Light Propagation in Complex Media: From Imaging, to Compressive Imaging and Machine Learning

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Scattering of light in heterogeneous media, for instance the skin or a glass of milk, is usually considered an inevitable perturbation or even a nuisance. Through repeated scattering and interferences, this phenomenon seemingly destroys both the spatial and the phase information of any laser illumination. At the spatial level, it gives rise to the well-known “speckle” interference patterns. At the temporal (or spectral) level, a short pulse entering a scattering medium will see its length greatly extended due to the multiplicity of possible path length light can take before exiting the medium. From an operative point of view, scattering greatly limits the possibility to image or manipulate an object with light through or in a scattering medium.

Multiple scattering is a highly complex but nonetheless deterministic process: it is therefore reversible. Speckle is coherent, and can be coherently controlled. By « shaping » or « adapting » the incident light, it is in principle possible to control the propagation and overcome the scattering process. Adressing this challenge is now made possible thanks in particular to unique tools: spatial light modulators (SLMs), able to digitally encode information on light beams, for display of for wavefront control [1]. This has allowed a revolution in imaging [4,5], by allowing focusing light and recovering images at depth in scattering media where all light has been multiply scattered.

I will present our recent work in the domain, with a particular emphasis on our recent experiments, results of a collaboration with signal processing and algorithms experts. We have explored how signal processing, within the recent framework of compressive sensing, can improve imaging using the natural randomness of complex media [2]. More recently, we realized that complex media can be exploited to perform optically a wide range of machine learning tasks. I will present some first proof of principle experiment in image classification [3].

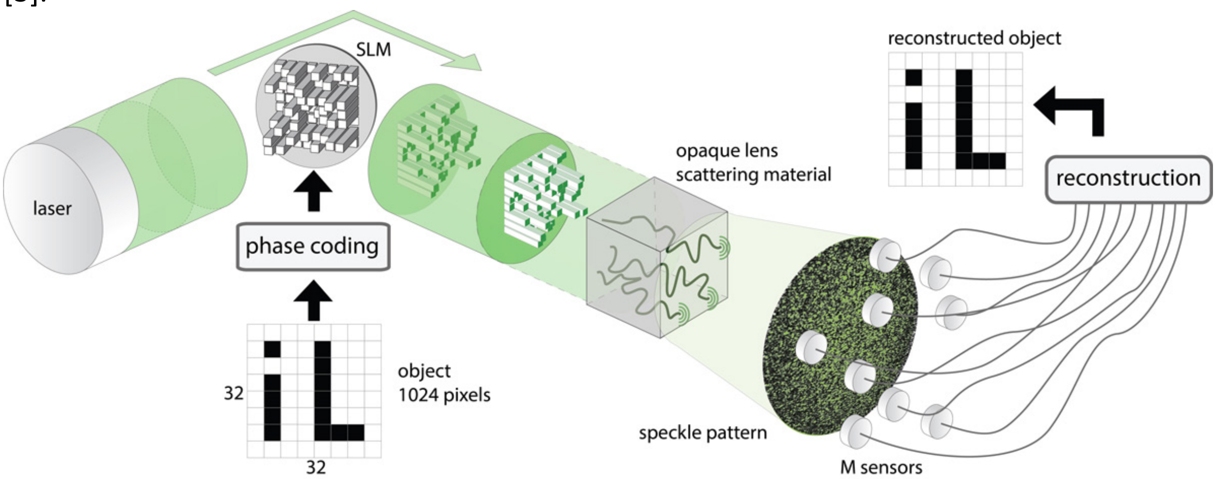

Figure 1:principle of compressive imaging through a scattering medium (from [2])

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