Bad Fusion

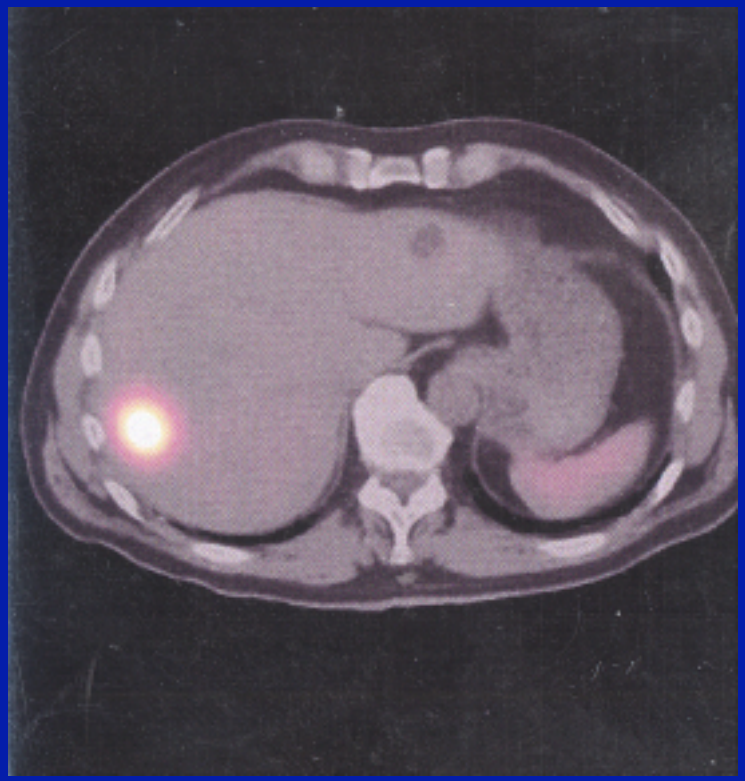
(counting the cost)

Erin McKay

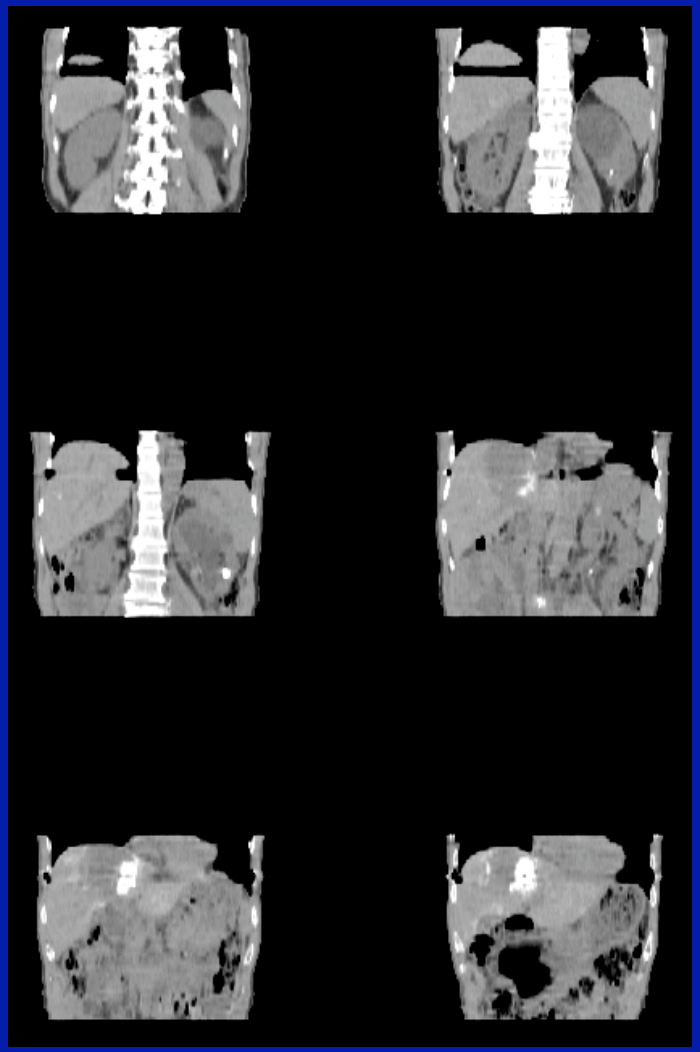
St. George Hospital

Sydney, Australia

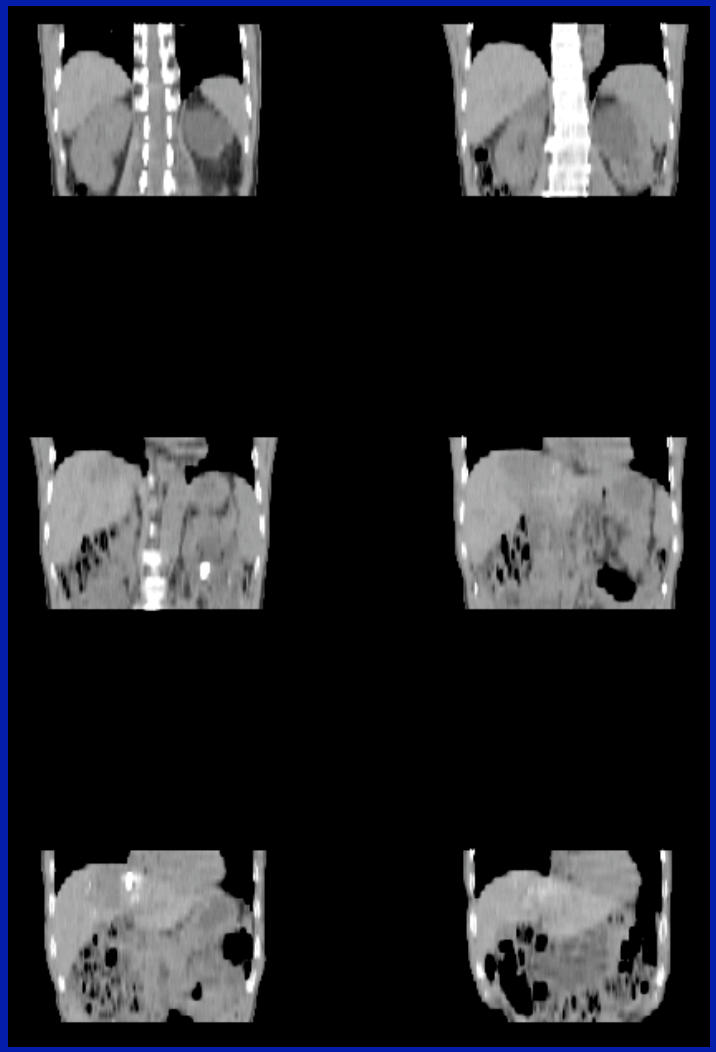
Isn’t technology wonderful?



Physiological Motion (breathing)



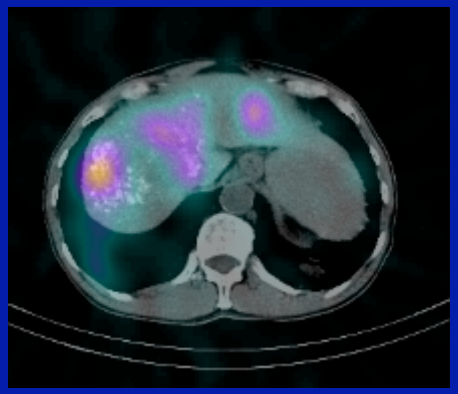
Free breathing



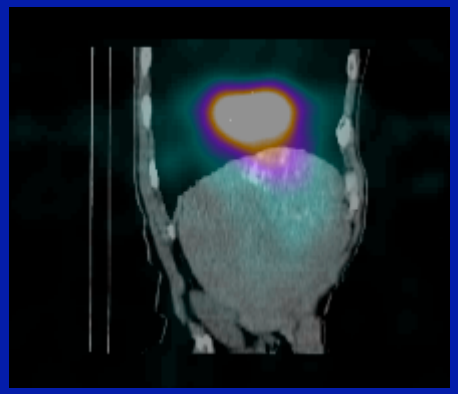
Breath hold

Hardware Fusion

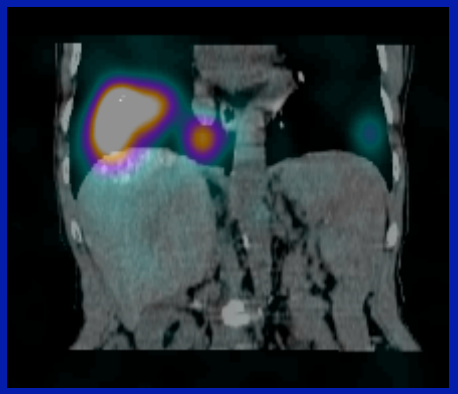
Fully inspired breath-hold



Transverse



Sagittal

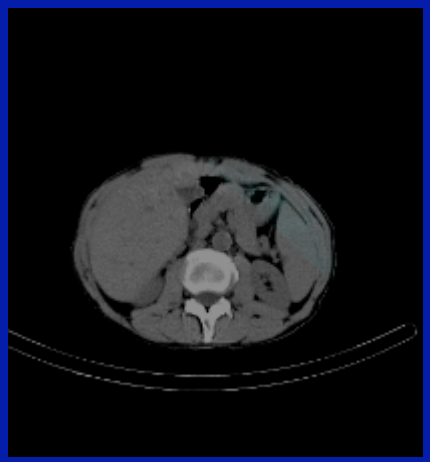


Coronal

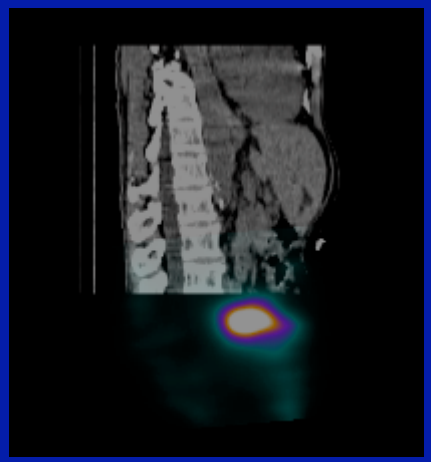
Rotation Z 0 Rotation X 0 Rotation Y 0

Translation (mm): X 0 Y 0 Z 0

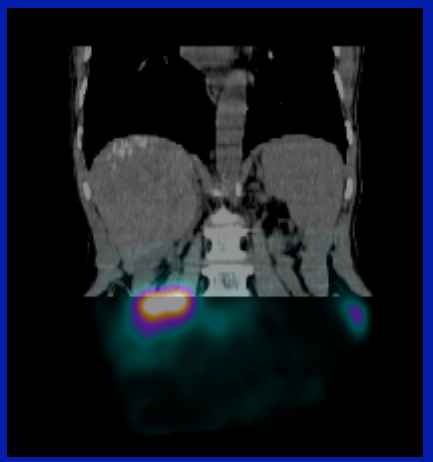
Software Fusion



Transverse



Sagittal

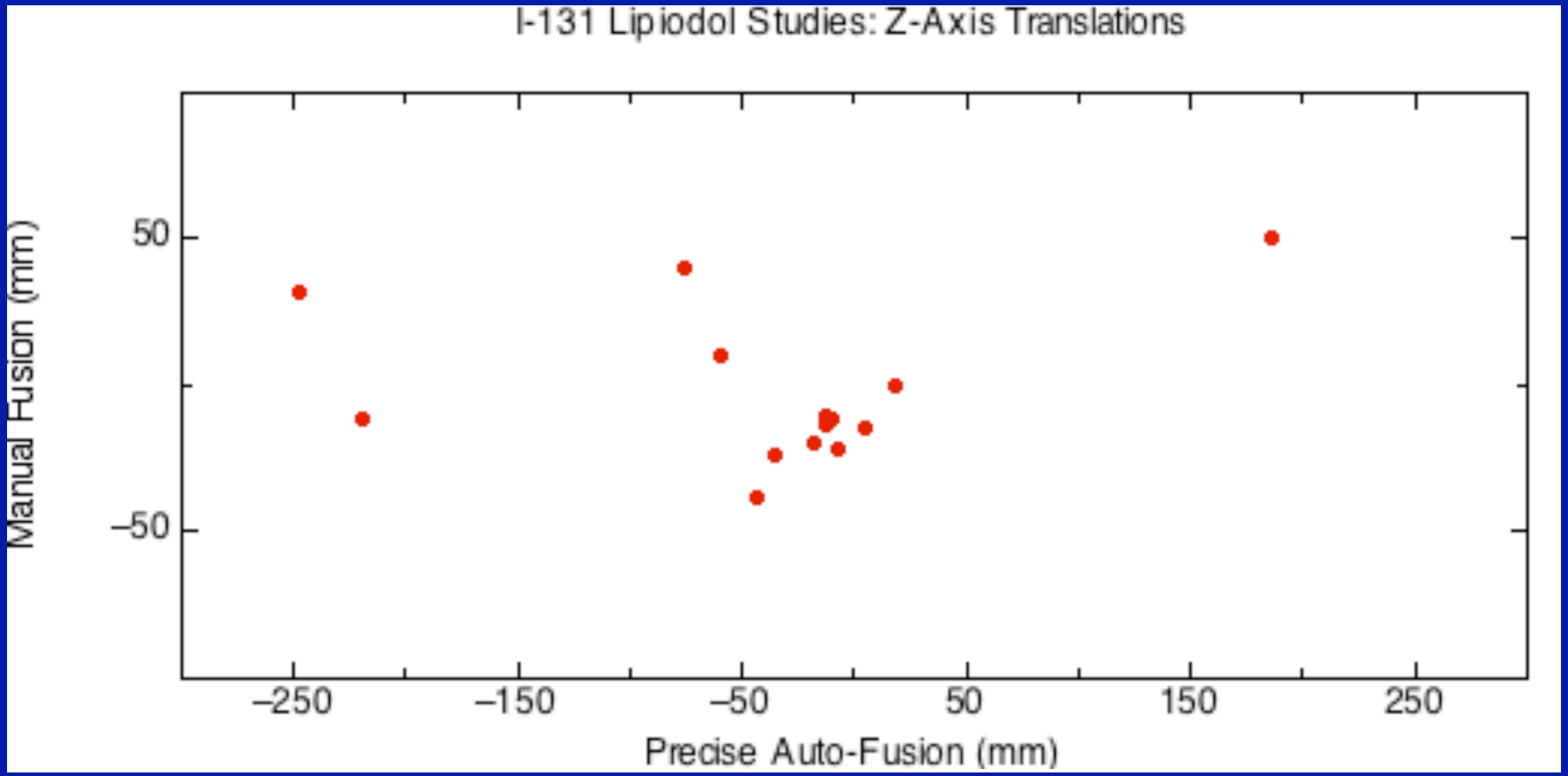


Coronal

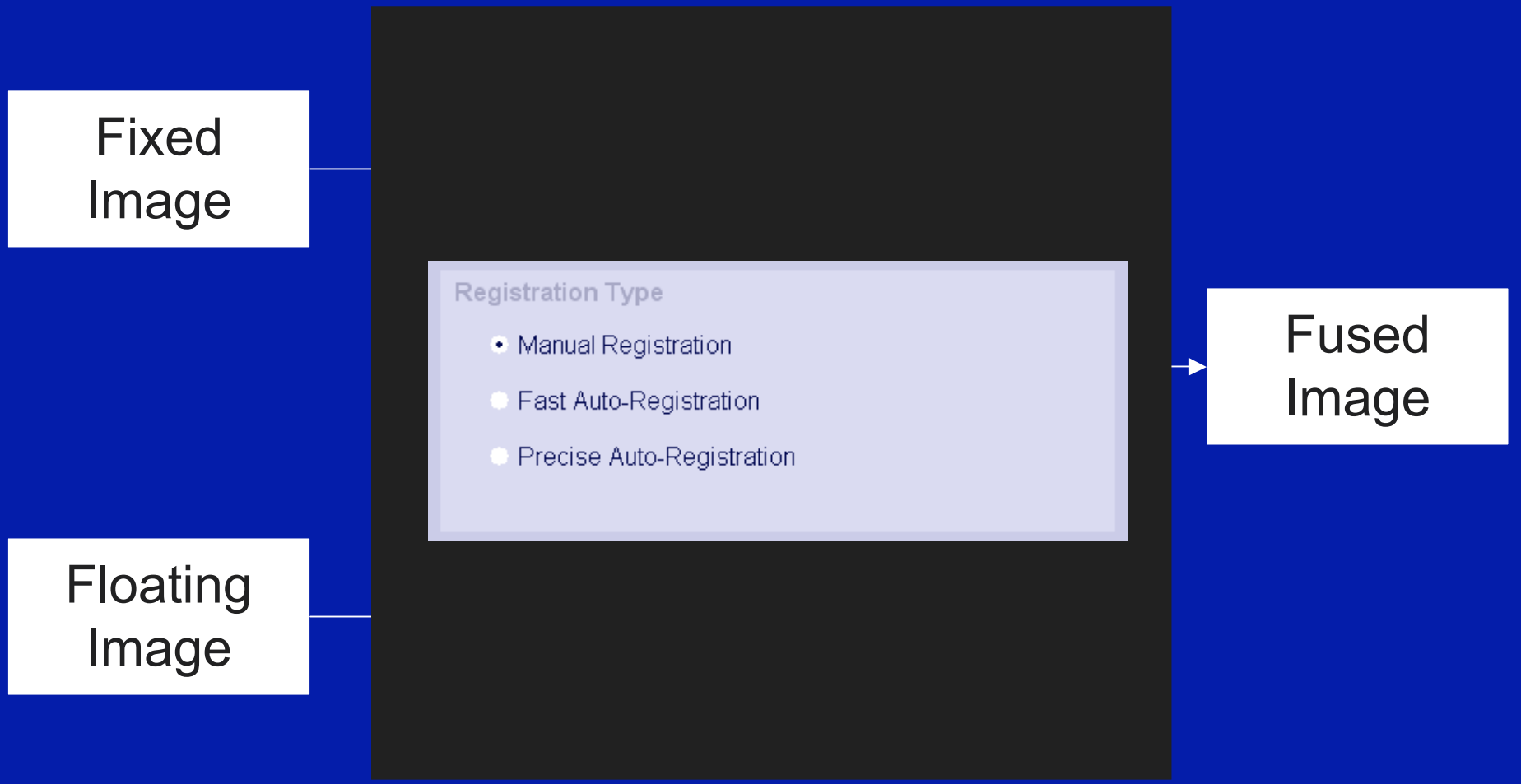
Rotation Z 13.5721 | Rotation X -5.8664 | Rotation Y -3.3636

Translation (mm): X 25.7761 Y -1.09608 Z -182.512

Lipiodol: Z-Axis Translation



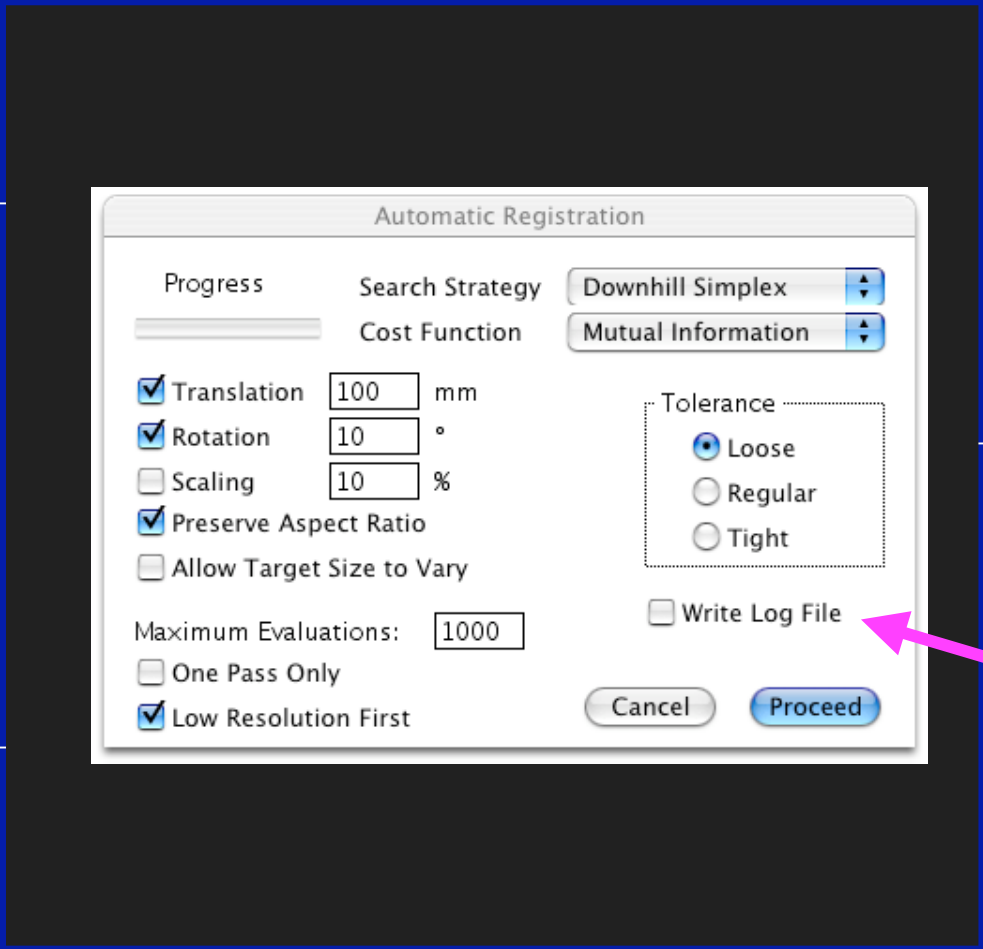
A Proprietary Algorithm



Another Proprietary Algorithm

Fixed Image

Floating Image



Registered Image

Innovation!

Can’t you just make it work?

- How is it supposed to work?
- Assessing the search strategy
- Assessing the cost function
- Assessing the consequences
- An image fusion framework

NB: the open-source IDL ‘fusion’ package developed for this work is available from the ANZSNM IDL SIG web site (www.anzsnm.org.au).

Assessing the consequences

- Attenuation correction
- Localisation
- Quantitative image analysis

This is a large topic and outcome is highly dependent on the specifics of a situation

Simulation may provide answers for many of these questions. Therefore need scriptable tools.

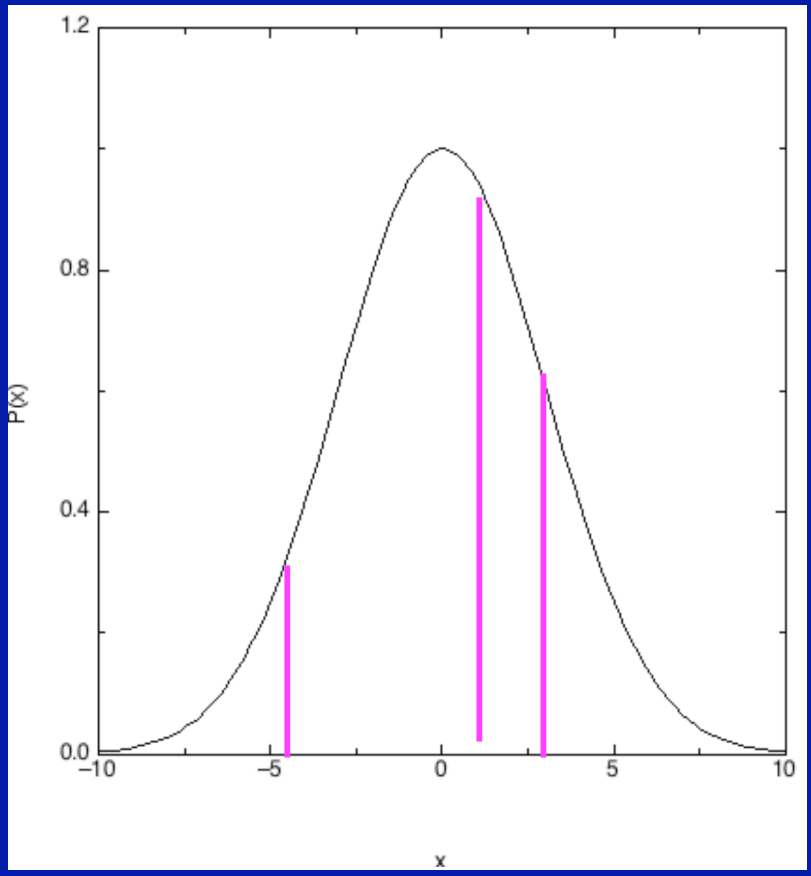
Measure Dispersion of Parameters

- Start with best guess
- Modify parameter vector
- Ask “Is it still OK?”
- Compute dispersion of “OK” values

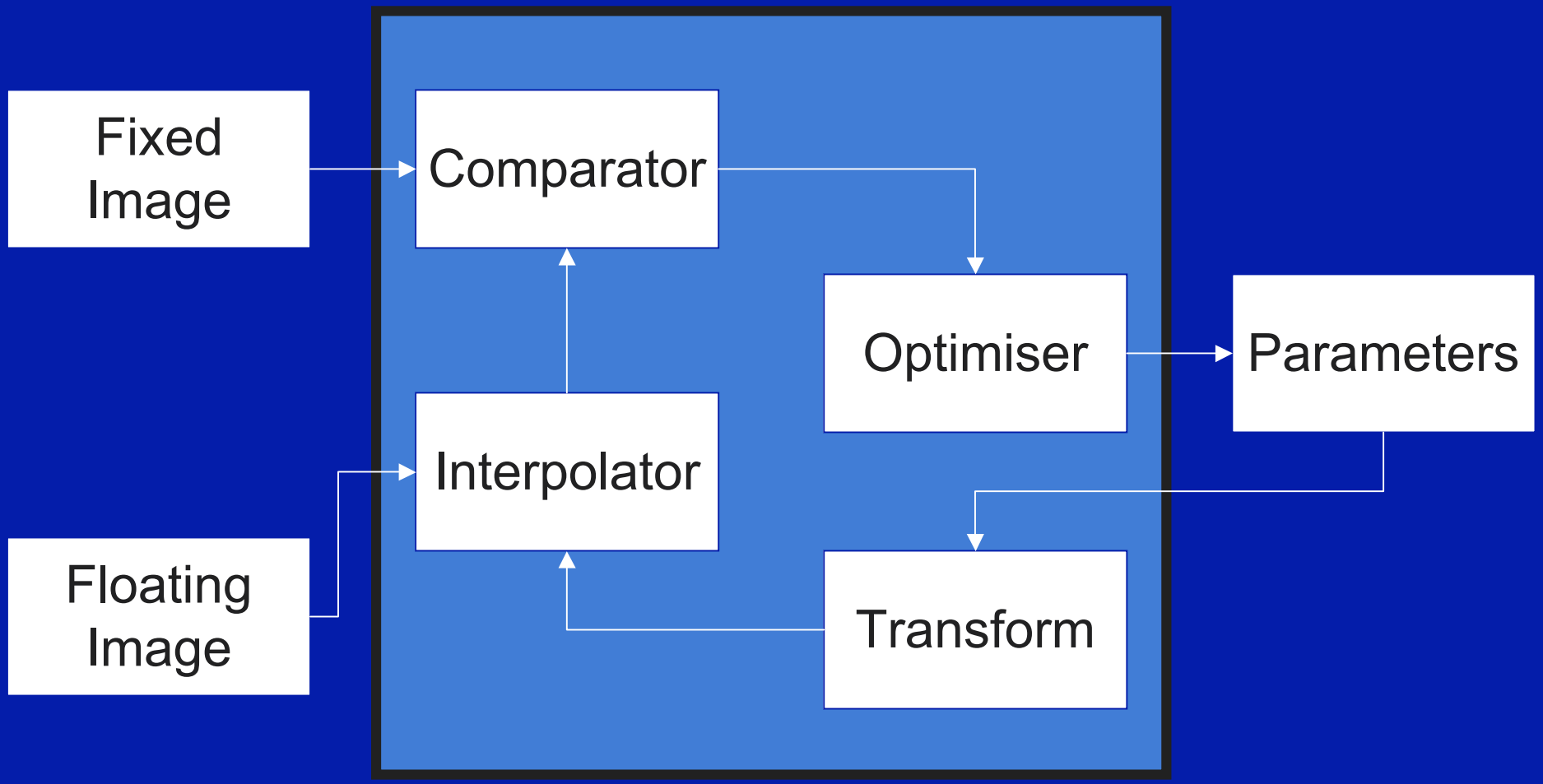
- Or do manual registration many times

Evaluate Impact of Dispersion

- Automate generation of report value (eg. MBq/cc in ROI)
- Take lots of samples from P(x)
- Generate report
- Calculate mean & SD for report

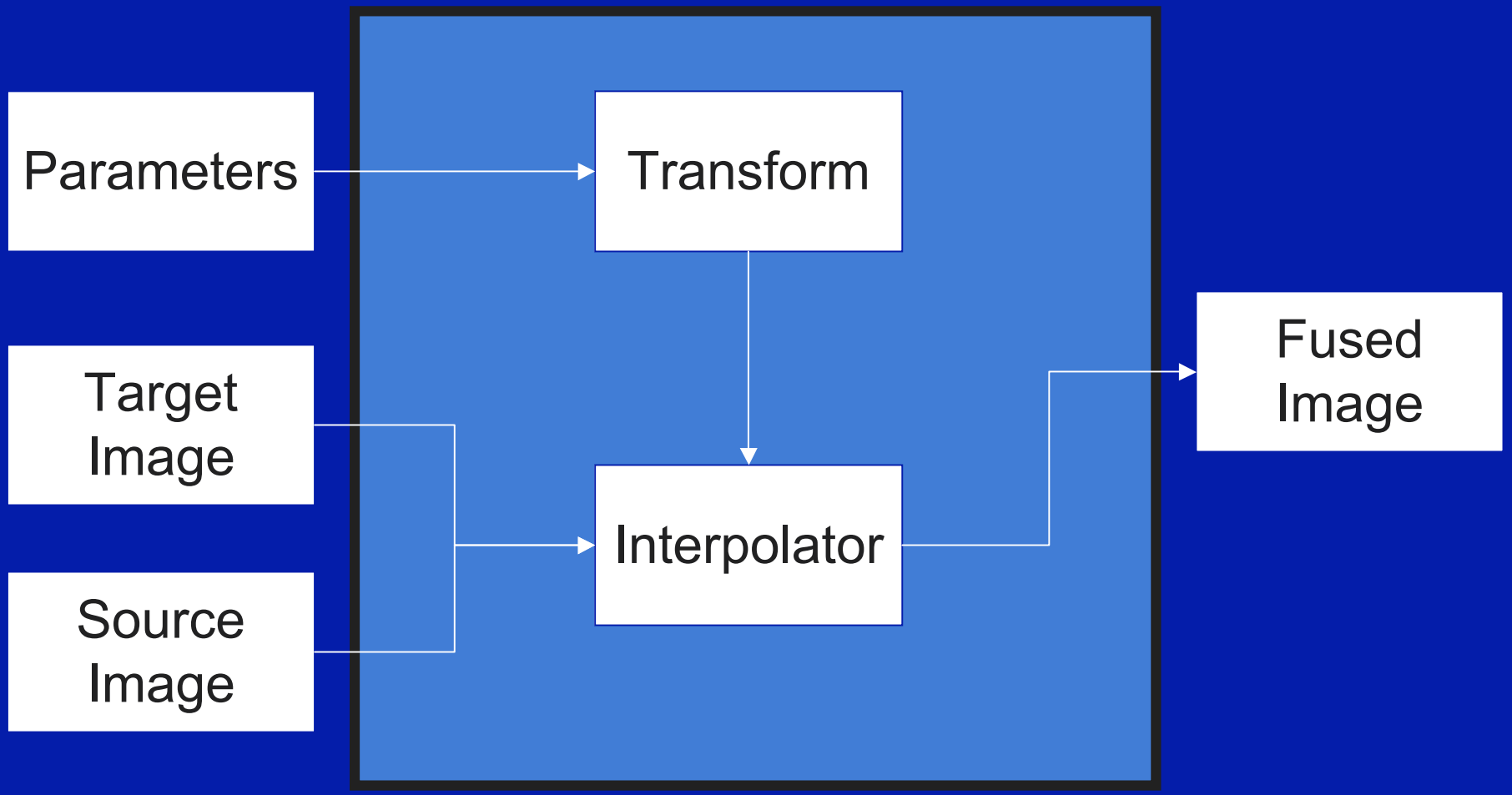


Two Easy Pieces #1: Registration



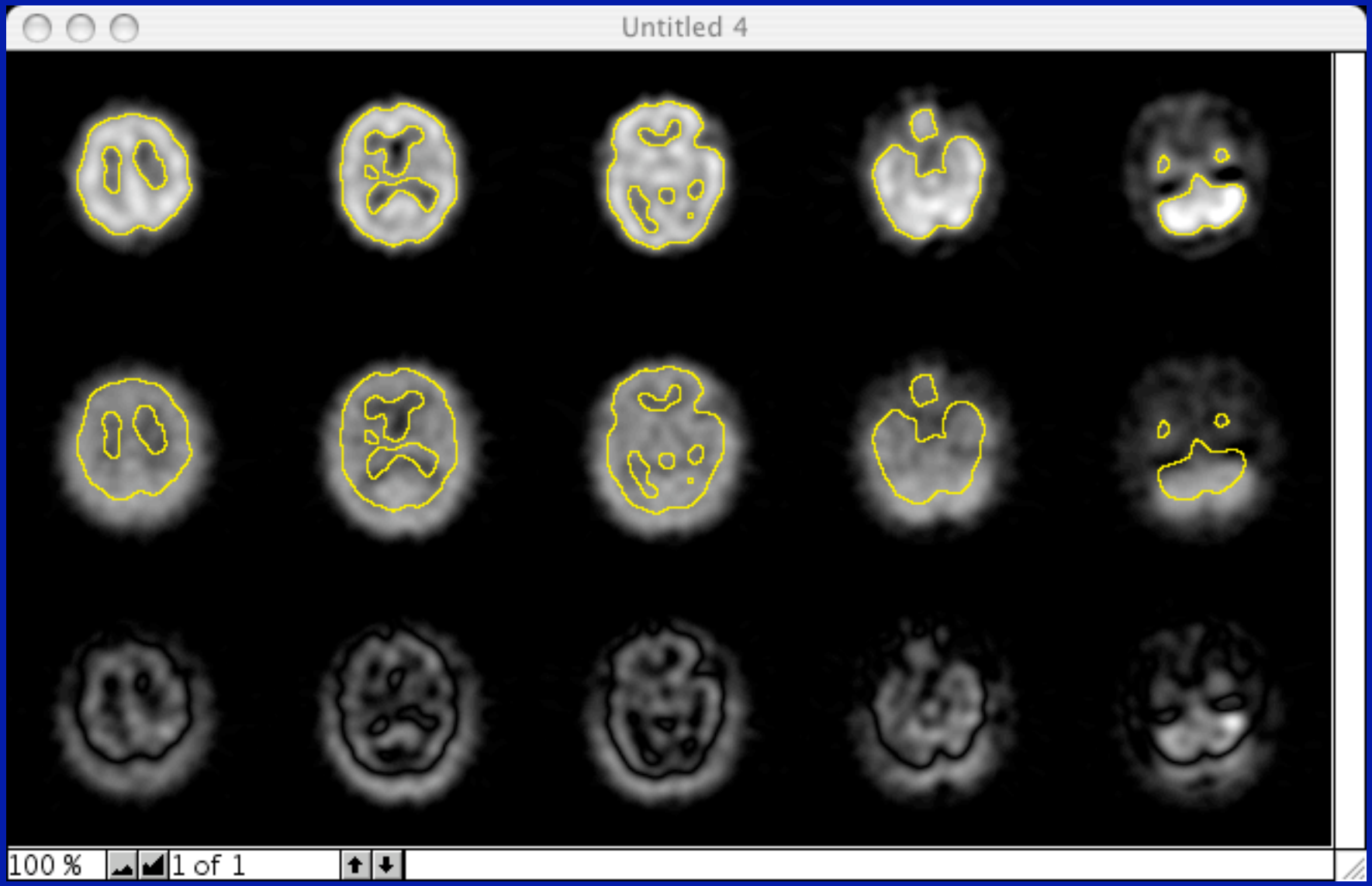

```
PRO AlignVolumes, fixedArray, fixedFrame,  floatArray,  floatFrame, parameters,  $
        optimiser=optimiser, transform=transform,  comparator=comparator, logfile=logfile
```

Two Easy Pieces #2: Resampling



FUNCTION MergeVolumes, fixedArray, fixedFrame, floatArray, floatFrame, parameters, $
transform=transform, reverse=reverse

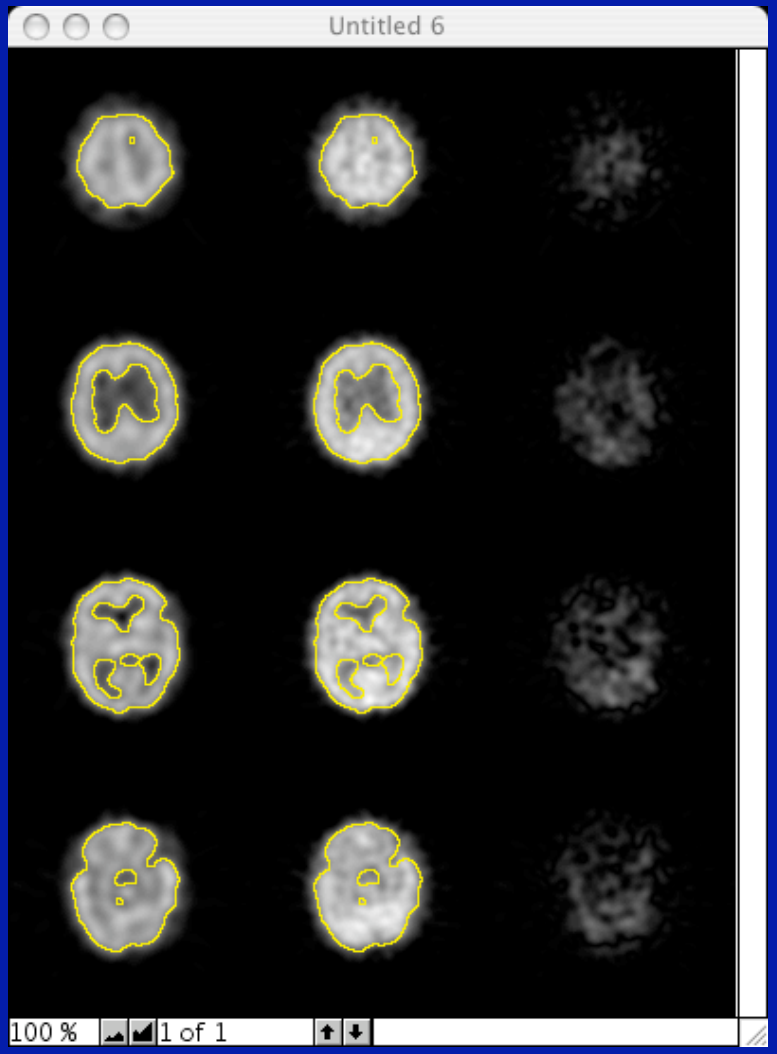
Toy Problem

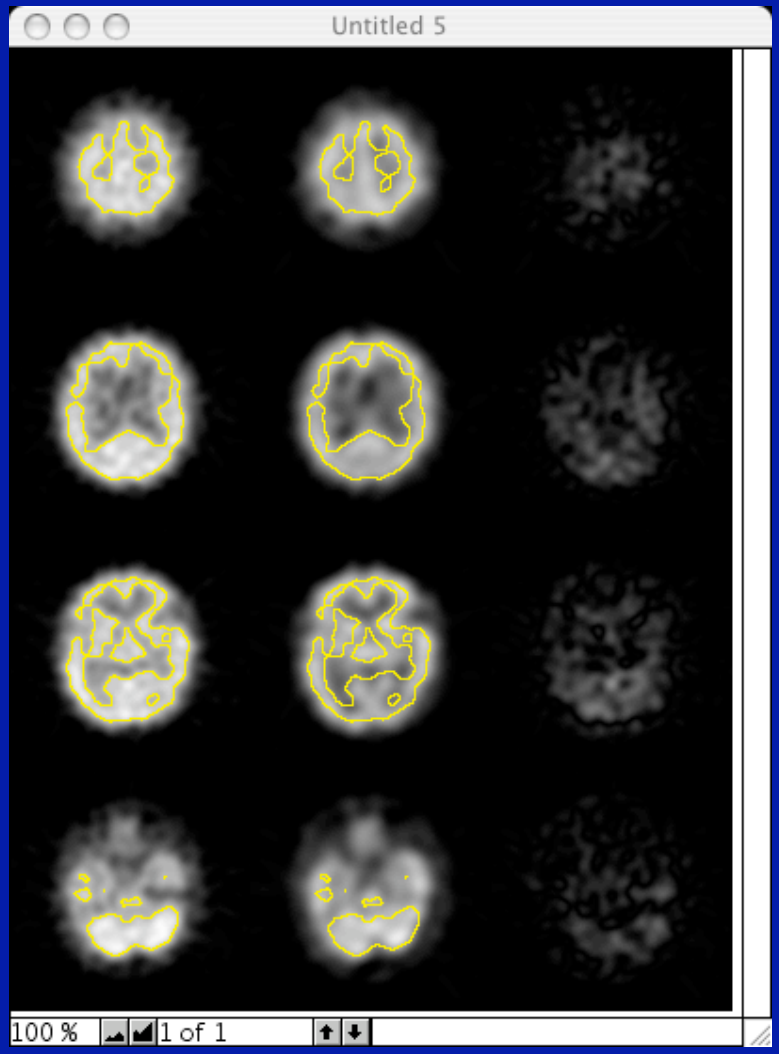


Toy Solution: Scaling

	X	Y	Z
Scaling (%)	-22.4	-18.5	-3.9
Rotation (°)	0.0	0.0	-4.0
Translation (mm)	-4.0	-13.8	0.5

Toy Solution: Resampling



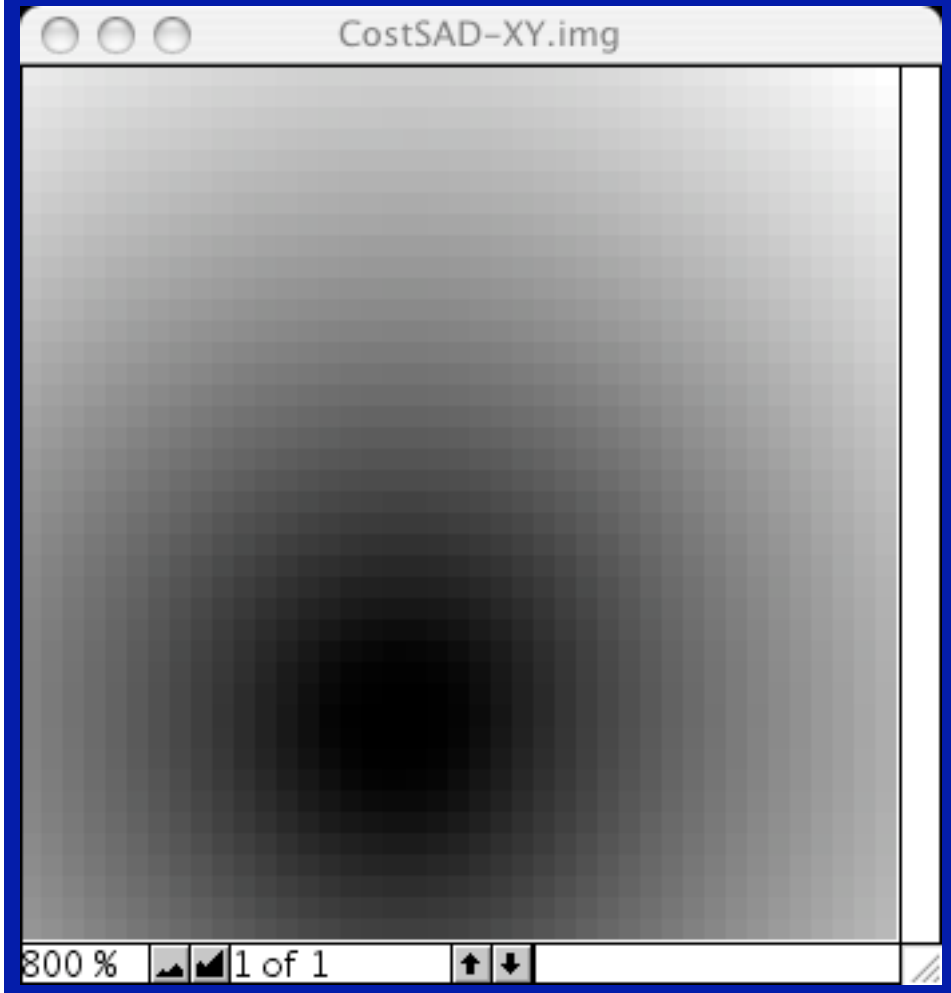


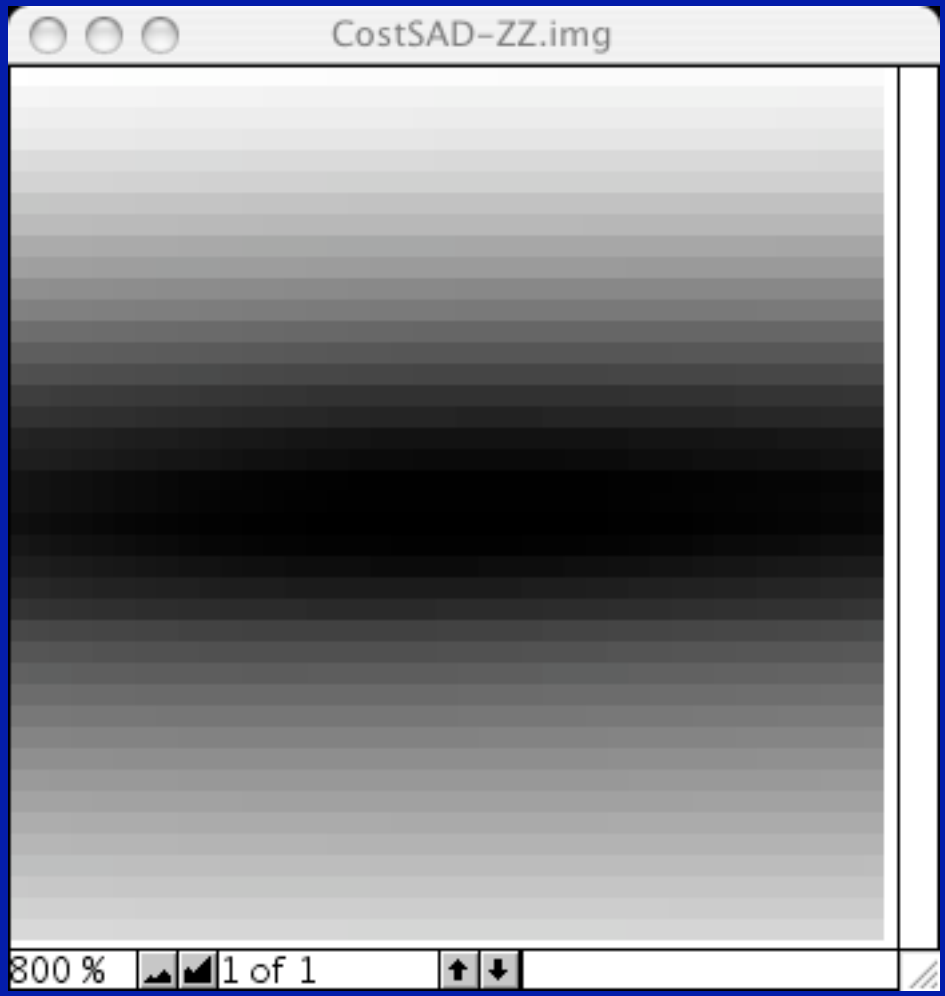
Assessing Cost Functions

- Smoothness of parameter space?
- Number of local minima?
- Computational cost?
- Multi-modality?

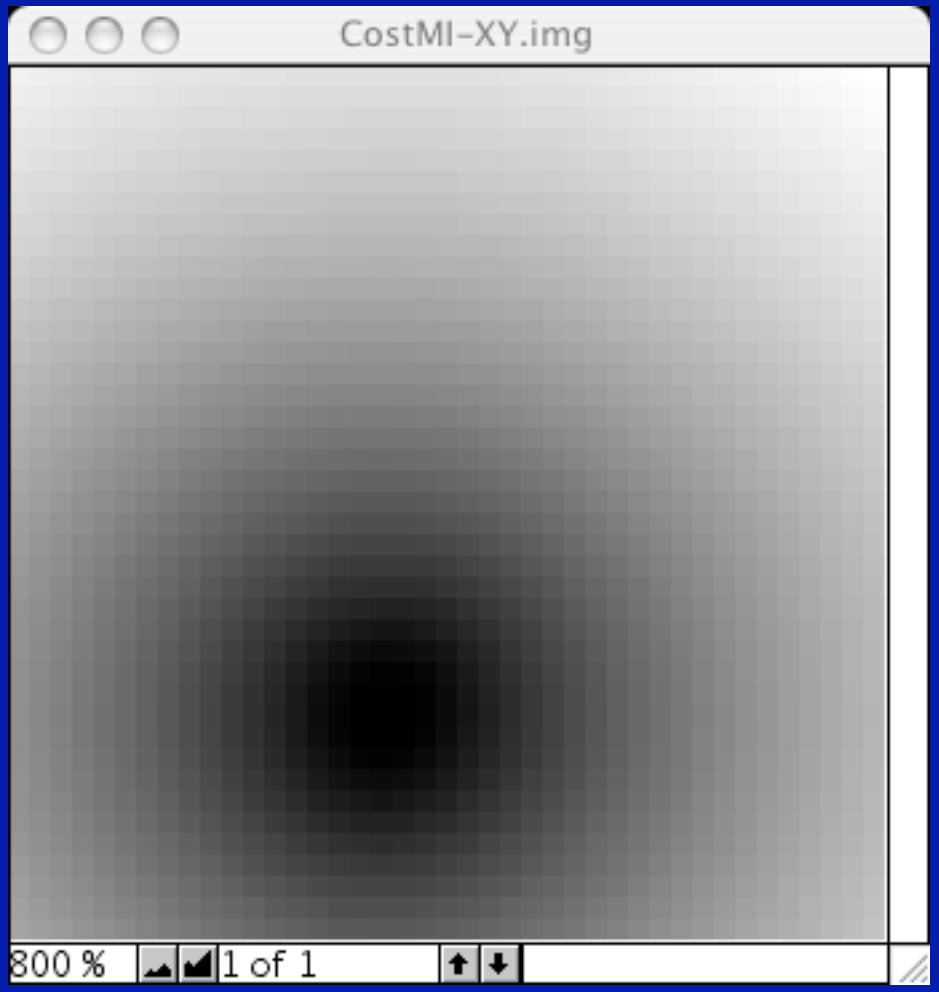
- Sum of Absolute Differences
- Mutual Information

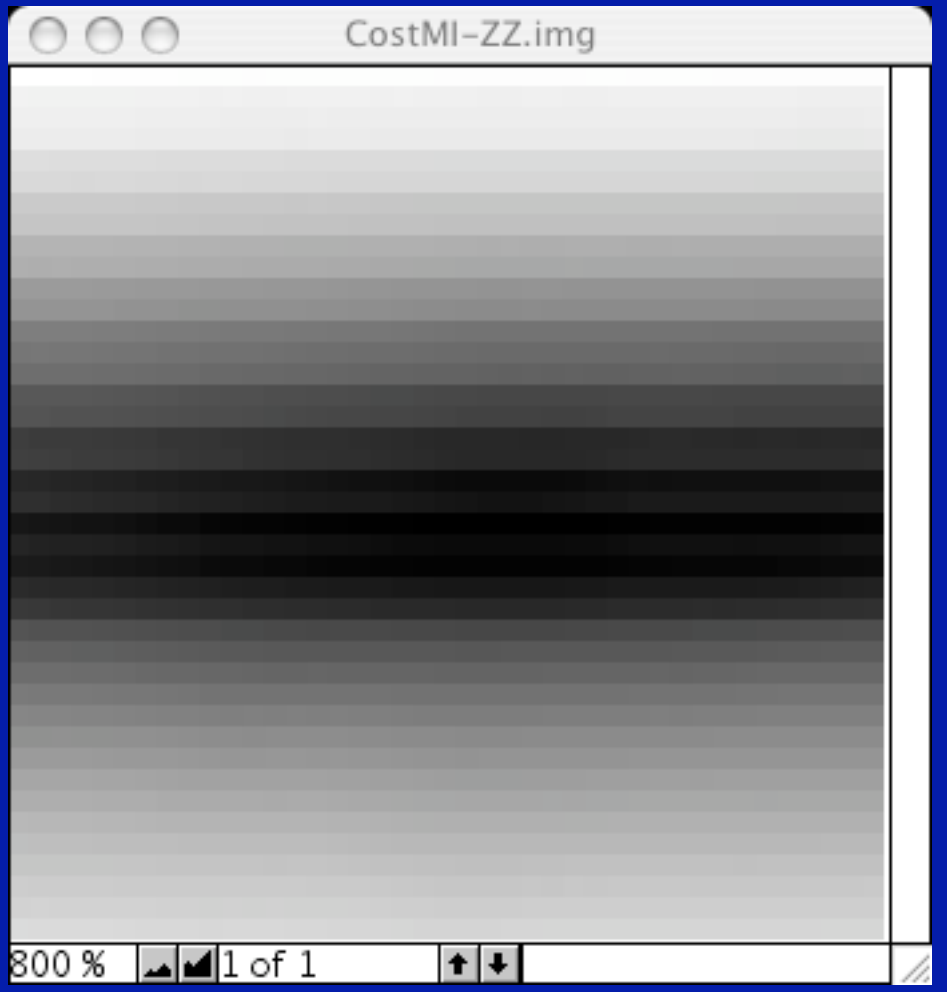
Cost Landscapes: SAD





Cost Landscapes: MI



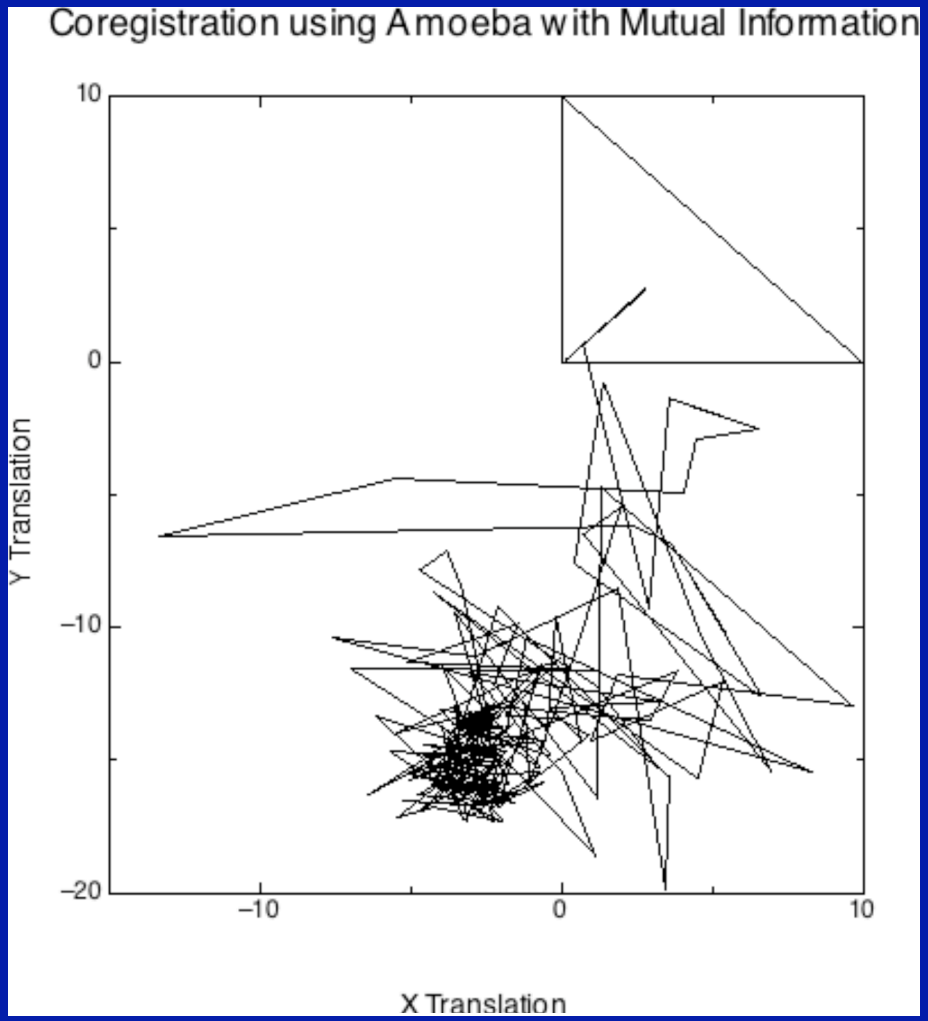


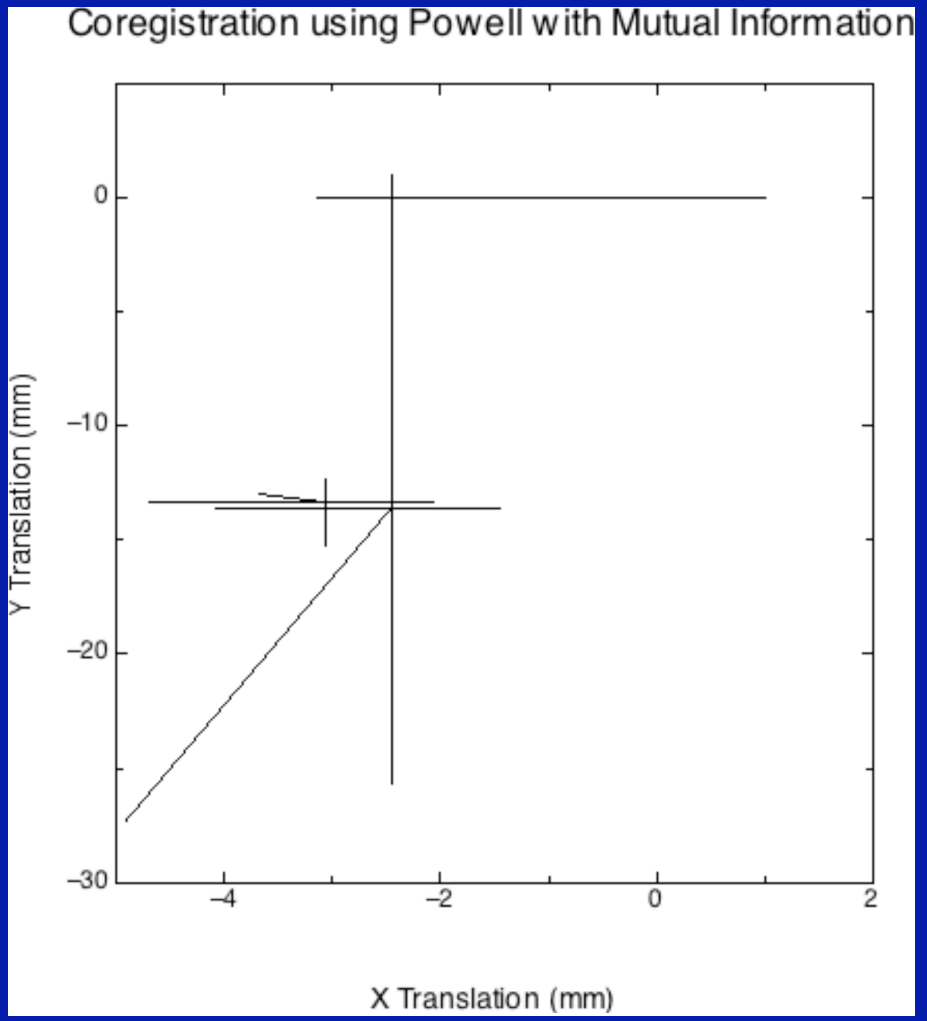
Assessing Optimisers

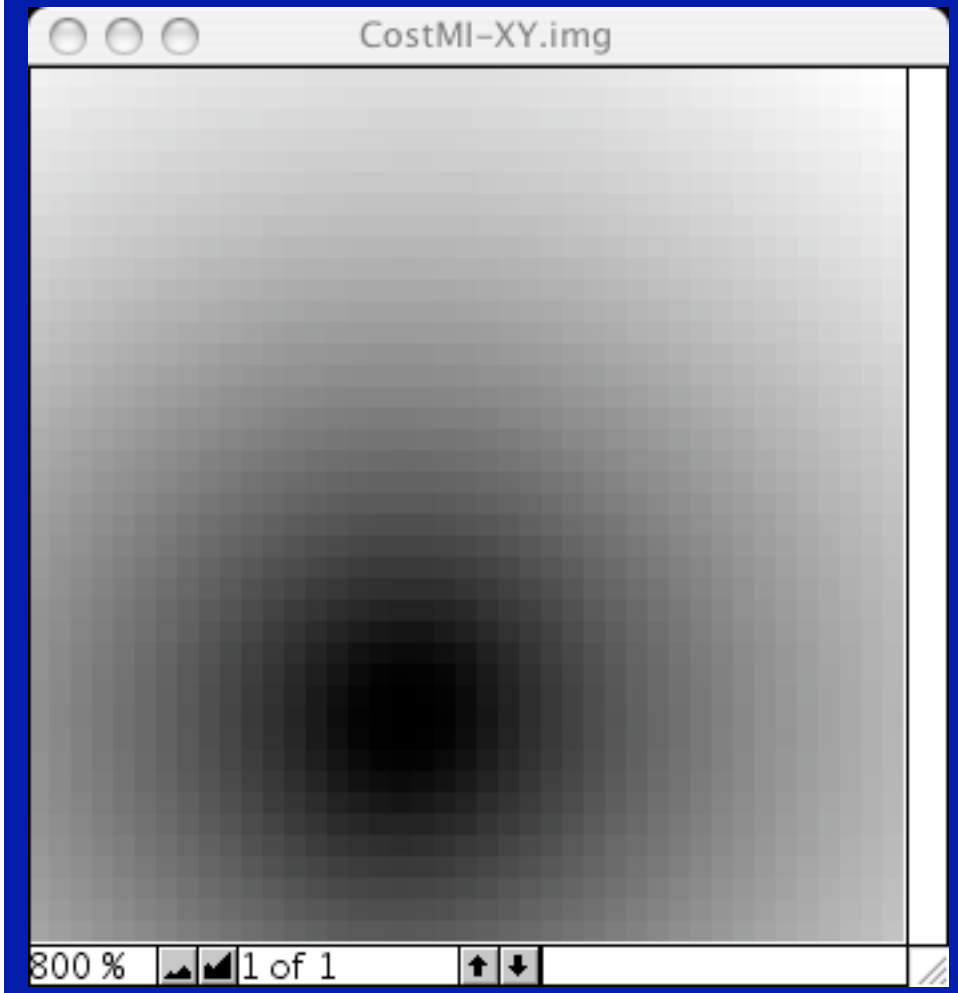
- Speed of convergence?
- Require gradients?
- Deterministic?

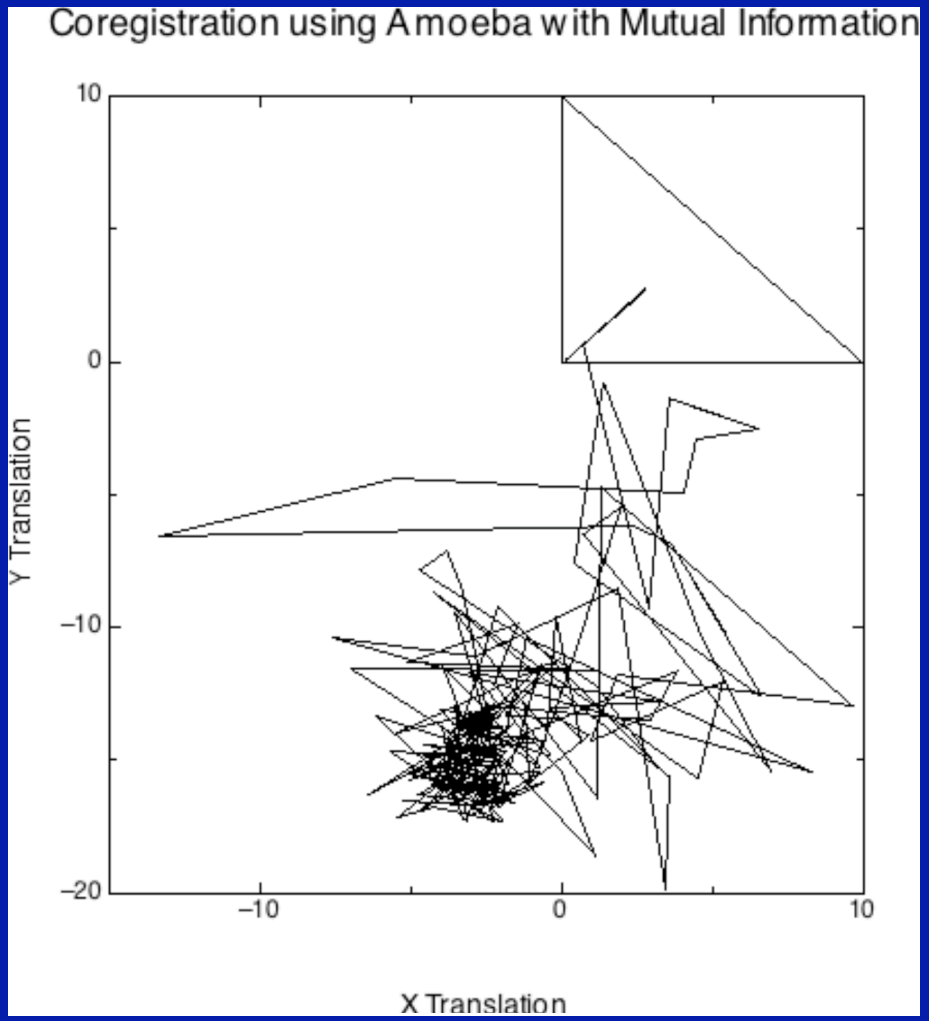
- Downhill Simplex (Amoeba)
- Powell's Method

X & Y Translation

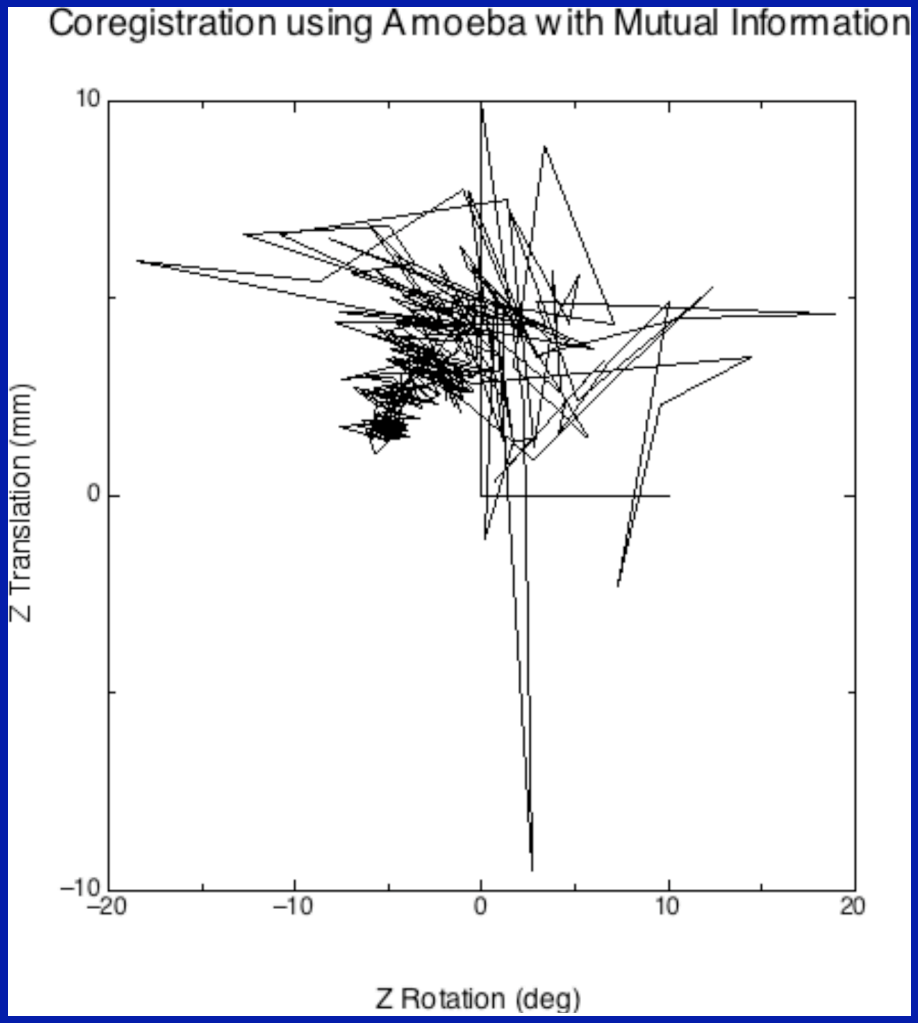


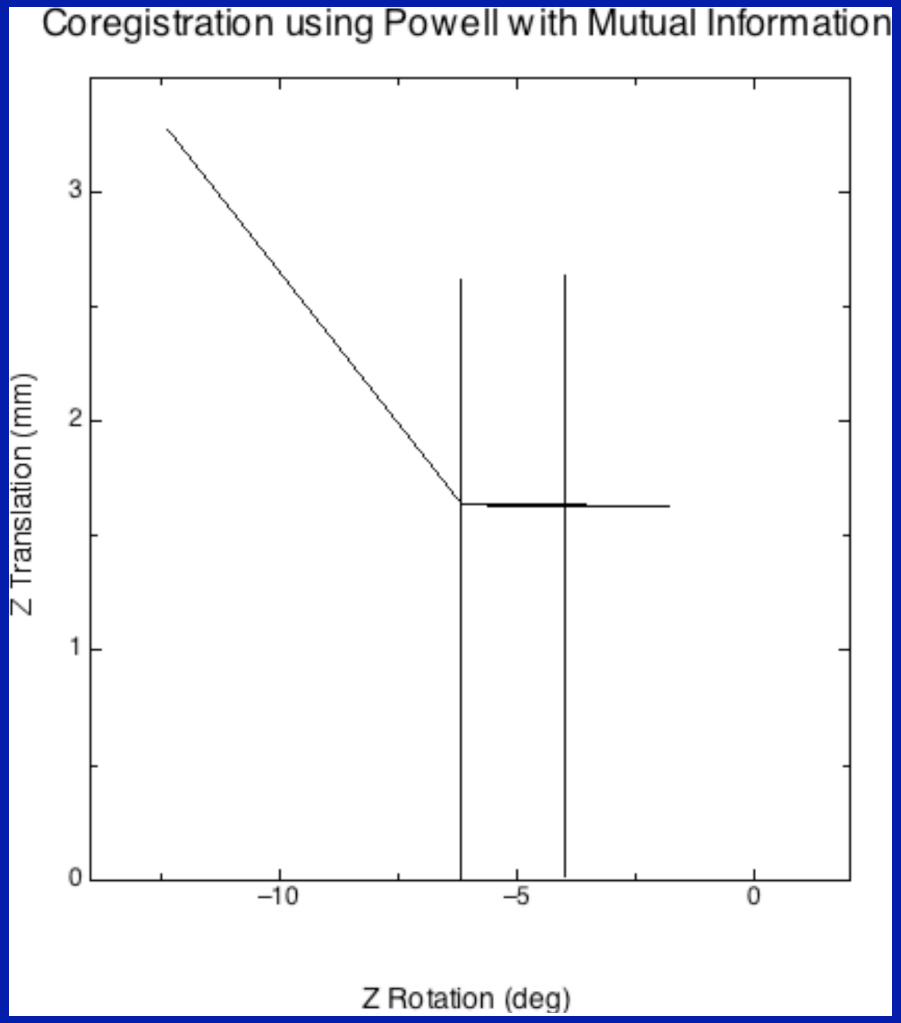


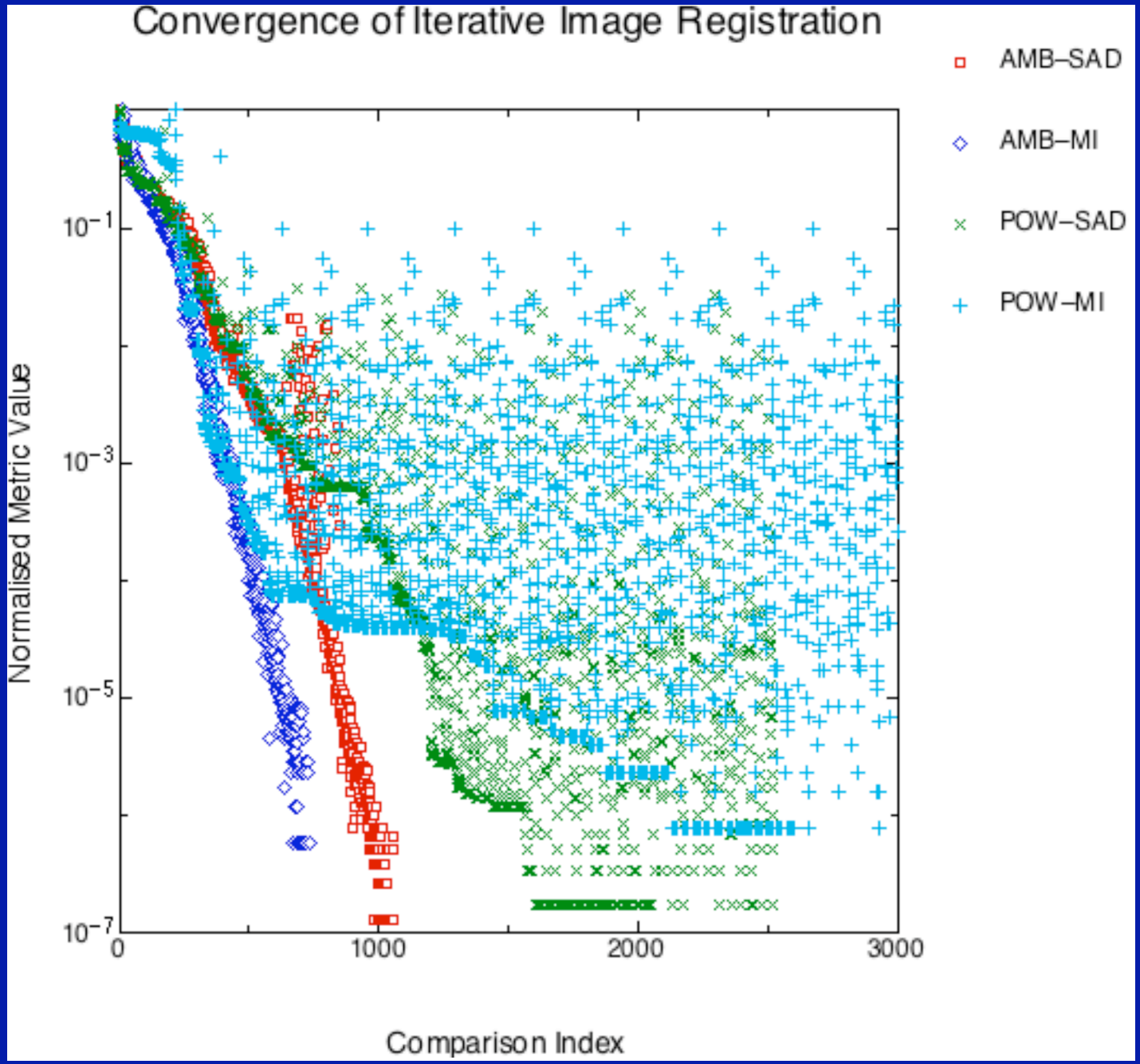

CostMI-XY.img
800 %
1 of 1


Coregistration using Amoeba with Mutual Information
Y Translation
X Translation
10
0
−10
−20
−10
0
10

Z Translation & Rotation






Convergence of Iterative Image Registration
AMB–SAD
AMB–MI
POW–SAD
POW–MI
Normalised Metric Value
10^{-1}
10^{-3}
10^{-5}
10^{-7}
0
1000
2000
3000
Comparison Index

Final Thoughts

- SPECT/CT fusion may not be 100% reliable.
- Final arbiter of quality is visual inspection.
- Patient set-up and scanning procedures have a big impact on hardware registration.
- Careful adjustment of parameters can make a considerable difference to software fusion quality.
- Separating image alignment and merging tasks offers many practical advantages.

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