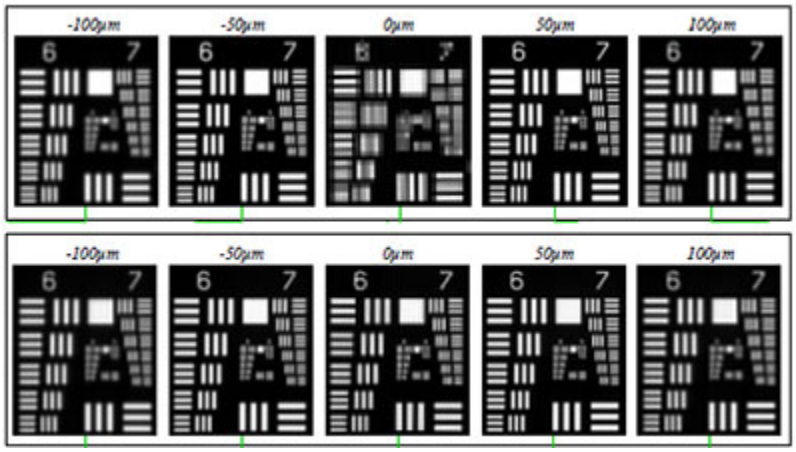
Docket #: S14-315

Enhancing the performance of the light field microscope using phase masks

Professor Marc Levoy and collaborators have enhanced the performance of the light field microscope (LFM) by solving the problem of non-uniform spatial resolution across the working range, especially the low spatial resolution at the native objective plane (in the middle of the working range) where the microscope is focused. Light field microscopy is a flexible fast technique for volumetric imaging. It uses a microlens array to capture spatial and angular distributions of light. Captured light field images can be processed to reconstruct a full 3D volume. A limitation with light field microscopy is that the spatial resolution of the reconstructed image can be non-uniform across depth, with some z planes showing high resolution and others, particularly at the center of the imaged volume, showing very low resolution. To overcome this limitation and enhance the performance of the LFM, the inventors have developed methods using phase masks to improve the spatial resolution. These methods allow the LFM resolution profile to be much more uniform across depth and improve the resolution around the native object plane. In addition, the technology provides more flexibility in the LFM's design so that it can be tailored to meet the needs of a specific application.



Comparison of LFM imaging of USAF 1951 target. Top- no phase mask. Bottom-with phase mask. The resolution at the native object plane (0um) is improved with the phase mask.

Stage of research
A prototype that includes a phase mask has been built and the deconvolution software has been modified to take into account the phase mask. The approach has been validated using both simulated data and experimental resolution measurements of a USAF 1951 resolution target. Furthermore, the utility for biological applications has been demonstrated with in vivo volumetric calcium imaging of larval zebrafish brain.

Related technology
This technology is part of a light field microscope portfolio developed by Dr. Marc Levoy and colleagues which includes the Stanford dockets S05-327 and S13-113.

Applications

- Light field microscopy
  - Research
  - Clinical pathology

Advantages

- Ability to control the spatial resolution profile of the LFM
- Improves resolution around the native object plane
- Improves the resolution of the LFM at the borders of the working range (e.g. +/- 100um from the native object plane)
- Deconvolution algorithm can accommodate any type of phase mask that may be used
- Better support for tracking small, fast moving objects in a volume

Publications

- Cohen N, Yang S, Andalman A, Broxton M, Grosenick L, Deisseroth K, Horowitz M, Levoy M. Enhancing the performance of the light field microscope using

wavefront coding. Opt Express. 2014 Oct 6;22(20):24817-39. doi: 10.1364/OE.22.024817

Patents

- Published Application: 20160062100
- Issued: 10,317,597 (USA)

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