Sujet de thèse

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Titre : Inverse design for new functional electromagnetic devices with artificial intelligence schemes

Description :
There is a growing need of finding electromagnetic materials with specified functionalities. The idea is not only to derive materials which will correctly fulfill the predefined objectives but to provide solutions which will exceed the engineers expectations, e.g., more efficient at converting sunlight to electricity in photovoltaic cells, enhanced photonic circuits with reduced losses [1], refined anti-reflection coatings [2], antennas with improved quality factors [3] …

In order to discover non-intuitive solutions, one way is to recast these problems as an inverse electromagnetic design problem. The optimal shapes of the electromagnetic devices, such as the antennas, surface textures, gratings, anti-reflection coatings structures, will correspond to the outputs of the considered optimization problem.

Because of the high computational cost associated to Maxwell's equations, these optimization methods are generally applied to relatively simple geometries, with parametric descriptive features. Indeed, heuristic methods such as genetic optimization or particle swarm optimization repeatedly modify a population of individual solutions in order to find a satisfactory one. When non-parametric or freeform shapes are sought, shape optimization approaches seem to be more appropriate [4]. It appears that the underlying algorithms are similar to the ones developed for solving inverse problems [5], which arise in imaging and non-destructive applications. Deep learning schemes for inverse design have made also recent progress [6] paving the ways toward new schemes and innovative technological solutions.

The goal of this thesis is thus to take advantage of the various inversion algorithms developed at Institut Fresnel [7][8], the growing interest in machine learning approaches [9], to derive new multifunctional elements for microwave and optical devices [10] [11].

Keywords — Optimization techniques – Deep learning – Photonics – Electromagnetism

Pre-requisites — The applicant must be highly motivated student, with a Master degree (acquired in applied mathematics, numerical analysis, electrical or telecommunication engineering, optics and photonics, for example). He must have good skills in applied mathematics, computer science and possibly signal processing. Extra knowledge in electromagnetics and/or photonics will be appreciated. The applicant should also be willing to carry out strong numerical developments.

Bibliography:

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