Chair of Computational Modeling and Simulation
TUM School of Engineering and Design
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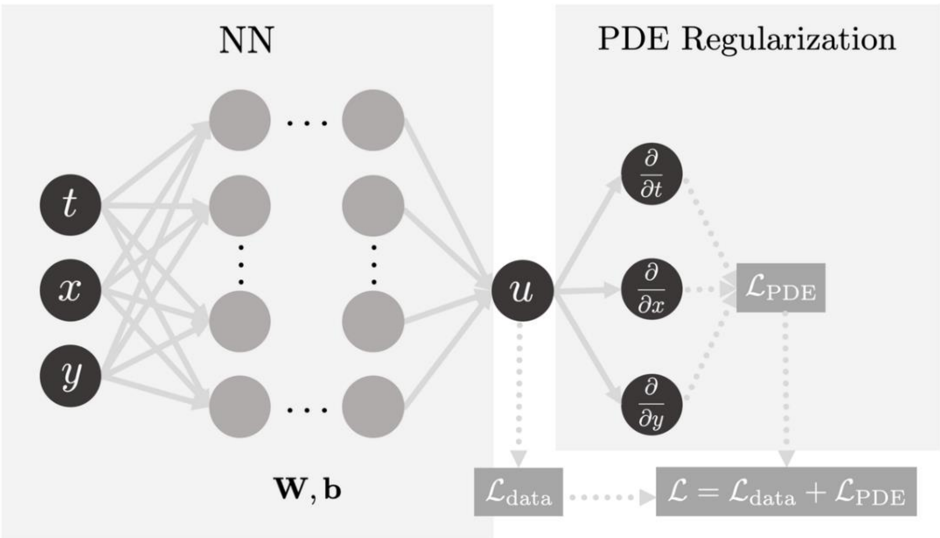
Modeling:
Mathematics:
Programming:
Science:

Software Lab:

Physics informed Neural networks for solving the wave equation

Description

The wave equation is a fundamental partial differential equation (PDE) used to model phenomena such as seismic wave propagation, acoustic waves, and vibrations in structures. Traditional numerical methods like finite difference or finite element methods can become computationally expensive for simulations with high degrees of freedom or complex geometries. This project leverages the concept of Physics-Informed Neural Networks (PINNs) (Raissi et al., 2019; Rasht-Behesht et al., 2022), which integrate the governing physics equations directly into the loss function of a neural network. The network is trained to approximate the solution to the wave equation while respecting the underlying physics, reducing the reliance on large datasets and computational resources. There has been a great deal of work on PINNs in the recent years(Cuomo et al., 2022) but none have been able to solve the wave equation for high frequency. Therefore, this study would focus on investigating methods and algorithms to mitigate this behaviour.



Objectives:

- Understand the theoretical foundation of PINNs and their advantages over traditional numerical methods
- Implement a PINN framework in Python to solve 1D/2D wave equations
- Analyze the effect of various network architectures and hyperparameters on solution accuracy
- Study the convergence properties with respect to increasing frequency of excitation

Supervisor

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References

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Raissi, M., Perdikaris, P., & Karniadakis, G. E. (2019). Physics-informed neural networks: A deep learning framework for solving forward and inverse problems involving nonlinear partial differential equations. *Journal of Computational Physics*, *378*, 686–707. https://doi.org/10.1016/J.JCP.2018.10.045

Rasht-Behesht, M., Huber, C., Shukla, K., & Karniadakis, G. E. (2022). Physics-Informed Neural Networks (PINNs) for Wave Propagation and Full Waveform Inversions. *Journal of Geophysical Research: Solid Earth*, *127*(5), e2021JB023120. https://doi.org/10.1029/2021JB023120