Profile of the position: PhD – 36 month

"Bio-inspired shape optimization for structural resistance"

Affectation
Laboratoire LMN (Laboratoire de Mécanique de Normandie), INSA de ROUEN, St Etienne du Rouvray

Context.
Nature is the best engineer and we need to learn from it. To improve the safety, durability, and cost of engineering structures, we must consider the uncertainties of design methods, operation conditions, and materials. Over the past 30 years, new probability-based approaches have been developed [1]: reliability-based design, robust optimization, probabilistic risk assessment, etc. These methods take into account the uncertainties of the natural environment - the same uncertainties that Evolution has had to overcome and integrate into its creations. Bio-inspired (or biomimetic) engineering studies the principles of Nature's design and is the priority of modern science.

Our central hypothesis is that Nature has means to improve engineering applications. It is necessary to study the effective and robust solutions created by Nature, extract the principles and implement them into engineering design to increase safety and reduce costs.

To answer this need, we propose to look for bio-inspired solutions that can be applied to structural design. A holistic and sustainable design can be inspired by a structure, topology and materials, organisms and natural ecosystems (trees, bones or shells [2]).

Research question.

This objective is twofold. We propose:

1. Formulate bio-inspired design criteria for robust boundary-state design, with marine (fluid-structure interaction) and civil applications.

2. Develop numerical models for topological and shape bio-inspired optimization of structures.

Methods.

Shape optimization is an efficient approach to structural design. Once an objective function is defined, a suitable numerical model of a structure has to be developed. In the present study isogeometric analysis (IGA), recently developed powerful technology in computational mechanics will be considered for numerical simulation. It provides needed flexibility for shape optimization during the design stage. Also, it reduces a computational cost, which is an important issue when taking into account random loading, as it will be done during the thesis.

This Ph. D. work will be the sequel of preceding projects realized in the same laboratory, where we developed the numerical models and experimental equipment of structural response to random impact loading.

Literature

1. Ellingwood, B. and Galambos, T.V., 1982. Probability-based criteria for structural design. Structural safety, 1(1), pp.15-26
2. Burns, L., Mouritz, A.P., Pook, D. and Feih, S., 2015. Bio-inspired hierarchical design of composite T-joints with improved structural properties. Composites Part B: Engineering, 69, pp.222-231.

Key-words

reliability, bio-inspired design, structural resistance, optimization, isogeometric analysis

Required competences

MD in Mechanical, Material science or similar

Competences in modeling the mechanical behavior of materials, structural calculation

Environment and working conditions

The work will be held at LMN, INSA Rouen. The PhD candidate will work outside of the ZRR zone (academic subject). This particular context implies compliance with confidentiality, security and ZRR rules applicable to part of the premises. She/he must respect a strict separation of the ZRR activities from those of the rest of the premises.