THESIS OFFER

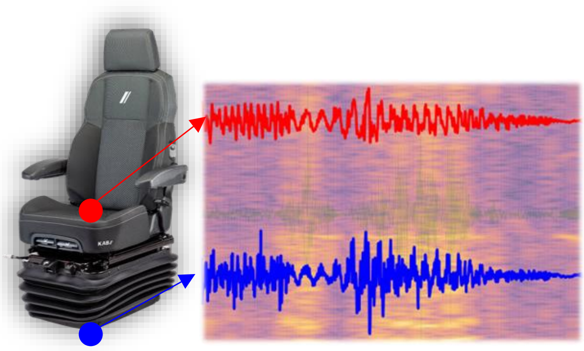
NUMERICAL SIMULATION OF THE DYNAMIC BEHAVIOR OF MACHINE SEATS USING A PHYSICAL MODEL ENHANCED BY MACHINE LEARNING METHODS

The research will be carried out at the *French National Research and Safety Institute for the Prevention of Occupational Accidents and Diseases* (*INRS*) in Nancy (FRANCE), in collaboration with the *FEMTO-ST* Institute in Besançon (FRANCE). The work will involve developing a model that reproduces the dynamic behavior of machine seats (loaders, dumpers, etc.) based on acceleration measurements. The originality of this thesis lies in combining a structural dynamics model with machine learning methods derived from artificial intelligence (neural networks, etc.) to simulate complex nonlinear systems.

CONTEXT AND OBJECTIVES OF THE THESIS

Machine operators (dumpers, loaders, forklifts, etc.) are exposed to vibrations that can lead to low back pain. Machine seats are equipped with suspension mechanisms designed to reduce this exposure. To prevent occupational risks, INRS has launched an ambitious scientific study aimed at improving the vibration isolation of seat suspensions. This study will involve *in-situ* assessment of the vibration insulation performance of seats used in the workplace.

The objective of the work to be carried out during this thesis is to develop a model capable of numerically reproducing the dynamic behavior of a vehicle seat based on time-domain acceleration measurements (digital twin).



To achieve this, laboratory tests will initially be conducted on machine seats using a hydraulic vibrating platform. Thus, acceleration signals similar to real field measurements will be produced, which will be used to train the model that will be developed through an innovative hybrid approach. Indeed, physical models alone may not fully capture the complex dynamics of seats, but machine learning enables the creation of hybrid models that enhance system representation (**Figure 1**). Therefore, models combining physical laws and machine learning algorithms (Bayesian filter, neural networks, etc.) will be developed to better represent the complex and non-linear behaviors of machine seat suspensions.

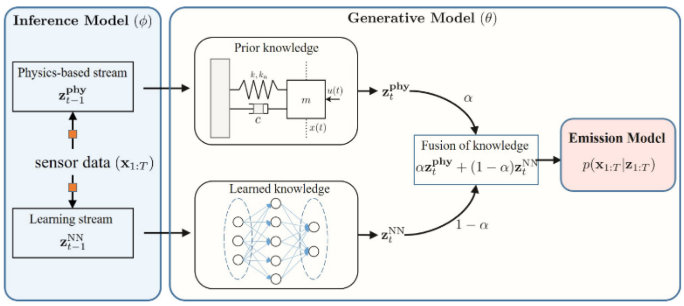


Figure 1 : Model of Liu, W., Lai, Z. & Chatzi, E. dans *A physics-guided deep learning approach to modeling nonlinear dynamics: a case study of a Bouc-Wen system*. in Proceedings of the 13th International Workshop on Structural Health Monitoring

The results of this thesis work will significantly improve the working conditions of machine operators and, consequently, advance knowledge in Occupational Health and Safety for numerous companies that use this type of machine.

REQUIRED PROFILE

Master's student (second year) or engineering school student in mechanics, system dynamics, or a related field.

Technical skills: Numerical modeling of physical phenomena, vibration and mechanical analysis, signal processing methods, programming (Python or MATLAB). Knowledge of machine learning methods would be appreciated.

Personal qualities: Scientific curiosity and rigor, analytical mindset, autonomy, and ability to work in a team.

Bonus: Interest in laboratory experiments and applications with real-world impact.

RESEARCH CONDITIONS

This PhD will be conducted at the EVO laboratory (Electromagnetism, Vibration, Optics) within the IET department (Work Equipment Engineering) at INRS (Vandœuvre-lès-Nancy, 54, France), in collaboration with the FEMTO-ST Institute of the Marie and Louis Pasteur University (UMLP) in Besançon. The research work will primarily be conducted at INRS, where the experimental facilities are located. Regular travel to the FEMTO-ST laboratory will be necessary to discuss the results obtained.

Supervisors: Maël AMARI (Co-supervisor, INRS), Quentin PIERRON (Co-supervisor, INRS), Émeline SADOULET-REBOUL (PhD Director, FEMTO-ST)

Duration: 3 years, fixed-term contract.

Gross salary: €2,676 per month

APPLICATION

Send your CV and cover letter to the following address: quentin.pierron@inrs.fr

Join an innovative research project at the intersection of physics and artificial intelligence, with real-world applications for workplace safety!

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