Deep Learning-based design of nano-photonics structures (Ramot)

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TAU Researchers have developed a unique deep-learning algorithm that can predict the spectral response of nanostructures with high accuracy as well as provide a single nanostructure's design, geometry and dimension, for a targeted or measured optical response.

Nano-optics and Nano-photonics aim to do what is unachievable with standard linear optics, which is to go beyond the diffraction limit and manage to image and characterize substances using sub-wavelengths resolution.
The modeling of the interaction of light with nanostructures is a complex task yet is crucial for both the optical characterization of such structures as well as the on-demand design of their optical properties.

There is therefore a need for a tool which can streamline the process and provide a unique, robust, time-efficient and accurate design and characterization capability for complex nanostructures based on their measured optical response. Current optimization techniques such as shallow neural networks, evolutionary algorithms and linear regression cannot handle efficiently this unique challenge - hence requiring many cycles of trial and error of modeling and characterization to predict or design a nanostructure for a desired or measured optical spectral response.

Applications:

- AI on chip, edge device implementations for Healthcare, IOT and Industry 4.0.
- A high-end design SW for nanostructure - Replacing costly finite element analysis simulators.
- SaaS model to support suggested applications - having a large & growing DB of nanostructure geometry design, and validated spectra.
- Sensing and Imaging application using higher than diffraction limit nano-optics.
- High-resolution spectroscopy for material characterization.
- Auto. adjustable nanostructure geometry for Lab-On-Chip applications (Ex: Mini-spectrometer).
- Plasmon-mediated cancer chemotherapy.

Advantages:

- A high accuracy, low-cost, and computationally fast method for estimating both nanostructure geometry from desired spectral properties, and spectrum from a given geometry, for high-resolution sensing, imaging and material characterization applications.
- The developed DNN architecture is anti-specialized; Allowing transference of knowledge between problems - hence increasing accuracy performance.
- "Breaking" current paradigm of design -> simulate -> manufacture -> verify/test iterations, as the DNNs with a large enough database manage to capture the complex non-linear relations between geometry and spectra.
- Reduces the cycles and cost for nanostructure manufacturing, hence reducing entry barrier for smaller startups and groups - greater competition and rapid innovation - offering better cheaper applications.
- Scanning electron microscope (SEM) can be used only for final validation if at all.

Patents:

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Related Publications:
Plasmon spectroscopy Theoretical and numerical calculations, and optimization techniques
Rodr�uez-Oliveros R, Paniagua-Dom�guez R, S�chez-Gil JA, Mac�s D. Nanospectroscopy. 2014;1(1).
https://www.degruyter.com/view/j/nansp.2014.1.issue-1/nansp-2015-0006/nansp-2015-0006.pdf

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