PhD Position:

Adaptive Design of Experiments and Supervised Machine Learning techniques for Process window identification and uncertainty mitigation

Keywords: Manufacturing, Process window, Design of Experiments, Machine learning, Classification techniques, Uncertainty

Proposal:

Today, production systems are subject to conflicting constraints, such as quality improvement versus cost and time reduction. To cope with these constraints, better control and monitoring of the different processes and means of production is mandatory. One way to gain a better understanding of a manufacturing process is to define the corresponding process window, taking into account the various technical specifications. This would enable the understanding of the physical phenomena involved and the identification of a robust manufacturing point.

However, the process window identification is sometimes problematic, i.e., the lack of reliable simulation tools for some processes (FSW, WAAM, …) leads to the establishment of experimental campaigns and the definition of Design of Experiments (DoE) based on expert knowledge.

Mainly, for the identification of process windows, Space-filling techniques are used for the establishment of suitable DoE. These DoE involve the definition of a large number of experiments, which is usually exhaustive and costly. Various techniques can thus be applied to reduce the number of experiments, such as adaptive Design of Experiments for the creation of surrogate models.

Accordingly, the main objective of this thesis is to reduce the number of experiments by developing an adaptive Design of Experiments combined with machine learning classification techniques for the identification of the process window, while considering the uncertainties inherent in the measured data as well as their impact on the different results.

Meeting the main objective involves addressing two challenges:

1. As the definition of an adaptive DoE is performed in a recurrent manner, a first challenge of this thesis consists in defining an enrichment criterion that allows defining the new experiments to perform based on the results of the previous experiments. The definition of the enrichment criterion must take into account: the experiments complexity, the experiments costs, the measurement uncertainties, and the uncertainty of the classification results.
2. The second challenge is the development of a shared purpose of the experimental strategy and the supervised learning technique.

On this basis, several scientific issues need to be addressed, namely: 1) The analysis and development of different techniques for the evaluation of each of the different enrichment criteria, i.e., evaluation techniques related to the complexity of the experiment, evaluation techniques related to data uncertainties, ... 2) The development of approaches to evaluate the confidence of the classification of machine learning techniques. This would allow enriching the DoE with points that meet a certain level of certainty. 3) Development and comparison of multi-criteria analysis techniques. 4) Identification of an appropriate experimental strategy and an appropriate classification technique, both of which are compatible.

Finally, the research methodology of this thesis can be summarized in the following tasks:

- T1: Specification of the requirements to define appropriate enrichment criteria.

- T2: Development and implementation of the enrichment criteria with respect to measurement uncertainties and classification uncertainty, as well as the assessment of their robustness to the impact of measurement uncertainties and the uncertainty of the classification results.
- T3: Development and implementation of enrichment criteria related to the experimental complexity.
- T4: Development and implementation of multi-criteria analysis techniques
- T5: Development and implementation of techniques for joint selection of the experimental strategy and the classification technique.
- T6: Dissemination of the results.

The proposed methodology will be developed for the Wire-Arc Additive Manufacturing (WAAM) process, and then the validated techniques will be deployed on other manufacturing processes, such as Incremental Forming or Friction Stir Welding (FSW).

Required qualification

The successful candidate should hold a Master's degree or Engineer grade in mechanical engineering. Candidates must have solid skills in Engineering and computer science, as well as excellent communication skills. Fluency in English is required. A strong motivation, interest in design engineering, reliability engineering, and computer science, and ability to work independently is also desirable.

Supervision

The successful candidate will be supervised at LCFC by Professor Jean-Yves DANTAN in collaboration with Dr. Sandra CHEVRET and Dr. Wahb ZOUHRI. The successful candidate will be registered as PhD student at the Arts et Métiers.

Contact

Jean-Yves DANTAN	jean-yves.dantan@ensam.eu
Sandra CHEVRET	sandra.chevret@ensam.eu
Wahb ZOUHRI	wahb.zouhri@ensam.eu

Term of contract

The position will be for a period of three years (October 2022- September 2025)

Salary

The position will carry competitive salary, matching the academic and professional profile of the applicant, and excellent work conditions (around 1700€ per month).

Location

LCFC lab, Arts et Metiers , 4 rue A. Fresnel, 57070 METZ, FRANCE

Please send a cover letter including a brief description of research interest and relevant experiences, a 2-page CV, the names of two referees that would be contacted upon the candidate being shortlisted and copies of your university diploma and transcripts in one pdf-file to Prof. Jean-Yves DANTAN (jean-yves.dantan@ensam.eu) noting in the subject of the message “PhD position”.

Deadline:

Mid of April 2022