian tremor signals troughs nonlinear time series analysis

Antonio Zippo[*], Francesco Pellicano[*] and Giovanni Iarriccio[*]

[*] *Department of Engineering "Enzo Ferrari", University of Modena and Reggio Emilia, Modena, Italy.*

Abstract. The vibrational phenomena studied in this work regards the arm and forearm vibration with the purpose to detect and recognize the dynamic properties and correlations of onset of pathological tremor in patients affected by Parkinson disease. Experimental data measured by patients will be analyzed using multiscale recursive analysis methodologies through the TISEAN package [1].

Introduction

The characterization and identification of pathological patterns detected through the surface electromyographic (sEMG) and accelerometric signals are an interesting challenge: methodologies for data analysis, time series analysis, and human skills must be combined to detect and extract characteristics for pathological identification. The complexity lies in the very nature of the experimental activity [2] since each patient has slight differences due to the various positions of the electrodes, the different pathologies and the stage of the pathology itself, and the intrinsic complexity of biological systems (high degree of non-linearity, non-stationarity, and signal noise).Pathological tremors can be classified accordingly to their frequency: low (2-4Hz) cerebellar, medium (5-7 Hz) Parkinson's disease (PD), high (>8 Hz) Essential Tremor (ET). The traditional treatment is pharmacological and there are no proven efficacy molecules in cerebellar tremors. Other methods are mechanical, as robotic exoskeletons, or neurosurgical, as deep brain stimulation (DBS), these techniques suffer from various limitations; on the contrary, functional electrostimulation (FES) shows attenuation of 73% in ET, 62% in PD, and 38% in multiple sclerosis (MS). To support the patient affected by Parkinson's disease (PD) or Essential Tremor (ET), physiotherapy and electrostimulation help to reduce the tremor and compensate for the functional loss. From a biomechanical perspective, scientific literature describes the muscular activation and force estimation in several studies and further models allow compensating for errors introduced by measurement and tools. Surface electromyographic signals (EMGs) could be used as inputs for tremor detection[3-4], prediction, and parameter estimation. These could benefit from the implementation, for example, of Active Vibration Control algorithms, where the overall effect of the control loop is to reduce broadband oscillations and mitigate single or multi-vibrated modes without negatively affecting other frequencies (those related to voluntary movements).

Results and discussion

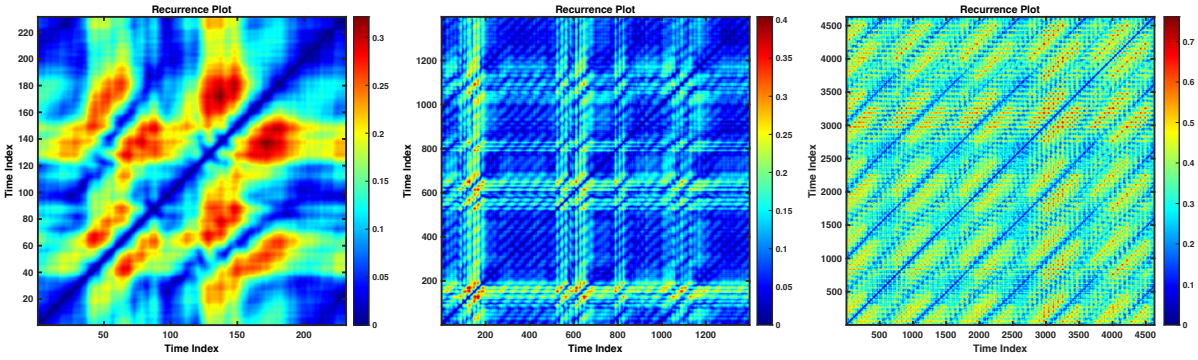

Figure 1: Recurrence plot of sEMG of Parkinsonian tremor at different time span: 0.1 seconds, 0.55second and 1.8 seconds

The showed case, see figure1, presents electrodes location in Arm - Biceps Brachii with posture seated, holding light object (sampling frequency is 2560Hz) and has been analyzed using multiscale recursive analysis methodologies through the TISEAN package; three time span has been considered, showing the complexity of this response in particular, the embedding dimensions is 3 in all cases, but periodicity seems more evident in higher time span related to the 5.153Hz pathological tremor corresponding to the samples distance between the diagonals in the 3rd recurrence plot.

References

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