Dimension Reduction of High Frequency and High Dimensional Data in Time and Space

PRODUCTIVE SECTOR: Health Care, Sport Analytics

PROBLEM DESCRIPTION

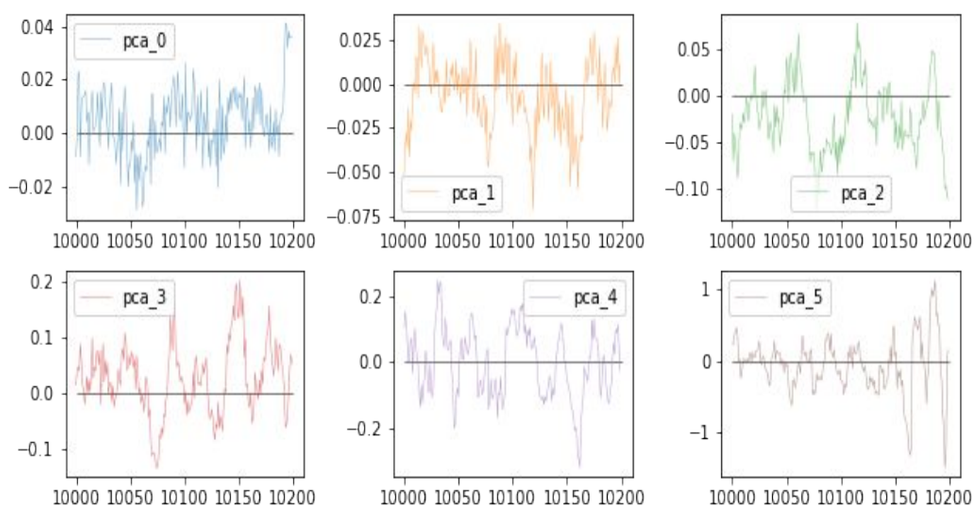
The objective of this research is to find the underlying main signals or driving latent sources detected by many motion sensors worn by different subjects, mainly athletes.

CHALLENGES AND GOALS

High and mixed frequency multidimensional data from noisy sensors; with the goal of finding dynamical principal components (PCs) of the underlying signals.

MATHEMATICAL AND COMPUTATIONAL METHODS

The spectral theory of stationary time series, developed mainly for one-dimensional processes a century ago, can be extended in many ways. Importantly for this project, it can be extended to dimension reduction of multivariate, discrete-time processes, to dynamic principal component analysis (d-PCA). The spectral density matrix of the multidimensional process can be estimated from a sample, and we can speak of the essential rank of it. This rank also determines the number of principal components worth examining, and we can realize a low-rank approximation of the time-series based on it as well. Linear algebra and Fourier analysis provide essential tools/methods in order to solve the problem at hand. and to implement the new algorithms.



A small segment (~0.4s) of the dynamic PCs estimated from the motion sensor data

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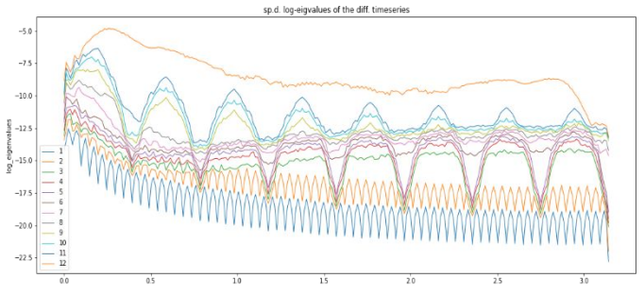
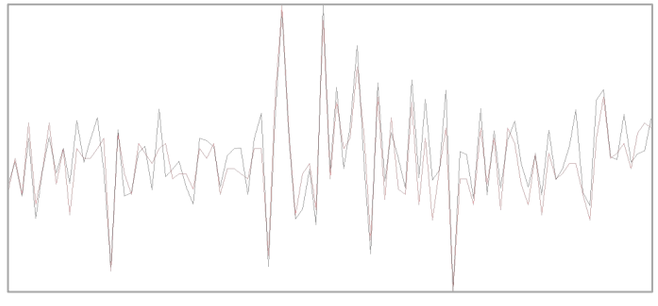
Results and Benefits

- We submitted two manuscripts to Web of Science journals based on the theoretical results.
- We developed and implemented an algorithm in Python to calculate/estimate the dynamic principal components of the multidimensional motion sensor data of the athletes.

As a result of the collaboration, I-QRS will receive a Python program for calculating and interpreting dynamical principal components of their sensor data. It may help them understand their data even better in the future.



Log-eigenvalues of the spectral density estimates of the mixed freq. data



A small segment (~0.2s) of one sensor (red) with its low-rank approximation (black)

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SZÉCHENYI 2020
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I-QRS International Kft.