Laboratoire Hubert Curien UMR • CNRS • 5516 • Saint-Étienne — 50 years 1976-2026

Post-doctoral job offer

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Optimal color selection algorithms for multiplexed image inscription

Context

For the past ten years, Toppan Security and the Hubert Curien Laboratory (LabHC) have collaborated to develop customized visual security features for identity documents. Over the last five years, they have developed a unique technology called laser-induced printed image multiplexing. This technology encodes a multiplexed image using a laser in a plasmonic quasi-random metasurface, revealing multiple independent images in specific observation modes. These images are completely entangled, so falsifying one image would alter the others in a noticeable way. The development of this technology has resulted in three patents [1-3] and to the publication of innovative scientific papers in selective journals [4-6]. Three Hubert Curien Laboratory teams were involved in this development: Functional Surfaces and Materials, Image Science and Computer Vision, and Machine Learning. This demonstrates the interdisciplinary nature of the work.

Toppan Security and the LabHC are offering a one-year post-doctoral position renewable for an additional year to continue developing and optimizing this promising technology. **We are seeking a postdoctoral researcher with a strong background in computational and algorithmic methods applied to physical systems**. The successful candidate will contribute primarily to the development and improvement of image multiplexing algorithms by working with experimentally acquired color images of laser-processed nanostructured films. Close interaction with the experimental team is required to ensure the relevance, robustness, and validation of the proposed computational approaches.

Objectives

Currently, there are no physical models that can predict laser-induced colors in different observation modes. Thus, laser-induced printed image multiplexing requires the creation of large experimental databases linking each set of laser parameters to the produced color in each mode. It also requires specific algorithms to identify the laser parameter sets that are adapted to multiplexing. Over the past five years, LabHC has developed and implemented several algorithms to search for laser parameters that create the color combinations required for image multiplexing in experimental databases. One algorithm is dedicated to multiplexing binary (two-color) images in two or three modes with a simple yet effective iterative algorithm. An example of multiplexing with this algorithm is shown in Fig. 1: four sets of laser parameters are selected to display two binary images in the different modes. Clustering nanostructures that display the same color in at least one mode reduces the combinatorial complexity of the multiplexing problem. This makes it easier to find the correct laser parameter sets in databases containing thousands of nanostructures. A second algorithm uses concepts from graph theory to answer the questions “How many images can we multiplex using these metasurfaces?” and “How many colors can these images have?”. After clustering, constructing a graph representation of our metasurface databases allows us to answer these questions.

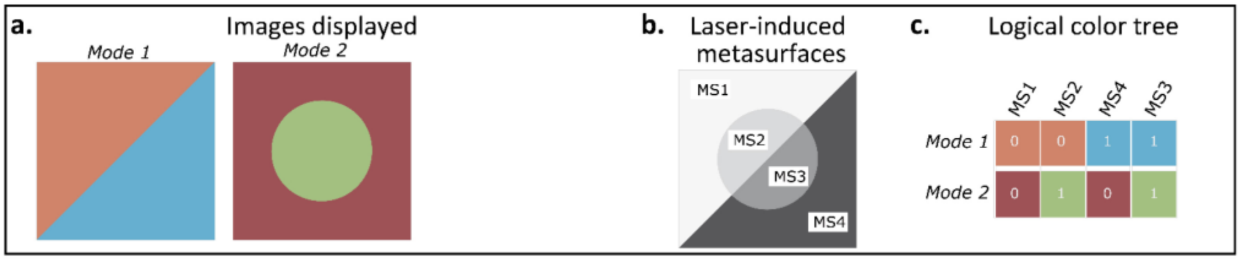

Figure 1: Principle of image multiplexing for 2 modes (a) 2 bicolor images to be displayed in mode 1 and 2. (b) 4 laser-induced metasurfaces (MS) are needed to multiplex the two images. (c) The colors of the 4 metasurfaces in modes 1 and 2 form a logical color tree with 2 modes and 2 colors per mode [5].

A third algorithm called continuous multiplexing algorithm generalizes the vector error diffusion model, which is used to print half-toned color images, to the multi-mode colors produced by our technology. This model is very promising because it allows for the multiplexing of full-color images. However, there is still room to improve the computational geometry problem in six-dimensional (or more) color databases.

The primary objective of this postdoctoral position is to enhance the methods employed for selecting laser parameters with a particular focus on the continuous multiplexing algorithm. The main step of this algorithm is restricting the full set of colors to the multiplexing solution, which is the set in which all possible color combinations in the different observation modes are possible. Currently, this is done by searching for the largest box that can be enclosed in the convex hull of the database. However, this box is not the optimal solution, so the first objective of the postdoc will be to automatically select the optimal polyhedron.

A second objective is to incorporate the properties of images to print into the algorithms. Constructing an imperfect multiplexing solution that better corresponds to the actual images could improve the color reproduction fidelity. Experimental work will be conducted to test the proposed modifications to our methods. They will consist of inscribing and characterizing the multiplexed images.

Desired profile:

- PhD in one of these fields: applied mathematics, applied physics, computational color science, or data science, **with a demonstrated interest in applying computational methods to physical or experimental systems**.
- Strong experience in **scientific programming** with **Python, including developing algorithms and numerical methods**.
- Proven experience in **two or more of the following areas: multi-objective optimization, image processing, computational geometry** (convex hulls, optimization in high-dimensional spaces)**, data-driven approaches** applied to physical systems, **ability to work with experimental datasets** (including imperfect, limited, or noisy data) and to develop methods adapted to such constraints.
- Solid analytical skills and the ability to **translate physical constraints and objectives into computational or algorithmic formulations**.
- Basic familiarity with **optics, photonics, or color science**, or the demonstrated ability and motivation to rapidly acquire the necessary domain knowledge.
- Strong motivation for **interdisciplinary research** combining physics, algorithms, and applications.

- Good communication skills, and the ability to clearly document code, algorithms, and experimental results.
- Capacity to work in close collaboration with academic researchers from different disciplines and an **industrial partner**.
- Proactive attitude, creativity, and interest in exploring non-standard solutions.

Duration and location:

One-year, with the possibility to renew for an additional year, at Hubert Curien Laboratory in Saint-Étienne, France, in close collaboration with Toppan Security.

The post-doctoral position can begin between March and October 2026.

References

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6. N. Destouches, N. Sharma, M. Vangheluwe, N. Dalloz, F. Vocanson, M. Bugnet, M. Hébert, J. Siegel , "Laser-empowered metasurfaces for white light image multiplexing", Adv. Func. Mater., 31, 2010430 (2021)

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