Improving reconstruction of targets hidden in scattering media by introducing Lucy-Richardson deconvolution algorithm into a system of multiview optical projections

Ariela Tsabary & David Abookasis
Department of Electrical Engineering, Ariel University, Ariel, Israel

Motivation

Optical systems tend to suffer from scattering which makes it difficult to reconstruct the shape of the object. Scattering affects the quality of the image, reduce the contrast of the image and resolution. In this work, we propose and demonstrate an hybrid algorithm that improves the recovery of objects hidden in a scattering medium.

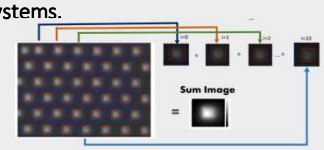
Introduction

Micro Lens Array - MLA

MLA allow to overcomes the limited spatial resolution of single imaging with larger numerical aperture objectives. Furthermore, the lens array increases the system numerical aperture, broadening the total field of view and improving the signal to noise ratio

Shist And Add -SAA

SAA is a simple mathematical operation developed to reconstruct atmospherically degraded solar images obtained by stellar speckle interferometry systems.



Lucy-Richardson Deconvolution Algorithm - LRA

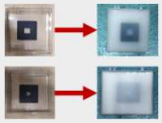
Iterative nonlinear image restoration method
Calculate the maximum likelihood solution for recovering an undistorted image that has been blurred by a known PSF
The algorithm resolves the undistorted image through an iterative process by using the formula:

$$f_{m+1}(x,y) = f_m(x,y)\left[h(-x,-y) * \frac{g(x,y)}{h(x,y) * f_m(x,y)}\right]$$

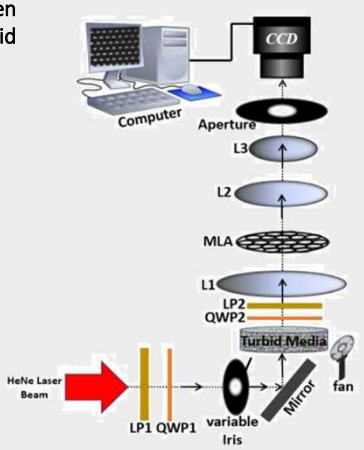
$f_m(x,y)$ - estimate of the image in the mth iteration
$g(x,y)$ - degraded image
$h(x,y)$ - PSF of the imaging system
$*$ - convolution operation

Experimental setup

two objects, used in the experiments and when embedded inside the turbid liquid:

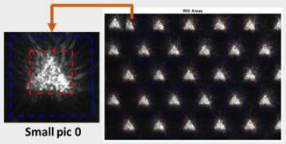


Experimental setup



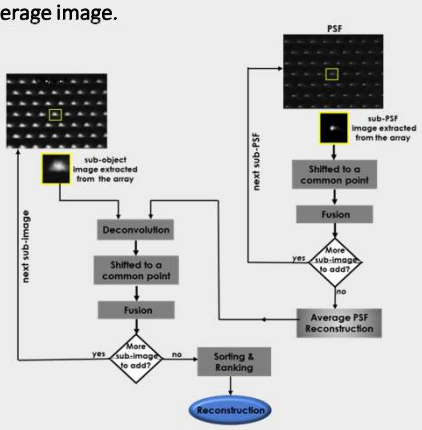
Methods

We applied different filtering strategies including polarization, deconvolution, and image sorting processing together with multiview projections. First the medium was illuminated with a polarized laser beam and single-shot multiple sub-images of the object were obtained from different viewpoints using MLA.



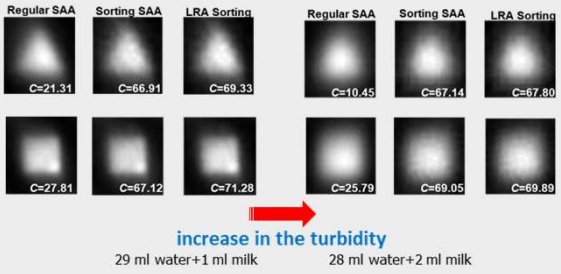
Each sub-image was deconvolved with the average PSF of the system following LRA. The deconvolved sub-images were than qualitatively evaluated by contrast-to-noise ratio and entropy metrics and sorted based on those metrics. Finally, the sub-images were shifted to a common center and summed together with other sub-images to single average image.

Sorting SAA & LRA with average PSF



Results & Discussion

Imaging quality was better when the LRA . Specifically, compared to the regular SAA reconstruction four-fold increase in contrast value is achieved and up to 11% improvement in comparison to sorting-SAA processing highlighting the merit of our approach.



Conclusion

Experimental results indicate success in image reconstruction as compared to regular SAA with an improvement in the image contrast metric. LRA with Sorting SAA has potential for use in a broad range of scientific fields such as medical diagnostics, sensing, underwater imaging, and more.