PhD subject: **Learning multivariate time series**
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## Project description:

The monitoring of engineering systems provides the analyst with useful quantities of interest (QoI) evolving with time and recorded at several locations in theses systems. The monitored time series can serve several purposes:

- forecasting, i.e. predicting the time evolution of the QoI in the near future. Examples can be found in hydrology/climatology (precipitations, floods, droughts), energy (wind speed, electric load or power consumption), economics and finance (monitoring of financial assets), personalized medicine, network or road traffic, …
- diagnosis and prognosis (e.g. prognosis of remaining useful life of systems, structural health monitoring in mechanical or civil engineering),
- learning of an unobserved QoI from several other interrelated monitored data.

The proposed work aims at developing data-driven approaches based on machine learning and applied to multivariate time series. The above mentioned problems will be addressed in the framework of supervised learning. Since times series are often related to each other, we will apply multi-task learning in order to account for correlation in the recorded times series. Jointly learning these times series is expected to be better than learning each of them independently. Recorded time series are often found to be non-stationary in real problems. The foreseen direction to address the non-stationarity is to combine wavelet analysis with machine learning techniques. Wavelets will also serve for denoising the recorded time series.

Several techniques will be investigated to learn the recorded time series, depending on the amount of data collected by the monitoring system (number of sensors, time-step and duration, ...), among which support vector machines, Gaussian processes and deep neural networks. In the case of a limited amount of data, we will establish prediction uncertainty with respect to the size of the training data set. This prediction uncertainty is of paramount importance in forecasting and prognosis approaches.

## Some introductory references:

[1] : Farrar C.R. , Worden K. (2012). Structural health monitoring: A machine learning perspective, Wiley.
[2] : Fu T.-c. (2011). A review on time series data mining. Engineering Applications of Artificial Intelligence, 24(1), pp. 164–181.
[3] : Sapankevych N. I. and Sankar R. (2009). Time series prediction using support vector machines: A survey. IEEE Computational Intelligence Magazine, 4(2), pp. 24-38.

## Applicant background:

Master's degree in applied mathematics, computational sciences or civil/mechanical/industrial engineering.
Strong background in probability and statistics, optimization (required).
Experience with machine learning and/or uncertainty propagation (a plus).
Familiar with developing scientific codes and advanced programming skills (Matlab or Python).
Fluency in English.

## Application:

Please send:
- a detailed CV,
- a letter of motivation,
- the academic transcripts of the last 3 years, your class ranking if available,
- the report of the last internship carried out,
- contact details of 2 referees or letters of recommendation, if available.