



PhD in ARCHITETTURA, INGEGNERIA DELLE COSTRUZIONI E AMBIENTE COSTRUITO / ARCHITECTURE, BUILT ENVIRONMENT AND CONSTRUCTION ENGINEERING - 39th cycle

PNRR 117 Research Field: A MACHINE LEARNING FRAMEWORK FOR ANOMALY DETECTION IN BRIDGES AS A DECISION SUPPORT TOOL FOR MAINTENANCE MANAGEMENT

Monthly net income of PhDscholarship (max 36 months)

€ 1400.0

In case of a change of the welfare rates during the three-year period, the amount could be modified.

Context of the research activity

Motivation and objectives of the research in this field

The focus of this PhD project is on the use of machine learning techniques based on artificial neural network to process monitoring data for anomaly detection purposes. In the perspective of the **ecological transition and sustainable mobility** promoted by the **Mission M2C2** of the **Italian PNRR** (Piano Nazionale di Ripresa e Resilienza), this project will promote a sustainable approach to bridge management through the development of methods to increase their service life through the efficient management of information relevant to their performance. This will limit both waste creation and consumption of non-renewable resources that are associated with reconstruction projects. This objective will be achieved leveraging the potentialities connected with the digitalization of the bridge performance information management. Operation, maintenance, and repair of bridges is currently still largely based on outdated and underperforming methods such as visual inspections. The efficient use of large volumes of data and digital technologies can greatly increase the efficiency of bridge maintenance management. In this perspective the outcome of this PhD project will also contribute to the **Mission M1C2 digitalization, innovation and**



	<p>competitiveness of the sector of bridge management. Not least, the project will foster the development and acquisition of theoretical and applied knowledge in a field scarcely investigated for civil engineering infrastructures thereby supporting the achievement of Mission M4C2: education, research and technological transfer of the PNRR. The overarching objective of this research project is to establish how artificial intelligence techniques based on machine learning can be used to manage the maintenance of a network of bridges.</p> <p>More detailed objectives of the project are:</p> <ol style="list-style-type: none"> 1. to provide a method to automatically detect anomalies related to diverse limit states using static and dynamic monitoring data; 2. to build a decision support tool to manage the operation and maintenance of the bridge based on the outcome of the data processing phase. <p>The topic of the project is highly interdisciplinary involving topics related to structural engineering, computer science and decision analysis. The collaboration with the industrial partner (SINA S.p.A.) will provide an intersectoral profile to the research that will facilitate both the technological transfer of the research outcomes and the cross-sectoral training of the PhD student.</p>
<p>Methods and techniques that will be developed and used to carry out the research</p>	<p>The objectives outlined in the previous section will be achieved through the following steps:</p> <ol style="list-style-type: none"> 1. selection of one of the bridges monitored and managed by SINA as exemplary case study to develop the procedure; 2. development of the finite element model of the bridge to produce the set of data needed to train, verify and validate the machine learning model of the bridge; several limit states, corresponding to diverse damage mechanisms will be simulated; 3. development of an anomaly detection based on outliers detection accounting for the effect of environmental parameters;



	<p>4. acquisition and processing of the data on the SINA case study; and</p> <p>5. implementation of the anomaly detection methodology on the case study.</p> <p>The development of the PhD thesis will be supported by the collaborations with:</p> <ol style="list-style-type: none"> 1. a leading company in the sector of bridge inspection and maintenance management (SINA S.p.A); 2. prof. Raid Karhoumi at Royal Institute of Technology (KTH) in Stockholm, Sweden, a research excellence in the field of Structural Health Monitoring and machine learning modelling. <p>The PhD student will spend a period of 6 months at KTH and an internship of 6 months at SINA S.p.A company.</p>
Educational objectives	<p>The Candidate will acquire expertise in signal processing, anomaly detection, artificial neural networks. Besides this, it is expected that the candidate will develop a publication record in recognized international journals and conferences and transversal skills related to communication and project management.</p>
Job opportunities	<p>The candidate will have wide employment possibilities in academia, R&D departments of companies in private or public bodies owning or managing structures and infrastructures (buildings, bridges, pipelines for oil and gas, water, waste-water, etc.).</p> <p>The expertise in the efficient use of machine learning and anomaly detection for maintenance management will make the PhD candidate a first choice for the market related to the Smartcity vision.</p>
Composition of the research group	<p>0 Full Professors 1 Associated Professors 1 Assistant Professors 3 PhD Students</p>
Name of the research directors	Prof. Maria Giuseppina Limongelli

Contacts
Prof. Maria Giuseppina Limongelli



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Additional support - Financial aid per PhD student per year (gross amount)	
Housing - Foreign Students	--
Housing - Out-of-town residents (more than 80Km out of Milano)	--

Scholarship Increase for a period abroad	
Amount monthly	700.0 €
By number of months	6

National Operational Program for Research and Innovation	
Company where the candidate will attend the stage (name and brief description)	SINA S.p.A - Sede Legale: Viale Isonzo, 14/1 20135 Milano - www.sina.it
By number of months at the company	6
Institution or company where the candidate will spend the period abroad (name and brief description)	Royal Institute of Technology (KTH) - Structural Engineering and Bridges - Stokholm, Sweden
By number of months abroad	6

Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information

Additional support:

Budget for the research activity (only for positions supported by scholarship): total amount Euro 5707.20 per student.

In detail:

- 1st year Euro 1902.40
- 2nd year Euro 1902.40
- 3rd year Euro 1902.40

Additional information about the organization and regulations of ABC-PhD programme can be found in the Regulations for the 39th Cycle of ABC-PhD: download is available at link: <https://www.dottorato.polimi.it/corsi-di-dottorato/architettura/architettura-ingegneria-delle-costruzioni-e-ambiente-costruito>

Additional information about ABC department and ABC-PhD programme: available at link: <https://www.dabc.polimi.it/>

Desk availability: The ABC department provides non-permanent desks to be temporarily booked in common PhD rooms.

This scholarship is funded by the PNRR national programme D.M. 117. This means that the owner of the position will be obliged to submit periodical reports about her/his activity.