Multibeam Steering and Point-spread-function Optimization Using Deformable Mirrors with Genetic Algorithm

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Multiplexed beam optical microscopy allows for improved imaging capabilities compared to the conventional nonlinear laser scanning microscopy by providing an increased imaging frame rate, multiplexing pulsed beams with varying optical properties, and simultaneous imaging at different depth in live microscopy. For our home-built multiplexes two beam optical microscope, we used deformable mirrors to shape beam wavefronts and to steer each beam separately. A genetic algorithm was implemented to optimize point spread function of each beam and to overlap the beams with better precision than the diffraction limit. A multiparameter optimization criterion was defined for genetic algorithm that depended on the intensity and the distance between the two beams, which was used as the fitness measure of the deformable mirror shapes. Simultaneously, second harmonics generation microscopy images of ZnSe nanowires were captured by time demultiplexing signals from the two beams. The fitness parameters were calculated by obtaining the distance between the objects in the multiplexed images while accounting for their intensities. The genetic algorithm required about $\sim 10^3$ mirrors shapes to overlap the two images. The technique is useful for automating the overlapping process of multiplexed beams and is scalable to many beams.

Figure: ZnSe nanowires imaged with the reference beam (left) and the aligned secondary beam (middle), and the combined two images (right) showing the first image in red and the second in green color. Each row shows the images recorded at different times during genetic algorithm evolution. Initially, images are recorded with displaced beams (top). The nanowires are identifiable and shifted closer during the evolution process (middle row). Finally, the two images overlap, get sharper with higher intensity at the end of the process (bottom row).