PHYSICS-INFORMED MACHINE LEARNING FOR EM WAVE PROPAGATION AND MATERIAL PROPERTY ESTIMATION

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ABSTRACT

Material property estimation through sensors that employ acoustic and electromagnetic (EM) wave propagation is widely performed for the non-destructive evaluation of infrastructure. Methods like waveform inversion, model-updating, or data-driven ML methods are often used to estimate material properties from observed sensor data. However, data-driven methods require large amounts of training data, and model updating requires performing hundreds or thousands of simulations that are computationally expensive. To mitigate these difficulties, physics-informed machine learning (PIML) can be used as a surrogate model that can work effectively with minimal training data. PIML integrates machine learning techniques with governing physical equations of the problem to create models that can learn from limited data and generalize better by satisfying the underlying physics. In this presentation, we will demonstrate how PIML can solve EM wave propagation that is governed by Maxwell's equations. We will also present the estimation of material properties (e.g., dielectric permittivity) by performing wave-inversion through PIML. The estimated material properties can be used for applications including concrete structure health monitoring, soil moisture estimation, and wildfire risk assessment.

REFERENCES

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