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X-ray imaging from different perspectives

Combining a new imaging method with existing ones

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X-ray image



X-ray source

X-ray detector



Current research: Spectral X-ray imaging





Medipix3 detectors. Electronics developed at Nikhef

From conventional to spectral

Metal foils (sample 3 x 3 cm)



Reducing ambiguity between sample 'thickness' and composition.

There is more to 'see'



- (Compton) scattered X-rays
- Fluorescence

Medipix3 pinhole camera

(fake?) teeth



There is more to 'see'



- (Compton) scattered X-rays
- Fluorescence



Spinach leaf



Our goals

- Single shot combination of:
 - 'Direct' X-ray imaging
 - (Compton) scattered X-rays imaging
 - Fluorescence imaging
- ightarrow Sample structure and composition
- Single shot ' 4π ' imaging (just add cameras) → Spatial information



Two lens-less imaging methods

Pinhole



- Point and extended sources
- Light efficiency < 10⁻³

Coded aperture



- Point sources
- Light efficiency > 10⁻¹

Take the best of both!

Coded aperture for extended sources Image Acquisition Optional: Raw-image averaging to Camera with Aperture Optical Engineering reduce pixel Coded on random noise Programmable SLM Bad Pixel Flat//Dark De-Noise Correction Removal Normalize Decode Recovered Lensless coded-aperture imaging with Image separable Doubly-Toeplitz masks Landweber Michael J. DeWeert Brian P. Farm Optical Engineering 54(2), 023102 (February 2015)

Seems promising!

Challenges and opportunities

Coded aperture:

- Noise sensitivity?
- Sensitivity to systematic effects?
- \rightarrow Sufficient light efficiency?
- Other (lens-less) imaging methods?
- What applications benefit most?
 - Currently looking at mammography

Opportunity for a new X-ray imaging technology!