Research Topics

Shayan Dodge

Computational & Applied Electromagnetics

- Multiphysics modelling
- Numerical EM solvers (FDTD, FEM, BEM)
- Lightning and power-system electromagnetic phenomena

AI for Electromagnetics

- Physics-informed neural networks (PINNs)
- ML-based inverse modeling
- Neural operators (DeepONet)

Bioelectromagnetics

- Transcranial magnetic stimulation (TMS)
- Specific Absorption Rate (SAR) estimation in biological tissues
- Medical Imaging (MRI, Electrical Impedance Tomography)

ORCID Profile

Forecasting Lightning Effects in Electrical Systems (FELINES)

Scan for the FELINES GitHub repository

Goal

- Use electromagnetic signals from early lightning inception (PBP) to predict dangerous return strokes (RS) and enable preventive protection of electrical infrastructures.

Approach

- Detection and analysis of Preliminary Breakdown Pulses (PBP)
- Electromagnetic field and coupling simulations
- Machine learning models for RS danger classification

Applications

- Power system protection
- Lightning detection and forecasting
- Smart grid monitoring and resilience
- Early warning systems for electrical infrastructures

DESTEC

DESTEC - Department of Energy, System, Territory and Construction Engineering -
University of Pisa

Physics-Informed Neural Networks for Electromagnetic Problems

Motivation

- Classical EM solvers (FEM, FDTD, BEM) can be computationally intensive for complex or inverse problems. PINNs offer a physics-informed AI alternative that learns solutions directly from governing equations.

My Research Contributions

- Development of PINN formulations for electromagnetic PDEs
- Weak-form PINN methods for improved numerical stability
- Adaptive residual PINN (STAR-PINN) for time-domain magnetic diffusion
- Hybrid Boundary Element–PINN Method for Electromagnetic Analysis

Applications

- Electromagnetic field simulation
- Inverse electromagnetic problems

AI-Based Optimization of Transcranial Magnetic Stimulation

Goal

- Develop a data-driven method to determine the optimal TMS coil position and stimulation intensity for targeted brain stimulation.

Approach

- MRI-based personalized brain models
- Electromagnetic simulations (FEM) of induced electric fields
- Model Order Reduction (MOR) for fast computations
- Deep learning models (VAE + CNN) for inverse prediction of coil position

Applications

- Personalized transcranial magnetic stimulation (TMS) therapy
- Optimization of brain stimulation protocols
- Treatment planning for neurological and psychiatric disorders
- Advanced bioelectromagnetic modeling