LABORATOIRE HUBERT CURIEN
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Prediction of multidimensional colors printed by laser on plasmonic metamaterials using deep learning and adaptive strategies

Laser processing is a flexible and cost-effective tool that recently opened new perspectives of applications in industry. Implemented on plasmonic metasurfaces, it produces very singular colors that can be tuned independently in different modes of observation. Laser-induced plasmonic colors thus enable printing multiplexed images, which have great promise in security printing and data storage[1,2]. However, the latter require very good accuracy in color printing. And, laser induced colors strongly depend on the initial state of the material. Predicting the full gamut of colors that can be observed in different modes of observation on plasmonic metasurfaces processed by a large set of laser processing parameters, when the initial state of these metasurfaces can vary from one batch to another, appears then as a crucial step for industrial implementation. As physical models are missing for such predictions, other approaches must be found.

Deep learning represents one of the most powerful family of models in machine learning when one has to make some predictions from data having some local structure such as images or surfaces. In this thesis, the objective is to provide some appropriate architectures accompanied with relevant objective functions to correctly train these architectures for accurate prediction of the laser printed colors[3]. A first challenge is to take into account physical properties of the materials and the laser processing parameters in the model. Then, another goal is to improve the robustness of the model by adapting existing adversarial robustness methods existing in image classification to laser printed colors[4]. Finally, the third aspect tackled in this project is to develop models for being able to automatically adapt the learned models to slightly different initial metasurfaces by means of transfer learning/domain adaptation strategies. This last objective intends to offer a certain tolerance to unwanted variations in the initial metasurface elaboration while maintaining a very good accuracy on the prediction of the laser printed colors.

References

(1) N. Destouches, et al. "Laser-empowered metasurfaces for white light image multiplexing", Adv. Func. Mater., 31, 2010430 (2021)
(2) N. Dalloz, et al. "Anti-counterfeiting white light printed image multiplexing by fast nanosecond laser processing", Adv. Mater., 34, 2104054 (2021)
(3) M. Raissi. “Deep hidden physics models: Deep learning of nonlinear partial differential equations”, Journal of Machine Learning Research, 19(25):1–24, 2018.
(4) A. Shafahi, et al. “Adversarially robust transfer learning”, in International Conference on Learning Representations (ICLR), 2020.

Expected candidate profile

- Very good knowledge and experience in machine learning and deep learning
- Background in color science and image processing
- Some knowledge in photonics and eager to expand his/her experimental skills in this field
- Open-minded, curious and interested in working with both computer scientists and physicists
- Ability to take initiatives and work in autonomy

Funding: 3-year Public funding

Application deadline: May 1st, 2022

Start date of the proposed thesis: October 1st, 2022

Place:

- Laboratoire Hubert Curien UMR CNRS 5516, 18 Rue du professeur Benoit Lauras, 42 000 SAINT-ETIENNE, France

Application

Applications must be sent to both contact email addresses as soon as possible and before May 1st, 2022. Application can be written in French or English.

All applications must contain:

- **a CV, with a possible list of publications and conferences, and the CEFR level in English (except if university courses were taught in English)**
- **a short motivation letter explaining why you should be successful in this research work**
- **Bachelor degree and transcripts**
- **Master transcripts (at least semester 1 and 2. Semester 3 if available)**
- **An example of project that you have carried out in deep learning**
- **References of academics to be contacted (or recommendation letters).**

All applicants will be contacted within 8 days of receiving their application.

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