Classification and Reconstruction from Single Lines

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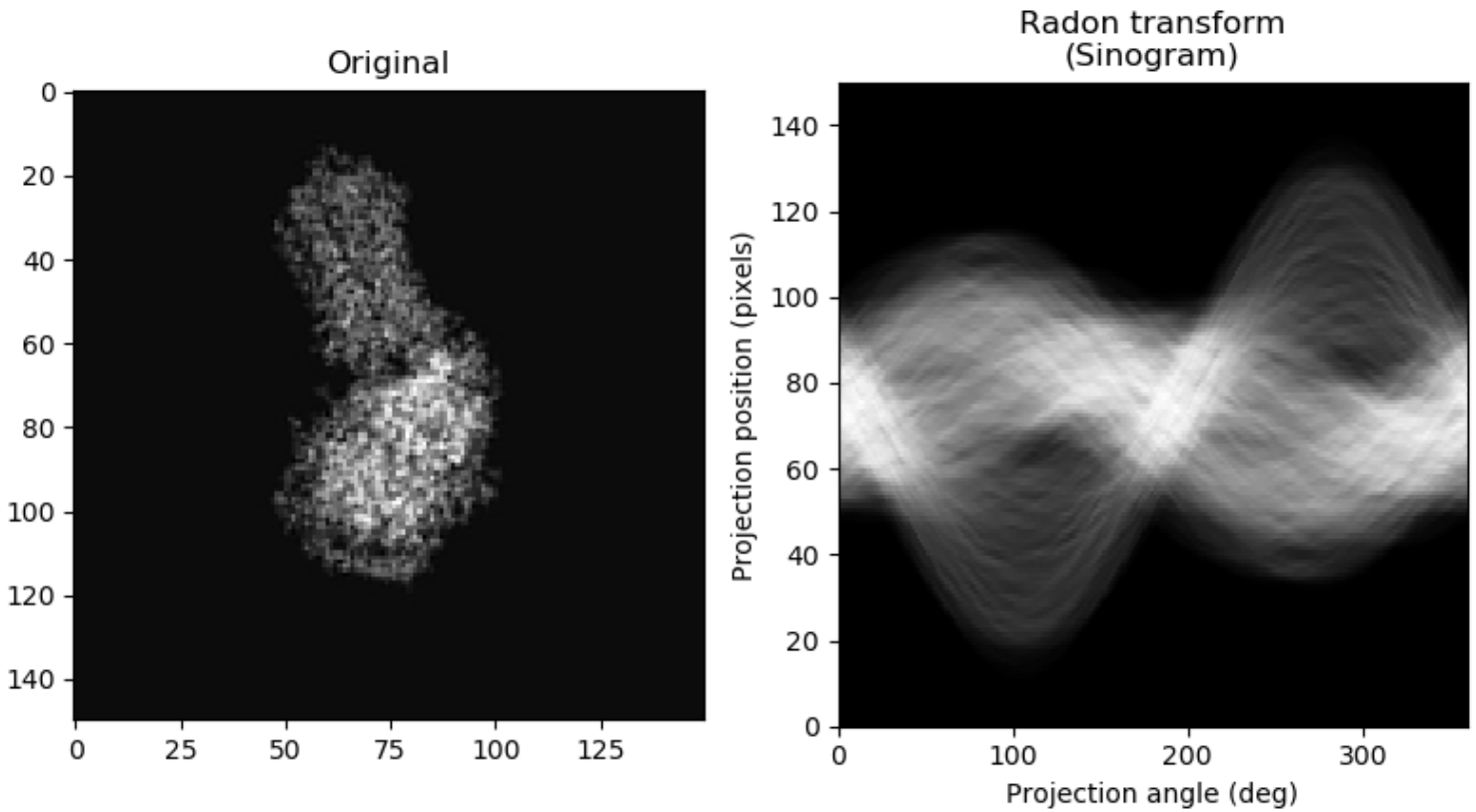
The Radon Transform



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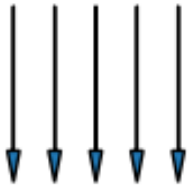

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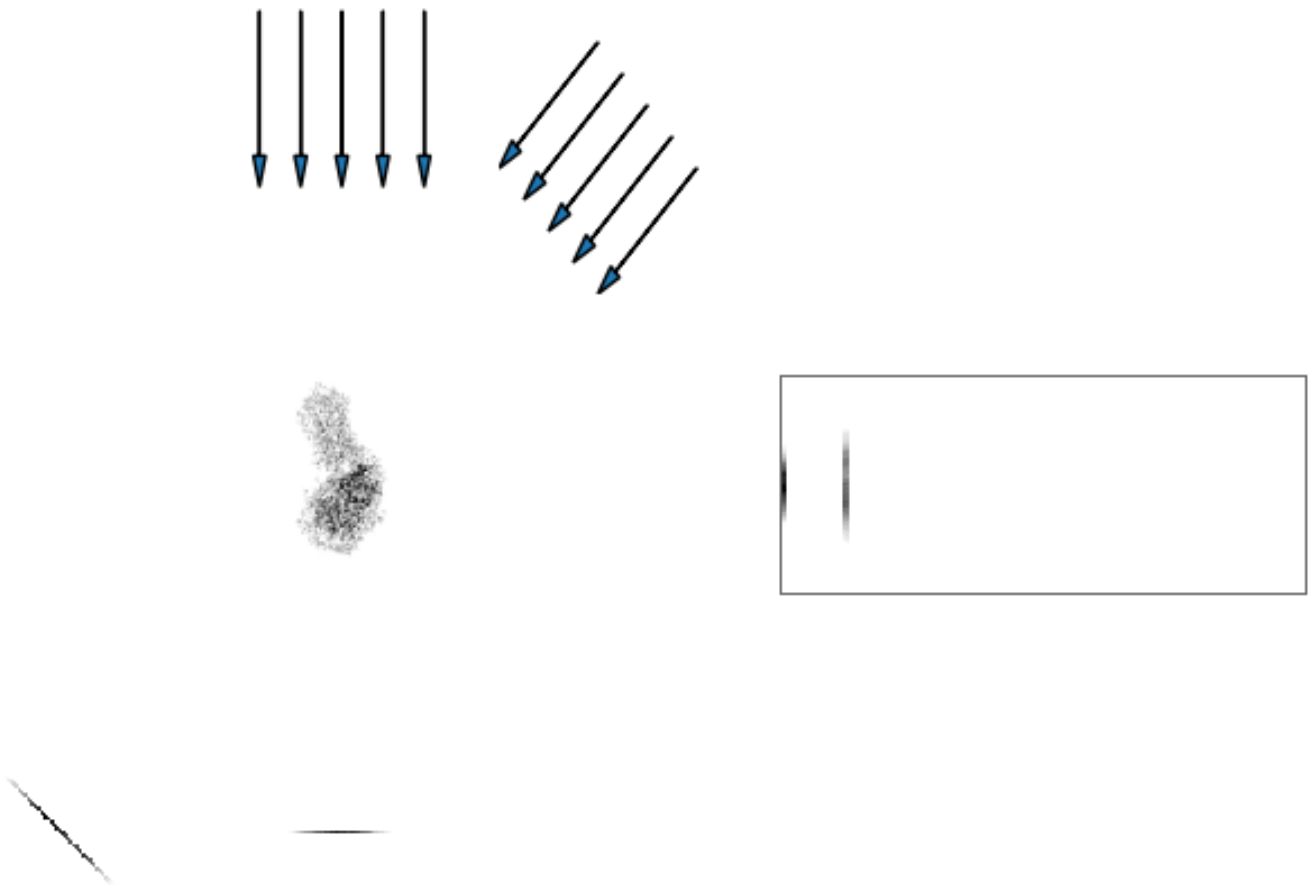

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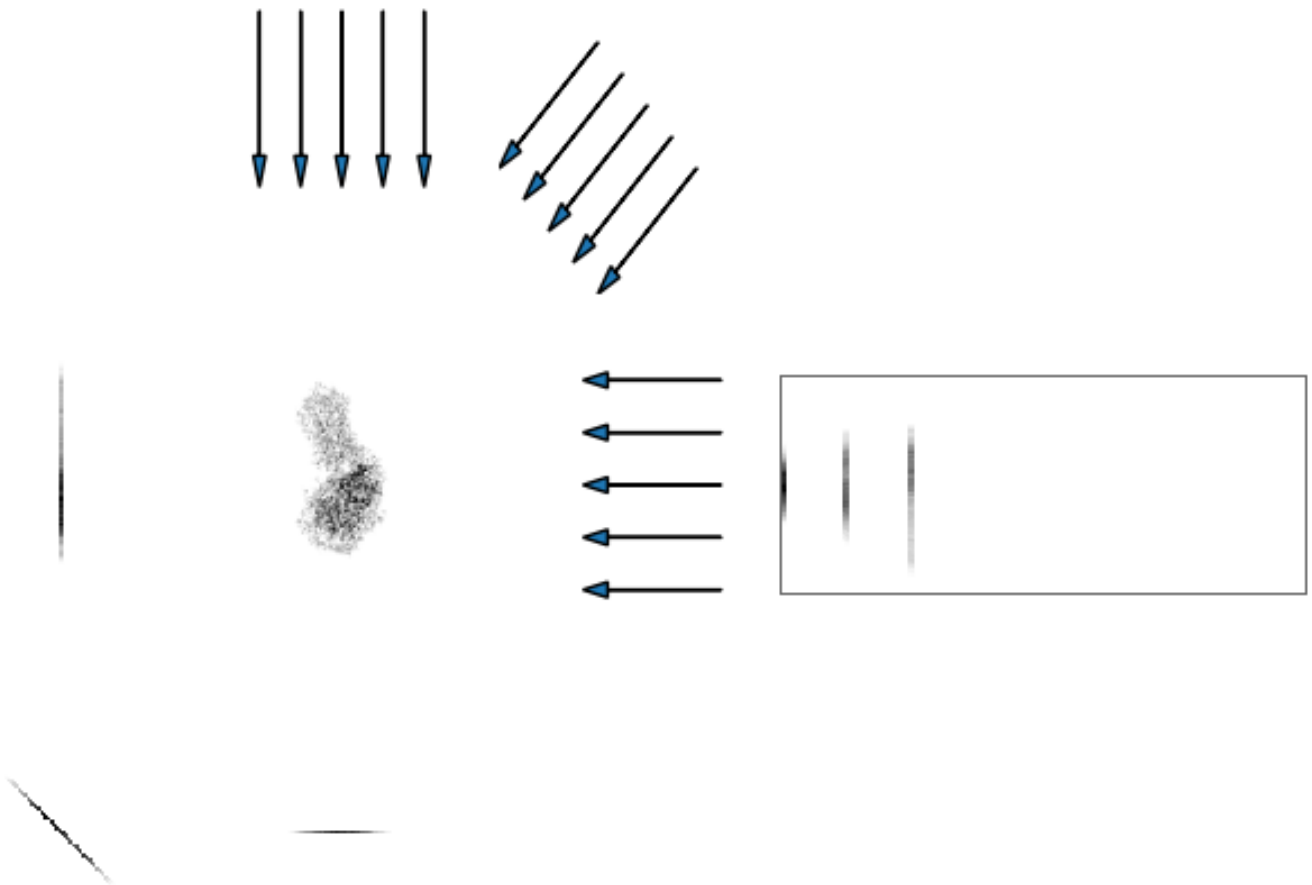

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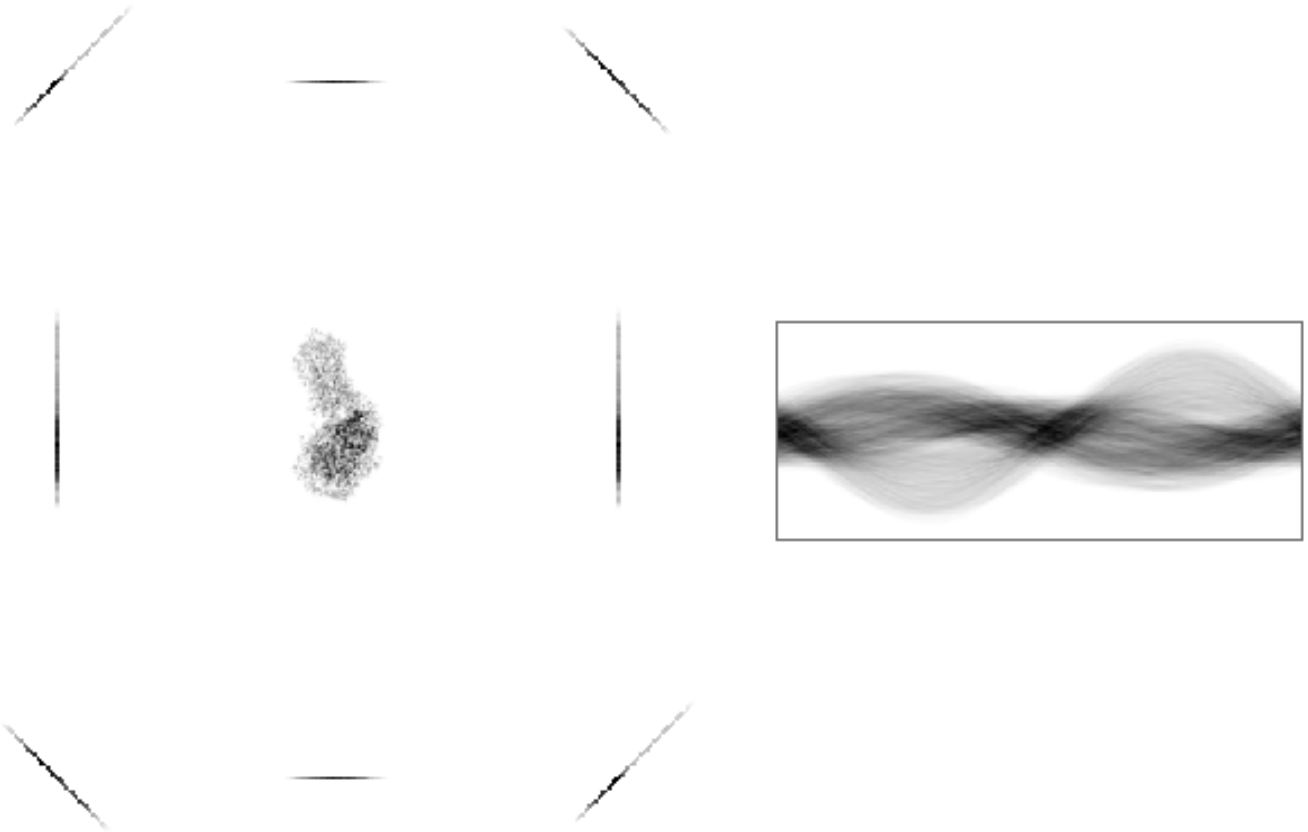
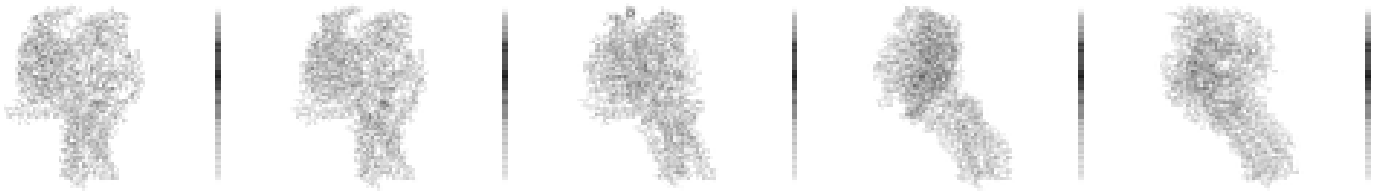
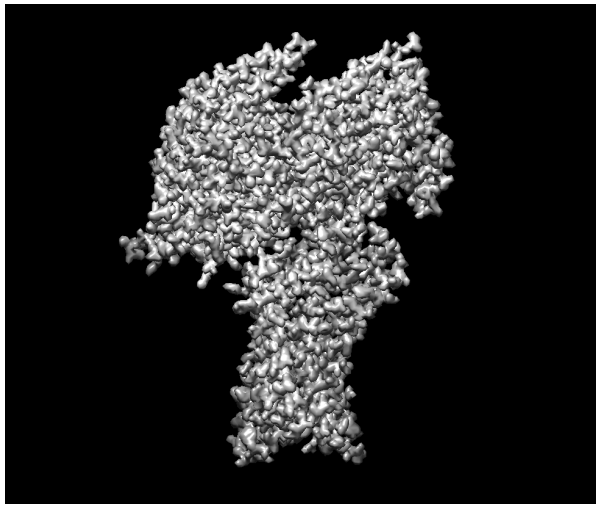


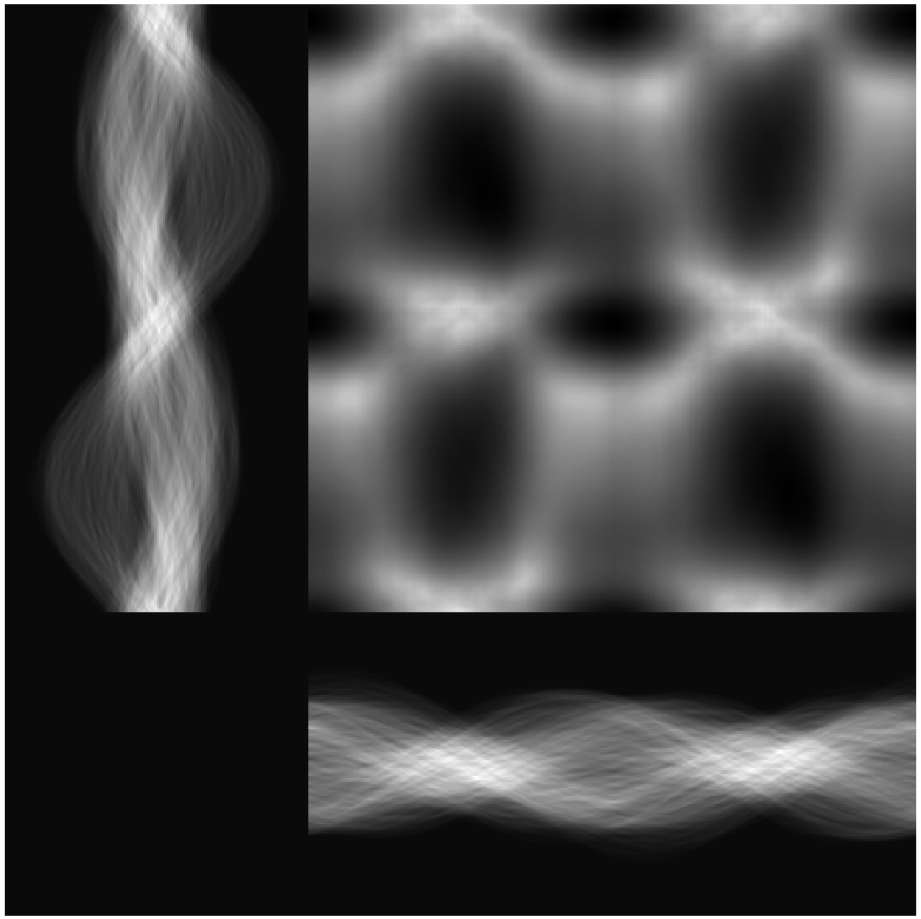
Common Lines

Two projections of the same 3D volume share at least one common line in the Radon transform



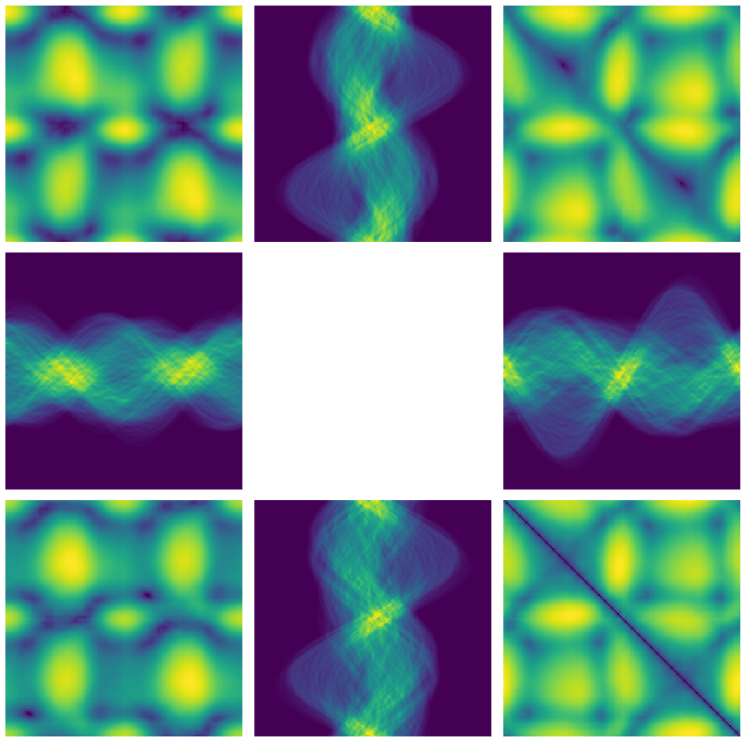


Sinogram Cross Correlation



Detour! Angular recovery from 3 Common lines

Common line gives axis of rotation. Three common lines gives 2 unique solutions for 3D orientation (One mirror of other)



Angular Reconstitution: A Posteriori Assignment of Projection Directions for 3d Reconstruction. Van Heel 1987

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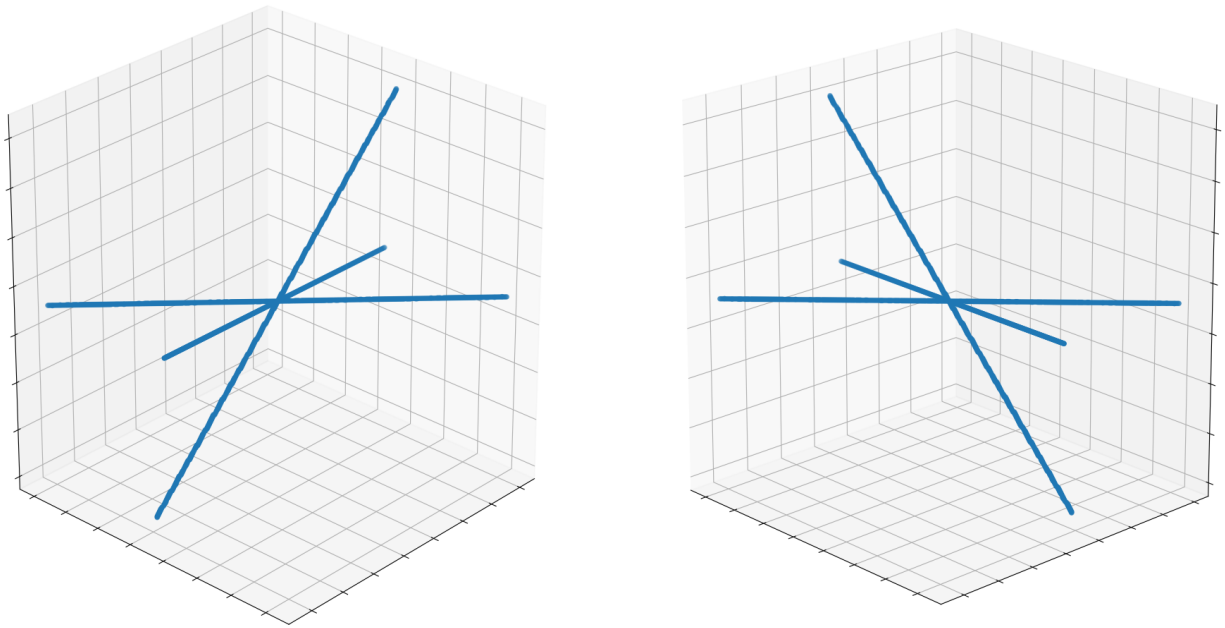

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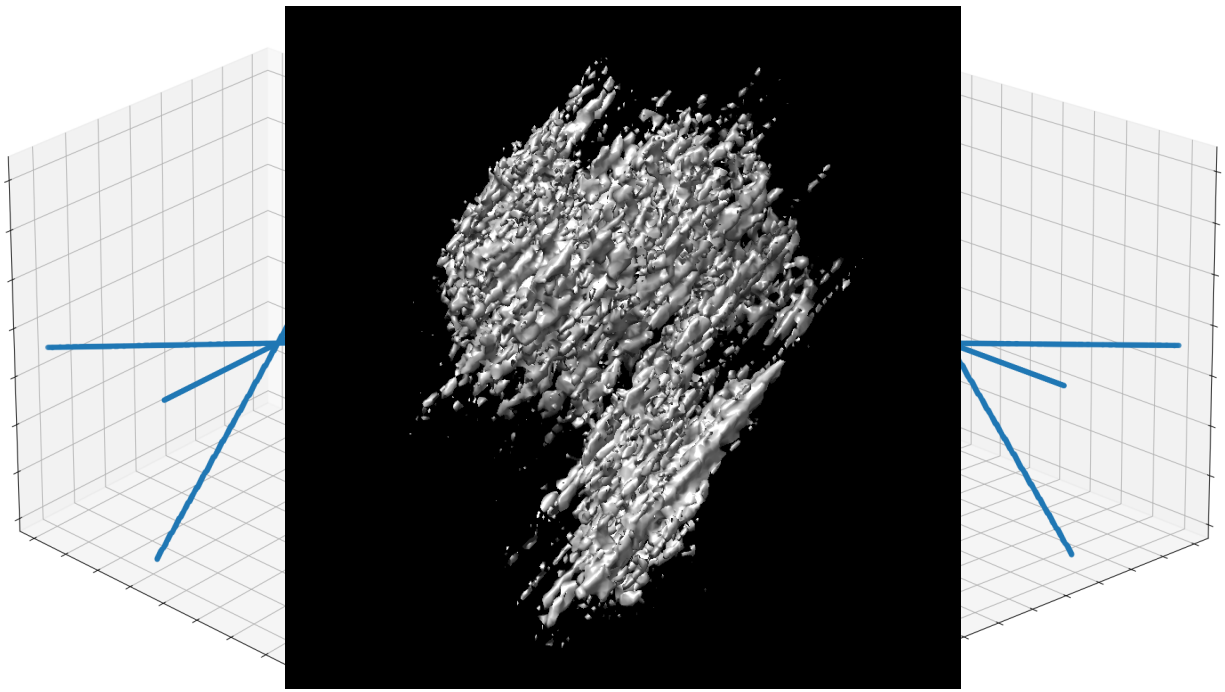

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Finding Common Lines

Challenges

- Noise
- CTF
- Heterogenaity
- Impurities

Raw single lines

Procedure for finding common lines:

- Projections $\rightarrow$ Sinograms
- Sinograms $\rightarrow$ Single Lines
- Find Euclidean Distances
- Smallest Distance = Best Match

Dimensional Reduction

PCA
LLE
Isomap

Comparison between linear and non-linear dimensions

Graph of how lin vs non-lin change for different noise levels and different number of components

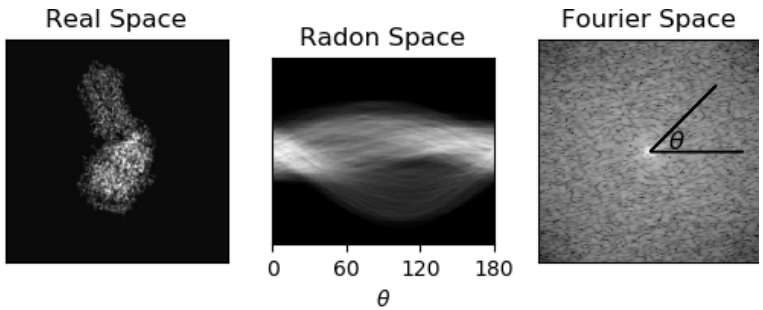
Bonus slide: NN architecture for comparing single lines

Could we use NN to find filters? Number of attempts but nothing stable as yet. Probably leave out as unsuccesful and long to explain - could do a passing mention

Reconstruction

Eigenvector Relaxation

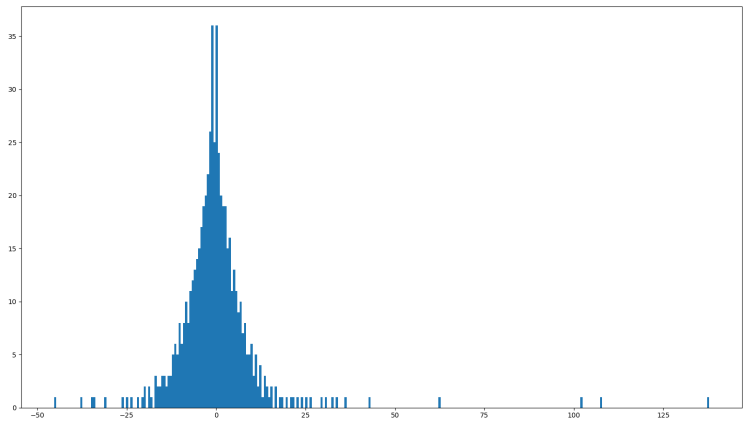
Aim: Given all common lines c for projections P, assign Rotation matrices R for each P to give greatest consensus volume.



$$cij = (cos(\theta_{ij}), sin(\theta_{ij}), 0), \quad cji = (cos(\theta_{ji}), sin(\theta_{ji}), 0) \qquad (1)$$

$$max \sum_{i \neq j} R_i c_{ij} \cdot R_j c_{ji} \qquad (2)$$

Maths*! Make large $(2N \times 2N)$ symmetric matrix S. Can recover R for each P from top 3 eigenvectors of S that maximise (2)!



*Three Dimensional Structure Determination from Common Lines in Cryo-EM by Eigenvectors and Semidefinite Programming. A.Singer and Y.Shkolnisky

Models!

Lots of models!

Computational efficiency

only calculating 95% of correct lines make others random. 6x speed increase. Parrallelisation needed! Show that adding random lines does not affect recon too much..

Priming matrix with tilt data! - Not done yet

With tilt data we know the tilt axis (and angle but this is not important) Can calculate what common single line would be for this data would be. can input straight into matrix

Clustering - Not done yet

Can heterogenaity be sorted by looking at common lines?

A

- Lorem Ipsum
- Dolor est
- Example incoming
- Example arrived

B

- Sometimes its hard to make up random content
- Othertimes not
- Filler words
- And filler phrases that are ever so slightly longer

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