FAISTOS AI & INDUSTRY

Sujet de stage Master 2 / fin d'études

Bayesian networks for reliable prediction of the durability of Low Carbon Concrete in marine environnement

Introduction

The conventional design approach for **durability of marine concrete structures** is nowadays prescriptive; this results in material constituents and proportion, construction practices and cover depth determination according to exposure classes with two standards. But, many researchers have pointed out that this approach ignores the performances of the new binders as Métakaolin added with high content to the concrete. Finally, the concrete strength is usually considered as the major parameter of durability, postulating that stronger is a concrete, more durable it will be, leading to 1) high cement contents into mix design and 2) high clinker content in the binder. As a result, the concrete mix design is not optimized, whether in terms of material performance or carbon footprint. In a world moving towards more eco-friendly construction, one challenge is to design and produce concretes such as **Low carbon concrete** (LoCC).
Characterization of this kind of material is time consuming and expensive. The researchers developed multi scale modelling to get these properties with more or less successful mainly because the hydration process is always under investigations and difficult to model.
According to J. Pearl, Turing Award 2011, a high level of Artificial Intelligence cannot only emerge from model-blind learning machines (i.e. most of the actual "Deep Learning" methods) but requires close collaboration between data and models, which is possible with probabilistic graphical models such as **Bayesian networks**.

The DUKe (Data User Knowledge) research group in LS2N, UMR CNRS 6004, is one of the laboratory's main group in the "data and decision science" theme, with its skills in data manipulation, data mining and interaction. In this framework, the team has developed numerous algorithms for learning and manipulating probabilistic graphical models (Bayesian networks, dynamic Bayesian networks, relational Bayesian networks).
The laboratory GeM UMR 6183 is interested in understanding and predicting the evolution and life span of existing and future structures. Its originality consists in studying the relationships between the composition, the implementation processes and the durability of materials. The approaches developed are based on experimentation and modeling and consider in particular the couplings between physical-chemical and mechanical stresses.

This work will be co-supervised by Philippe Leray, in LS2N laboratory, expert for more than 15 years on probabilistic graphical models such as Bayesian networks, and Stéphanie Bonnet from GeM Laboratory, expert in durability of construction materials and eco design of reinforced concrete structures in marine environment.

Objective of the internship

GeM and LS2N are currently collaborating about the proposition of a generic Bayesian network model able to (1) estimate model parameters in chloride ingress, from data measured in different contexts, and (2) deploy this model to predict the residual life of the structure.
This first study is only about Portland cement so with many data in the literature. The second step will be to study LoCC.

The objective of the internship is to become familiar with the previous work done in GeM and LS2N, and to develop one new Bayesian network approach for reliable prediction of the durability of Portland cement in marine environment.

Planning :
- Become familiar with the previous approach proposed in GeM and LS2N
- Become familiar with PILGRIM library (C++) dedicated to Probabilistic Graphical Models
- Become familiar with Portland and Low Carbon Concrete context
- Propose one new BN approach in this context
- Implement and test this model
- Prepare a scientific poster illustrating the work carried out and the results obtained

In practice

Period : 6 months maximum between 27/01/2025 and 29/08/2025
Main location : LS2N, DUKe, site de Polytech/Chantrerie
Internship allowance: approx. 670 € / month

Skills

This subject requires methodological and scientific rigor, and is aimed at candidates in their final year of engineering school or Master's 2 with a good knowledge of one or more of the following fields :
* Concepts of probability and statistics, probabilistic graphical models
* C++ programming
* interest in interdisciplinary projects

Application

CV + cover letter + academic results (PDF format) to philippe.leray@univ-nantes.fr and stephanie.bonnet@univ-nantes.fr