Title

IMPROVING IMAGING BY USING GENETIC ALGORITHMS TO FIND ARBITRARY PROFILES OF BESSEL BEAM LASER

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Abstract:

Adaptive optics is a process used to enhance the performance of an optical system by reducing the effect of wave front distortions using an active optic (deformable mirror or spatial light modulator SLM). One approach to achieving such an enhancement is the use of genetic algorithms to control the optimization of the active optics. Genetic algorithms are a type of optimization algorithms that grade potential solutions based on their fitness and ability to “survive” in a given environment. Their components can be categorized as: parents, reproduction, offspring, and selection. “Parents” in a genetic algorithm contain properties which are reproduced and passed to offspring who may or may not survive depending on how “fit” the offspring are for their environment. In the “reproduction” stage, parents’ genetic information is copied, mixed, and mutated. “Offspring” are the resulting entities whose properties are yielded by reproduction. “Selection” is the actions that decide which offspring is most suited for parenting. Evolution of the contending solution(s) occurs over many generations.

The goal of my project is to develop a genetic algorithm to control a spatial light modulator (SLM) used for shaping the profile of a laser beam. Naturally, the shape of a laser follows a Gaussian function. There is lots of interest to use Bessel-shaped beams instead of Gaussian beams to improve different devices or techniques (light-sheet microscopy, optical beam trapping, acoustic waves, etc). Here, our genetic algorithm will interface with a SLM to shape a laser, and the result of the shaping will be measured by a 2D camera. Our goal is to improve the Bessel beam by finding new (unknown) profiles, hence the use of a learning optimization method.

The first part of the project consists of developing the basic structure of the GA and testing with the transformation of Gaussian to Bessel which already has known solutions of SLM shape. Then, after the basic GA is written, it will be improved by changing the fitness function to make it optimize from one camera image to several (three to four) images taken at different planes. In this manner, the GA will optimize the laser in a volume instead of just optimizing in a 2D plane. The convergence and stability of the GA will then be investigated using optimization on several criteria (laser size, profile similarity between planes, maximum of secondary peaks on the camera) instead of a single criterion for optimization.