Master project: Reconfigurable optical neural network

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This project aims at realizing and testing a reconfigurable optical neural network. Coupling between individual network nodes is realized by spatial light modulators (SLMs), while an optical non-linearity is realized in form of a Cesium vapor cell representing a saturable absorber. Using computer controlled feed forward optical deep neural networks will be realized and applied, e.g. to image recognition.

Classical digital computer architectures are visibly approaching their technological and physical limits. Thus, there is a growing interest in developing post-digital computing approaches to overcome these limitations. Besides quantum computers, approaches that emulate neuromorphic processes represent a very promising alternative because they mimic the massively parallel, energy-efficient computations carried out by the human brain. Such computations constitute the building blocks of the pattern recognition algorithms underpinning the success of machine learning and artificial intelligence (AI). Optically integrated systems promise 2–3 orders of magnitude higher energy efficiency compared to today's electronic approaches.

We will realize machine learning with optical neural networks (Fig. 1), in a free-space bulk optics approach. That is, we want to use light to power machine learning. The starting point is the realization of a reconfigurable neural network in a tabletop free-space optical experiment. To this end, the methodology from modern optics is applied. Spatial light modulars (SLMs) are used to realize linear mappings between an input and output data (e.g. images). In addition, an atomic Cesium vapor severs as optical non-linearity. In combination of these, optical neural networks (ONN) will be realized. The performance of the realized ONN will be first demonstrated on data classification, i.e. image recognition. Building on the gathered knowledge, a strategy for all-optical multilayer neural networks shall be developed.

This challenging interdisciplinary project requires a highly motivated student with background in optical physics, as well as with affinity to computer science.

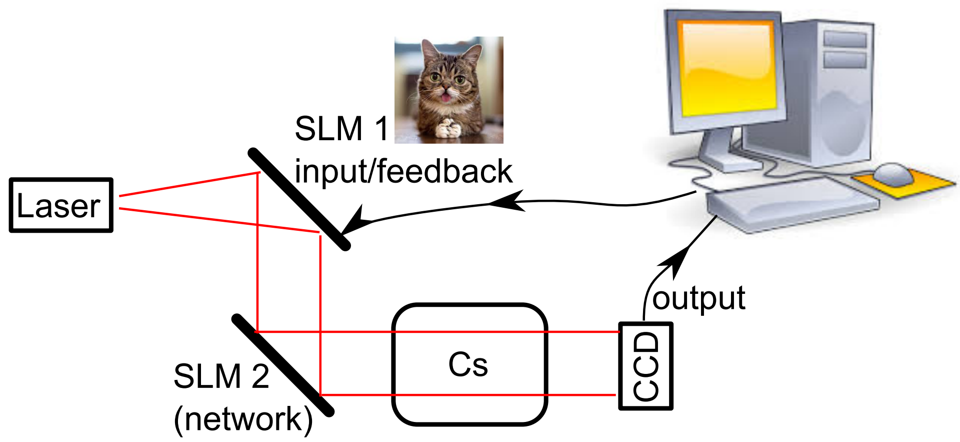

Fig. 1: Idea of the experiment that will be realized. A first spatial light modulator (SLM 1) is used to encode data (e.g. an image) onto a laser beam. A second SLM 2 realizes a linear transformation of the input data. By sending the transformed data through a saturable absorber (Cs atoms) a non-linear function is realized. The system's output is recorded by a CCD camera. Thereby a single layer neural network is realized. Multilayer networks for deep learning will be realized by feeding the recorded data back into thy system. The vapor cell is removed for the experiments in WP2.