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Analog Logic Gates of Structured Light based on nonlinear optical neural networks

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Artificial Intelligence (AI) has revolutionized many areas of information technology, such as data analysis, automation, predictive modeling, and decision-making processes. However, as we continue to generate and process an ever-growing tsunami of data, the global electricity consumption associated with these operations is becoming a significant concern. Photonics, the science of light generation, detection, and manipulation, offers a promising approach to augment or even replace traditional electronic architectures for AI. Photonic systems are renowned for their parallelism, high-dimensionality, and low-power consumption, making them ideal for handling the increasing demands of AI applications. They can help make AI faster, more efficient, and more sustainable, thereby addressing the pressing need for energy-efficient data processing. Despite these advantages, the mutual influence of AI and optics has so far been mainly confined to the realm of deep learning inference in computer vision, microscopy and other visual computing tasks. While these fields have seen significant advancements, there is a vast, unexplored potential for further integration of AI and optics.
This Master thesis aims to transcend the boundaries of existing optical architectures and propose a novel optical system for physical neural networks. The objective is to implement an analog all-optical system realizing logic operations. This will serve as the basis to advance the frontier of nonlinear structured light. The ultimate goal is to generate optical lifeforms capable of self-organization, evolution, complex interactions, and dynamic adaptation.

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