Thesis title: **Artificial intelligence computational procedure for identifying parameters of a surrogate functionally graded shell model in crash simulation**

Keywords: Artificial intelligence; deep learning; crash simulation; surrogate model; finite element; functionally graded shells.

Skills of the applicant: Finite element; structural mechanics.

Summary: Artificial Intelligence (AI) has known over the recent few years, tremendous breakthrough research and applications which have enabled key advances in numerous engineering fields including computer vision, speech recognition, autonomous driving as well as autonomous AI-robots used in manufacturing, supply chain, distribution and services.

On the other hand, numerical simulation of crashworthiness which is widely used in several industrial sectors such as automotive, aeronautics, railway, etc., uses increasingly complex CAE models including billions of finite elements together with advanced material models requiring high computational time. Though, engineer's expertise is still necessary in order to evaluate the complex results, with various competing criteria. Hence, with the recent advances of AI, it appears feasible to collect crashworthiness knowledge of experts in computers and apply their choice to complex simulation results. In order to reduce computational efforts, usually surrogate structural models are adopted, by using coarse finite element mesh, simplifying some geometrical details and adopting conventional material models. Generally, these surrogate models need to be calibrated to fulfill the requirement of reproducing the global response of the physical model obtained experimentally. However, the calibration procedure is time consuming and tedious process which needs experienced experts.

The objective of the thesis is to develop an AI computational procedure based on deep learning techniques to allow identifying the functionally graded material parameters of the surrogate shell model which will be used as a substitute to a given complex CAE model. In order to validate the proposed approach, several benchmarks based on CAE models will be simulated at first, using refined finite element mesh together with the advanced material models and contact conditions. Then for each configuration, the AI computational procedure will be conducted to identify parameters of the surrogate model allowing its use without the need of the complex and expensive model. At the end numerical results obtained by the developed AI computational technique will be evaluated and compared with respect to the one obtained using the classical identification technique.

The roadmap for the thesis work can be stated as follows:

1. Perform a literature survey on the Artificial Intelligence modeling algorithms (deep learning, machine learning, artificial neural networks, etc.).
2. Define and build up a set of refined CAE structural models using LS-DYNA software.
3. Numerical development of the Artificial Intelligence computational procedure, for simple academic benchmarks (beams, 2D plates, axisymmetric shells).
4. Extension of the Artificial Intelligence computational procedure for the identification of the functionally graded surrogate 3D shell model.
5. Application to complex real parts, comparison and evaluation of numerical results with the classical approach.

Supervisor:

Prof. Hakim NACEUR
LAMIH, INSA Hauts-de-France, Valenciennes
E-mail: hakim.naceur@uphf.fr
Phone: +33 327 511 412