INSTITUT NATIONAL DES SCIENCES APPLIQUÉES CENTRE VAL DE LOIRE

Vibration-based structural health monitoring by bio-inspired soft-computing approaches

PHD PROPOSAL

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Keywords : Structural health monitoring; vibration; frequency; mode shape; modal analysis; damage detection; soft computing; Optimization methods; Particle Swarm;

I. Context

Structural damage detection based on vibration testing has received a lot of interest in recent years. Various methods (finite element methods, wavelet analysis, classical indicators methods, experimental and numerical methods, artificial intelligence techniques, Aunt Colony methods, ...) have been employed for the damage detection. But due to the large dimension of the structural identification problem, these approaches often get trapped in a local optimum and failed to obtain the reasonable solution. In this PhD, an investigation of bio-inspired soft computing methodology is proposed in order to increase the efficiency, accuracy and precocity of the structural monitoring. After a literature review of existing methods, the work will start with Particle Swarm Optimization and an original search space browsing strategy will be performed. In order to evaluate several parameter configurations and different fitness functions, parallel computing technics will be used and interactions/correlations analyzed. In the second time, a possible classification based on artificial intelligence and deep neural networks should be studied. The crack detection algorithms will be developed with Euler-Bernoulli beam simulated data and contrasted with others methods. Finally, a validation on experimental beam measurements will be performed.

II. Work plan and expected results

The PhD student will be integrate the laboratory of Mechanics LaMé of INSA Centre Val de Loire and particularly the "DivS" research team with many international students and 2 past CSC PhD students.

The work could be start by the following steps:

- 0 – T0+6m: Literature review, knowledge of bio-inspired soft-computing methods and numerical tools, first simulations of Euler-Bernoulli beam damage detection
- T0+6m – T0+12m: Parameter sensitivity configurations and evaluation of different fitness functions, parallel computing technics will be used
- T0+12m - T0+18m: parameters interactions/correlations of proposed approaches and effects on efficiency and accuracy
- T0+18m – T0+24m: Comparison with others methods and validation on experimental test bench.
- T0+24m – T0+32m: Finalization of results and Journal paper redaction
- T0+32m – T0+36m: PhD dissertation redaction and presentation

III. Background required for the applicant

After a top Master graduation in **mechanical engineering or applied mathematics** where the applicant developed excellent skills on mathematics, engineering science, computational methods, programming; finite element and statistical concepts, *we are looking for an applicant which has a goal to excel and live up the expectations in performing the project assigned*.
The applicant should have a **great motivation** about the field of the thesis and a **strong determination to push down scientific limits**.
The co-supervisors will help the applicant to start his scientific career on this relevant topic.

References

Li X-L, **SERRA R**, Olivier J. A multi-component PSO algorithm with leader learning mechanism for structural damage detection, *Applied Soft Computing*, Volume 116, 2022, 108315, ISSN 1568-4946, https://doi.org/10.1016/j.asoc.2021.108315.

Li X-L, **SERRA R**, Olivier J. An Investigation of Particle Swarm Optimization Topologies in Structural Damage Detection. *Appl. Sci*. 2021; 11(11):5144. https://doi.org/10.3390/app11115144

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