

Electromagnetic Detection and Identification of Concrete Cracking in Highway Bridges

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Abstract

Bridge structures, being critical to human life, we need a powerful method for continuous monitoring and maintenance to ensure their prolonged lifespan. Non-destructive testing (NDT) methods have become indispensable in civil engineering for assessing the integrity, quality, and durability of materials without causing damage to the structure. Ground penetrating radar (GPR) is one of the NDT methods that use operates on the principle of sending electromagnetic pulses into the ground to explore and image subsurface. In this research we are trying to solve the crucial task that is detecting and monitoring aging civil infrastructures in New England. Our approach involves utilizing visual information and subsurface images obtained through ground-penetrating radar (GPR) within a virtual reality (VR) environment for enhanced data visualization. Additionally, we employ machine learning (ML) techniques for the interpretation of the gathered data to obtain a pattern of material degradation. For our case study, we have focused on a reinforced concrete (RC) highway bridge (I-495, Chelmsford, MA), selecting it as a representative infrastructure component for high-frequency nondestructive testing (NDT) inspection. we used GPR to scan bridge columns to collect data for our investigation. The application of GPR in this context is aimed at providing valuable insights into the condition of subsurface materials and understanding of the aging mechanisms and structural integrity of the chosen bridge.

Our findings suggest that GPR B-scan images of reinforced concrete bridge piers can be influenced by environmental conditions, such as temperature and moisture. Despite these influences, the study concludes that GPR proves to be a viable NDT method for effectively monitoring the condition of subsurface steel rebars, particularly in the context of corrosion monitoring.

Keywords: GPR, NDT, corrosion, machine learning, virtual reality, material degradation

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Introduction

The problem we are trying to solve is the detection and monitoring of aging civil infrastructure components and systems in New England by using visual information and subsurface images in a virtual reality (VR) environment for data visualization and machine learning (ML) for nondestructive testing (NDT) data interpretation. Material aging and structural deterioration of selected candidate structures (e.g., highway bridges) will be frequently (from twice a day to once a week) inspected to develop large amount of sensor data for condition assessment using machine learning.

Objectives

- Condition assessment of high-frequency NDT data using ML and artificial intelligence (AI)
- Correlation between high-frequency NDT data (e.g., Ground Penetrating Radar (GPR) B-scan images) and material aging and structural deterioration
- Development procedure of 3D bridge VR models and VR platform



Fig. 1: a) VR chamber with a desktop computer; b) Point cloud data (PCD) models of bridge components; c) GPR field data collection; d) and e) The RC column (E3) for sample collection; e) GPR mini LT.

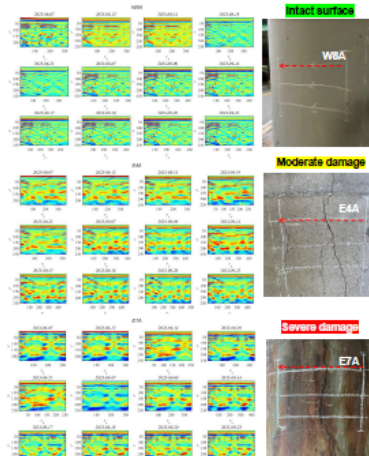


Fig. 2: GPR B-scan images of RC bridge pier WBA-E4A-E7A during 06/07/23 and 10/02/23.

Results

- Fig. 2 shows our high-frequency GPR B-scan images collected from a reinforced concrete (RC) bridge pier(WBA intact surface column, E4A moderately damaged column, E7A severely damaged column) of I-495 in Chelmsford, MA, during 06/07/23 and 10/02/23.

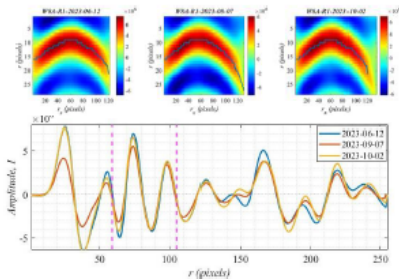


Fig. 2: Compare GPR A-scan of WBA in 3 different dates

Fig. 3 displays our A-scan plot collected from a reinforced concrete (RC) bridge pier (WBA) on different dates, illustrating the changes in rebar amplitude over this period.

Conclusion

- GPR B-scan images of RC bridge piers can be affected by environmental conditions (temperature, moisture).
- GPR can be used as a NDT method to evaluate the rebar condition (for corrosion).

Publications

- K. Raisi, N.N. Khun, and T. Yu (2022), SPIE, DOI: [10.1117/12.2613083](https://doi.org/10.1117/12.2613083)
- K. Raisi, R. Batchu, and T. Yu (2023), SPIE, DOI: [10.1117/12.2657731](https://doi.org/10.1117/12.2657731)
- R. Batchu, K. Raisi, and T. Yu (2023), SPIE, DOI: [10.1117/12.2658173](https://doi.org/10.1117/12.2658173)
- T. Yu, K. Raisi, and R. Batchu (2023), SPIE, DOI: [10.1117/12.2657741](https://doi.org/10.1117/12.2657741)
- N.N. Kulkarni, K. Raisi, N.A. Valente, J. Benoit, T. Yu, and A. Sabato, (2023), AIC, DOI: [10.1016/104784](https://doi.org/10.1016/104784)

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