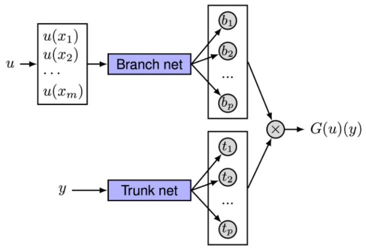
Lehrstuhl für Akustik mobiler Systeme
Department of Engineering Physics and Computation
Technische Universität München

Master-Thesis

Invertible Neural Operators for Generative Design of Acoustic Metamaterials

Topic



Acoustic metamaterials enable unprecedented control over sound propagation through engineered subwavelength structures. Their performance strongly depends on complex geometrical configurations, making the design process computationally expensive when relying solely on conventional numerical simulations such as finite element methods. Recent advances in machine learning, particularly neural operators, offer a promising alternative by learning mappings between physical fields and design parameters. Invertible neural operators extend this concept by enabling bidirectional mappings between metamaterial geometries and their acoustic responses, opening the door to generative design approaches where new metamaterial structures can be automatically synthesized to achieve desired acoustic properties. The objective of this thesis is to investigate the use of invertible neural operators for the generative design of acoustic metamaterials. A machine-learning-based framework will be developed to learn the relationship between metamaterial geometries and their acoustic response. The trained model will then be used to generate candidate designs that achieve specified acoustic objectives. The performance of the approach will be evaluated using numerical simulations and compared with conventional design strategies.

Tasks

- Literature review on acoustic metamaterials, neural operators, and generative design methods.
- Study of machine learning approaches for physics-based modeling of wave propagation.
- Develop and implement invertible neural operator architectures.
- Train models to learn mappings between geometry and acoustic response.
- Investigate inverse design capabilities for generating new metamaterial configurations.
- Validate generated designs using numerical simulations (e.g., FEM).

Requirements

- Background in engineering, physics, applied mathematics, computer science, or a related field.
- Strong knowledge of machine learning and deep learning methods.
- Interest in acoustics, metamaterials, and physics-informed modeling.
- Programming experience in Python and familiarity with machine learning frameworks (e.g., PyTorch or TensorFlow).
- Knowledge of inverse problems, generative models, or operator learning is highly desirable.
- Basic understanding of numerical methods or wave propagation is beneficial.

Contact

Technische Universität München
Lehrstuhl für Akustik mobiler Systeme
Mert Dogu, M. Sc.
Boltzmannstraße 15, 85748 Garching b. München
Tel. +49 (89) 289 - 55134
mert.dogu@tum.de
https://www.epc.ed.tum.de/vib/mitarbeiterinnen-und-mitarbeiter/