

Application of Artificial Intelligence to Advanced Non-Destructive Testing in Civil Structural Engineering

1. Context and state of the art:

The safety and durability of civil infrastructure are major challenges in the context of rapid urbanization and the increasing complexity of civil engineering projects. The assurance of structural integrity is therefore essential to prevent failures, plan maintenance operations, and extend the service life of structures. Traditional inspection methods, although accurate, are often destructive or intrusive, potentially compromising the stability of the inspected structures.

Non-Destructive Testing (NDT) techniques have emerged as essential solutions, enabling the detection of internal defects (such as cracks, corrosion, and delamination) without damaging the materials. However, conventional NDT methods present significant limitations: subjective interpretation, reliance on operator experience, difficulties in analyzing multilayered structures or complex geometries, and time-consuming processing of large volumes of data.

With advances in artificial intelligence, new opportunities are emerging to make these tests smarter, more accurate, and more automated. AI can help address challenges related to signal analysis, automated defect classification, and predictive maintenance.

2. Methodologies and techniques used:

2.1 Main Objective:

Develop, implement, and validate an integrated approach combining NDT techniques and artificial intelligence algorithms to improve the detection, analysis, and monitoring of defects in complex infrastructures.

2.2 Sub-objectives:

- Automate the interpretation of data from various NDT techniques using AI algorithms (deep learning, signal processing,...).
- Design a decision support system for predictive maintenance based on real-time analysis and modeling of defect evolution.
- Demonstrate the effectiveness of the system on real-world case studies (bridges, tunnels, historic or industrial buildings).

2.3 Research methodology

State of the Art and Literature Review:

- Synthesis of NDT techniques used in civil engineering.
- Review of AI approaches applied to pattern recognition, NDT image segmentation, and signal processing.

Data Collection and Annotation:

- Construction of a multi-source dataset from processed NDT data



- Creation of a reference database of typical defects annotated for supervised learning.

AI Model Development:

- Development of adequate AI models to process, analyze, and predict the condition of the structure

Experimental Validation:

- Testing on representative structures in laboratory settings and real sites.
- Comparison with traditional methods in terms of sensitivity, accuracy, and processing time.
- Implementation of an intelligent NDT diagnostic system prototype.
- User interface, defect visualization, and automatic report generation.

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4. Study Duration and Starting Date:

This Ph.D. thesis is for a period of 3 years starting in October 2025. The Ph.D. student will have access to numerical and experimental resources to carry out his/her Ph.D.

5. Funding:

This Ph.D. thesis will be funded by Advanced Construction Technology Services ACTS.

6. Candidate profile:

The ideal candidate holds a research master's degree in civil engineering with a strong interest in interdisciplinary applications.

The candidate should demonstrate:

- A solid foundation in artificial intelligence and machine learning.
- Good knowledge of NDT techniques or a strong motivation to learn them.

7. Scientific valorisation and perspectives:

The results of this work will be the subject of participation in national/international conferences and/or scientific publications in international journals.