

Sparse Aperture Optics and Image Construction Algorithms

Peter R. Lynn, Jr.

Code 8210.1

Naval Research Laboratory

Washington, DC 20375

Phone: 202-767-0702

fax: 202-767-6429

email: plynn@space.nrl.navy.mil

Dr. David Mozurkewich

Code 7210

Naval Research Laboratory

Washington, DC 20375

Phone: 202-762-1417

email: dmozurk@rsd.nrl.navy.mil

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LONG-TERM GOAL

Our long-term goal is to develop the appropriate algorithms necessary to support sparse aperture imaging system envisioned for future use in the surveillance community. Sparse aperture optical configurations have been proposed as a means of obtaining high resolution optical data without using prohibitively large optical elements. The limit of sparsity needs to be fully understood in the context of providing useful reconstructed images.

OBJECTIVES

The objective is to develop and evaluate image deconvolution, which will be required for extraction of image information from an extremely sparse aperture optical diffraction pattern. Past efforts in simulations have shown that image reconstruction is possible as long as at least 15% of the aperture is filled. Of particular interest is the exploration of possible advantages, which are anticipated for spectral channelization of the image data. It is anticipated this approach will yield useful reconstructed images that can be taken with extremely sparse aperture optical systems with fill fraction approaching 5% or less. In addition, the spectral channelization should result in shorter integration times, partially overcoming one of the major obstacles to applying these techniques. Results from the Navy Prototype Optical Interferometer (NPOI) has shown significant improvement of the u-v plane filling with the use of multi-wavelength synthesis.

APPROACH

A laboratory testbed has been developed and is being used for the evaluation of various sparse aperture telescope designs, and for the validation of image deconvolution algorithms, which are being developed for extraction of image information from the sparse aperture diffraction pattern. The testbed evaluates the white light imaging performance as well as the potential advantages of spectral channelization of the image data. The approach makes use of a known, high quality, full aperture commercial telescope system, and uses masks at the entrance aperture to produce fractional fill factors in any of several different subaperture position configurations. Figure 1 shows a set of several different aperture masks as well as several different image sets that vary in complexity and extent.

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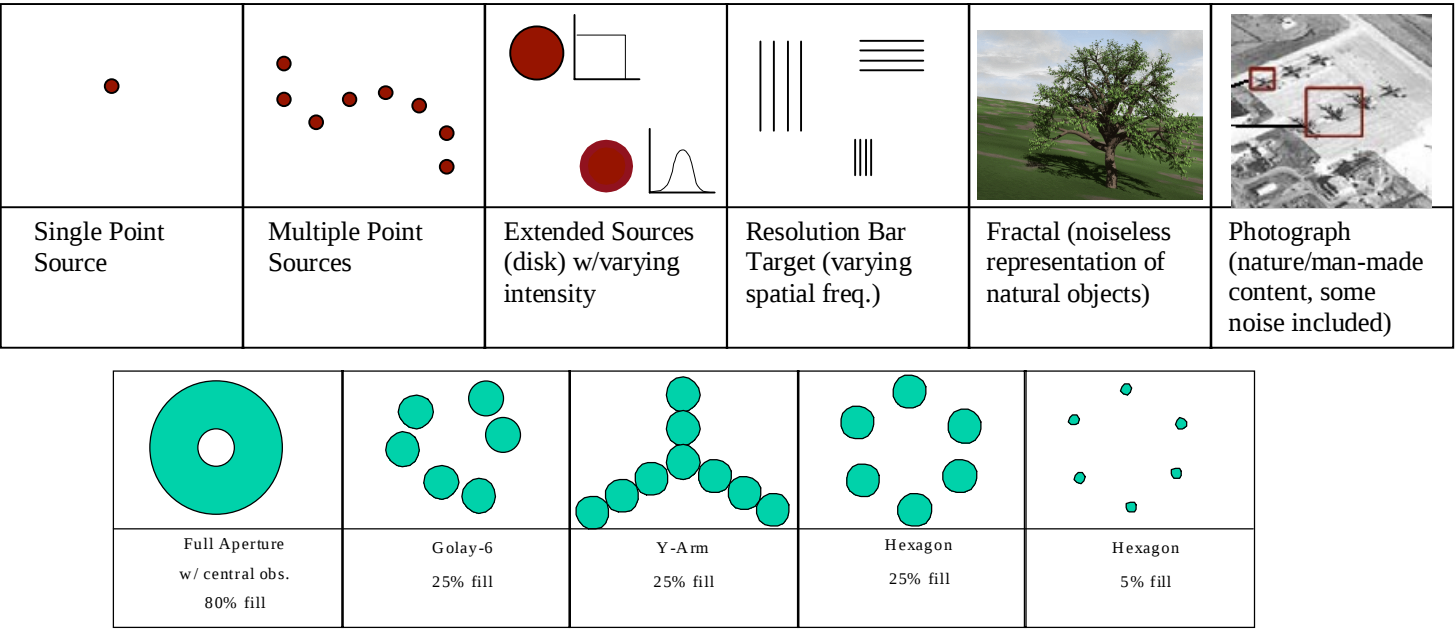


Figure 1

Figure 2 shows the process this is being used to develop and test the algorithms as well as aperture configurations.

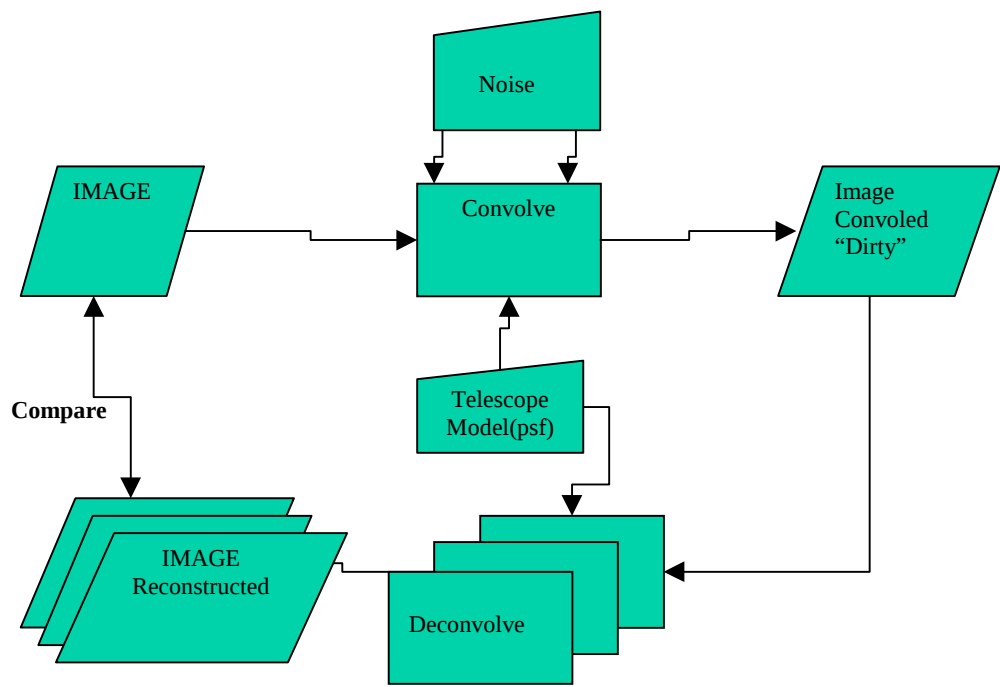


Figure 2

WORK COMPLETED

Optical scene generator, beam expander, imaging optics, and several masks were procured and installed into the imaging test bed. Hi resolution CCD imaging camera and data acquisition hardware was procured and installed, integrated and tested.

Narrow band and white light point spread functions have been acquired on the full aperture as well as several test aperture masks. Some errors in beam expander and imaging telescopes are present and both systems are currently out for alignment and characterization.

Several test images such as gray scale line art, resolution targets, and extended color photography have been successfully imaged with sparse aperture masks.

First iteration algorithms have been built and a promising commercial reconstruction algorithm has been purchased.

IMPACT/APPLICATION

The method of using the multi-wavelength aspects of the extended scene to increase u-v plane coverage for a sparse aperture imaging system is novel and appropriate for continued future investigation. Extremely sparse aperture imaging systems could yield a greater than 5 times improvements in achievable aperture diameter for same mass optical system.

TRANSITION

The developments of this investigation have direct application to both national and airborne electro-optical reconnaissance programs.

RELATED PROJECTS

- 1- Multi-wavelength synthesis is being developed and evaluated for use on astronomical sources by NRL/USNO at the NPOI facility.

REFERENCES

None

PUBLICATIONS

None