**FOR APPLICATION, PLEASE CONTACT ADVISOR(S) BY EMAIL WITH COPY TO: ali.siadat@ensam.eu AND yvon.velot@ensam.eu**

## Research Topic for the ParisTech/CSC PhD Program

***Field (cf. List of fields below):***
1. Materials Science, Mechanics, Fluids
2. Mathematics and their applications
3. Design, Industrialization

***Subfield***: Mech. Eng.

***Title***: Shaping the third millennium engineering: instantaneous numerical predictions, & data-driven engineering.

***ParisTech School***: ENSAM Angers

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***Short description of possible research topics for a PhD***:

Disruptive design needs exploring in almost real-time the whole design space, and even the space outside. The same constraint applies when addressing processes supervision and control, decision-making and in general any DDDAS (Dynamic Data Driven Application System) present in smart factories and FabLabs where a variety of twins (virtual, digital and hybrids), robots and augmented reality and intelligence coexists in a fully connected system (IoT). The key player: a cheap, fast, robust, adaptive and flexible numerical technique.
Model Order Reduction techniques aim at reducing the computing time without impacting the solution accuracy. Proper Generalized Decomposition, intensively considered and nowadays successfully coupled with virtual prototyping tools, allows for the construction of parametric solutions that integrate advanced artificial intelligence techniques for accomplishing unimaginable performances.
The present PhD position aims at conceiving new numerical tools for evaluating complex mechanical systems subjected to millions of loading cycles producing fatigue. Robust designs need for properly describing multi-scale loadings (where different characteristic times operates, from the one of the action (seconds) and the one of the component or system life (years). Then, that time multi-scale description should be adequately introduced into the modelling framework to anticipate general responses. Using these modelling different defaults can be synthetically produced for training neural networks for proceeding with predictive and operational maintenance by invoking standard or advanced artificial intelligence tools. Finally, gaps between predictions, assumptions (loading, assembling tolerances, …) and responses, will be integrated into a data-driven model able to ensure predictability performances.
Thus, systems could be monitored, inspected, controlled in service, all along their life in a radical new framework, by coupling models and data, all kind of "intelligence".

***Required background of the student***:
- Engineering Mechanics (Continuum medium)
- Numerical Analysis
- Finite Element discretization

***A list of 5(max.) representative publications of the group:*** (Related to the research topic)


- *Nasri, M.A., Robert, C., Ammar, A., El Arem, S., Morel, F. Proper Generalized Decomposition (PGD) for the numerical simulation of polycrystalline aggregates under cyclic loading. Comptes Rendus - Mecanique, 346 (2) : 132-151, 2018. http://dx.doi.org/10.1016/j.crme.2017.11.009*
- *I. Alfaro, D. González, F Bordeu, A. Leygue, A. Ammar, E. Cueto, F. Chinesta. Real-time in silico experiments on gene regulatory networks and surgery simulation on handheld devices. Journal of Computational Surgery, 1:1, 2014. http://dx.doi.org/10.1186/2194-3990-1-1*
- *A. Ammar, A. Zghal, F. Morel, F. Chinesta. On the space-time separated representation of integral linear viscoelastic models. Comptes Rendus Mécanique, 343(4), 247–263, 2015. http://dx.doi.org/10.1016/j.crme.2015.02.002.*
- *C. Chancellor, A. Ammar, F. Chinesta, M. Magnin, O. Roux. Linking discrete and stochastic models: The chemical master equation as a bridge between process hitting and proper generalized decomposition. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 8130 LNBI, 50-63, 2013. http://dx.doi.org/10.1007/978-3-642-40708-6_5.*