

PhD subject: **Learning multivariate time series**

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### **Project description:**

The monitoring of engineering systems provides several useful quantities of interest (QoI) evolving with time, possibly recorded at different locations in these 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. A specific emphasis will be put on multi-task learning by leveraging the information of multiple and mutually related time series for an increased accuracy in predictions. Recorded time series are often found to be non-stationary in real problems. We will address non-stationarity by combining wavelet analysis and machine learning. 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 small datasets, we will compute the prediction uncertainty of the trained models, which is of paramount importance in some 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.

**Remuneration:** Stipend of ~1400 € net per month for 3 years (+extra salary for teaching activities).

**Starting date:** September-October 2020.

### **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.