Multifrequency illumination patterns in single snapshot tissue optical properties imaging
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Motivation
- Spatial Frequency Domain Imaging (SFDI) is a non-invasive wide-field blood oxygenation measurement technique based on structured light illumination.
- Illumination patterns are simple 2D sinusoids, one spatial frequency at a time.
- Multiple spatial frequencies improves accuracy of optical properties extraction.

Goal:
Sample tissue at multiple spatial frequencies in one snapshot by optimizing the illumination pattern.

New Technique
Improved single-snapshot SFDI illumination patterns.
- Multiplexing spatial frequencies in a layered pattern (SSOP).
- Superimposing spatial frequencies in an angled pattern (SSMD).

New demodulation algorithms for better separation of DC/AC signals.
- Vertical deblurring in multiplexing
- Multifrequency angle optimization

Project patterns on sample with DMD
Demodulation
Extract reflectance

Related Work
Spatial Frequency Domain Imaging (SFDI) [1]:
- Illumination: Multiple spatial frequencies and phases of single sinusoid patterns.
- Processing: Average over phase-shifted images to extract DC/AC reflectance.
- # images: 3+ (2 frequencies/3 images)
- Image Quality: Low noise, minimal artifacts.

Single Snapshot Optical Properties (SSOP) [2]:
- Illumination: 1 2D sinusoidal spatial frequency.
- Processing: Line-by-line low/high-pass filter to separate DC/AC reflectance respectively.
- # images: 1 (2 frequencies/image)
- Image Quality: High noise, significant depth variation artifacts.

Single Snapshot Multiple frequency Demodulation (SSMD) [3]:
- Illumination: 2 superimposed sinusoid patterns.
- Processing: Average over sliding window to extract DC/AC reflectance.
- # images: 1 (3 frequencies/image)
- Image Quality: Better than SFDI and SSOP in noisy images.

Experimental Results
Angled pattern SSMD:
45° is the optimum angle. Smaller angles lead to larger window size and lower resolution. Larger angles causes more severe aliasing.

Multiplex SSOP:
Higher multiplexing frequency decreases accuracy due to diffusion but is somewhat recoverable with vertical deblurring.

Future Work
- More sophisticated 1D deconvolution methods to eliminate vertical diffusion blurring

SSOP
- Overlay more spatial frequencies in a single snapshot
- Construct polygon shaped unit cell for demodulation

References