Robust artefact reduction in tomographic imaging

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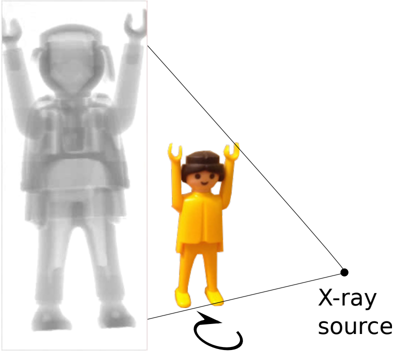
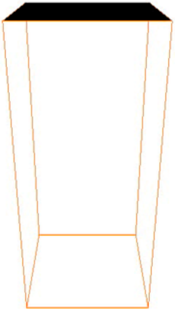
CWI Scientific meeting

Tomography

Tomography is a technique for reconstructing an object from projection data



projections on detector



reconstruction

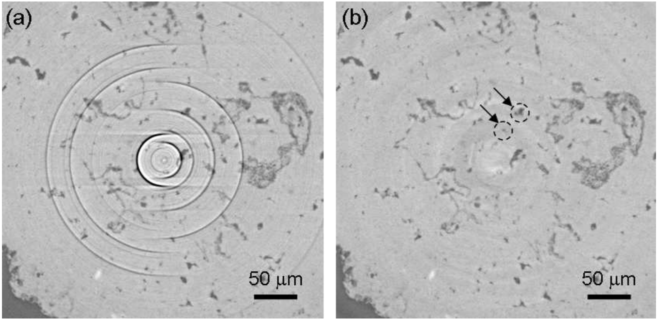
Courtesy of University of Antwerp

Advanced Tomography

synchrotrons

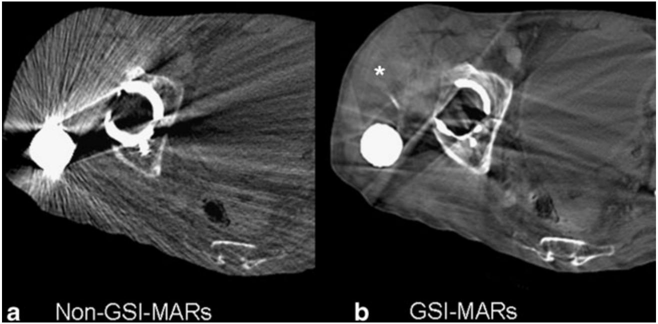
electron microscopes

Artefacts in tomography



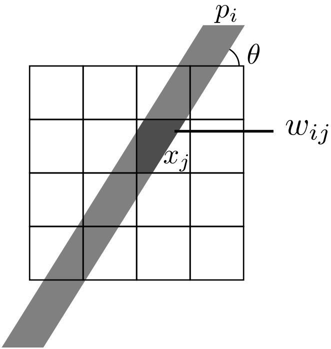
ring artefacts

Artefacts in tomography



metal artefacts

Mathematical representation



Attenuation along the ray path can be modeled as linear combination of pixel values.

Leading to a linear system of equations:

$$W\vec{x} = \vec{p}$$

The reconstruction problem

Solve

$$W\vec{x} = \vec{p}$$

by a least squares method (in ℓ_2-norm):

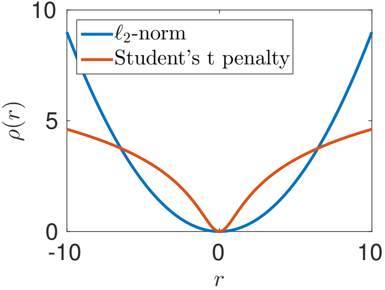
$$\underset{\vec{x}}{\text{minimize}}\ \frac{1}{2}\|W\vec{x} - \vec{p}\|_2^2$$

Challenges:

- W is extremely large
- W is underdetermined, solution is not unique
- no solution exists, if $\vec{p}$ is not in the range of W

Least-squares and Student's t

comparison

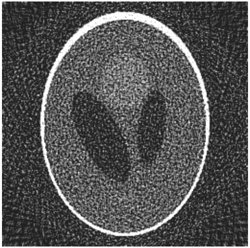


Penalty functions

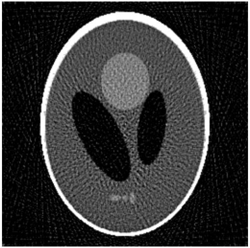
Results

randomized projections

ground truth



least-squares solution



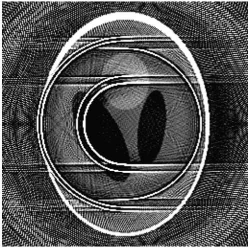
Student's t solution

- $256 \times 256 \times 256$ test image
- 180 projections were simulated
- 45 projections were replaced by white noise

Results

defective camera pixels

ground truth



least-squares solution

Student’s t solution

- Effect from defective camera pixels

Conclusions

- Be careful using the ℓ_2-norm for penalizing outliers in the data
- With a small adjustment, by using the Student's t-penalty, we can have radically improved reconstructions

Thank you for your attention!