PhD in Civil and Environmental Engineering

Research Title: Structural Design - Advanced Artificial Intelligence methods for structural engineering

Funded by	Politecnico di Torino

Supervisor	Prof. G.C. Marano

Contact	Includere website del gruppo di ricerca, in modo che il potenziale candidato possa accedere ad altre info

Context of the research activity	Civil engineering is fraught with problems that defy solution via classical modelling, namely physical based analytical formulations models and traditional computational techniques. Artificial intelligence (**AI**) is proving to be an efficient alternative approach to classical modeling techniques in many technical applications and scientific areas. **AI** refers to the branch of computer science that develops machines and software with human-like intelligence, and it aids to solve many problems affected by high uncertainty or complexity. In addition, AI-based solutions are good alternatives to determine engineering design parameters when testing is not possible, thus resulting in significant savings in terms of human time and effort spent in experiments. AI is also able to make the process of decision making faster, decrease error rates, and increase computational efficiency. Among the different AI techniques, machine learning (ML), pattern recognition (PR), deep learning (DL) and evolutionary computing (EC) have acquired considerable attention and are establishing themselves as a new class of "intelligent" methods, and are very promising as an alternative way for solving some class of problems in structural engineering. It might be taking longer than other industries, but **structural engineering** is slowly coming round to the idea of **artificial intelligence (**differently from other engineering branches) because its practices have remained the same for more than a century.

Objectives	The main objective of this phd is to explore the potential of artificial intelligence methods in the typical applications of structural engineering, evaluating their ability to manage and overcome the restrictions of conventional models.

	The main objective is to evaluate future directions, emerging applications and issues related to the efficiency and robustness of AI methods for some typical structural engineering problems, to assess their potential and future trends. Specific attention will be paid to the study of AI not only as an alternative to classical methods in some problems, but also as the only approach to problems that otherwise would not even be feasible due to their complexity. Specific fields of application, where classical approaches have performed badly, can be already envisaged. These are structural optimization for robust and resilient design, support to inspection protocols, maintenance strategies and multi-criteria choice of best retrofit operations on infrastructures. The work will be organized around the following phases: **State of the art** - In-depth analysis of the state of the most recent applications of AI, both in the scientific literature and in technical applications, revealing the effectiveness in some areas that suffer from the limitations of conventional methods. **Evaluation in applications** - Study of the existing application of AI techniques to one or more structural problems, such as structural health monitoring, damage detection, performance evaluation, structural identification, optimal structural design, material and structure modeling and others that may emerge during the search. **Effectiveness** - Since artificial intelligence methods for solving structural engineering problems are no longer in the initial phase, it is important that the study identifies a clear motivation for the use of specific AI methods, capturing and exposing their advantages over methods conventional. Furthermore, a key point is to move from simple exploratory uses to well-targeted, rational and practical implementation of different algorithmic options, since the different methods of artificial intelligence can lead to various levels of performance and accuracy depending on the investigated application. In this context, the developed AI techniques will be trained by means of with a full-scale experimental campaign that is running on large infrastructures at the SISCON lab, in order to feed the data base of the machine learning phase. **Level of innovation** - Evaluate and discuss the advantages deriving from the use of new AI methods in structural engineering, making comparisons with the classic ones. Moreover, the research should propose alternative solutions for the adopted AI method in which it is believed that the optimal parameters for the algorithms improve the precision, exposing the process by which the optimal algorithmic parameters have been chosen (ie formation, validation and test). It is also fundamental to identify problems that cannot be analyzed with classical techniques, and which can therefore be studied only with AI techniques. **Future trends** - Definition of a clear identification of structural engineering problems that can significantly benefit from the application of AI in the near future. This analysis must not be

	limited to only improving the performance or accuracy of the solutions, but must go further by identifying totally new applications, potentially not yet defined, as they cannot be analyzed with standard methods.

Skills and competencies for the development of the activity	Relevant skills in mathematics and structural engineering Basics of computer programming (Matlab, Phyton, etc)