University of Dayton
School of Engineering

Doctoral Defense
Friday, November 22, 2019
Fitz Hall 568 at 1:30 p.m.
All are welcome to attend.

Computational Phase Correction of a Partially Coherent Multi-Aperture System

Sarah Krug
University of Dayton

Adviser: David Rabb, Ph.D.

Abstract

Multi-aperture arrays can be used to reduce the size, weight, cost, and power of an imaging system. However, all of the apertures in an array need to be properly phased in order to create a synthesized image with the maximum possible resolution gain. Phase errors that obstruct aperture phasing can be caused by hardware misalignments or atmospheric turbulence. Remapping the aperture fields between the entrance and exit pupils of an imaging system can be used for piston, tip, and tilt corrections. Remapping the pupils separates the components of the spatial frequency spectrum of an image, allowing maximum likelihood estimation to be used for piston estimation while a least squares matrix method estimates the tip and tilt errors. Images generated to simulate different amounts of atmospheric turbulence and image noise were used to test these piston, tip, and tilt correction algorithms. It was found that atmospheres with Fried parameters the size of a single aperture show the strongest correction results. Anisoplanatic images can be corrected if they are masked to the size of an isoplanatic patch and as long as there is enough spatial frequency support. The final phase corrected results are comparable with or better than the results of blind deconvolution for higher signal to noise ratios. Pupil remapping is done using blazed gratings located at an intermediate image plane to create a wavelength dependent aperture shift that results in a constant shift in the spatial frequencies. If the apertures in an array are placed along only one axis, the target or imaging system can be rotated and multiple images can be collected, corrected and rotationally synthesized to create resolution gain in all directions. Future work could include expanding on isoplanatic correction techniques, improving piston, tip, and tilt estimation methods and creating an experimental system with more than two apertures that could be tested in the field.