

THESIS TOPICS: 2026-2027

Title: Implementing a spatially multiplexed photonic matrix-vector multiplier

Description:

Matrix-vector multiplication (MVM) is a basic mathematical operation that is at the heart of many modern computational systems. These operations are carried out in great quantity in training and inference in deep-neural networks, but also in solving optimization problems. Although many different digital systems can be used for this purpose, the most performant approach nowadays is to implement this on dedicated GPUs (graphical processing units). Still, these systems are limited in speed and are power hungry. Therefore, there is a considerable interest to explore and benchmark alternative approaches to perform these MVM operations. Photonics has long been proposed as such a viable alternative owing to its possible advantages in speed, energy efficiency and multiplexing.

In this master thesis project, the goal is to implement and test a photonic MVM system that makes use of spatial light modulators (SLMs) to perform the multiplication operation, while the summation that is part of the MVM is effectively performed by intensity measurements with a CCD camera. A schematic of this setup is given in the image below. Starting from a uniform laser/LED beam, the input vector will be encoded onto the beam's spatial intensity profile using e.g. a first SLM. The second SLM then modulates the intensity of each pixel by setting up the SLM as intensity modulator. Next, the light beam passes through a cylindrical lens such that different pixels are imaged onto the same region of the CCD camera, which will then measure the sum of the different pixels' intensity. During this project, you will develop, build, and test the system in the lab. Of particular importance will be to benchmark the speed but also the total energy consumption of the computation per basic multiply-accumulate operation.

The work will be mainly experimental.

Link to current research project: aphy.research.vub.be/eos-project

Location: VUB - Etterbeek

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Promotor 2

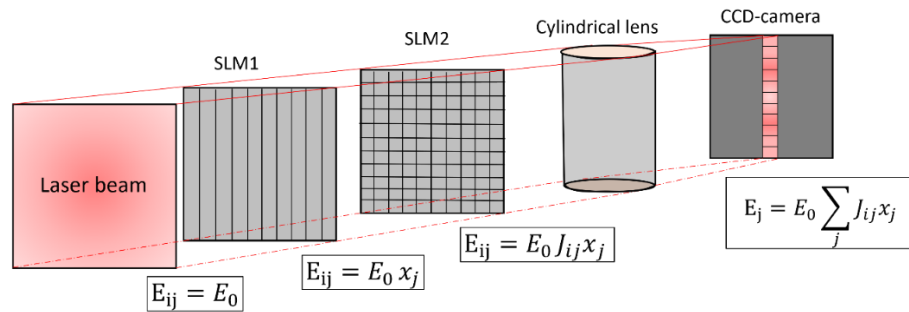
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Schematic illustration of how an MVM can be implemented using free-space optics. A coherent laser beam with amplitude E_0 (red square) travels through two SLMs (SLM1 and SLM2), where it picks up two additional amplitude contributions. The exact value of these contributions depends on the spatial position on the SLMs.