UMR CNRS 8201

Internship Proposal 2022

Title: Kernel design for simulating random fields in mechanics with Gaussian processes.

Keywords: mechanical codes, stochastic modeling and simulation, uncertainty quantification.

Place: Campus Mont Houy, Polytechnic University of Hauts-de-France, 59300 Aulnoy-lez-Valenciennes.

Host laboratories:

- Laboratory of Ceramic Materials and Mathematics (CERAMATHS), Dept. DMI (previous LMI).
- Laboratory of Industrial and Human Automation, Mechanics and Computer Science (LAMIH).

Duration: 6 months, starting in March 2022. **Salary:** defined according to the French government.

Application deadline: early February 2022. **Research mobility funding:** up to 0,9k€.

Profile and skills required: The candidate must be a 3rd year Engineering student or a 2nd year master student (or equivalent), with knowledge in both applied mathematics and mechanics. Outstanding programing skills in R and/or Python are required. The internship can be guided in French or English.

Presentation of the project, context and objective

The intern will apply state-of-the-art techniques related to stochastic processes, more precisely Gaussian processes [1], to model and simulate 2D mechanical random fields. In particular, the interest lies in the emulation of typical wear topographies in automotive brake systems.

- **Wear topography in automotive brake systems.** It is well known that the highly fugitive behavior of squeal phenomena cannot be modeled with traditional deterministic finite element simulations. As shown by [2], the integration of non-deterministic data, considering topological and topographical uncertainty, can clearly improve the predictability of simulations.
  In this project, we consider an automotive application, where random fields describe the spatial wear topographies in brake pads due to the effects of the third body (which creates stripes at the pad surfaces). In a Gaussian process framework, the covariance function (or kernel) plays an important role for a better understanding of mechanical events.
- **Objective.** There are settings where kernel designs would be relevant in mechanics but are not necessarily exploited, which is here a loss of opportunity. Therefore, the main objective is *to encode expert knowledge into kernels modeling mechanical transient random fields describing wear topography in automotive brake systems.*
- **Potential research activities.** The activities of the intern can be:
  1. To capture the results of real experiments and to encode the knowledge of mechanical experts into a kernel design.
  2. To generate a large number of virtual experiments using the resulting Gaussian process model. The virtual experiments can then be processed through machine learning techniques to characterize other random events, e.g., the detection and identification of brake faults **(optional)**.
  3. To propose numerical implementations based on existing open-source toolboxes related to Gaussian processes (see, e.g., [3, 4]).

External collaborations: The internship can benefit from other collaborations with the departments of Mathematics and Industrial Engineering (GMI) and Mechanics and Materials Processing (MPE) at Mines Saint-Etienne. Further discussions can be expected with other partners from the project EUNICE.

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