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Supervisor Expression of Interest
MSCA - Marie Sklodowska Curie Action - (PF) Postdoctoral Fellowship 2024

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Link "Pagina docente":
https://www4.ceda.polimi.it/manifesti/manifesti/controller/ricerche/RicercaPerDocentiPublic.do?evn_didattica=evento&k_doc=56652&polij_device_category=DESKTOP&__pj0=0&__pj1=fe953c0bb106fe1c54ce69049c3ea916

Department Name: Department of Civil and Environmental Engineering (DICA)

Research topic: Advanced Health Monitoring of Civil Infrastructure : Climate Change Resilience via Sensing and Machine Learning Innovations

MSCA-PF Research Area Panels:

- ☐ ECO_Economic Sciences
- ■ ENG_Information Science and Engineering
- ☐ ENV_Environmental and Geosciences
- ☐ LIF_Life Sciences
- ☐ MAT_Mathematics
- ☐ PHY_Physics
- ☐ SOC_Social Sciences and Humanities
- ☐ CHE_Chemistry

Brief description of the Department and Research Group (including URL if applicable):

The Civil and Environmental Engineering Department at Politecnico di Milano is known for its strong research and practical engineering solutions. I lead a research team here focusing on statistics, modeling, and understanding how climate changes affect the environment. We use Machine Learning and data analysis to help make buildings and structures safer and more sustainable, especially considering changes in the climate. Our team is recognized internationally and has received funding from the European Space Agency and the European Commission because of our collaborative research and significant publications. We have a good record of working with researchers from around the world and publishing our findings in well-known journals. We have published 152 papers in international journals, 18 in conference proceedings, contributed to 8 book chapters, and written a significant book (details available on my Google Scholar profile). Our work supports the advancement of civil and structural engineering and aims to improve the safety and longevity of infrastructure.

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TITLE of the project: Monitoring and Resilience Assessment of Civil Infrastructures under Climate Changing by Innovative Sensing Technologies and Machine Learning-Assisted Solutions

Brief Project Description: (max 1 page) In Europe today, essential infrastructure like roads, dams, buildings, bridges, and offshore structures face constant threats from aging, natural disasters, environmental changes, climate shifts, and technological challenges. Our project addresses these issues with a fresh approach, combining smart sensing technologies and advanced computing methods using Artificial Intelligence (AI) and Machine Learning (ML) for Structural Health Monitoring (SHM) and Structural Resilience Assessment (SRA). This initiative brings together the latest technology and practical strategies to revolutionize SHM practices throughout Europe. By integrating sophisticated sensing devices with data analytics and AI, we aim to not only meet the immediate needs for infrastructure monitoring but also lay the groundwork for the future of civil engineering and safety standards.

Project Essence: The main goal of our project is to develop a new, effective, and cost-efficient method for monitoring the health and resilience of civil infrastructures, especially in light of climate change. We are taking advantage of widely available technology, such as spaceborne remote sensing, cutting-edge yet affordable sensors like digital cameras and smartphones, and common sensors like micro-electro-mechanical systems, to gather a vast amount of data cheaply. This data is then analyzed using advanced AI and ML techniques, including a variety of algorithms and models (generative, discriminative, and predictive). Our aim is to offer innovative, sophisticated, yet affordable ways to thoroughly check the condition of civil infrastructures. This includes spotting irregularities, assessing possible damage, predicting how structures will behave and respond, reducing uncertainties, forecasting potential failures, and improving sustainability and resilience against climate change, natural disasters, and human-made risks.

Methodology Overview: Our project approach starts with identifying areas in Europe at risk due to climate change using spaceborne remote sensing. We then pinpoint key civil infrastructures within these areas and assess them using modern sensors (like digital cameras and smartphones) or sensors already in place. The data collected includes vibration feedback and visual information, such as images and videos. Through smartphone sensing technology, we plan to set up both crowdsourced and non-crowdsourced data collection systems, supported by IoT technologies and edge/fog/cloud computing. Following data collection, we turn our attention to AI and ML algorithms and models to process and analyze this data for Structural Health Monitoring (SHM) and Structural Resilience Assessment (SRA). The implementation of our methodology is structured into five strategic phases:

1. Two-level Selection of Sensing Systems: This phase includes some products of available satellites and then installed/next-generation sensors
2. Data Preprocessing, Analysis, and Feature Extraction: Collected data from selected sensing systems is pre-processed and analyze by AI/ML algorithms and signal/image/video processing techniques to extract engineering features.
3. Integration with Cloud-Based Platforms: Aims at centralizing data and analysis results on cloud platforms for accessible real-time monitoring data, especially in relation to smartphone sensing technology.
4. Implementation of SHM and SRA Tasks: Using measured data or extracted features, different generative, discriminative, predictive ML models as well as computational models are developed to perform SHM and SRA tasks on civil infratuctures with the emphasis on addressing challenges related to climate changing, disaster assessment, intelligent inspection, etc.
5. Development of Smartphone Apps and Web Interfaces: The final step is creating applications to make SHM findings easily available, supporting maintenance and disaster prevention.

Impact and Benefits: This project enhances Structural Health Monitoring and Structural Resilience Assessment by making these crucial processes more accessible, efficient, and cost-effective. Utilizing advanced sensing systems and AI/ML algorithms, it addresses climate change challenges and other critical issues facing civil infrastructures. Our solutions aim to ensure the durability, resilience, and sustainability of European infrastructures, thereby safeguarding public safety and economic stability, and providing a forward-looking approach to managing infrastructural challenges in the face of global changes.

Conclusion: This project introduces innovative approaches to address the vital task of preserving infrastructure integrity. By integrating dual sensing systems, AI/ML algorithms, and cloud computing, it lays the foundation for advanced Structural Health Monitoring and Structural Resilience Assessment methodologies in the context of climate change.