Postdoc position
Hybrid modeling via machine learning and physics in mechanical engineering

Duration: 24 months
Funding: BIGMECA chair of Fondation Mines ParisTech at PSL Research University.
Contact: david.ryckelynck@mines-paristech.fr
Location: Centre des Matériaux, Mines ParisTech- PSL Research University
Web site: http://www.mat.mines-paristech.fr/About-us/

BIGMECA is a scientific program funded by SafranTech that aims to promote hybrid approaches integrating mechanical engineering and machine learning. Examples of such hybridations are already available in the scientific literature, such as the systems integrating Artificial Neural Networks and Finite the Element Method [1,2]. Hybrid approaches are known to be relevant for fault detection and diagnosis [3]. Such fault detection improves product quality.

Industrial processing plants are usually heavily instrumented with a large number of sensors and cameras. The primary purpose of the sensors is to deliver experimental data for process monitoring and control. It is time to make use of the large amounts of data being measured and stored in the process industry by building predictive models, for fault detection, based on this data. Particular attention will be paid to data from 2D, 3D and 4D (3D+time), images. In the context of process industry, these predictive models are called *Soft Sensors* [4,5].

Hybrid approaches aim to incorporate both simulation data and experimental data in the same predictive model. At Mines ParisTech, we develop model reduction methods for that purpose. Physics-based equations are projected on a reduced approximation space by using both simulation data and experimental data [2]. It turns out that the numerical model involves many layers to process theses data by using available numerical methods and machine learning algorithms. New processing layers have to be investigated such as clustering and convolutional neural network, as proposed in [2].

The main goal of the postdoc is to develop a convenient informatics framework in order to: (i) manage a data lake that contains experimental data (especially tomographic data) and simulation data, (ii) prune the data saved in the data lake if we need to free up memory storage [6], (iii) develop the components of multi layered models in the framework of machine learning for hybrid predictive models [2], (iv) assemble multilayered models.

This informatics framework aims to make consistent, the speed of generating observational data or simulation data with the speed at which we can analyze them.

[1] Jakub Gajewski, Tomasz Sadowski, Sensitivity analysis of crack propagation in pavement bituminous layered structures using a hybrid system integrating Artificial Neural Networks and Finite Element Method, Computational Materials Science, Volume 82, (2014), pages 114-117, https://doi.org/10.1016/j.commatsci.2013.09.025.

[2] Franck Nguyen, Selim M. Barhli, Daniel Pino Muñoz, and David Ryckelynck, Computer Vision with Error Estimation for Reduced Order Modeling of Macroscopic Mechanical Tests, Complexity, (2018), Article ID 3791543, 10 pages, https://doi.org/10.1155/2018/3791543

[3] Venkat Venkatasubramanian, Raghunathan Rengaswamy, Surya N. Kavuri, Kewen Yin, A review of process fault detection and diagnosis: Part III: Process history based methods, Computers & Chemical Engineering, Volume 27, Issue 3, 2003, Pages 327-346, https://doi.org/10.1016/S0098-1354(02)00162-X.

[4] Petr Kadlec, Bogdan Gabrys, Sibylle Strandt, Data-driven Soft Sensors in the process industry, Computers & Chemical Engineering, Volume 33, Issue 4, (2009), Pages 795-814, https://doi.org/10.1016/j.compchemeng.2008.12.012

[5] Carlos A Escobar, Ruben Morales-Menendez, Machine learning techniques for quality control in high conformance manufacturing environment, advances in Mechanical Engineering, Volume: 10 issue: 2, (2018), https://doi.org/10.1177/1687814018755519

[6] William Hilth, David Ryckelynck, and Claire Menet, Data Pruning of Tomographic Data for the Calibration of Strain Localization Models, Math. Comput. Appl. 2019, 24(1), 18; https://doi.org/10.3390/mca24010018