SOME AI IN MEDICAL IMAGING

PRESENTED TO CS886

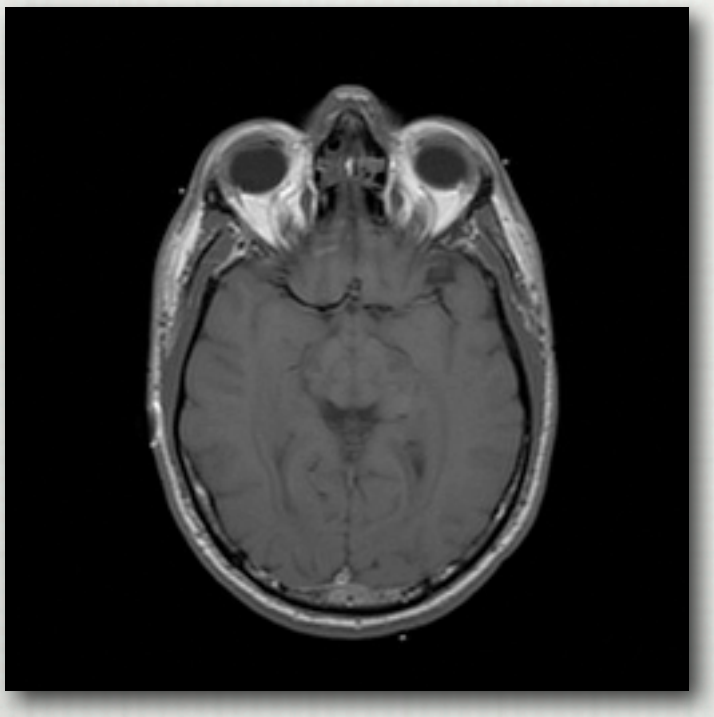
Jeff Orchard

David R. Cheriton School of Computer Science

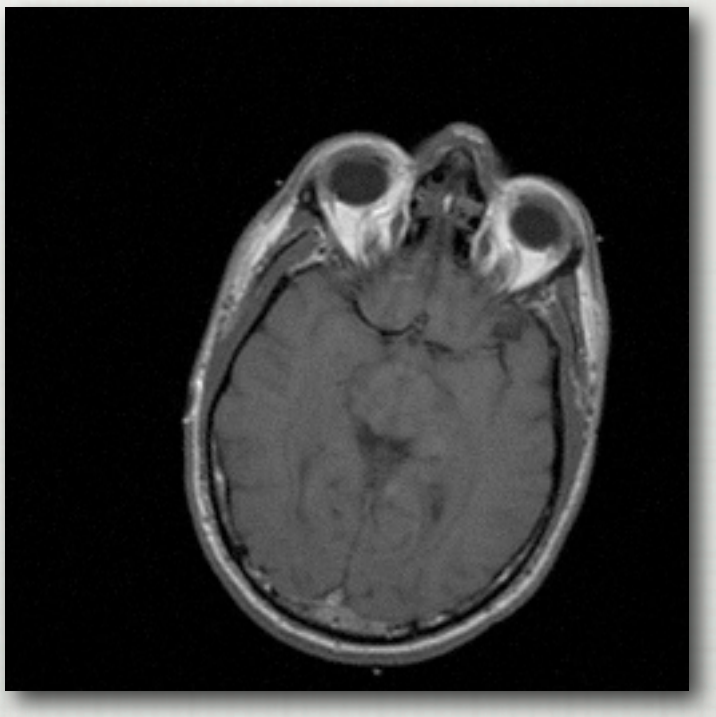
University of Waterloo

REGISTRATION

SCAN 1



SCAN 2

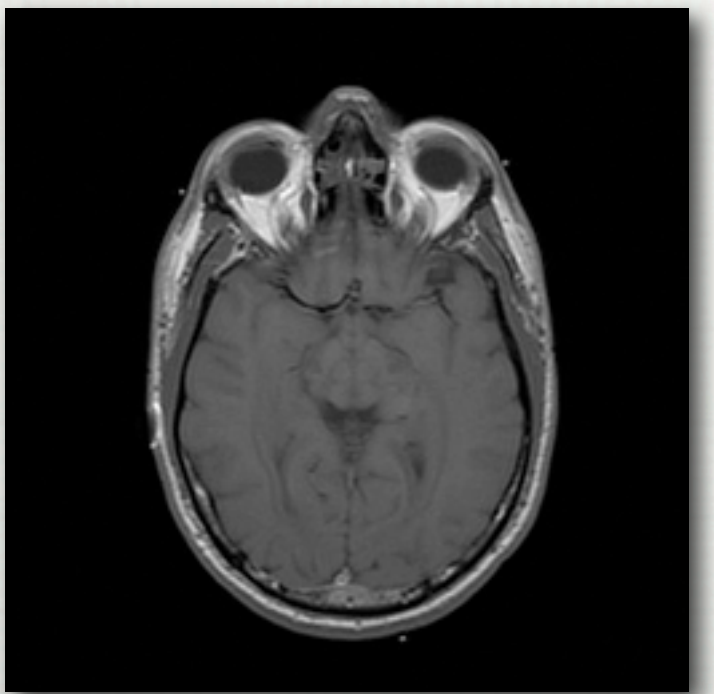


REGISTRATION

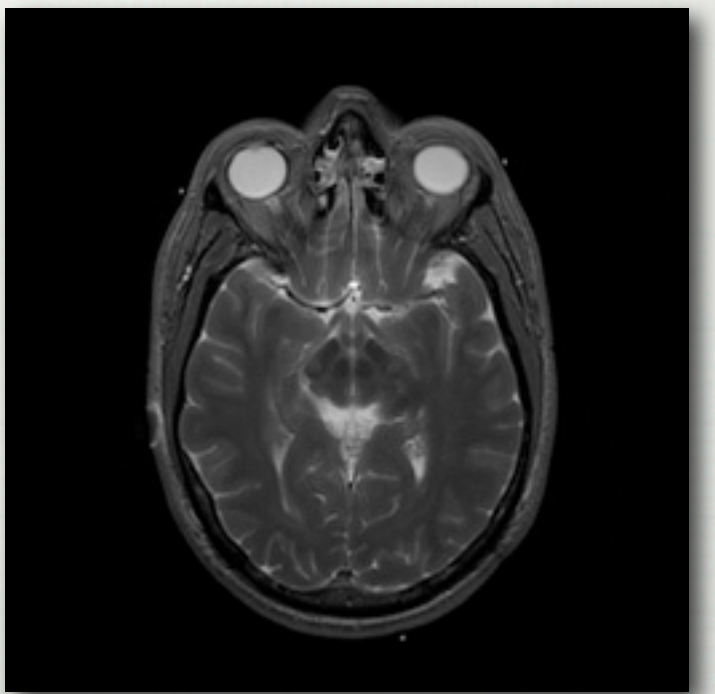
REGISTRATION

REGISTRATION

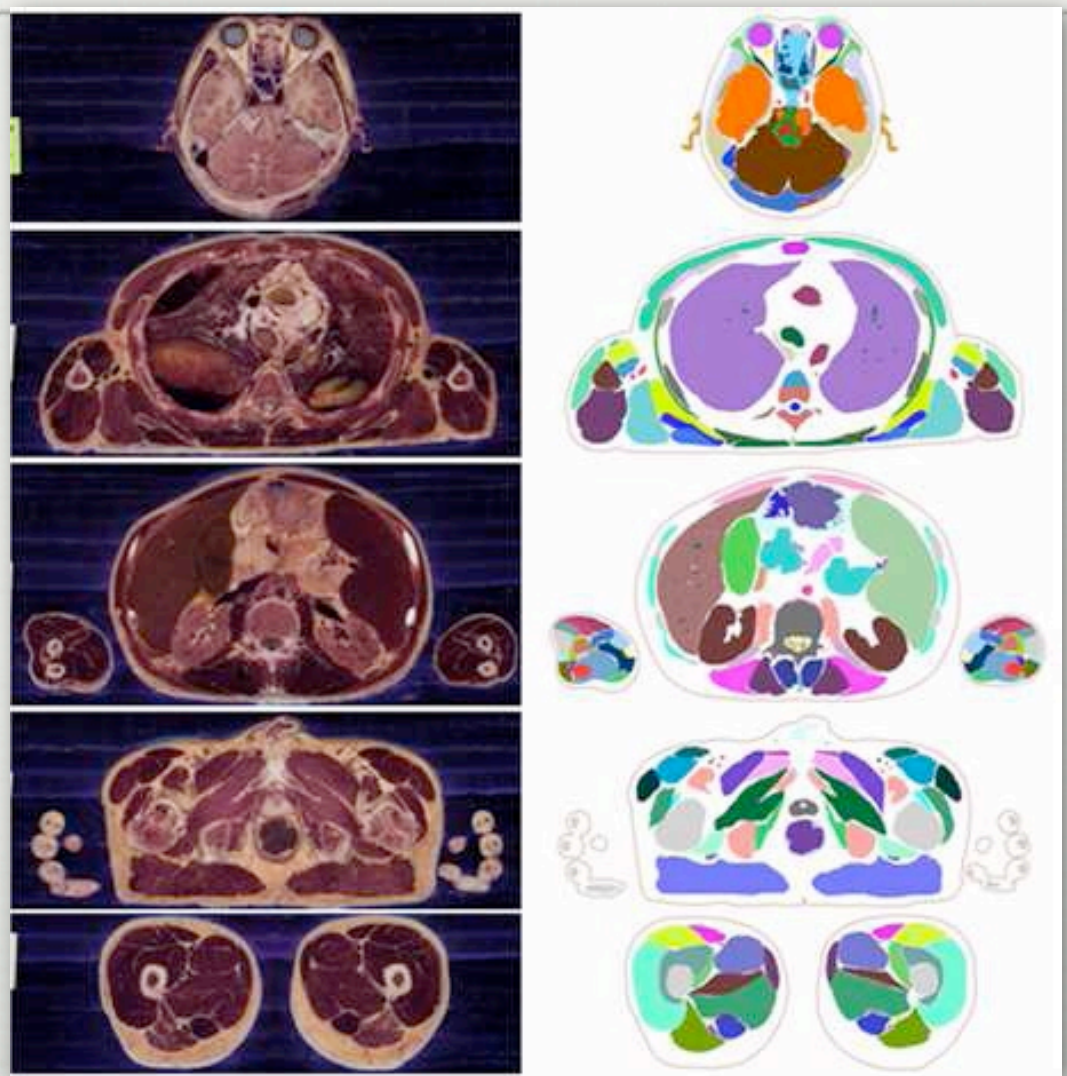
T1



T2

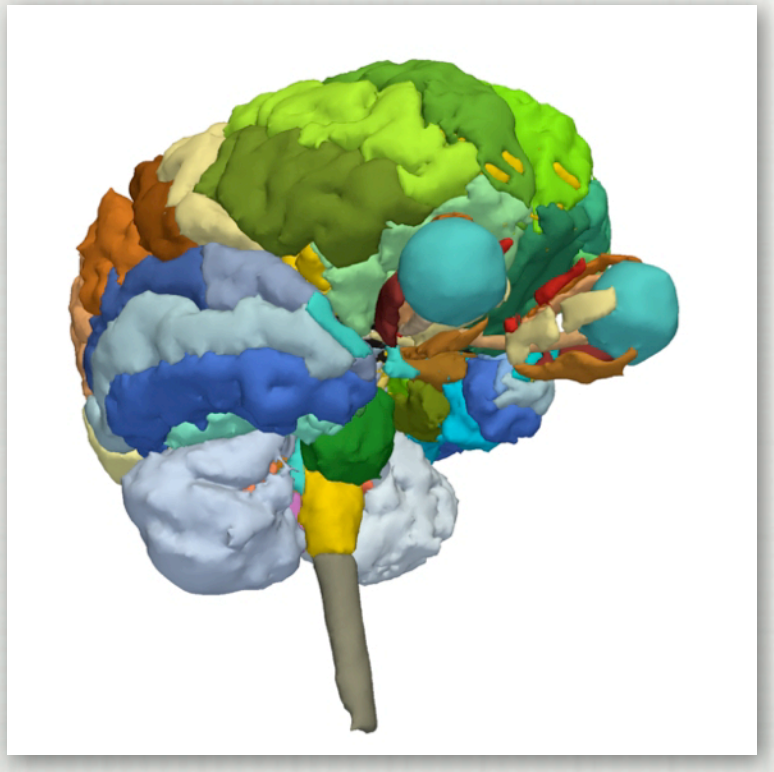


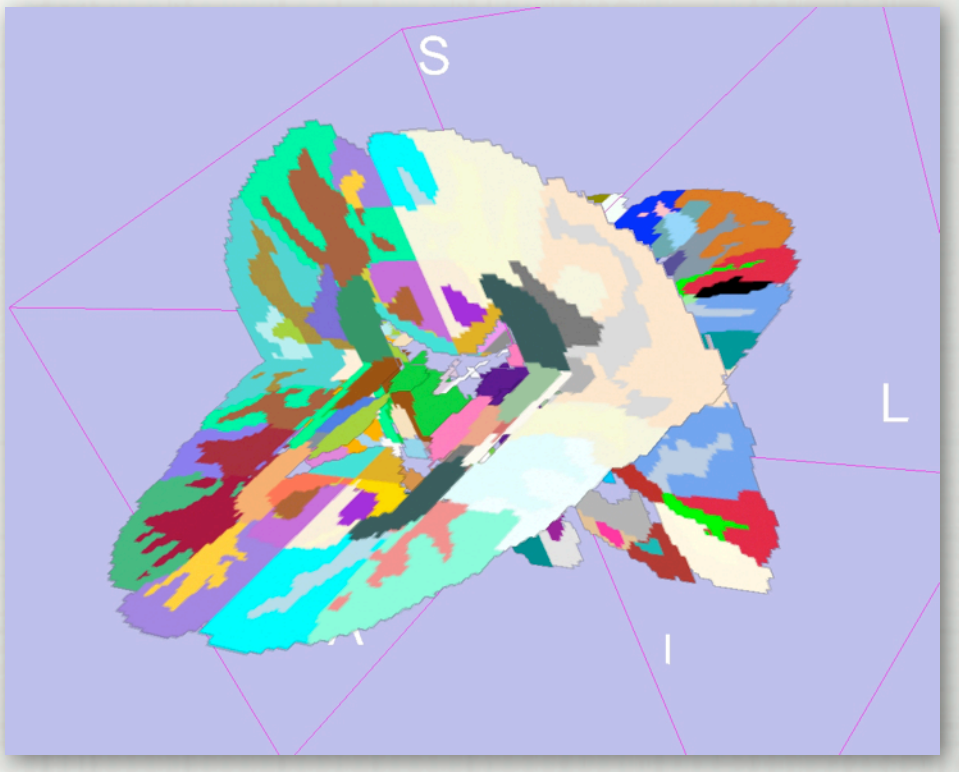
SEGMENTATION



http://vkh.ajou.ac.kr/vkh.ajou.ac.kr/staff/ajou/Min%20Suk%20Chung.htm

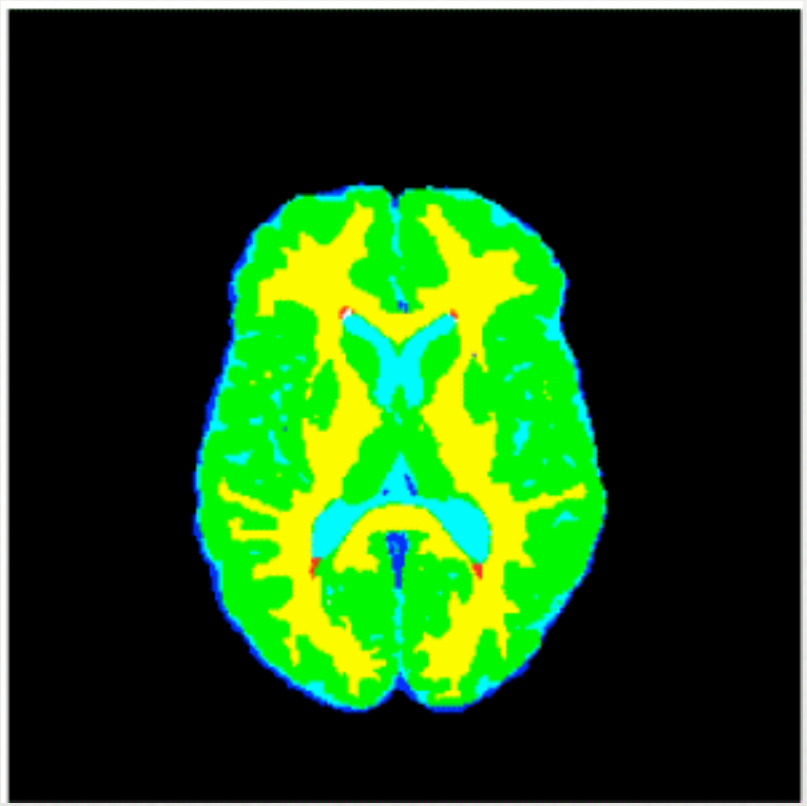
SEGMENTATION





http://www.spl.harvard.edu/publications/item/view/1265

COMPUTER AIDED DIAGNOSIS



http://www.cim.mcgill.ca/~rharmo/research/MRF.gif

GENERAL THEME

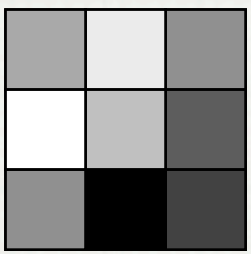
LOOK FOR PATTERNS IN SOME REPRESENTATION OF THE DATA

IMAGE SPACE

EACH IMAGE IS
ONE POINT

IMAGE SPACE

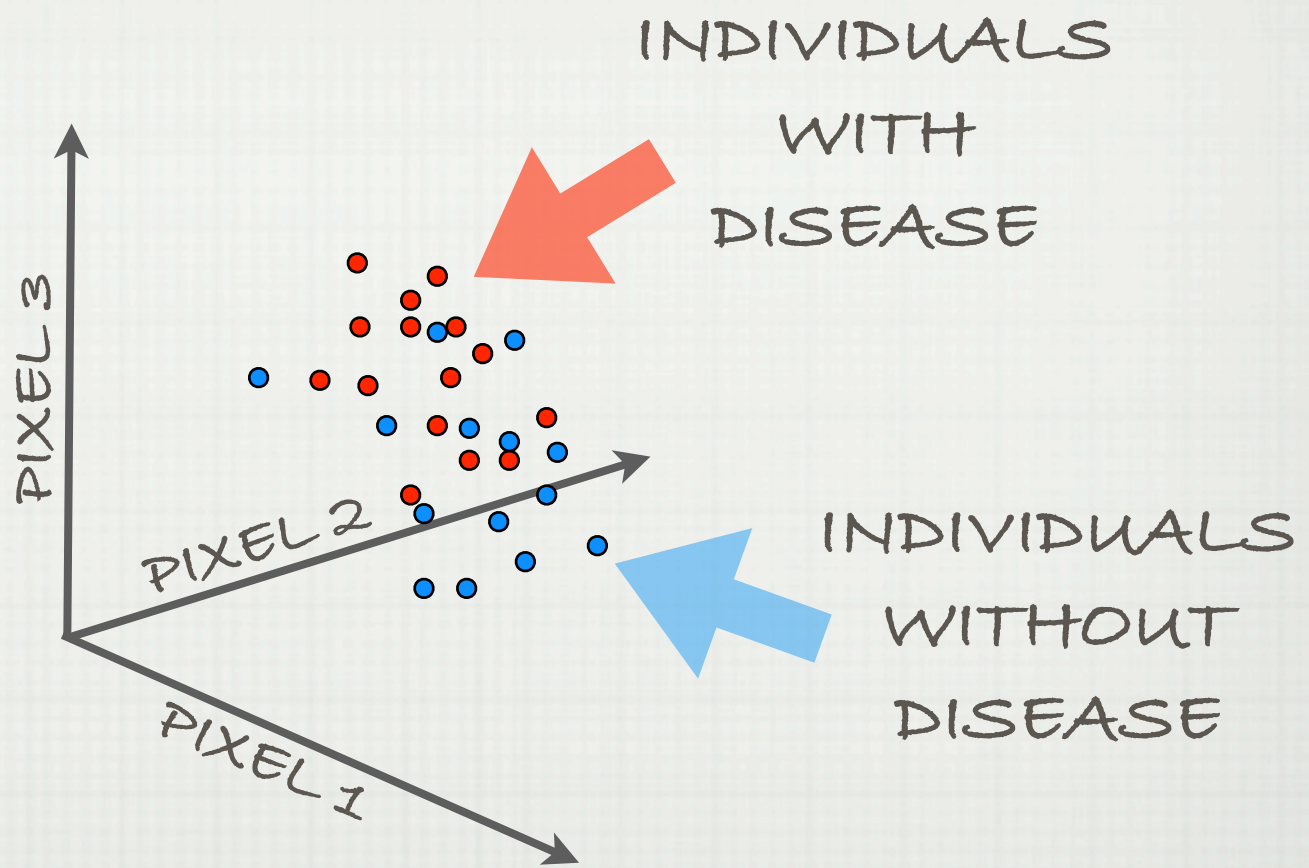
IMAGE

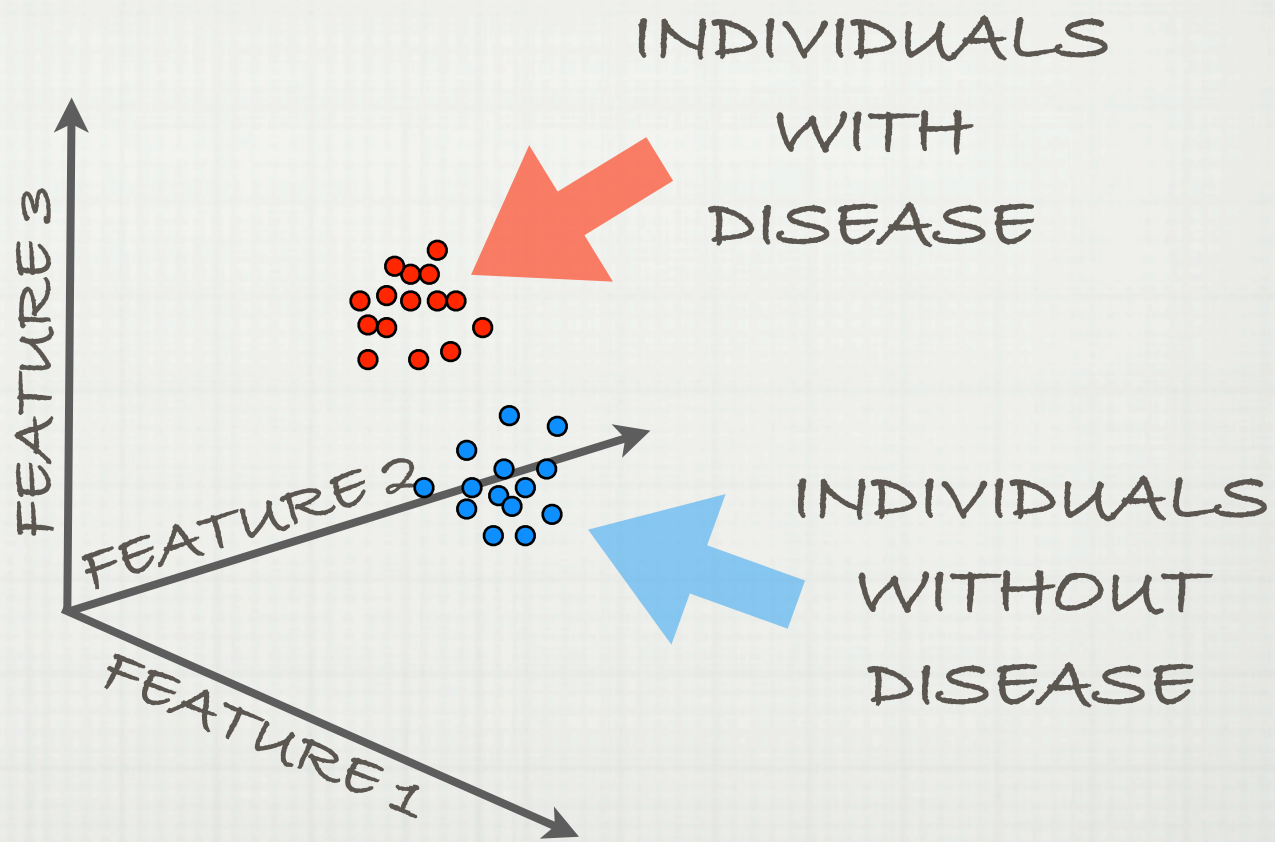


$\mathbb{R}^{3\times 3}$

IMAGE VECTOR

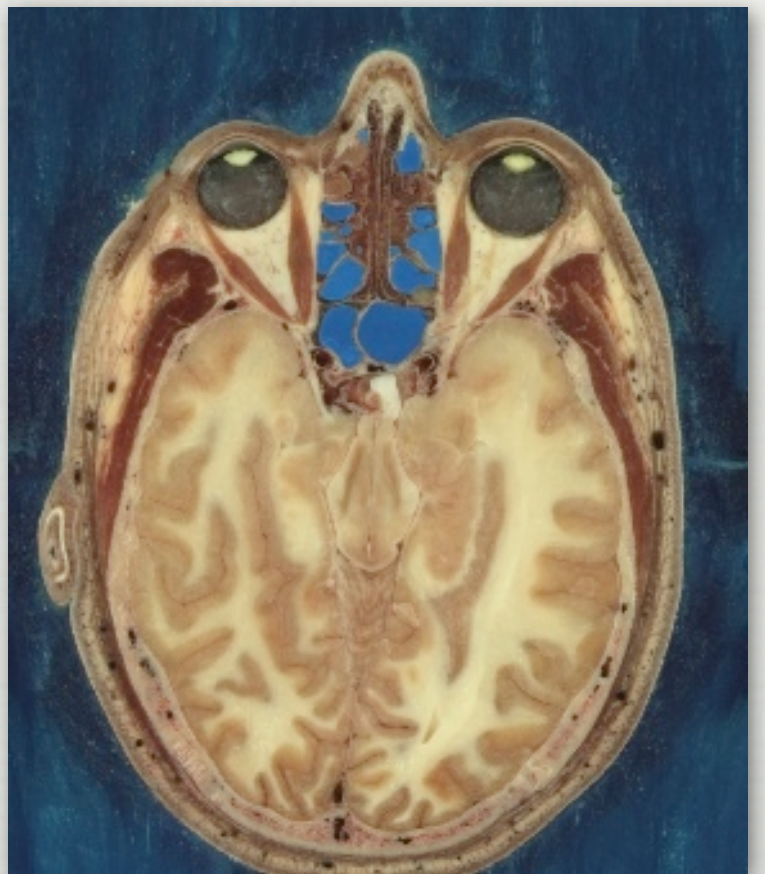
$\mathbb{R}^{9}$

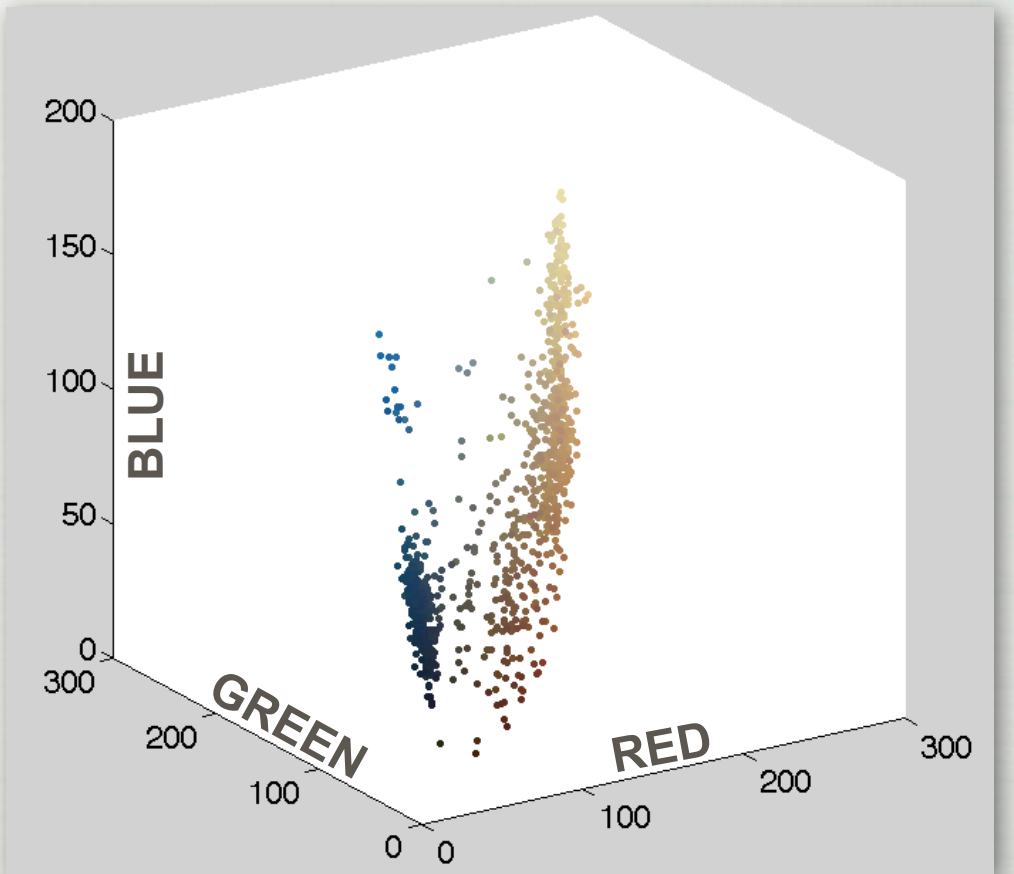

INDIVIDUALS
WITH
DISEASE
PIXEL 3
PIXEL 2
PIXEL 1
INDIVIDUALS
WITHOUT
DISEASE

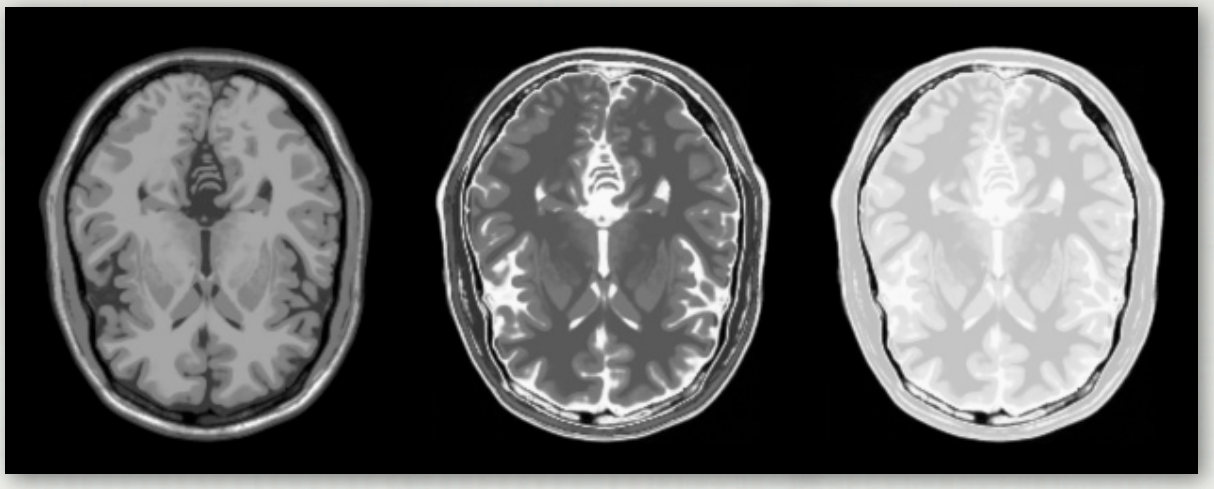

INDIVIDUALS
WITH
DISEASE
FEATURE 3
FEATURE 2
FEATURE 1
INDIVIDUALS
WITHOUT
DISEASE

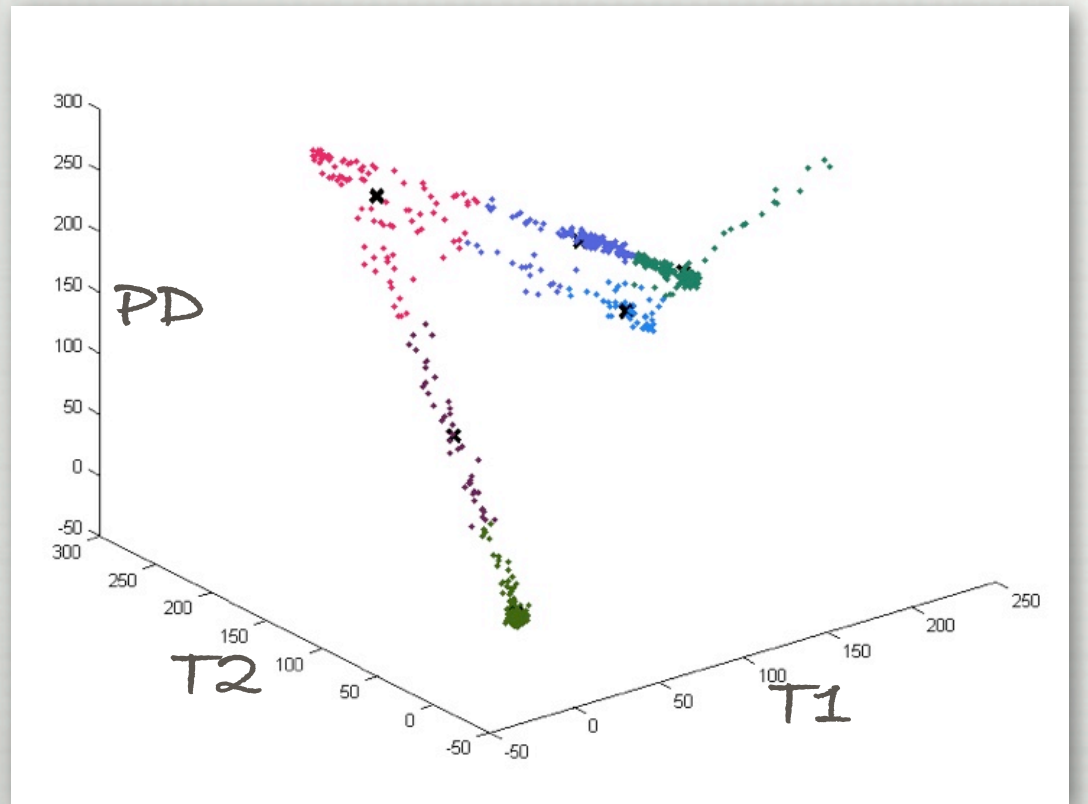
PIXEL SPACE

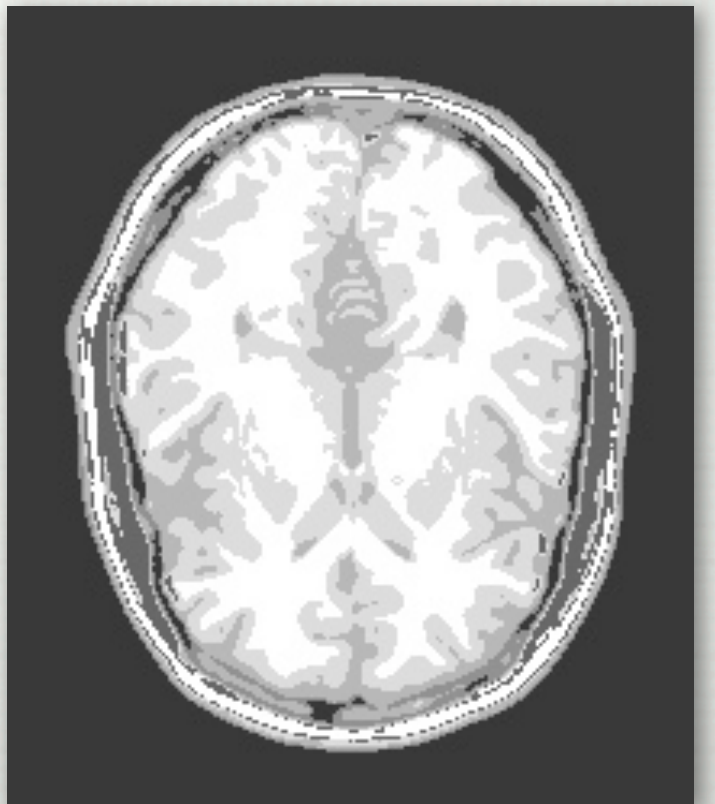
EACH PIXEL IS ONE POINT

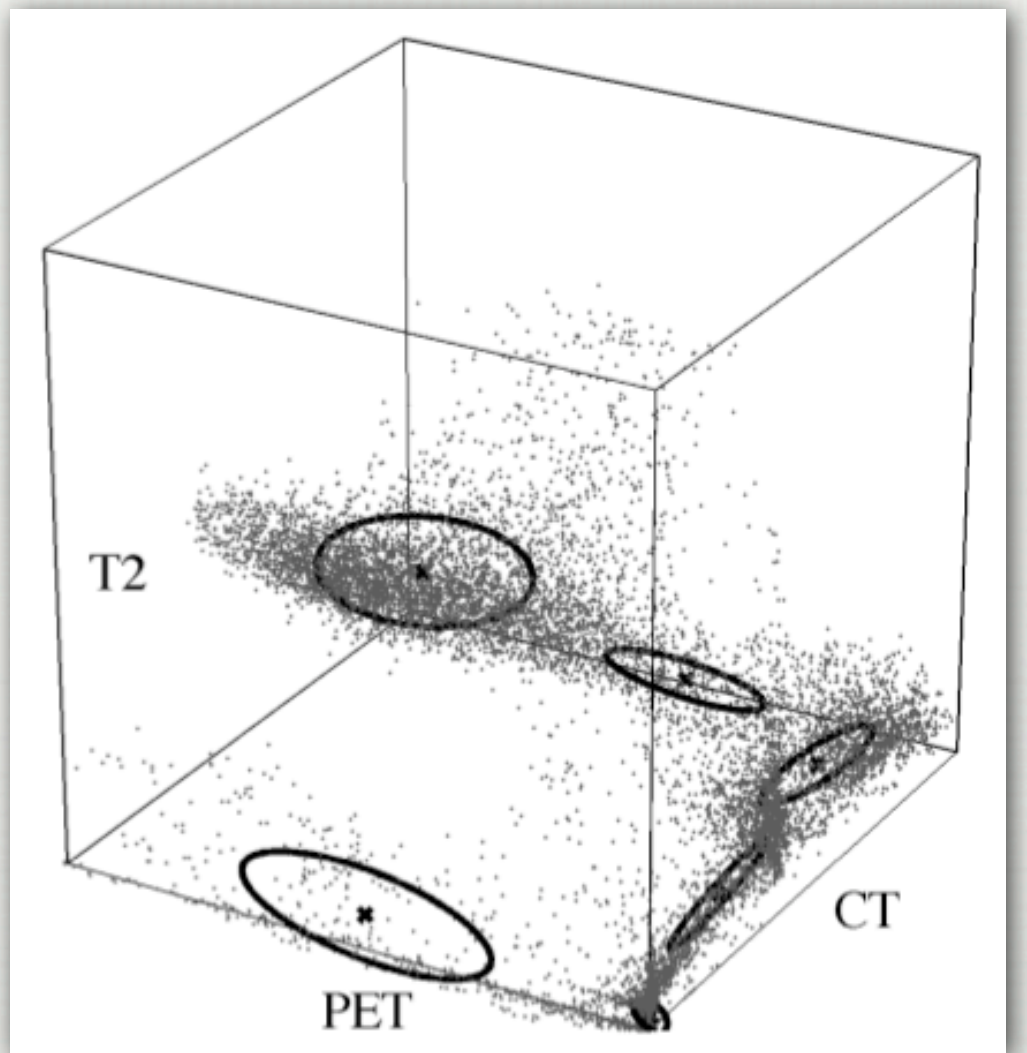



200
150
100
50
0
BLUE
300
200
100
0
GREEN
0
100
200
300
RED


T1
T2
PD

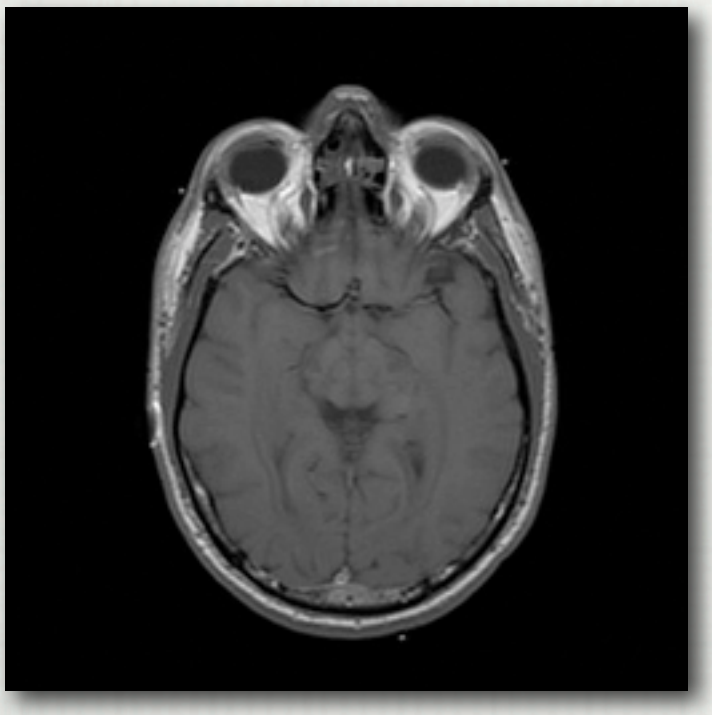

PD
T2
T1
300
250
200
150
100
50
0
-50




T2
PET
CT

REGISTRATION

SCAN 1



SCAN 2

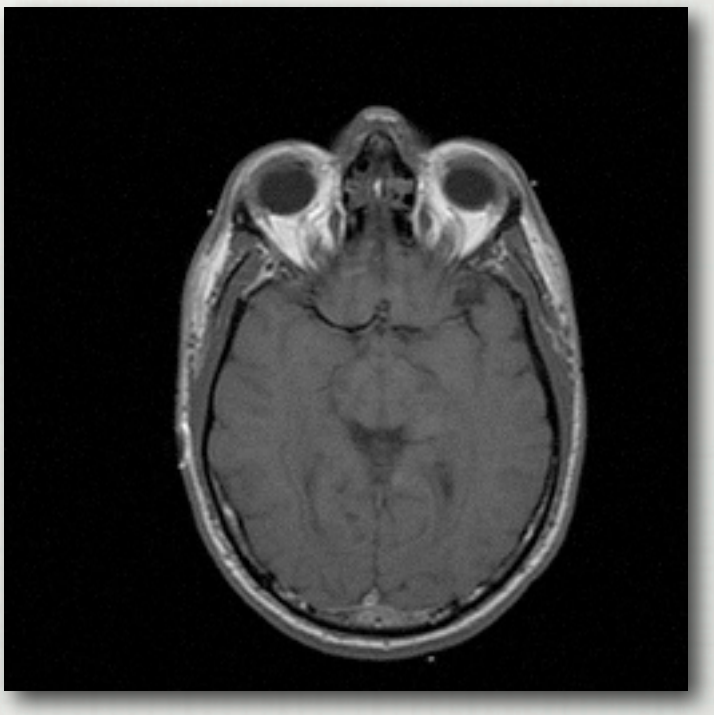
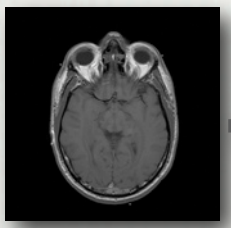
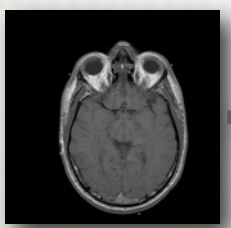


IMAGE REGISTRATION





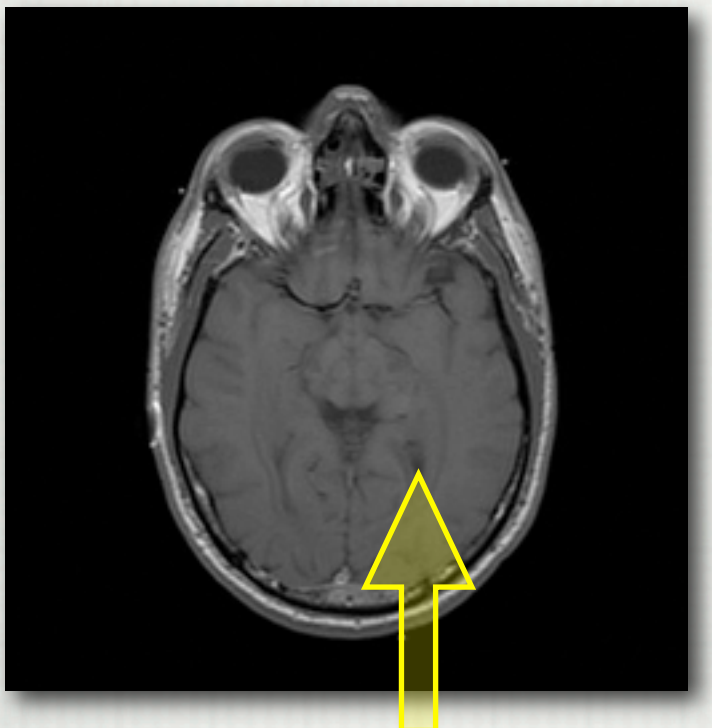
COMPARE IMAGES

APPLY MOTION

ADJUST MOTION PARAMETERS

JOINT INTENSITY

T1



49

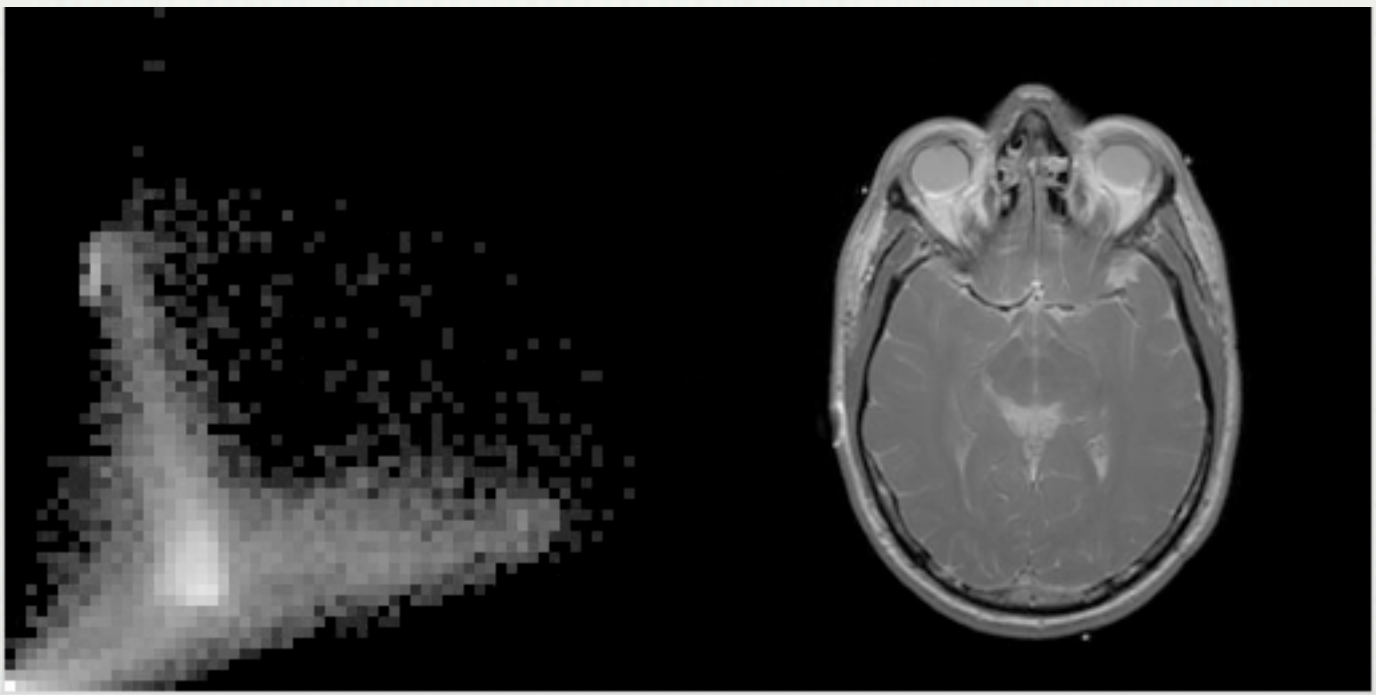
T2

147

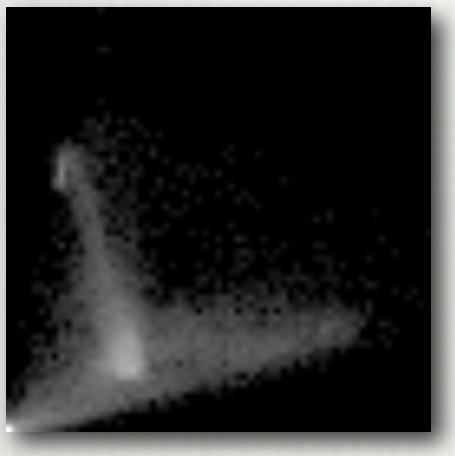
(T1, T2) = (49, 147)

JOINT INTENSITY SPACE

JOINT HISTOGRAM



JOINT INTENSITY



JOINT ENTROPY

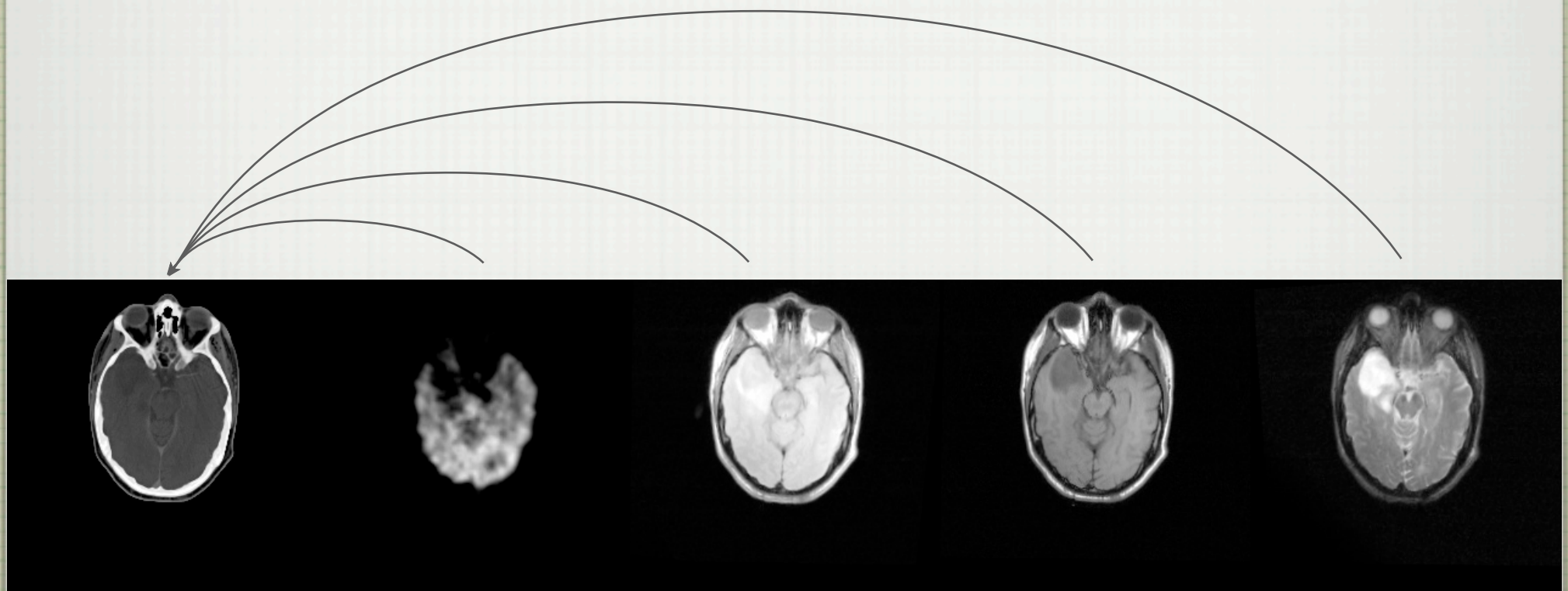
$$H(f,g) = \sum_i \sum_j p_{i,j} \log p_{i,j}$$

MUTUAL INFORMATION

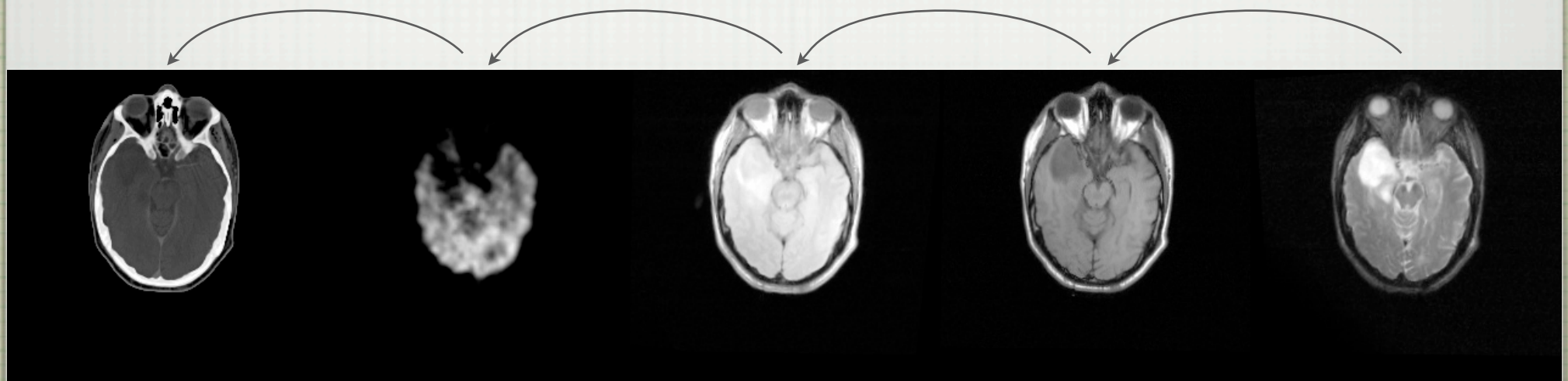
$$I(f,g) = H(f) + H(g) - H(f,g)$$

$$= \sum_i \sum_j p_{i,j} \log \frac{p_{i,j}}{p_i p_j}$$

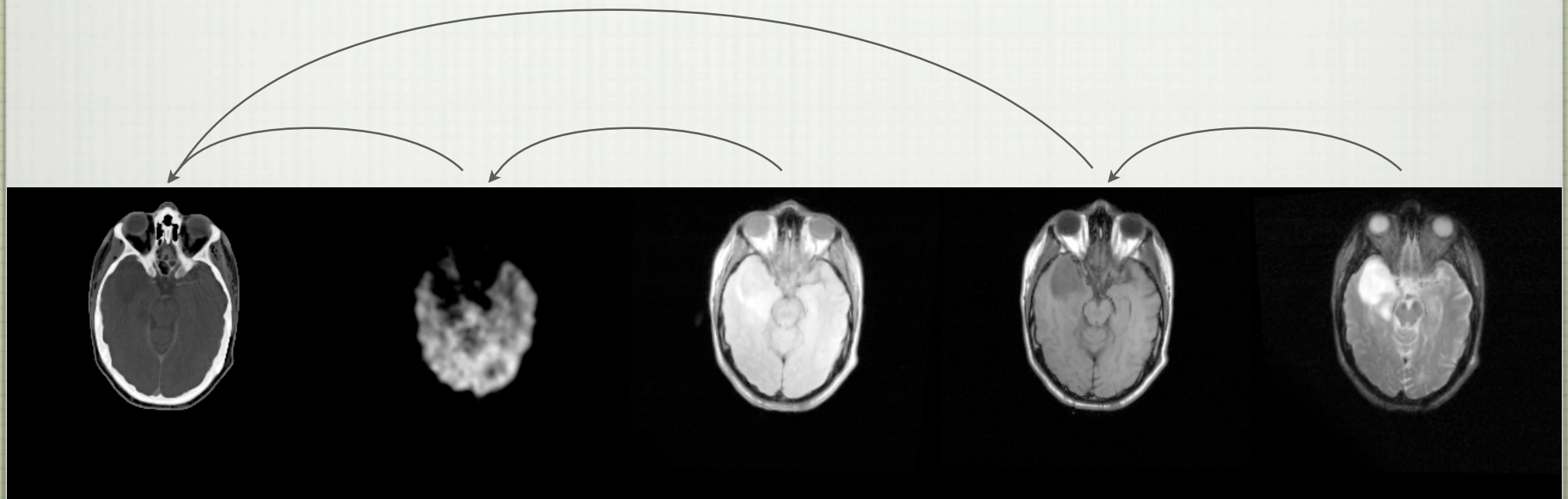
ENSEMBLE REGISTRATION



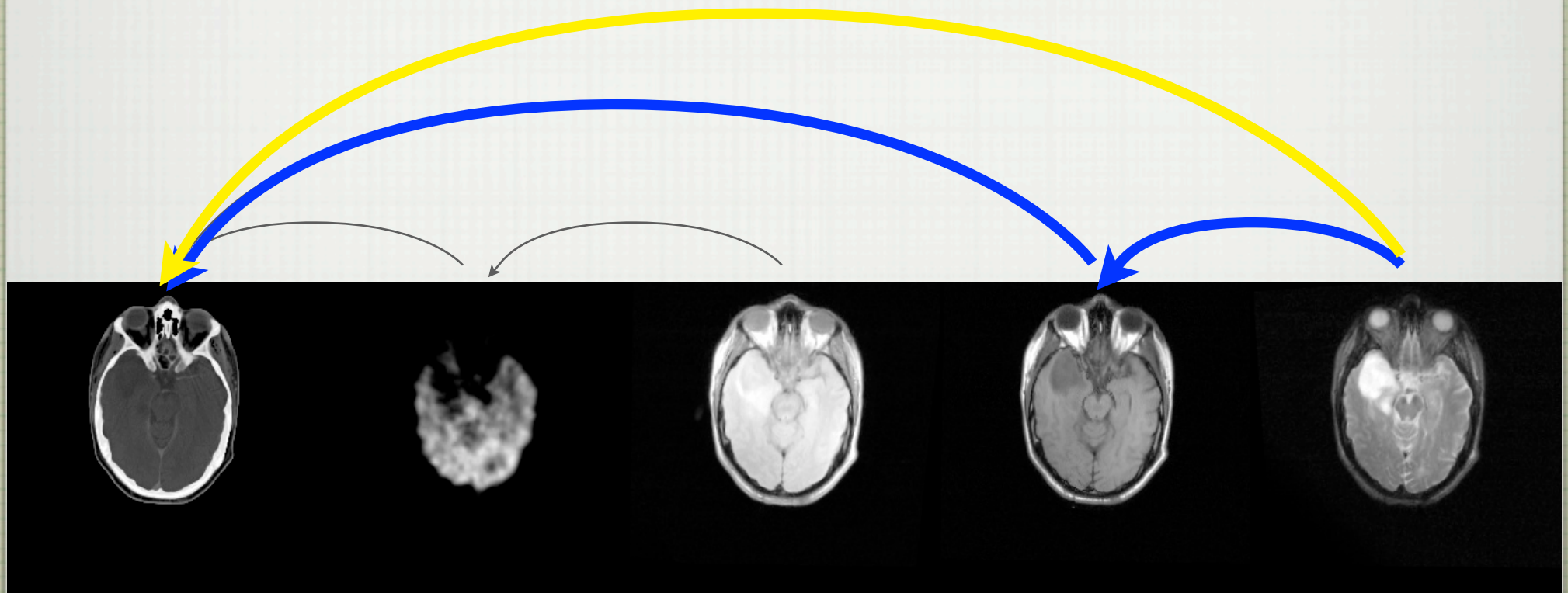
ENSEMBLE REGISTRATION



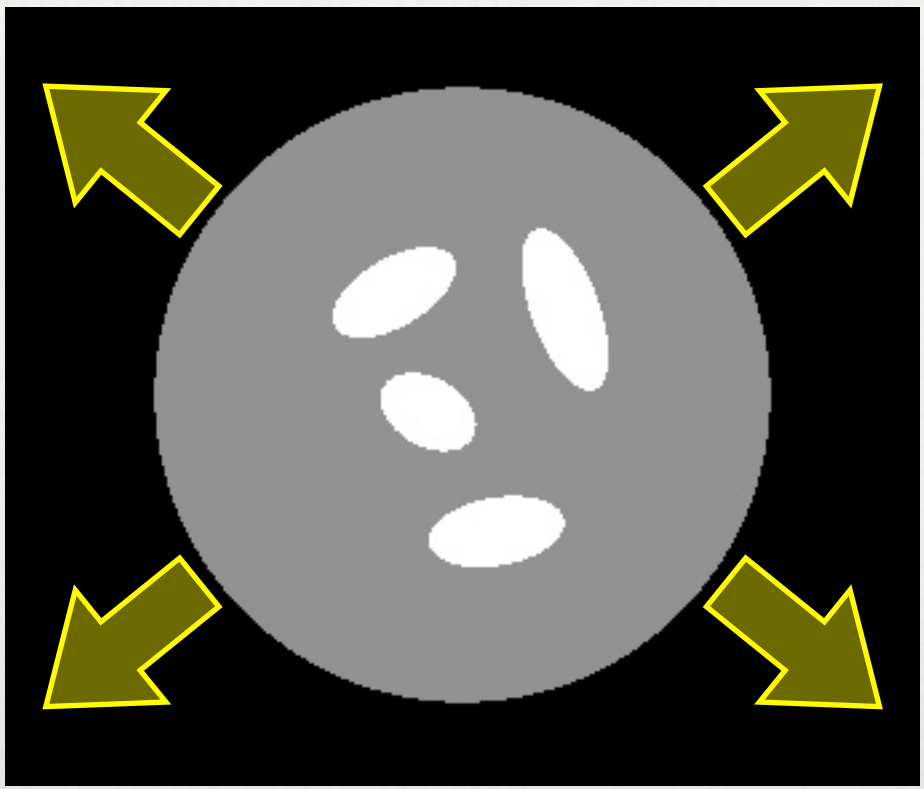
ENSEMBLE REGISTRATION



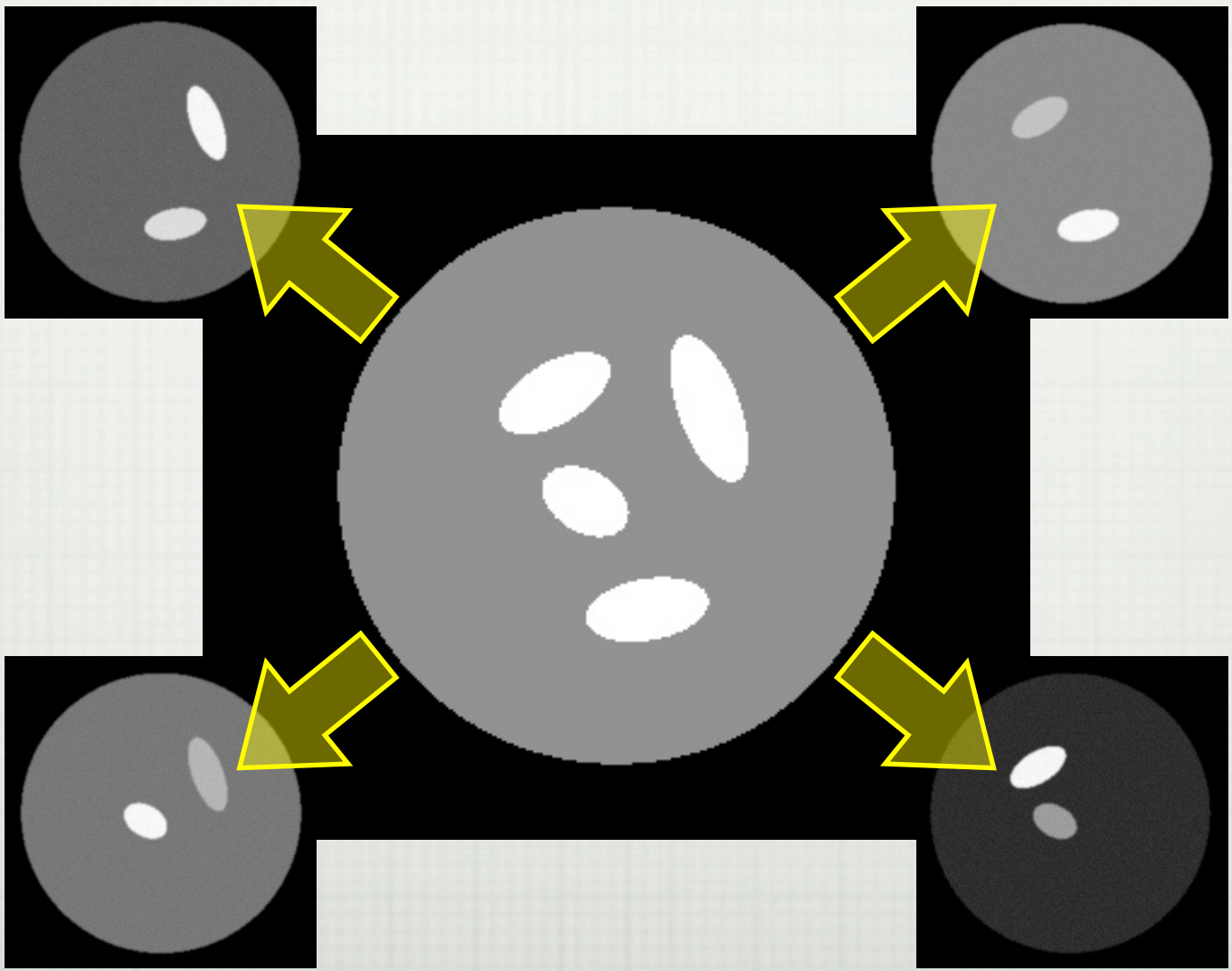
ENSEMBLE REGISTRATION



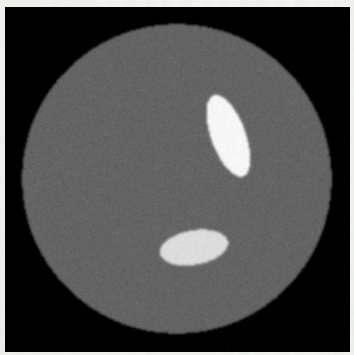
MULTIMODAL PHANTOM

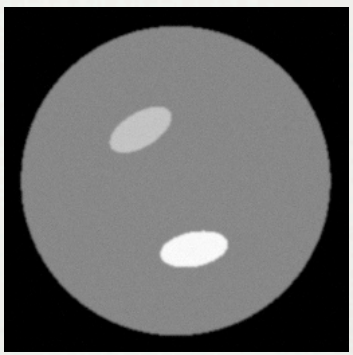


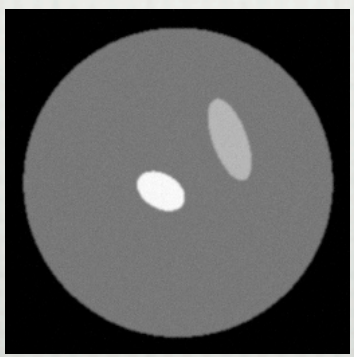
MULTIMODAL PHANTOM

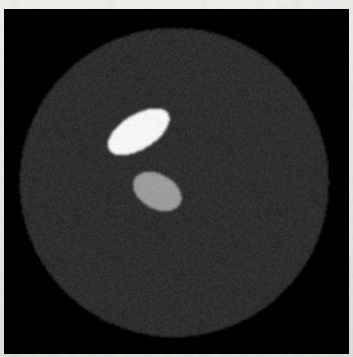


MULTIMODAL PHANTOM

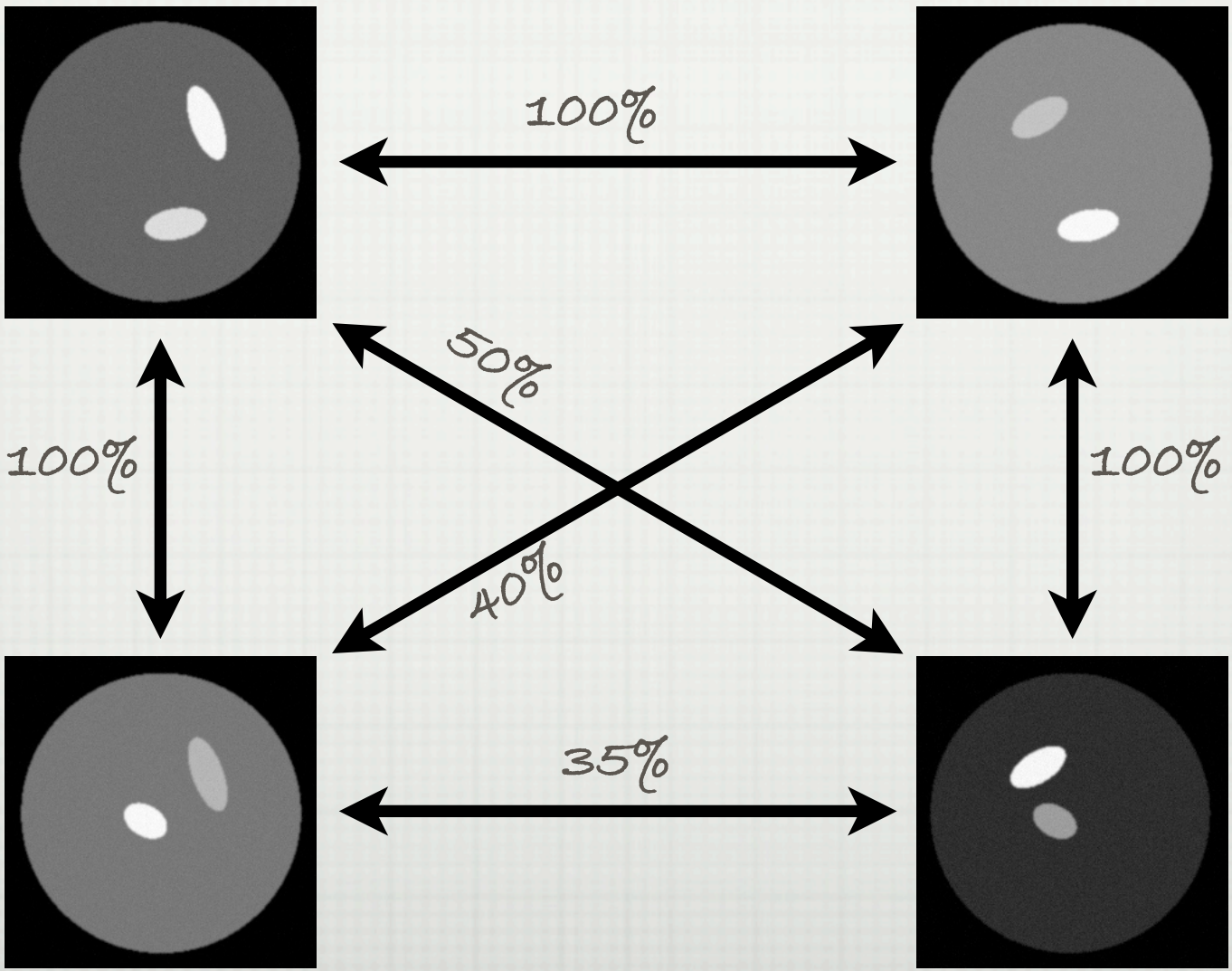




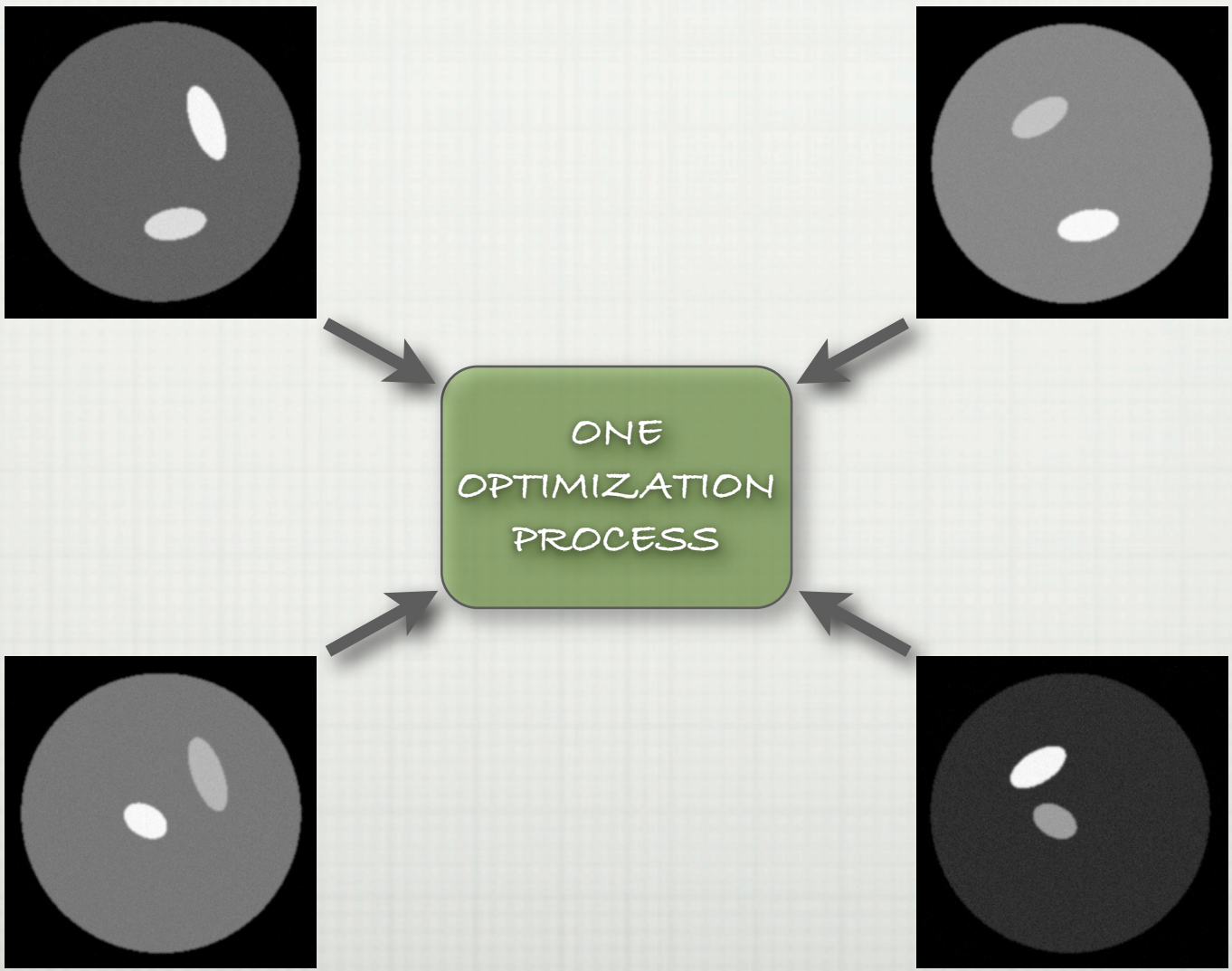




NMI SUCCESS RATE



ENSEMBLE REGISTRATION

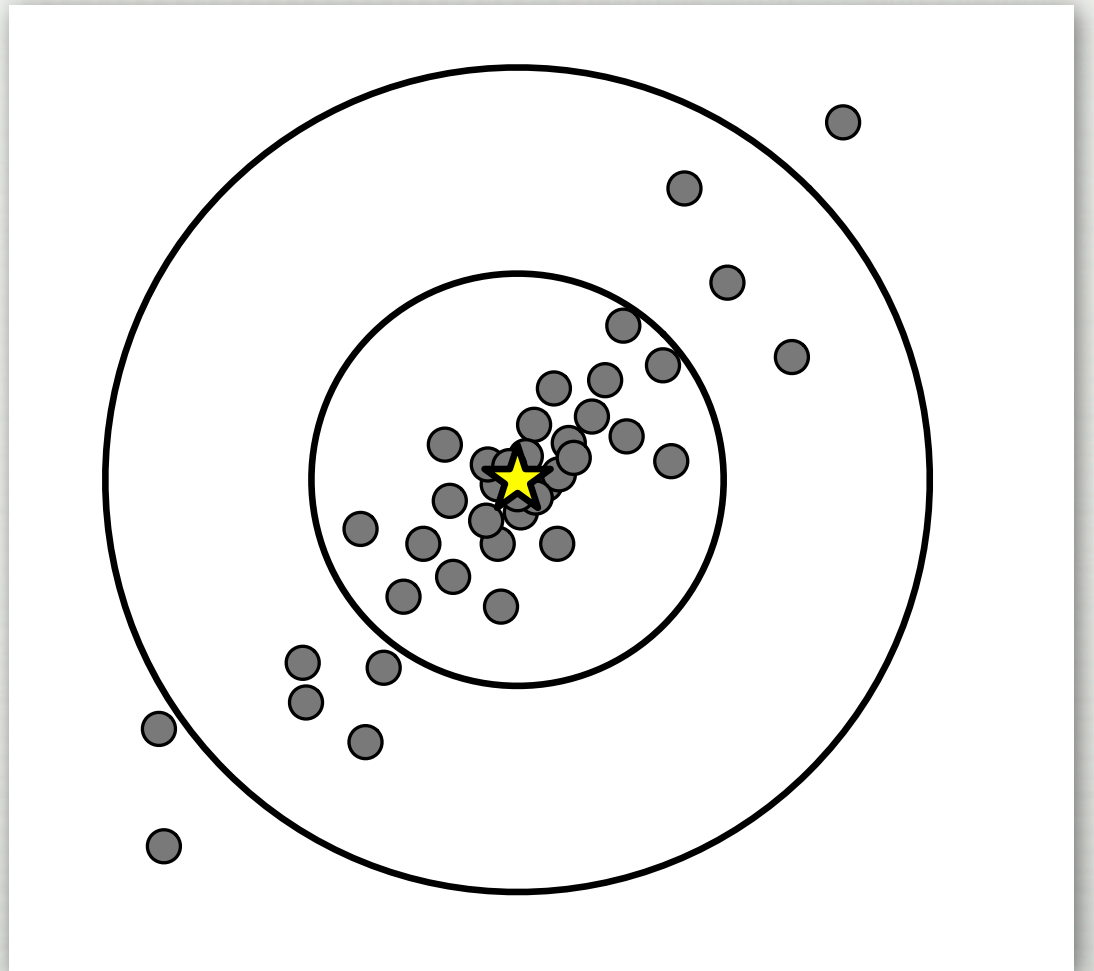


ENSEMBLE NMI?

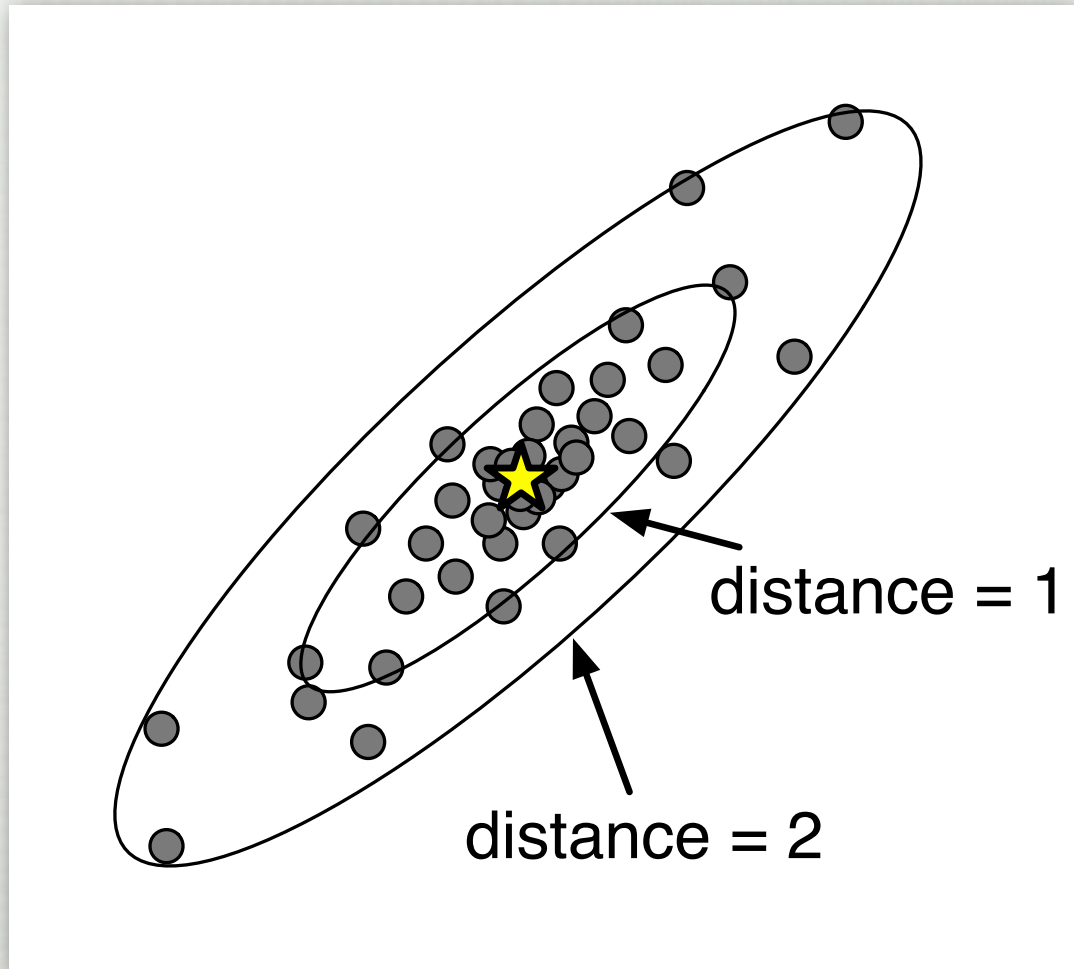
- ☐ 5 IMAGES
- ☐ 64 INTENSITY BINS PER IMAGE
- ☐ 2^{30} HISTOGRAM BINS (16 GB)

- ☐ 5 IMAGES
- ☐ 256 INTENSITY BINS PER IMAGE
- ☐ 2^{40} HISTOGRAM BINS (16 TB)

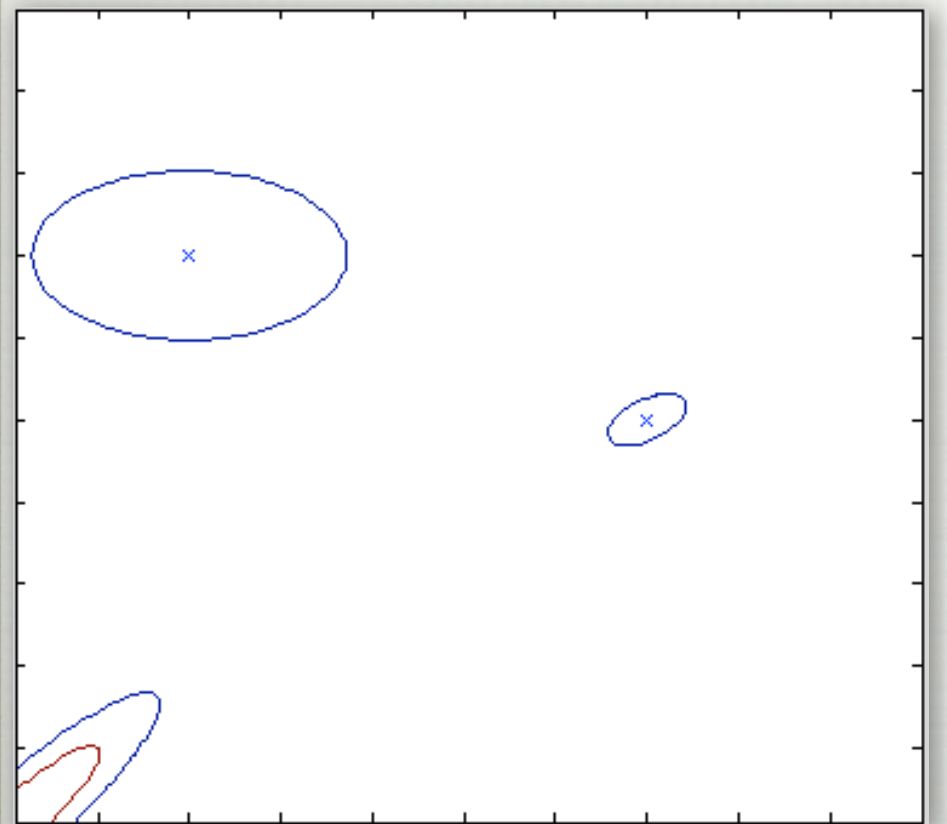
EUCLIDEAN DISTANCE

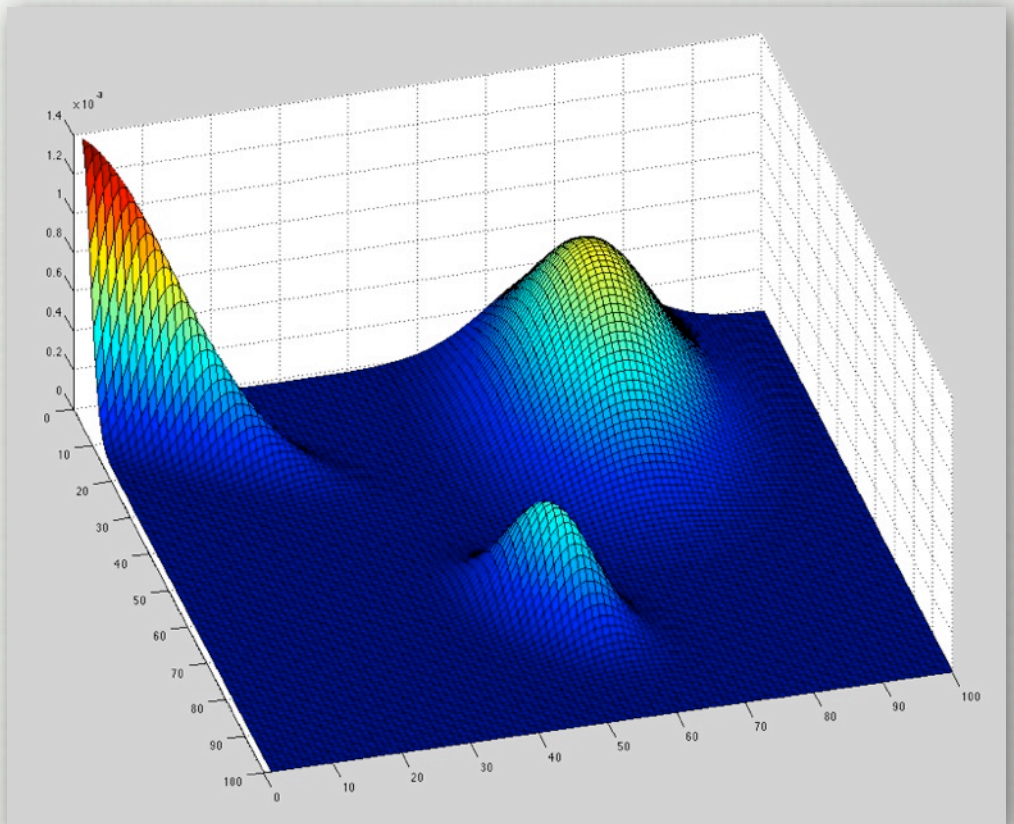


GENERALIZED EUCLIDEAN DISTANCE



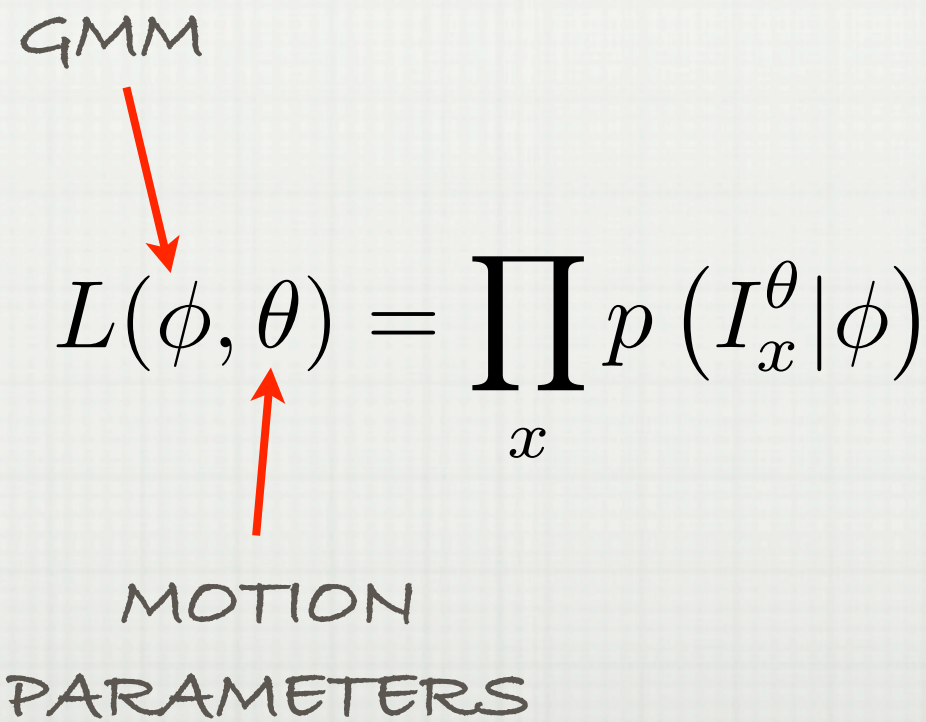
GAUSSIAN MIXTURE MODEL



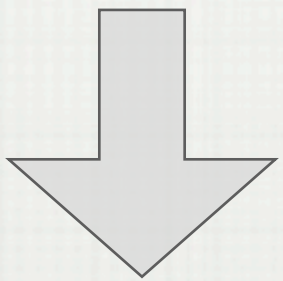


ϕ

MAXIMUM LIKELIHOOD



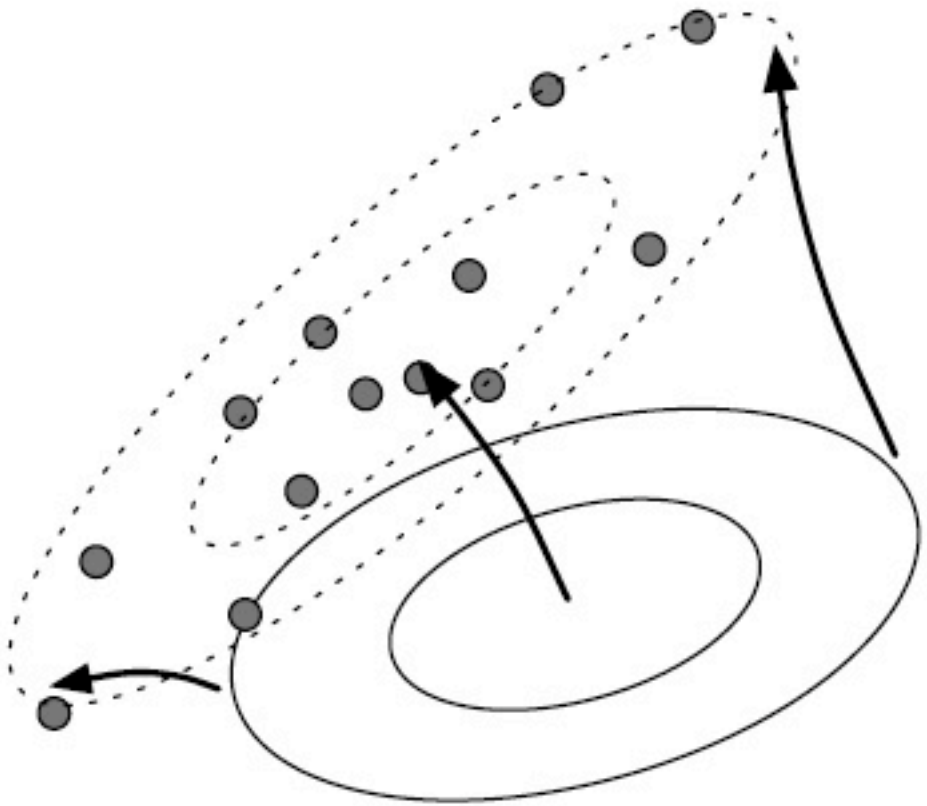
OPTIMIZE $L(\phi, \theta) = \prod_x p\left(I_x^\theta | \phi\right)$



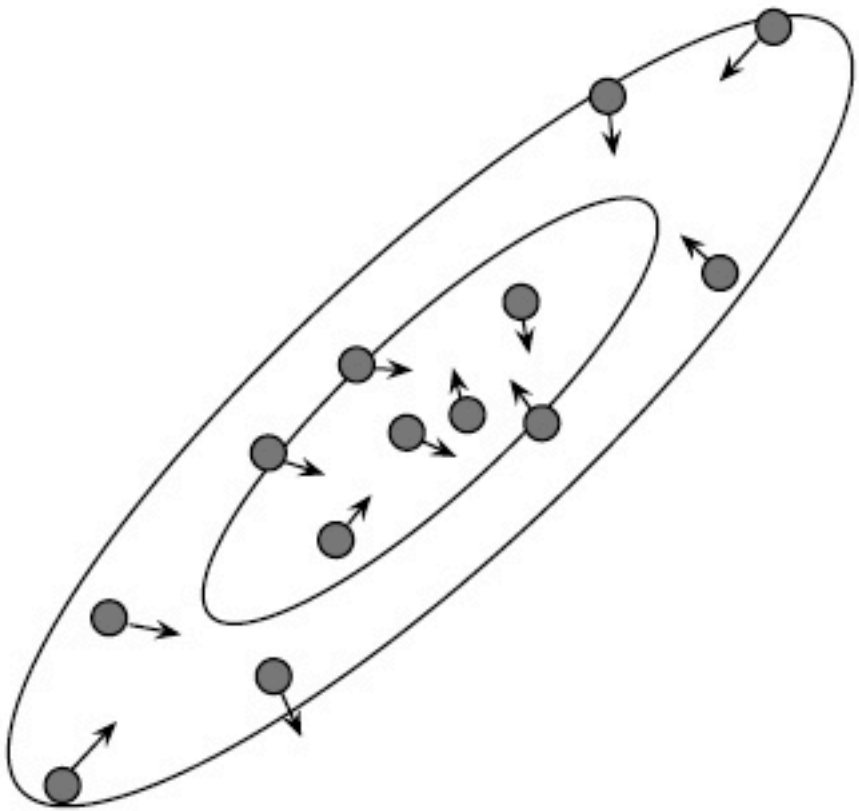
OPTIMIZE WITH RESPECT TO ϕ.

OPTIMIZE WITH RESPECT TO θ.

Fix θ, update ϕ

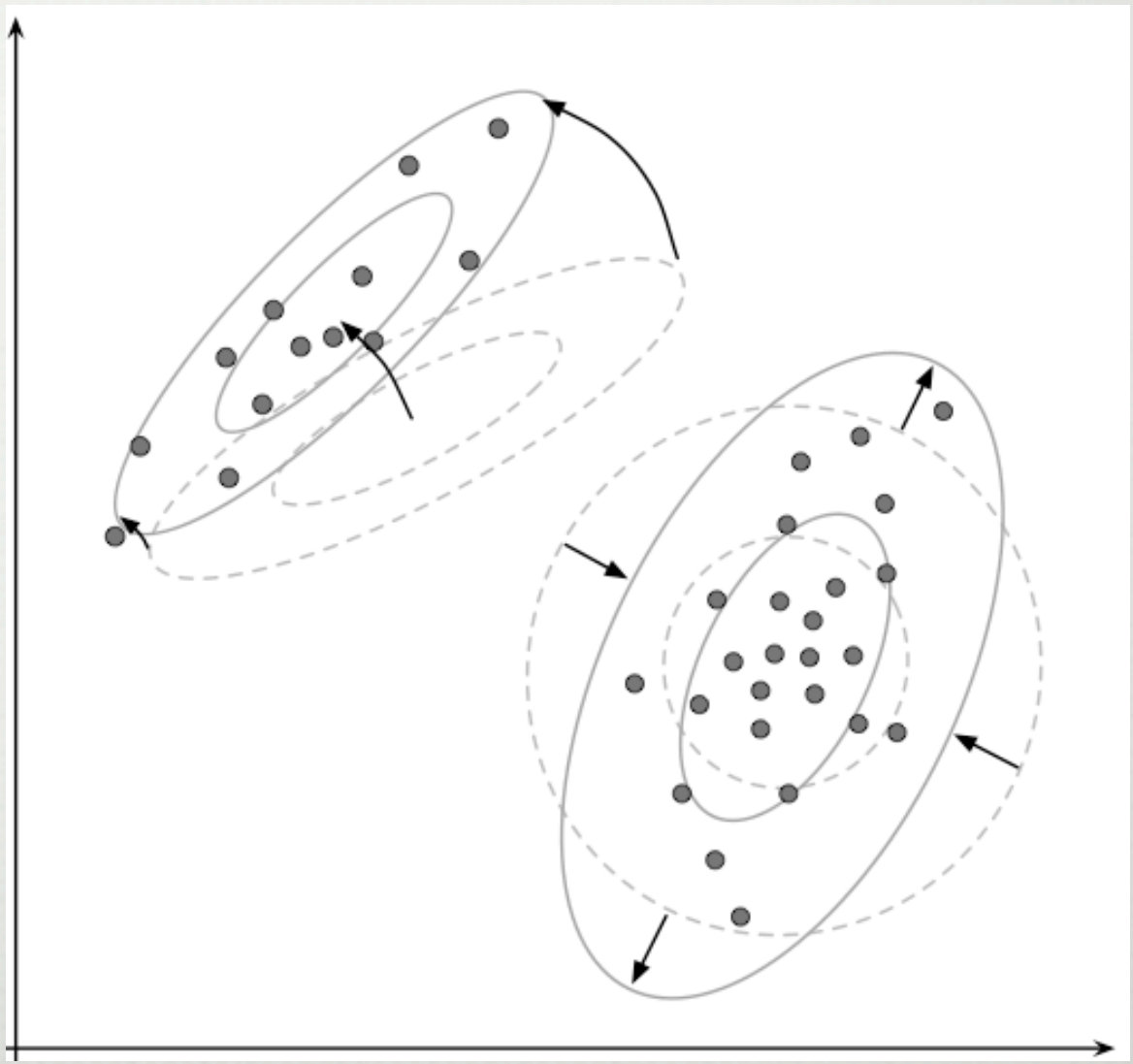


Fix ϕ, update θ



Fix θ, update ϕ

1. UPDATE PIXEL MEMBERSHIPS
2. UPDATE μ'S
3. UPDATE $\sum$'S



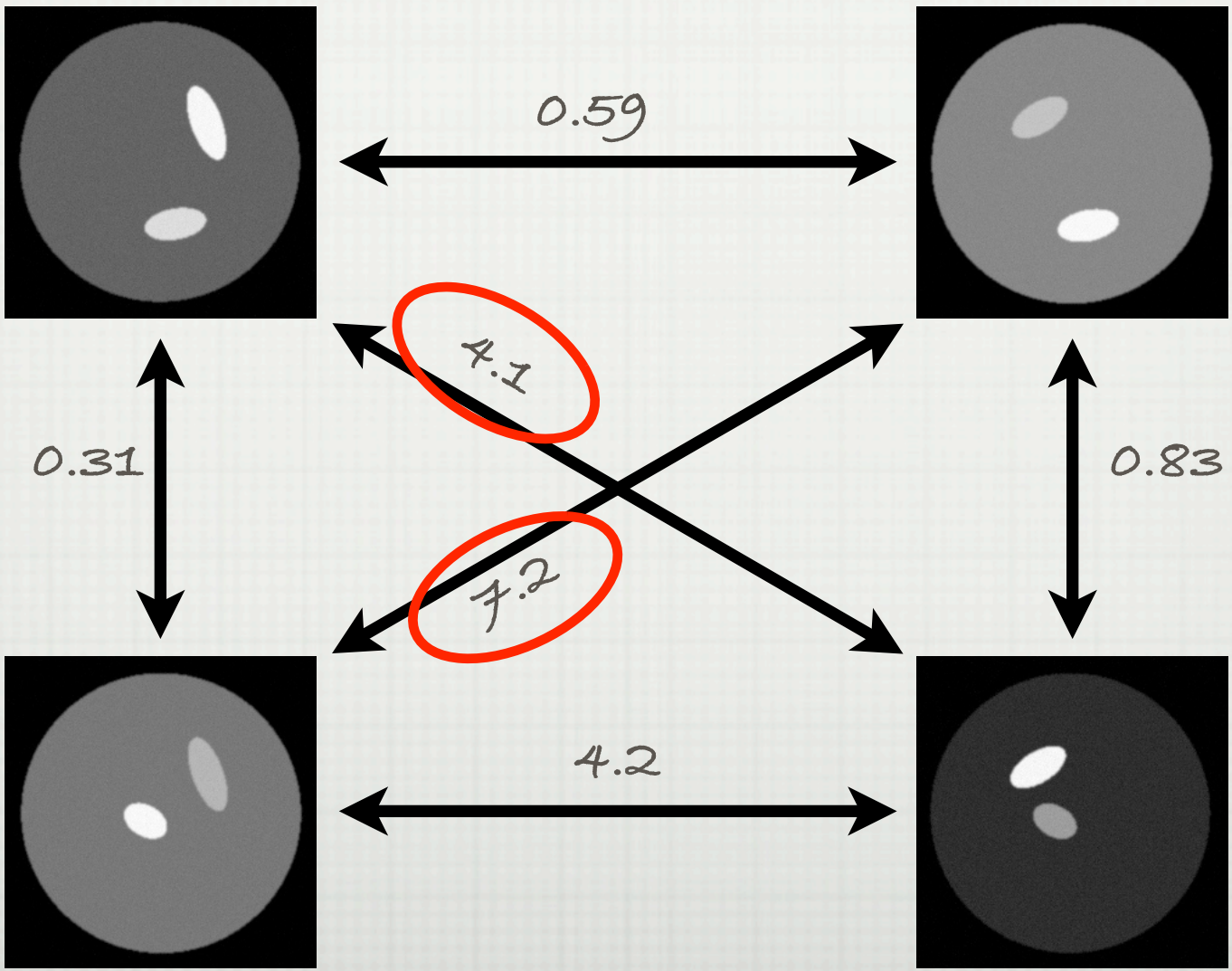
Fix ϕ, update θ

$$\frac{\partial}{\partial \tilde{\theta}} \log L(\phi, \theta + \tilde{\theta}) = 0$$

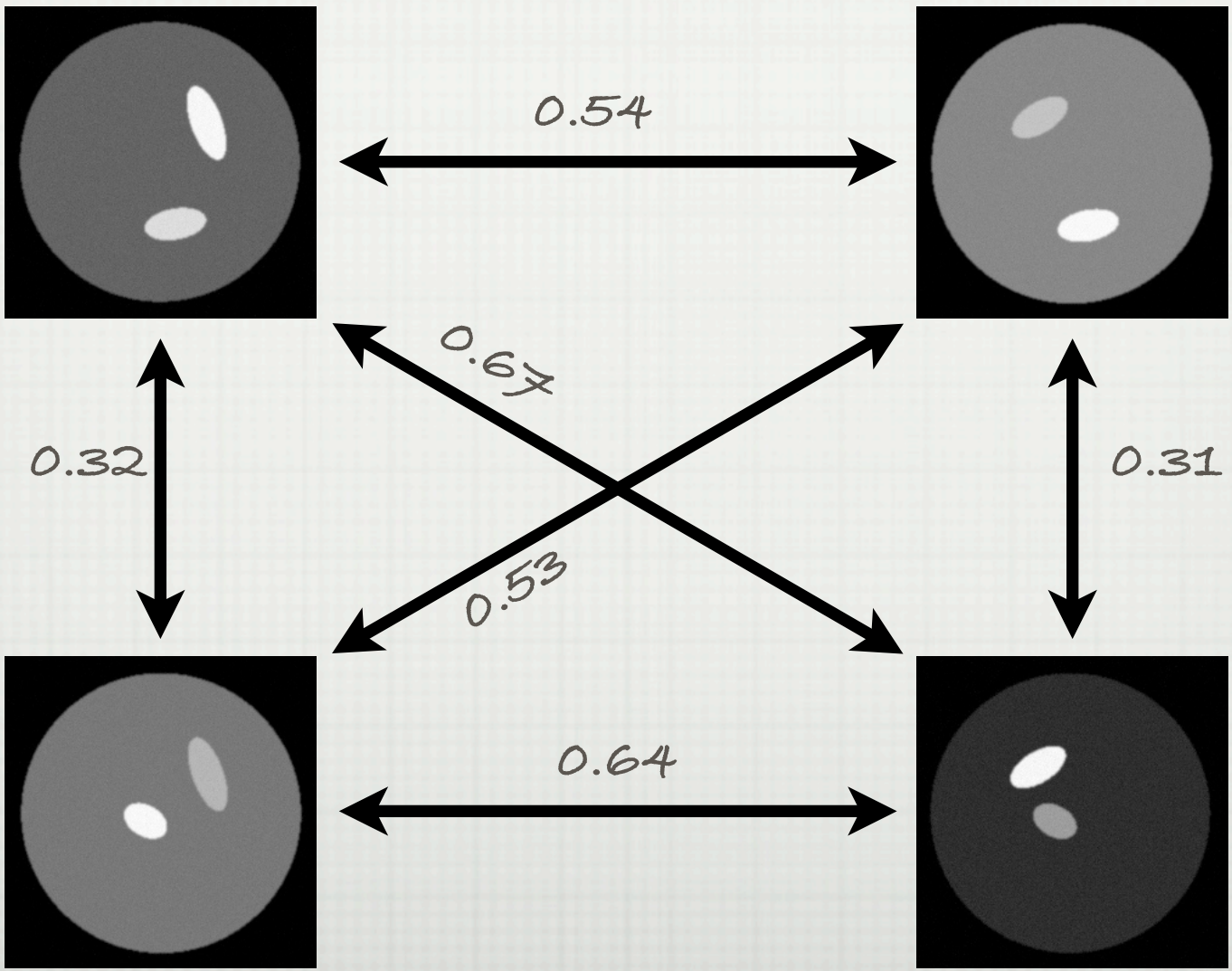
$$\sum_x \frac{-1}{p\left(I_x^\theta | \phi\right)} \sum_{k=1}^{K} \pi_k \mathcal{N}_k\left(I_x^\theta\right) \frac{\partial I_x^\theta}{\partial \theta} \Sigma_k^{-1} \left(I_x^\theta + \frac{\partial I_x^\theta}{\partial \theta}^{\mathrm{T}} \tilde{\theta} - \mu_k \right) = 0$$

$$A\tilde{\theta} = b$$

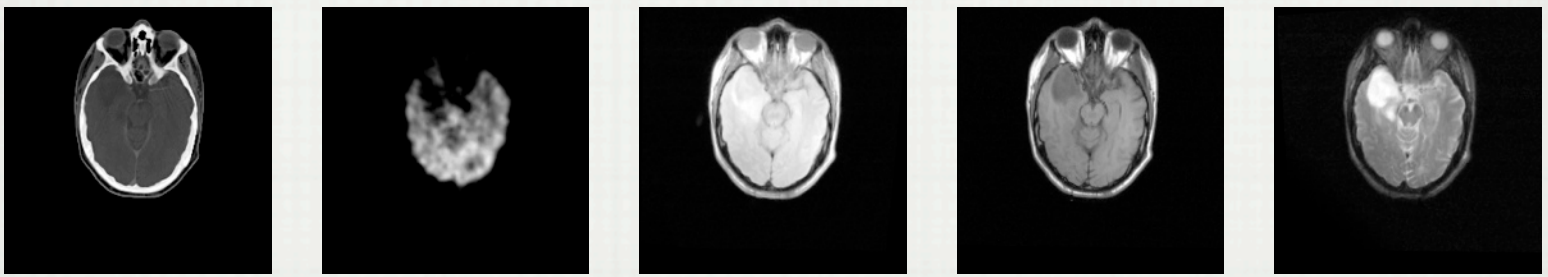
MI ERROR



ENSEMBLE ERROR



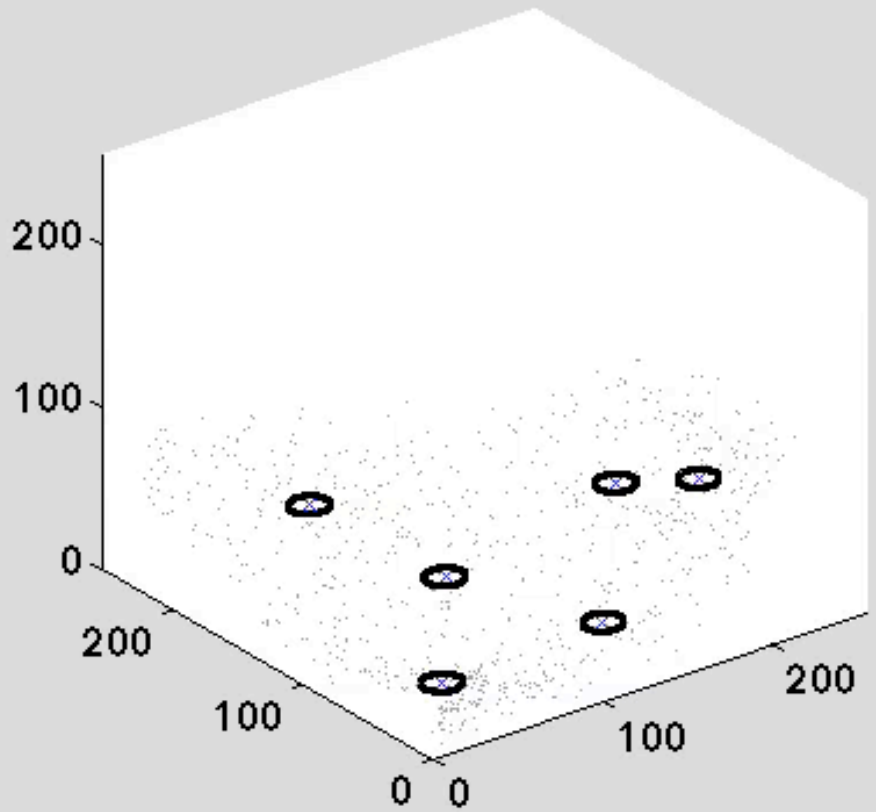
CT PET PD T1 T2

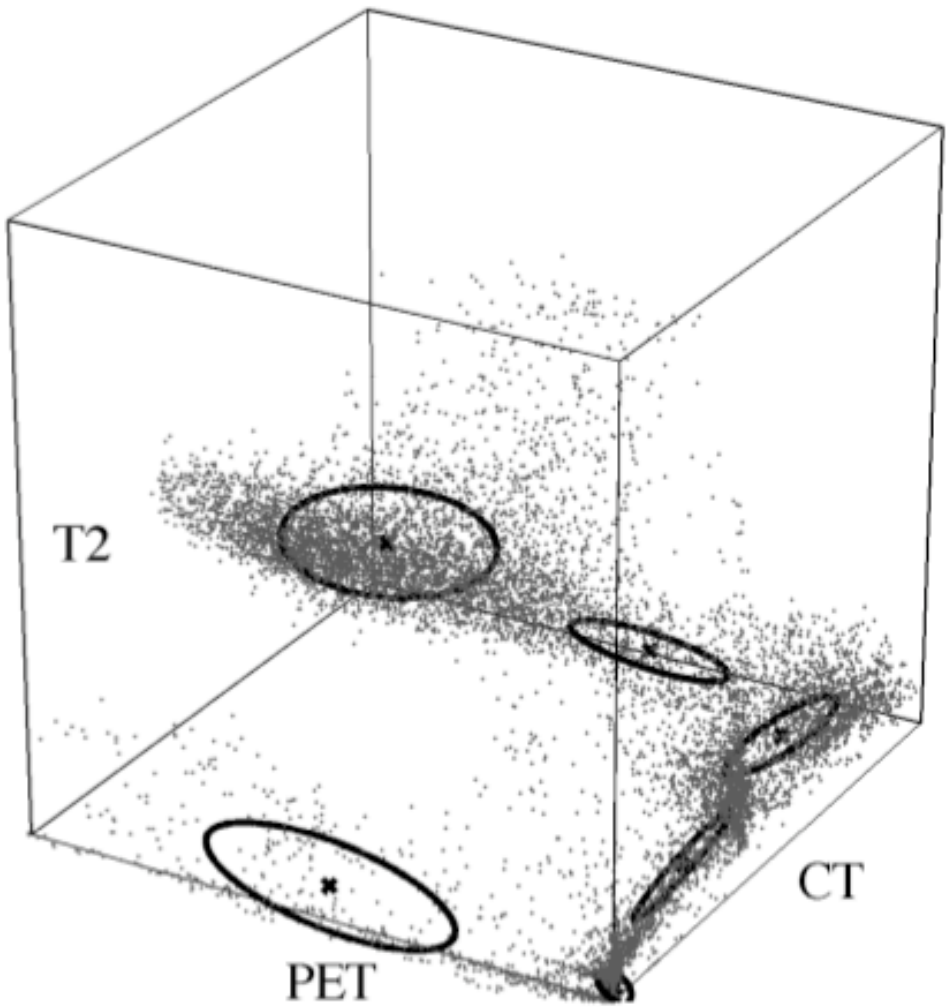


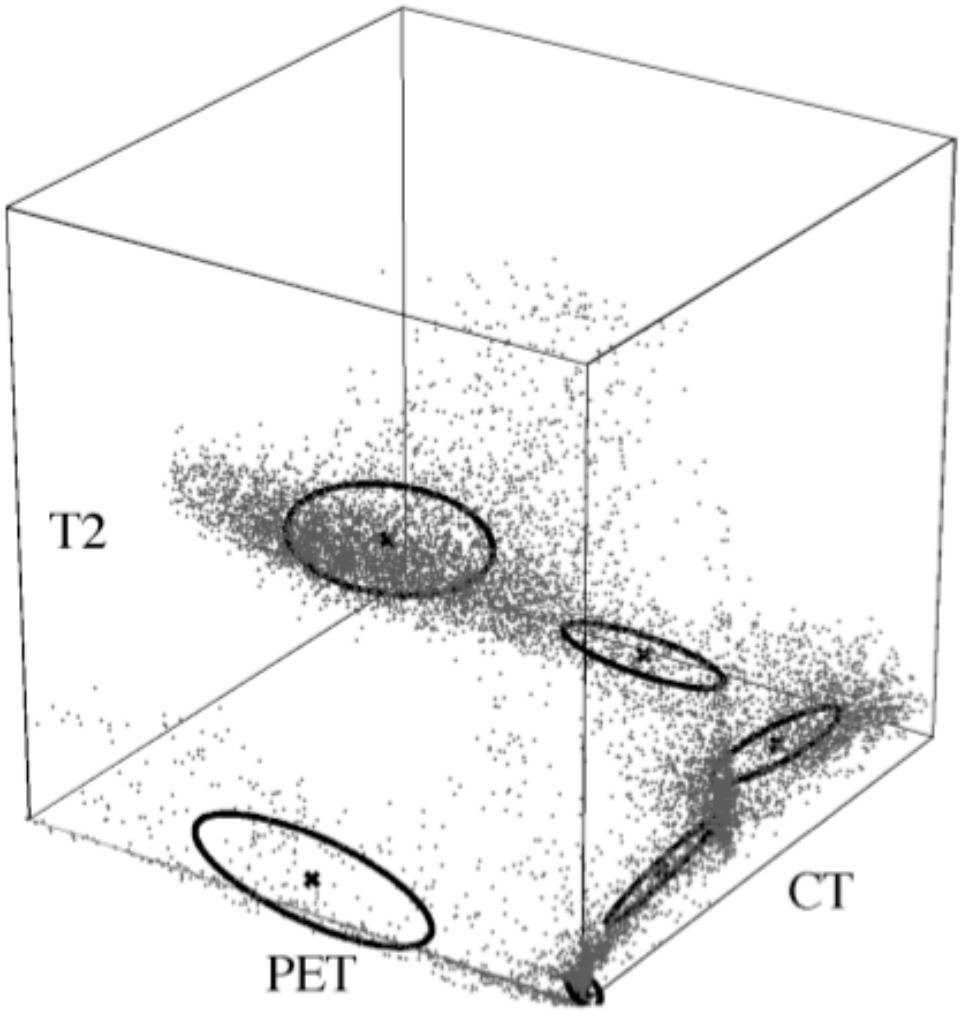
Method	CT-PET	CT-PD	CT-T1	CT-T2	PET-PD	PET-T1	PET-T2	PD-T1	PD-T2	T1-T2	Mean
NMI (pairwise)	6.1	7.7	2.6	8.2	7.6	5.9	6.7	6.0	4.9	7.7	6.34
Ensemble (pairwise)	1.9	0.80	1.1	1.2	2.6	2.9	2.6	0.93	1.4	2.0	1.73
Ensemble (full)	1.9	0.74	0.87	0.72	1.8	1.7	1.4	0.50	0.73	0.92	1.13

J Orchard, L Jonchery, "Ensemble Registration: Aligning Many Multi-Sensor Images Simultaneously", Proc. SPIE Electronic Imaging, January 2009.

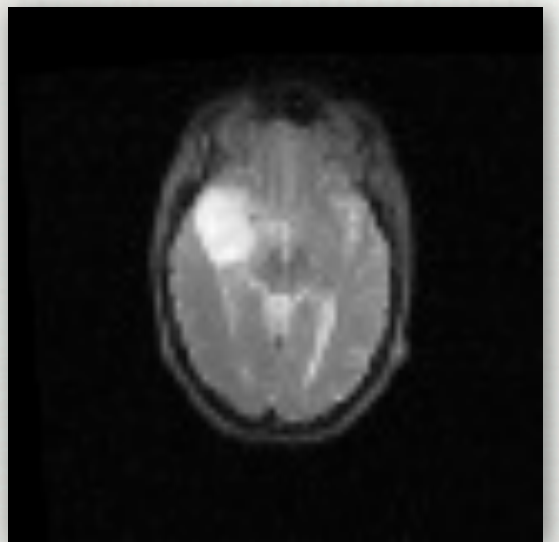
DEMONSTRATION


200
100
0
200
100
0
0
100
200

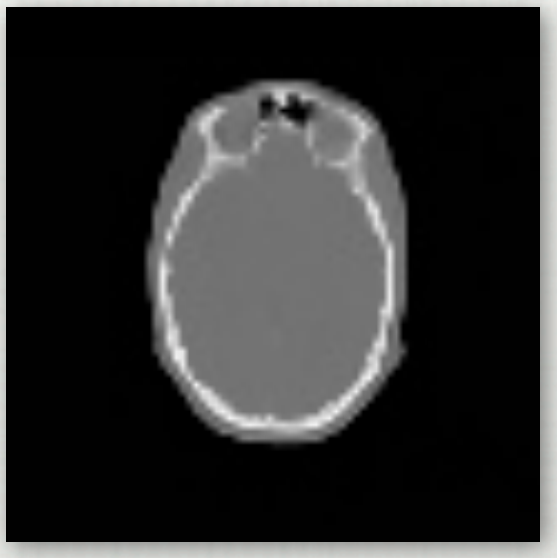

T2
CT
PET


T2
CT
PET

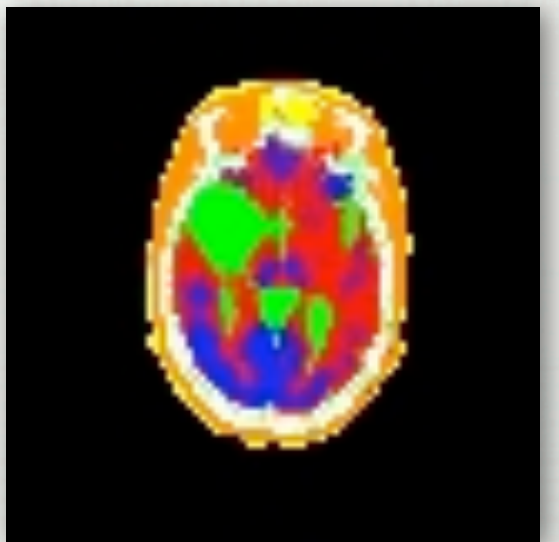
BONUS: SEGMENTATION



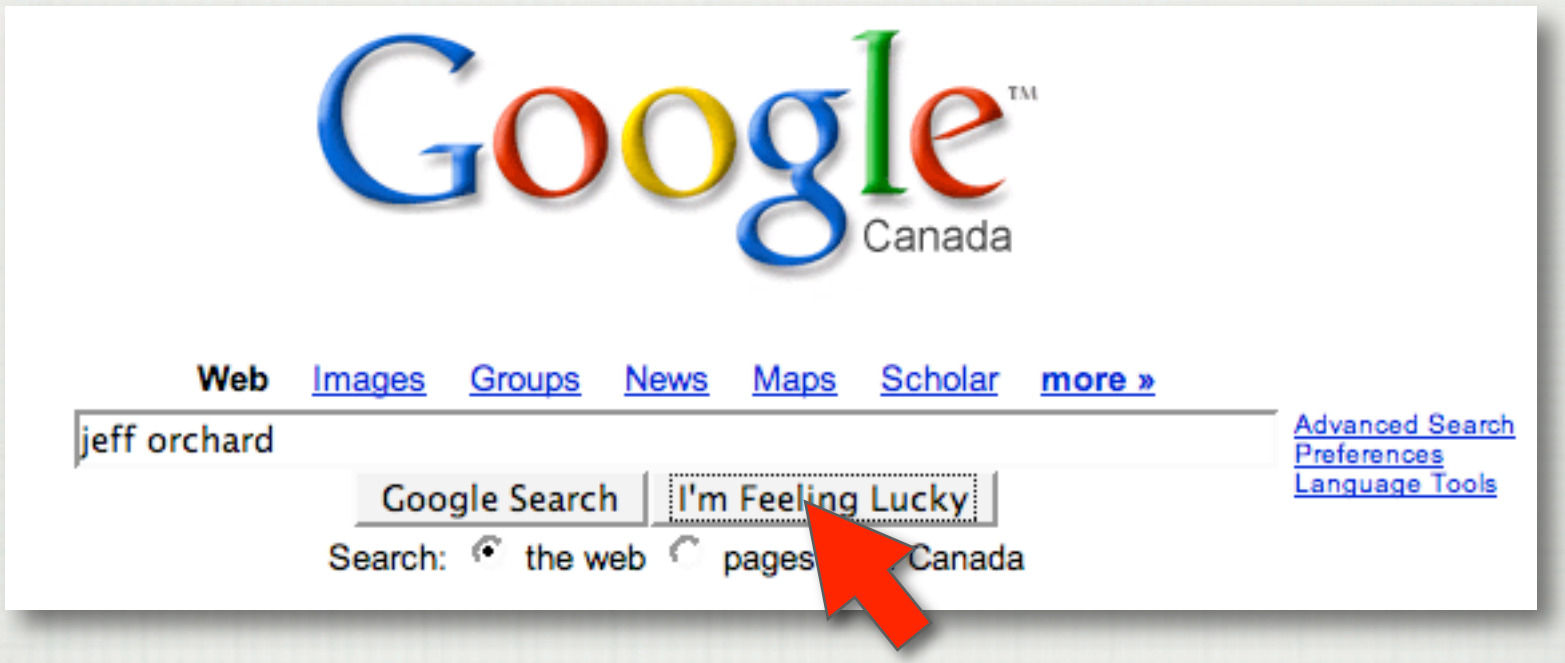
T2-MRI



CT



CLASSIFICATION


Google™
Canada
Web Images Groups News Maps Scholar more »
jeff orchard
Advanced Search
Preferences
Language Tools
Google Search
I'm Feeling Lucky
Search: the web pages Canada