PhD SCHOLARSHIP APPLICATION

Division/Business Area: Construction/Infrastructures

Building/Province: Derio / Bizkaia

Doctoral thesis co-director: Aguirre Font, Miquel

SCHOLARSHIP DESCRIPTION

Title: Structural damage detection algorithms (SHM) through a combination of computational mechanics and Deep Learning

Brief description:

The scholarship proposed is oriented to research in advanced techniques for infrastructure damage detection (Structural Health Monitoring or SHM). To do so, a combination of fundamental and applied research in 1) developing inverse finite element algorithms; 2) Deep Learning techniques for data-driven learning; and 3) validation in experimental environment, are proposed. These types of techniques intend to develop algorithms to facilitate rapid and accurate calculations of structural health in a type infrastructure.

Detailed description:

Tecnalia Infrastructures Division is launching research lines in the field of advanced mechanics and simulation, to address infrastructure needs such as ageing and resilience against extreme events. For that purpose, research lines will be developed in the following areas: 1) structural status diagnosis; 2) damage prediction; and 3) design of advanced structural solutions.

For the first research line in the field of diagnosis, the strongest commitment undertaken by the department will be focused on the design of algorithms to characterise structural status, based on acceleration sensors, deformation and other critical variables, precisely arranged throughout the structures. In particular, the use of computational mechanics algorithms (inverse finite elements) will be promoted to allow inferring fundamental parameters to enable damage characterisation.

Nevertheless, these algorithms contain fundamental numerical difficulties often derived from an incorrect approximation of a mathematical problem, as well as high computational costs. This is often results in non-physical results as well as long computational times, representing a major hurdle for real environment application.

This thesis aims to combine simulation through FEM methods and Deep Learning techniques to obtain inverse SHM algorithms to calculate structure status in a reliable way and in real time. To do so, research will focus on the following specific areas:

- implementation of SHM algorithms for increased complexity problems in a high performance computing environment; open-source academic algorithms, such as Florence (https://github.com/romeric/florence) will probably be used. This has been implemented at the University of Swansea and is also part of the PhD thesis scope of Aratz García in this division.

- Algorithms for finite-element-model updating for inverse calculation: FEM updating algorithms will be implemented, validated and applied to structural status inverse calculation, which will be later used to compare the results of Deep Learning models proposed in this thesis.
- Deep Learning Algorithms: the applicability of machine-learning models based on multilayer neural processing, highlighting new ways of computing to identify space-time patterns (memory perceptrons or convolutional networks). Research will include how to hybrid both types of neural computation to find complex patterns in time and space domain.
- Deep-Learning algorithm training through the creation of multiple damage scenarios using HPC algorithms. Validation through different synthetic results. For data sampling, the possibility of using Monte Carlo method or other alternative methods will also be considered:
- Creation of reduced model experimental scenarios. The scale bridge built in the infrastructure area will be used to validate algorithms developed within the scope of this thesis. For that purpose, the candidate will be supported by the department personnel with experience in the use of sensors and processing data generated.

In any case, the candidate will be given flexibility to propose research lines of his/her own interest, in line with the thesis theme (damage detection in structures, using a combination of data analytic algorithms and computational mechanics).

The candidate will receive the backing of the department with an experienced team in structural modelling and new model development. Moreover, the candidate will be supported by personnel with experimental experience and on-site experience. Regarding data analytics, the Candidate will be supported by the research team led by Javi Del Ser of the University of the Basque Country (UPV-EHU), in the JointResearchLab (JRL) (led by Javi Del Ser and where Miquel Aguirre is an active member); and GEI of ICT OPTIMA Big Data.

Finally, the PhD student may work in collaboration networks at Basque Country as well as international levels, where both thesis Directors participate. For example: a very close collaboration is currently consolidating with David Pardo, Ikerbasque Research Professor of the Basque Center for Applied Mathematics (BCAM), and the University of the Basque Country (UPV-EHU), who are jointly working in this specific field of application.

REQUIREMENTS:

Degree and specialisation:

A degree in Civil Engineering; Computer Engineering; Mathematics; Physics

Languages:

Advanced level of English.

IT skills:

Knowledge of programming languages (Python, C, Fortran, Java); calculation and simulation software (ANSYS, ABAQUS); and data analysis software (R language, Octave, Matlab, Scikit-learn, Weka, Encog).

The following will be a plus:

Knowledge of Mechanics of Continuous Media and Mechanics of Structures.

Knowledge of the use and/or development of FEM techniques.

Knowledge of the use and/or development of machine learning techniques.

Previous research experience at master level.

Further information and applications*:* http://bit.ly/2J0NH1f