Master thesis project: Deep learning for the design of optomechanical crystal nanocavities

Background

Recently, approaches for the design and optimization of photonic crystals based on deep learning have been successfully demonstrated to yield an advantage over conventional design methods [1]. A photonic crystal is a dielectric nanostructure pattern with a periodic array of holes. The periodic patterning of the material leads to the formation of band gaps for photons and allows to confine them in optical nanocavities with mode volumes on the order of the photon wavelength. Strong confinement of photons is a key necessity to enable strong light-matter interactions with mechanical excitations of the material – so-called optomechanical interactions. Strong optomechanical interaction requires the optomechanical cavity parameters to be carefully optimized [2]. Conventionally, this is achieved by iterative variation and optimization of the cavity parameters assisted by finite-element simulations (such as COMSOL).

Project description

Based on recent approaches for the design of photonic crystal cavities [1], the aim of this project is the implementation of a deep learning algorithm for the design of optomechanical crystals such as silicon nanobeams (see Fig. 1). The student will generate training data using existing code for finite-element simulations of silicon nanobeams. The training data will be used to train a deep neural network to recognize optomechanical parameters of the designed structures based on the hole positions and sizes. The trained network can be used to optimize the design parameters based on an iterative algorithm.

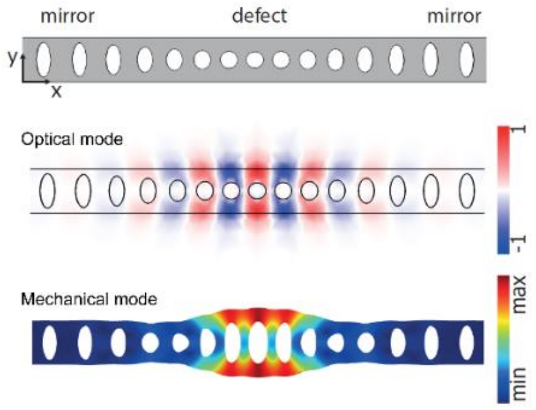

Figure 1 Nanobeam optomechanical crystal cavities [3].

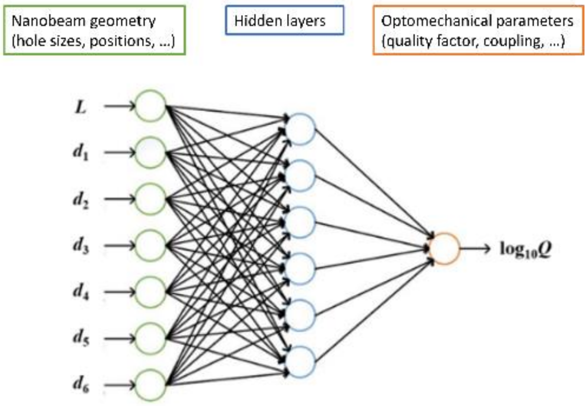

Figure 2 Schematic of a neural network for estimating optomechanical parameters.

Learning experience

- Finite-element simulations of optomechanical crystal cavities (based on COMSOL)
- Training and evaluating the performance deep neural networks
- Development of optimizing algorithms based on deep learning
- Characterization of optomechanical properties of the designed structures in the lab

References

[1] Asano, Takashi, and Susumu Noda. "Optimization of photonic crystal nanocavities based on deep learning." Optics express 26.25 (2018): 32704-32717.
[2] Chan, Jasper. PhD thesis, California Institute of Technology (2012).
[3] Wallucks, Andreas. PhD thesis, TU Delft (2020).

Interested?

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