Spinning Registration Reconstruction Quantization

a new reconstruction method for electron tomography

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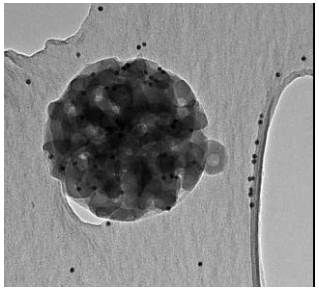
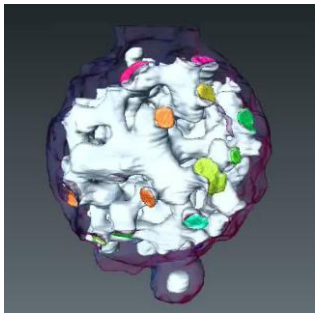
Electron tomography

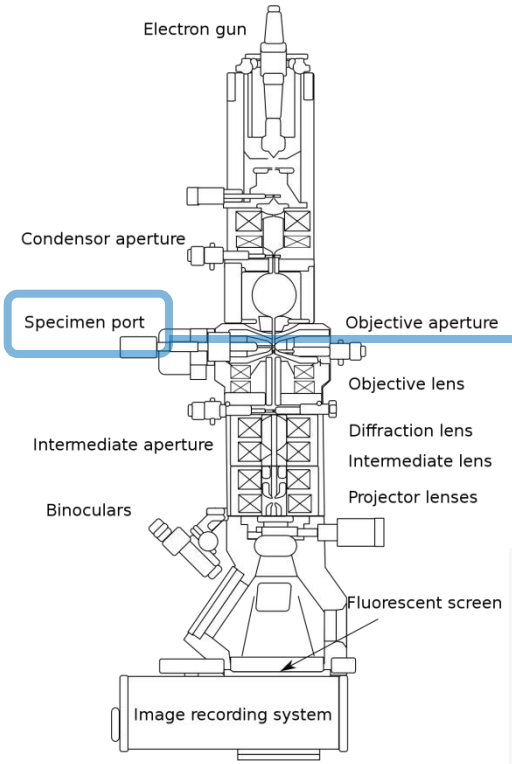
- What is ?
  - Tomography using projections from TEM (Transmission Electron Microscopy)
- For what?
  - 3D reconstruction at nanometric scale
- For ?
  - These data help developing new catalysts improving understanding of the porous network

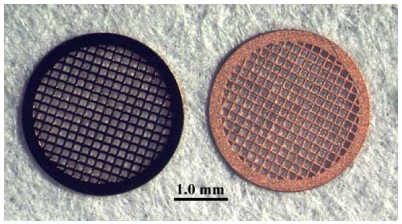


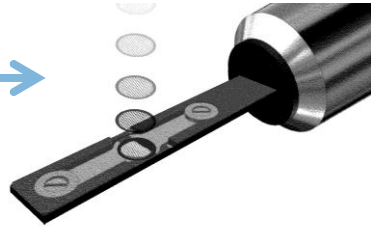


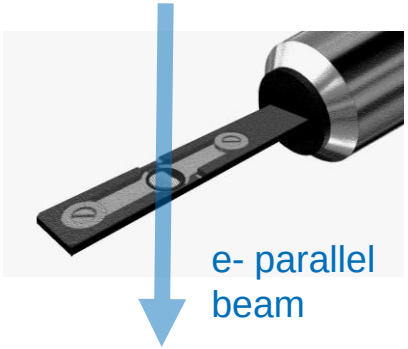
Electron tomography : how ?

- Put object on a grid in specimen port
- e- pass through the object (parallel geometry)
- Tilt specimen port and acquisitions
- Do tomographic reconstruction







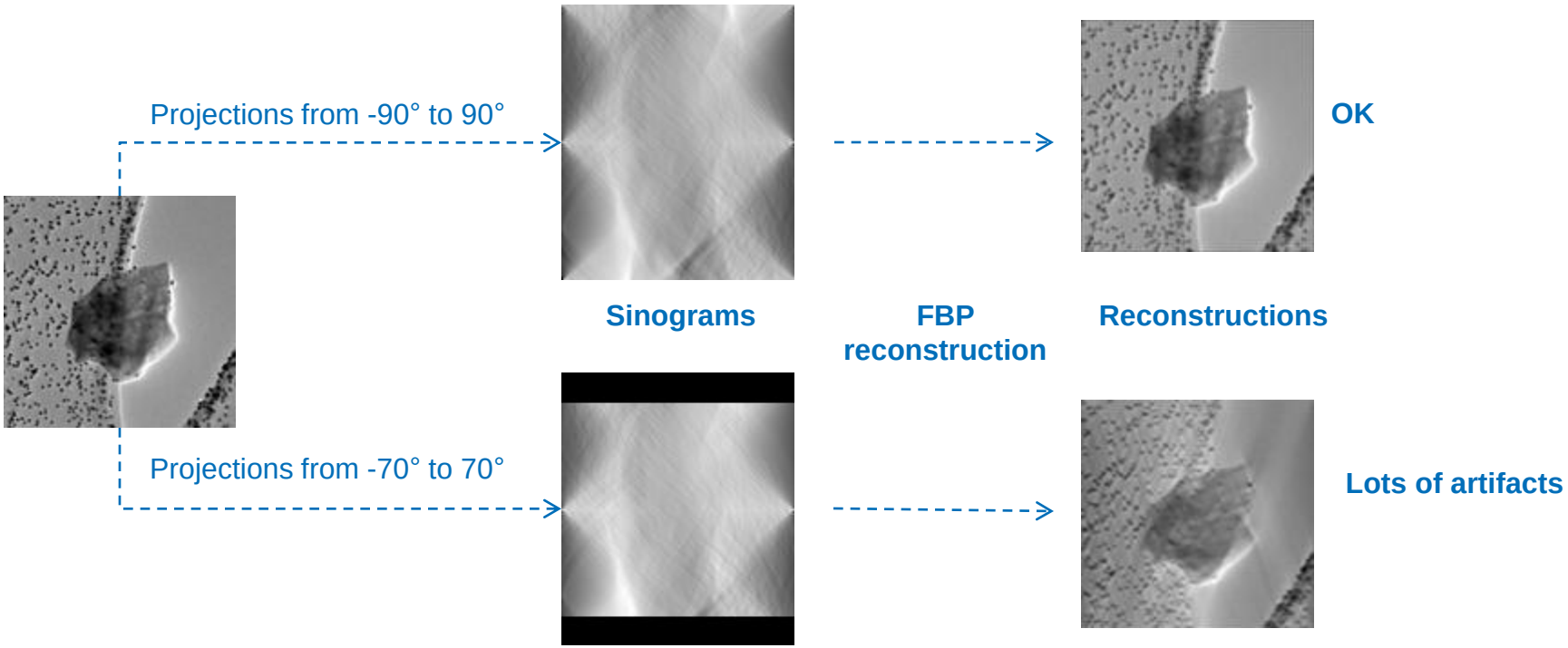


It sounds easy ! But…

Electron tomography : issue 1

- **Tilt of specimen port is limited to ± 70°**

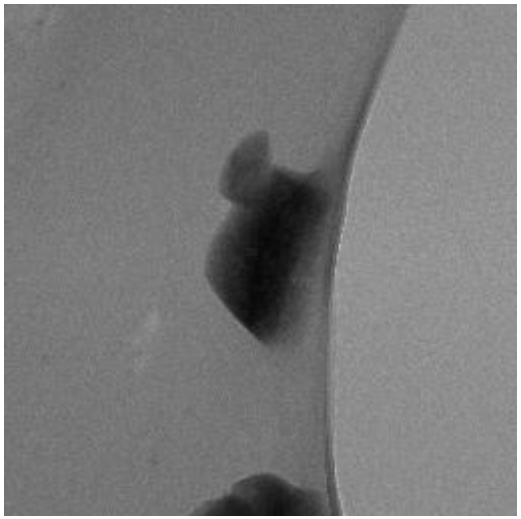
Reconstruction with incomplete data (limited range of projections)



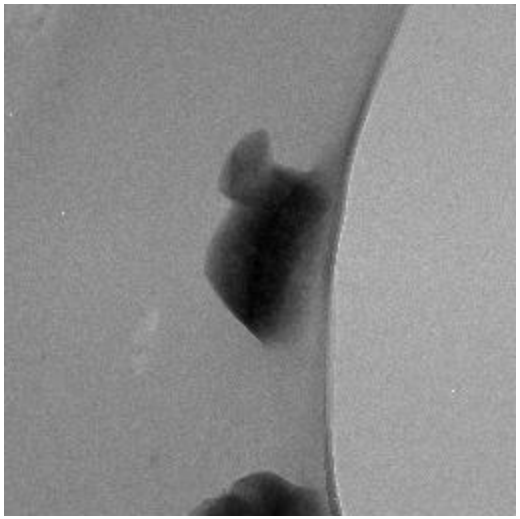
Electron tomography : issue 2

- **Mechanical displacement of the specimen port**

Projections not properly aligned with respect to a parallel geometric model of acquisition



What we have



What we need *

* from VD Tran et al., Optimization Methods for Robust Registration of Image Series in Electron Tomography, submitted to 21st International Conference on Pattern Recognition, November 11-15, 2012, Tsukuba Science City, JAPAN

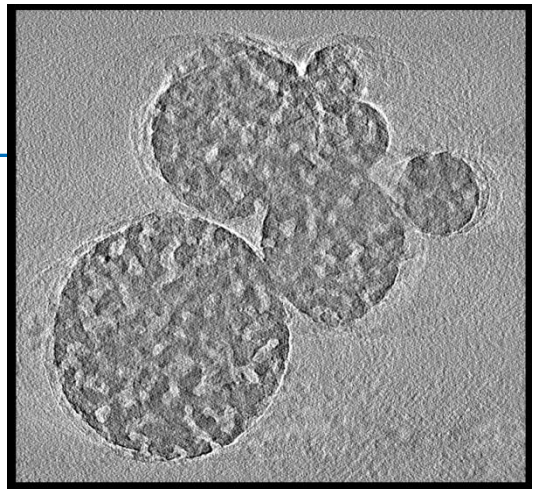
Outline

Spinning Registration Reconstruction Quantization

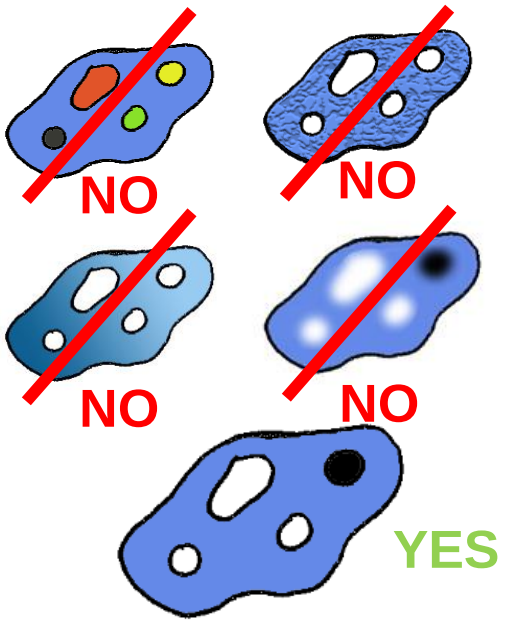
- Context, electron tomography
- Catalysts supports : specific constraints
- SRRQ method
- Results
- Perspectives

Catalysts support for refining

3D TEM, alumino silicate support



- We want to reconstruct an object with :
  - Limited numbers of known phases (two or three)
  - Constant phase, no texture
  - Sharp transitions between phases
- We don't want information about chemical or density of the phases
- We want information about morphology



To summarize …

- We need a reconstruction method complying with :
  - Limited range of projection
  - Misaligned projection

  } *experimental data constraints*

  - Reconstruction of objects with two or three constant phases, and sharp transitions between phases

  } *a priori constraints*

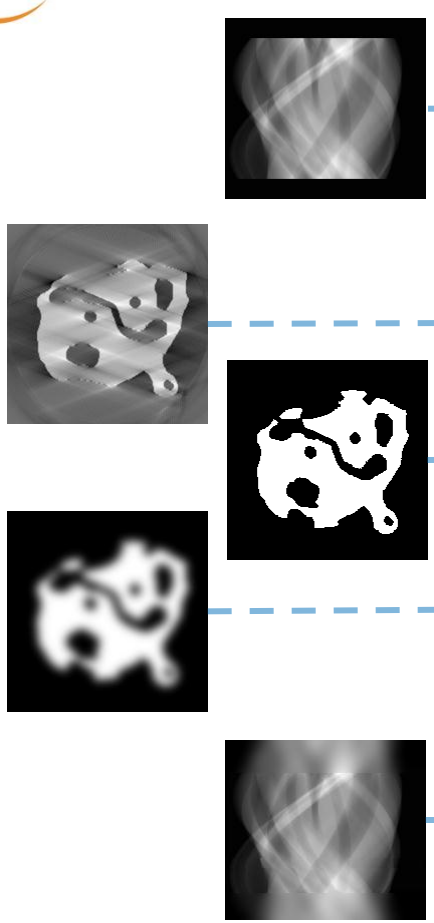
→ Spinning Registration Reconstruction Quantization

SRRQ method

Spinning Registration Reconstruction Quantization

- Alternately and iteratively reconstruction of an object
  - Complying a priori constraints ①
  - Which some projections complied registrated projections known experimentally ②

SRRQ scheme



Initialization : exp. projections on [a;b], 0 otherwise

FBP reconstruction

Smooth with preservation of strong transitions
Object with no texture and constant phases

Segmentation in N phases
Object with known nb. of phases

Contour relaxation, smooth with factor α
*Poorly reconstructed contour of phases for 1st ite.**

Decrease α

Projections

Reference to the exp. data and registration
Replacement on [a;b] with registrated exp. proj.

Stop criterion : Dif. between 2 succ. ite. after seg.
Decrease border relaxation factor or exit

If criterion verified and w>0

If criterion unverified

If criterion verified and w=0

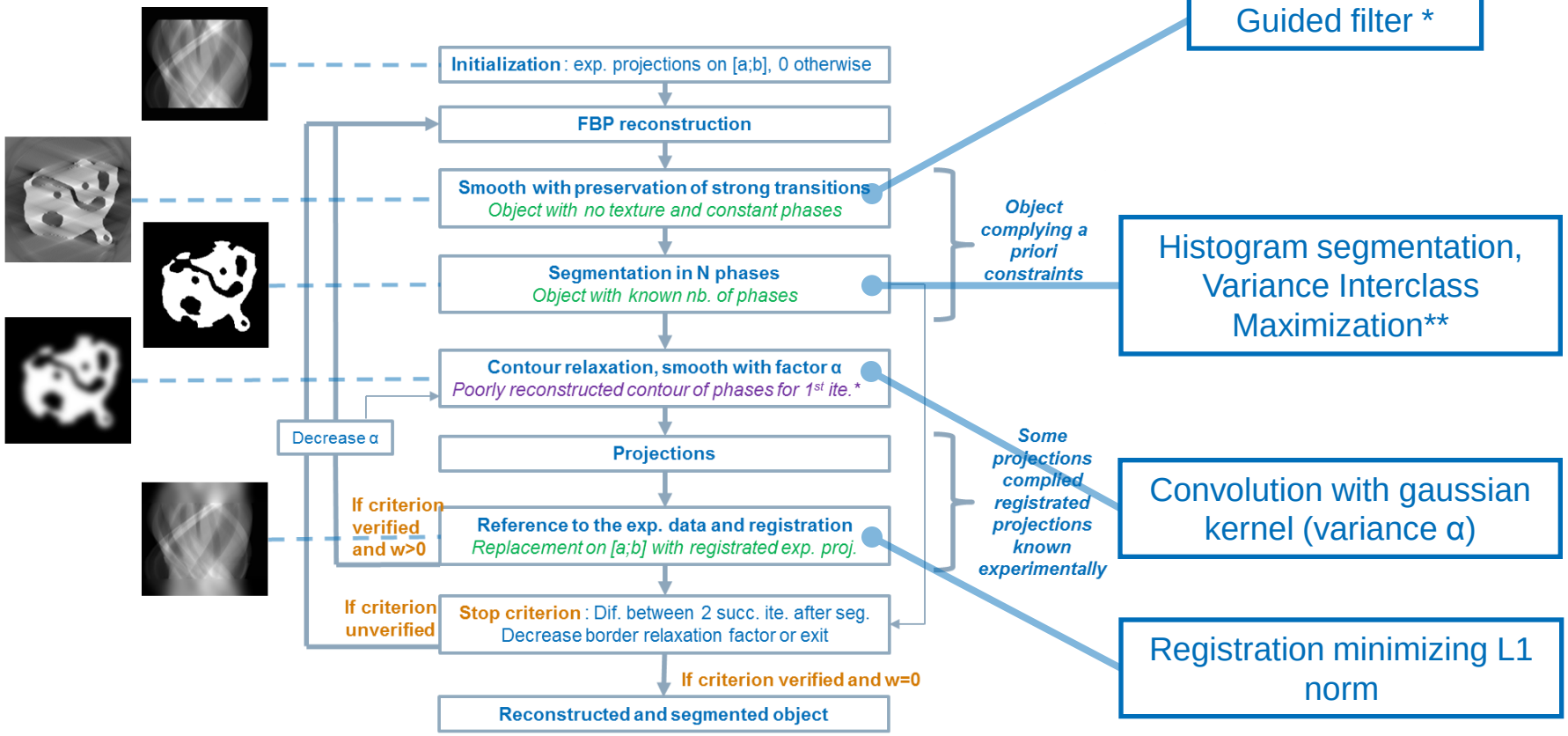
Reconstructed and segmented object

Object complying a priori constraints ①

Some projections complied registrated projections known experimentally ②

* KJ. Batenburg and J. Sijbers. DART: a fast heuristic algebraic reconstruction algorithm for discrete tomography. Proceedings of the IEEE International Conference on Image Processing (ICIP), San Antonio, Texas, USA, September, 2007.

SRRQ scheme



* K. He et al., Guided image filtering, Proceedings of the 11th European conference on Computer vision: Part I, Springer-Verlag, Heraklion, Crete, Greece, 2010.

** N. Otsu, Threshold selection method from gray-level histogram, IEEE Transactions on Systems, Man, and Cybernetics 9 1 (1979) 62–66.

Some results with binary 2D simulations

- Two binary datasets (256x256)

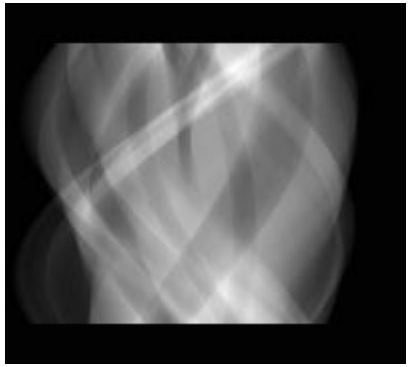
Obj.1

Obj. 2

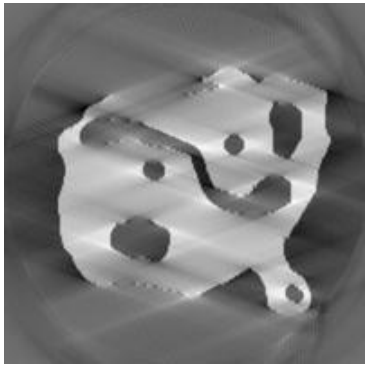
- Limited range of simulated projections on ± 70° (141 proj.)
- White noise added on projections (±10%)
- Random misalignement of projections (±10%)

Some results with binary 2D simulations

- Limited range ± 70° of simulated projections (141 proj.)



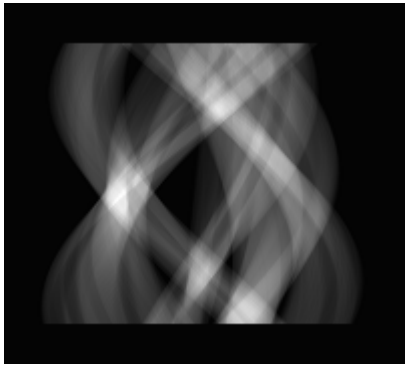
Init.



FBP (ite. 1)

real

Ite. 6



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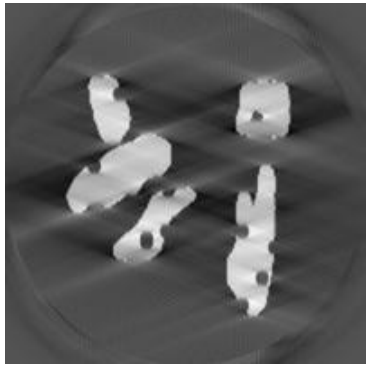

FBP (ite. 1)

real

Ite. 5

Some results with binary 2D simulations

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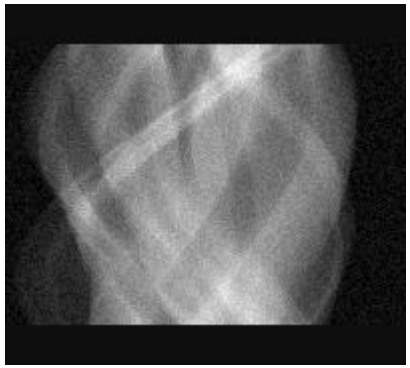

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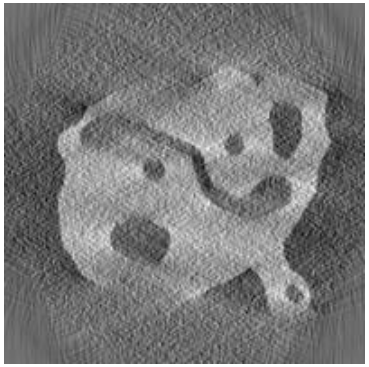

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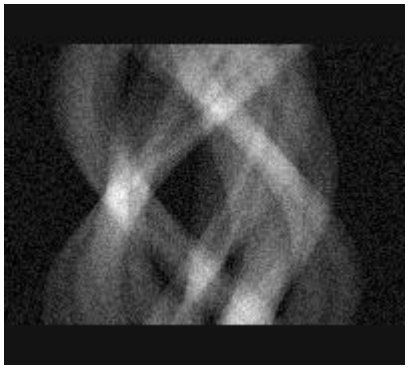
Ite. 9



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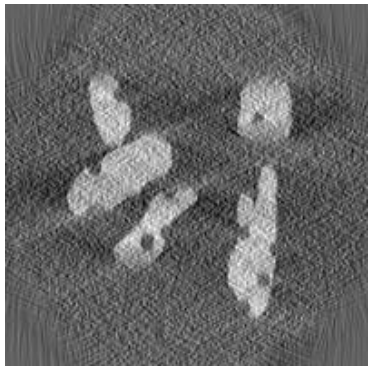

FBP (ite. 1)

real

Ite. 6

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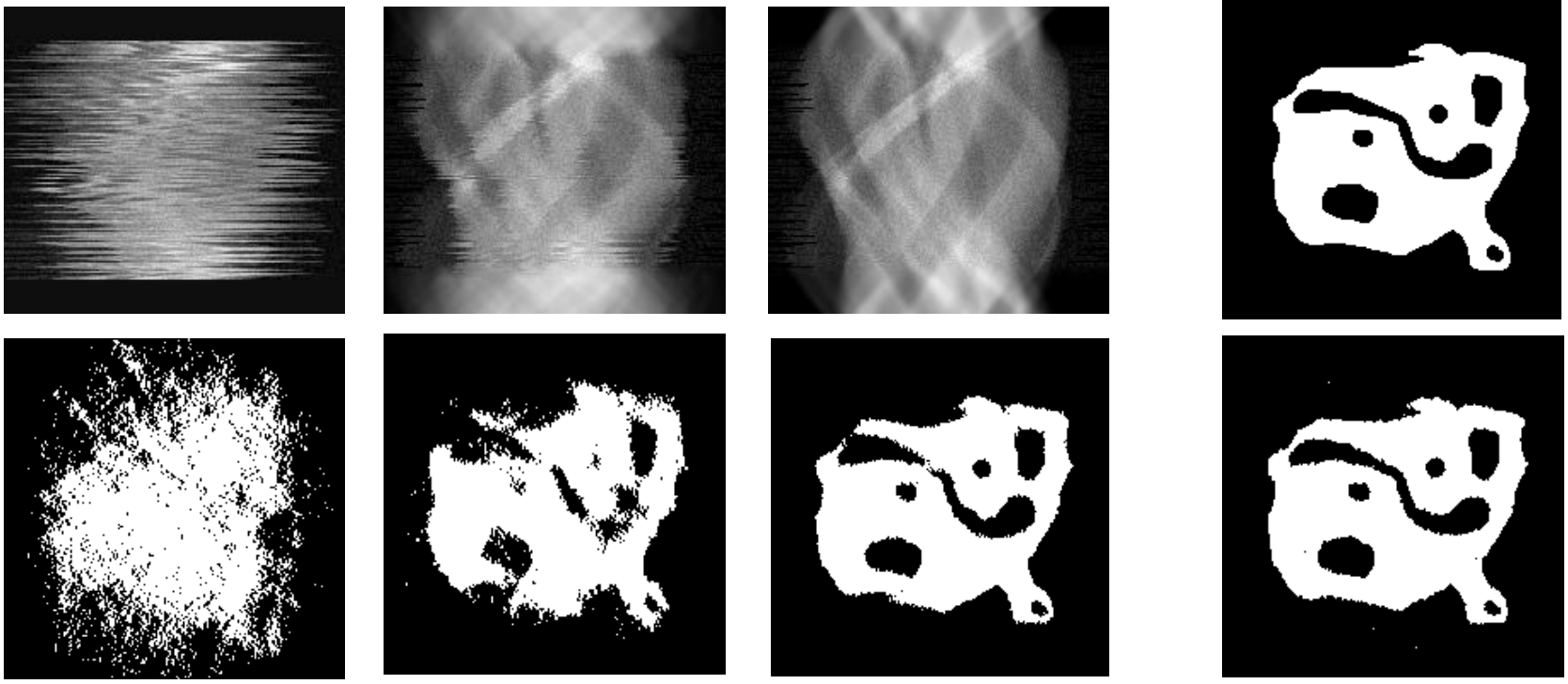

ite. 1 ite. 2 ite. 5 ite. 14

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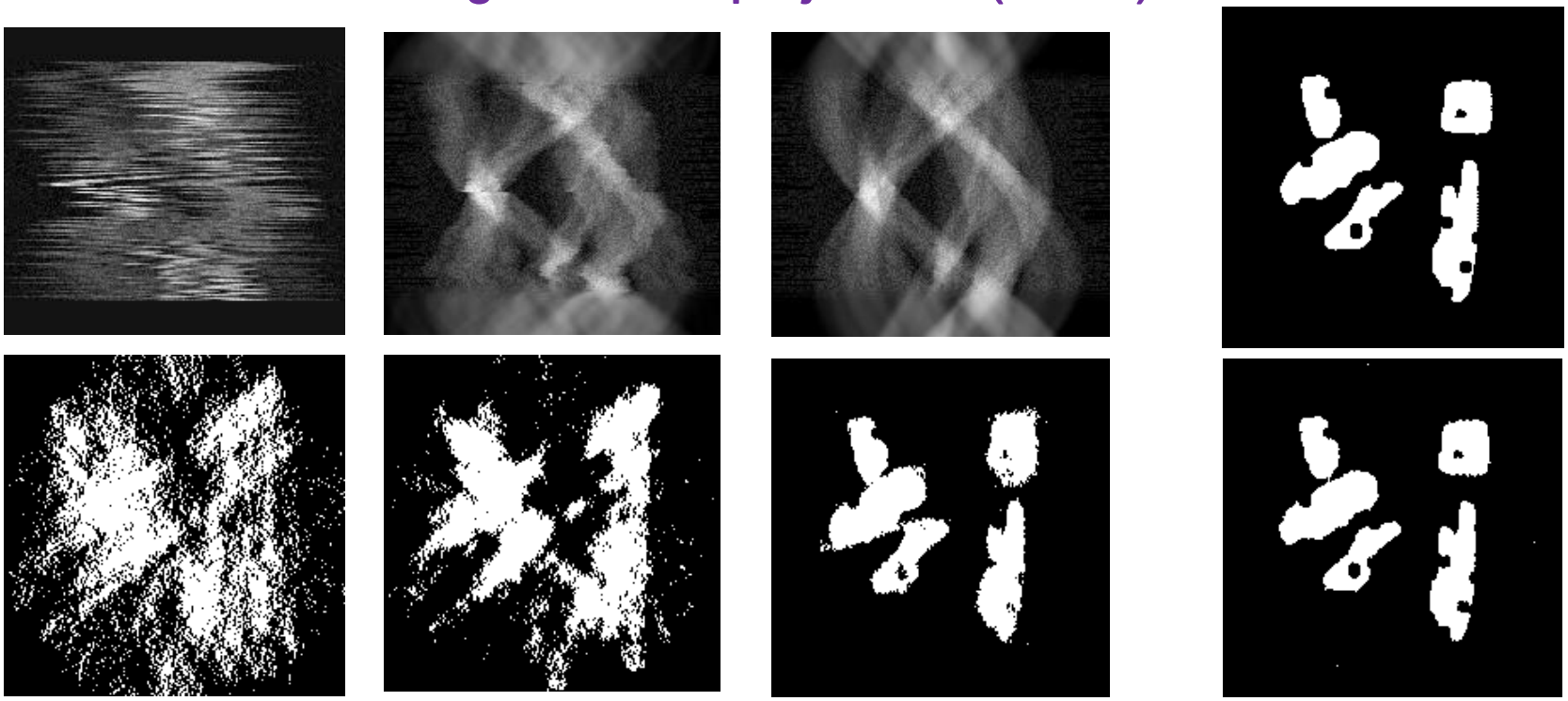

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Perspectives

- Tests on 3D simulations (parallel geometry)
- Tests on real 2D TEM projections (3D reconstruction)
- For segmentation step, test method minimizing projection distance*
- Integrate and use SRRQ with registration procedure from **

* KJ Batenburg and J Sidjers, Optimization thrshold selection for tomogram segmentation by projection distance minimization, IEEE Transactions on Medical Imaging (2009), Volume: 28, Issue: 5, Pages: 676-686

** VD Tran et al., Optimization Methods for Robust Registration of Image Series in Electron Tomography, submitted to 21st International Conference on Pattern Recognition, November 11-15, 2012, Tsukuba Science City, JAPAN

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Thank you for your attention

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