Registration - I

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(Shashi)

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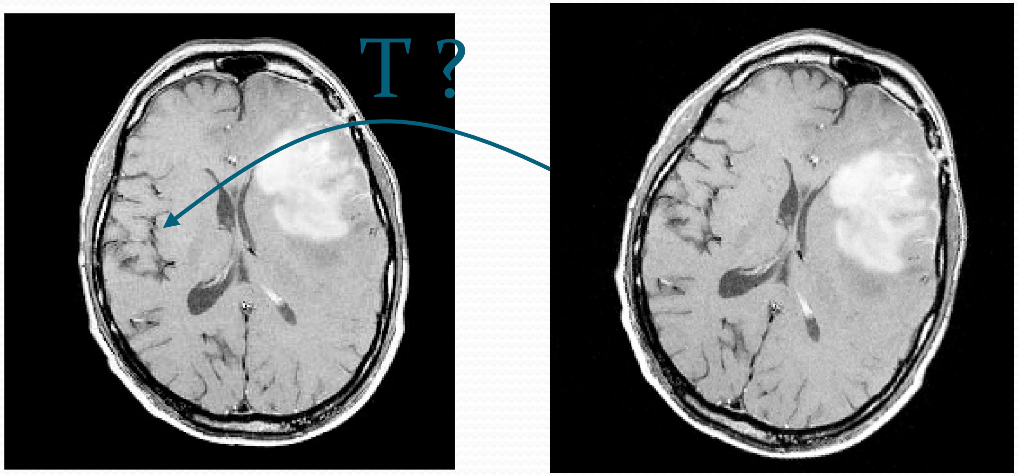
- What is registration?
- Why registration ?



Formulation of problem

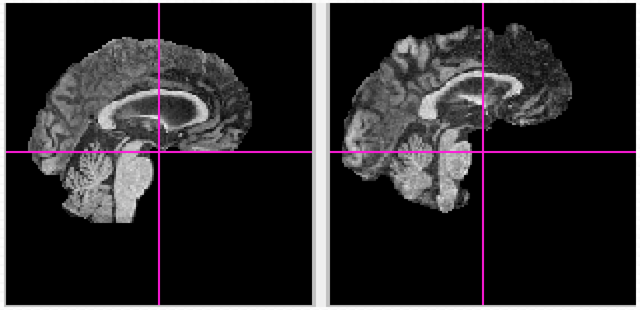
Find feasible transformations φ,

$$\varphi \in \prod_{1}^{d} (R^d) \text{ , such that } \quad D[\varphi] = min$$

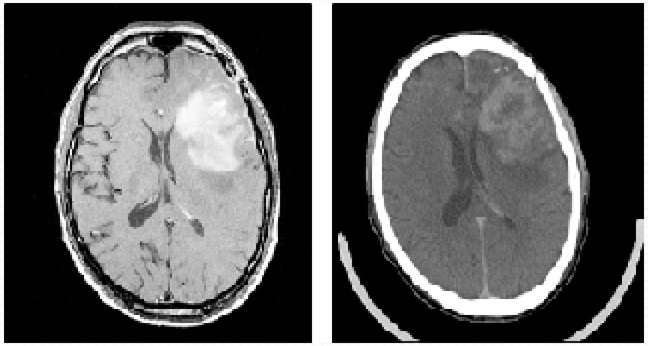
$$D[R, T; \varphi] = D[R, T o \varphi]$$

Distance Measures?

- Uni Modality
  - Intensity based.
  - Correlation



- Multi Modality
  - Mutual Information and joint Entropy
  - Maximum Likelihood
  - Kullback-Leibler Divergence



Intensity Based

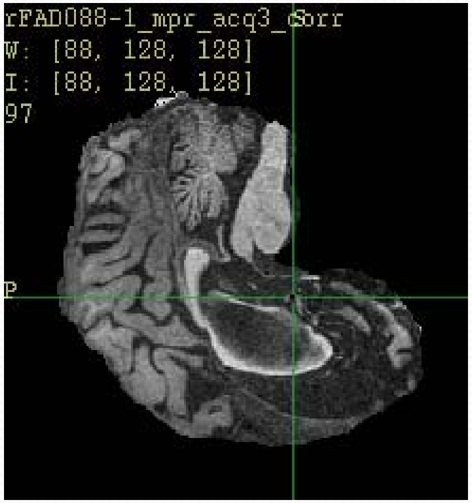
- Minimisation of squared differences

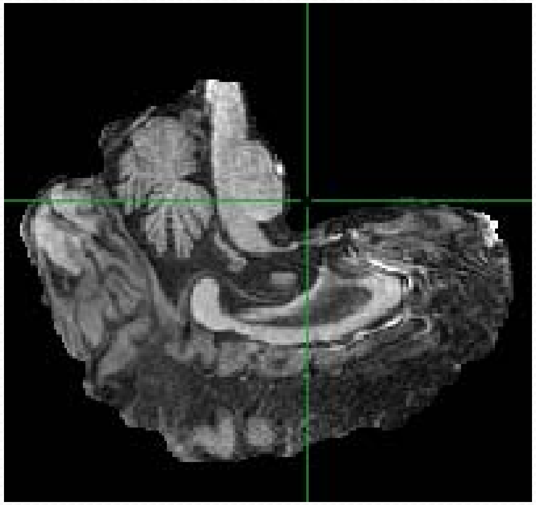
$$D^{SSD}[R,T] := \frac{1}{2}\|T - R\|_{L_2}^2$$

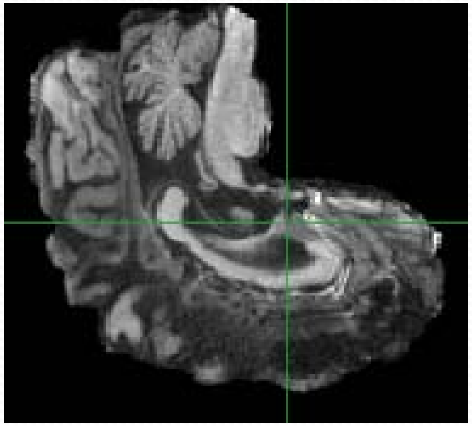
$$\frac{1}{2}\int_{R^d} \left(T(x) - R(x)\right)^2 dx$$

$$D^{SSD}[R,T;\varphi] = D^{SSD}[R,T o \varphi]$$

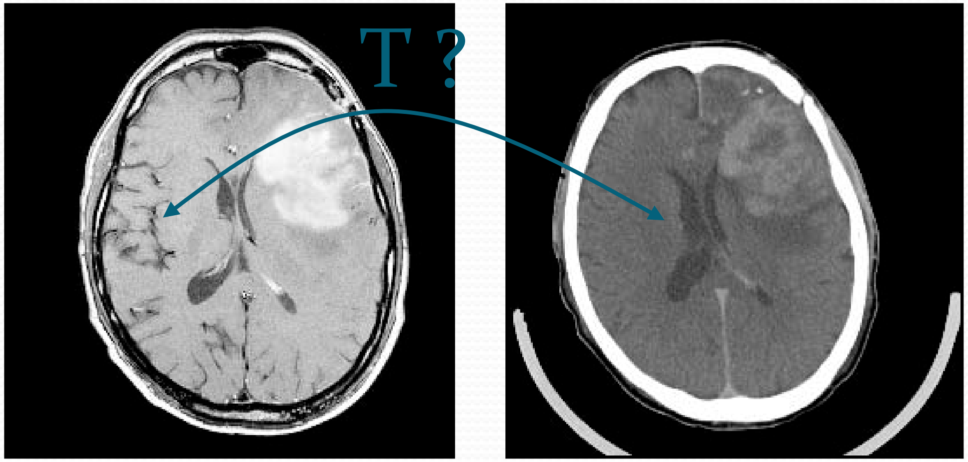
Results

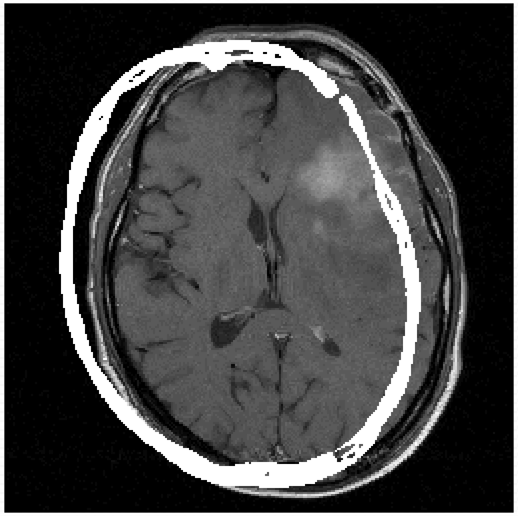






Mutual Information





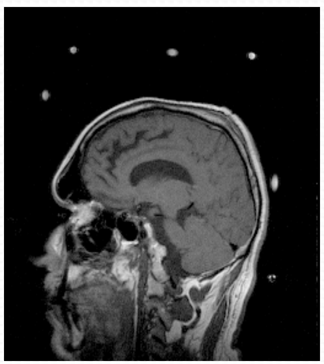
2-D Histogram

- How does a 2-D histogram of two same images look like ?

Registration compensates for different head position at acquisition.

Image 1

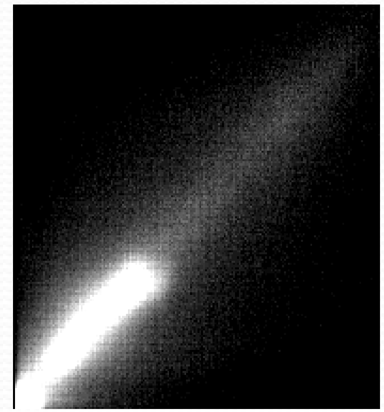
Image 2



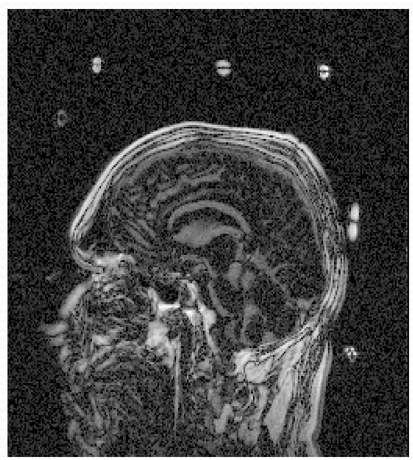
sagittal slices
256 x 256 x 9
1.2 x 1.2 x 4mm

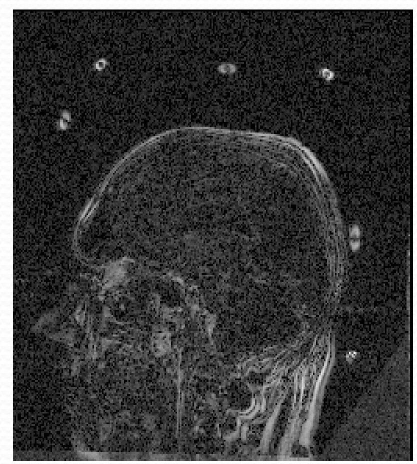
unregistered

registered



Histogram

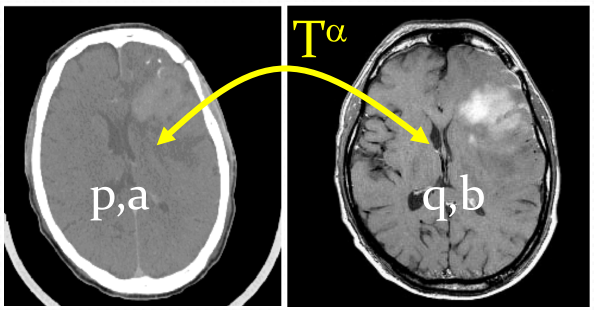




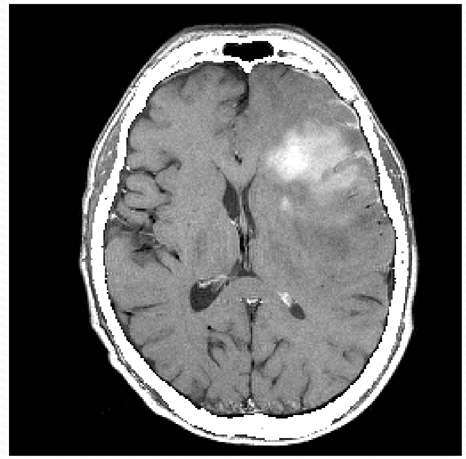
Difference image

Histogram dispersion

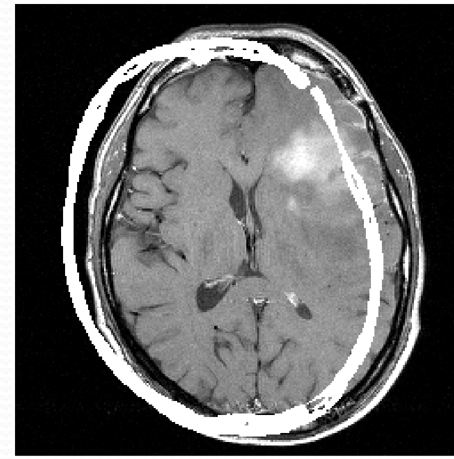
A B



Registered

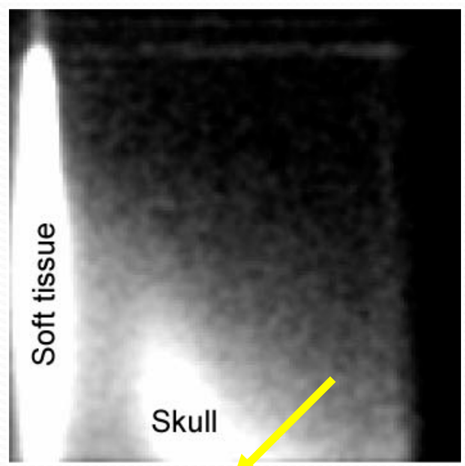


Not registered

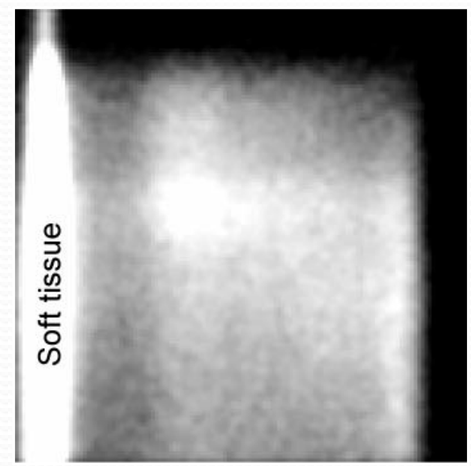


2-D histogram

MR intensity

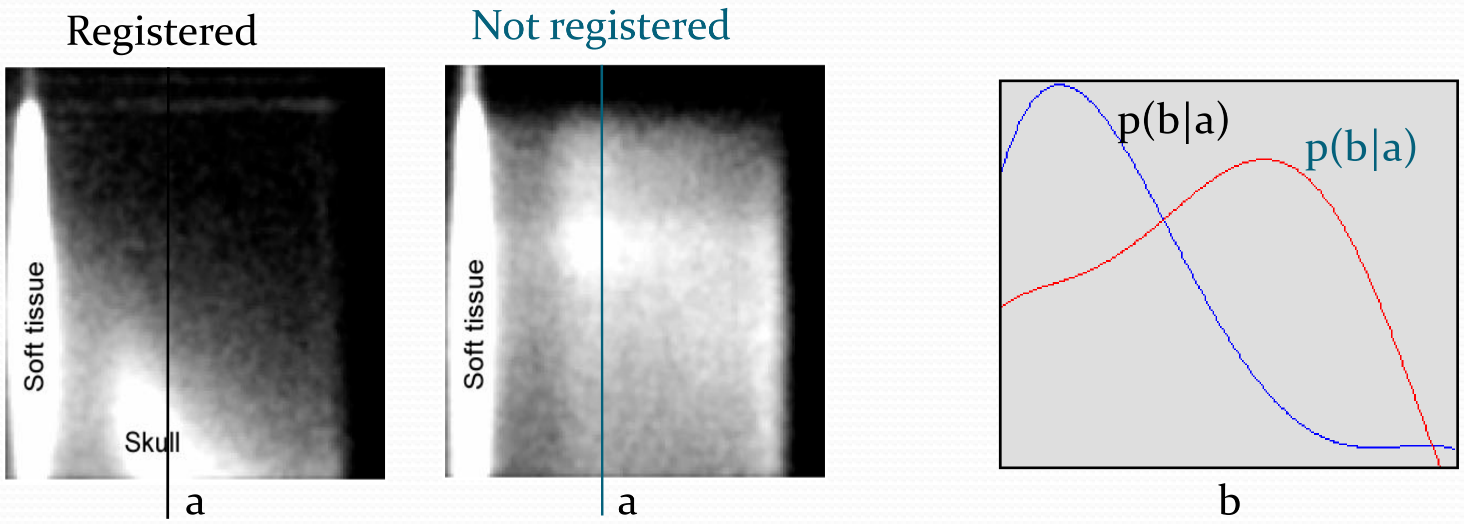


CT intensity



CT intensity

Registration criterion



the statistical dependence of corresponding voxel intensities is maximal at registration

Maximization of mutual information

Interpretation

$H_A(\alpha)$, $H_B(\alpha)$	marginal entropy of A and B, respectively
$H_{AB}(\alpha)$	joint entropy of A and B
$I_{AB}(\alpha)$	mutual information of A and B

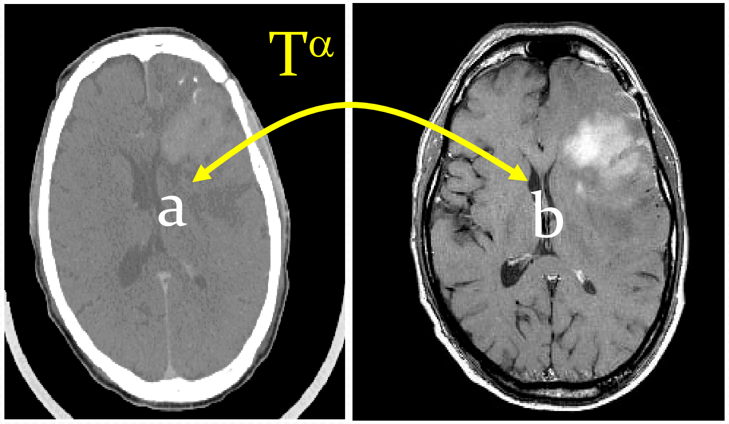
$$\boxed{I_{AB}(\alpha) = H_A(\alpha) + H_B(\alpha) - H_{AB}(\alpha)}$$

"Find as much of the complexity in the separate datatsets (maximizing H_A and H_B) such that at the same time they explain each other well (minimizing H_{AB})."

$$\boxed{I_{AB}(\alpha) = H_A(\alpha) - H_{A|B}(\alpha)}$$

"Find as much of the complexity in datatset A (maximizing H_A) while minimizing the residual complexity of A knowing B (minimizing $H_{A|B}$)."

Maximization of mutual information

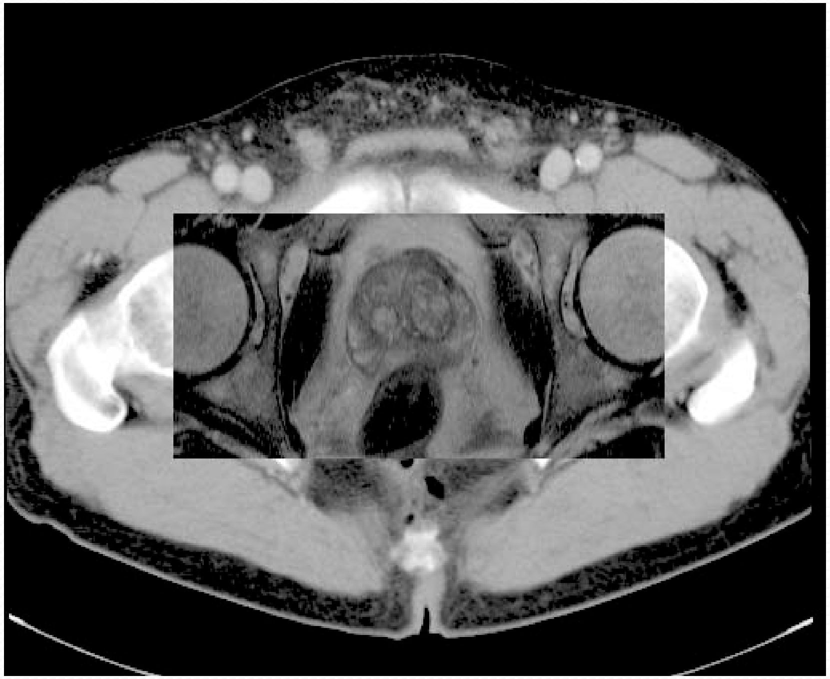


$$I(A,B) = \sum_{a,b} p_{AB}(a,b) \log_2 \frac{p_{AB}(a,b)}{p_A(a).p_B(b)}$$

$$\boldsymbol{\alpha}^* = \arg\max_{\boldsymbol{\alpha}} I(A,B)$$

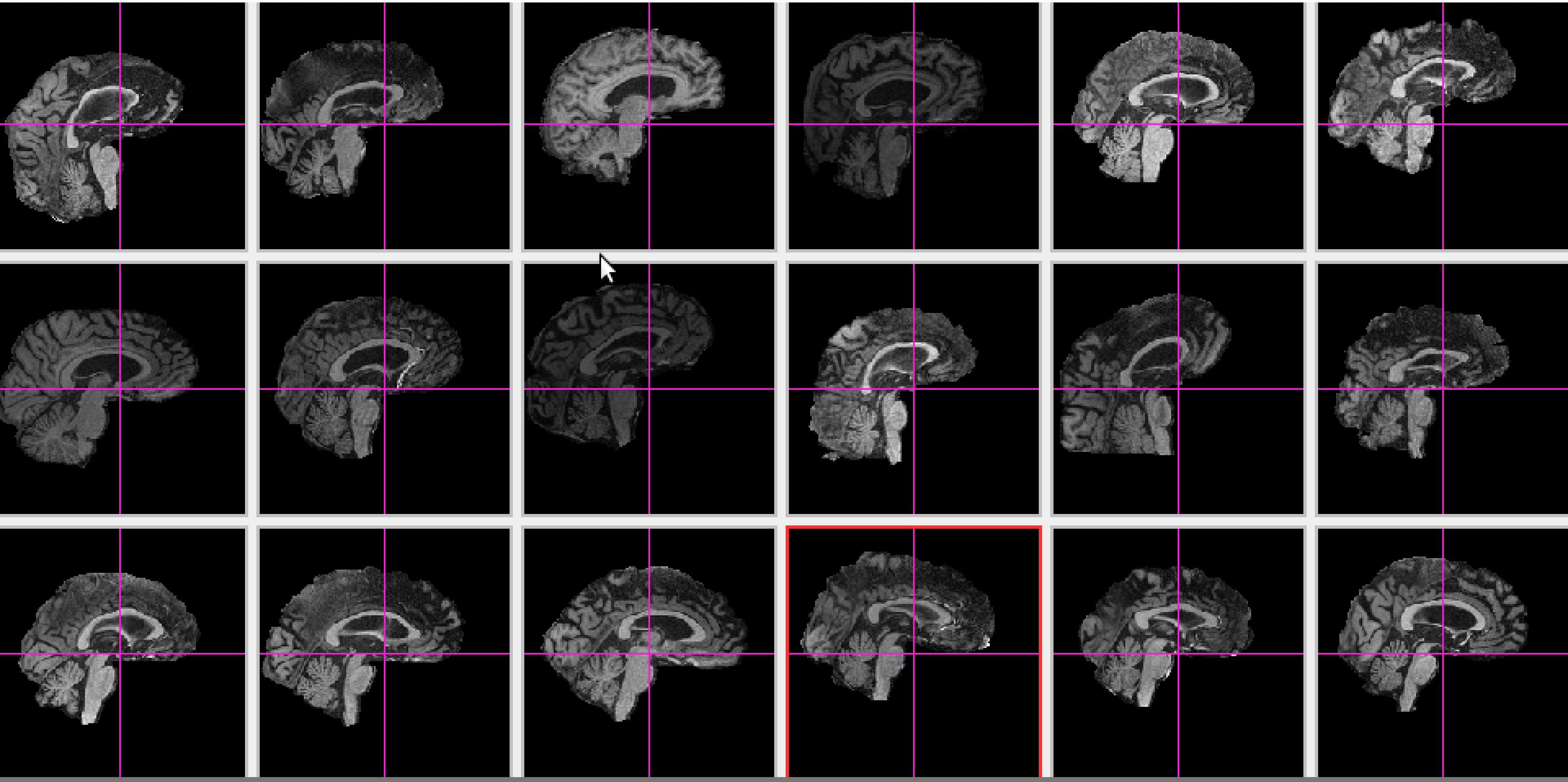
Application

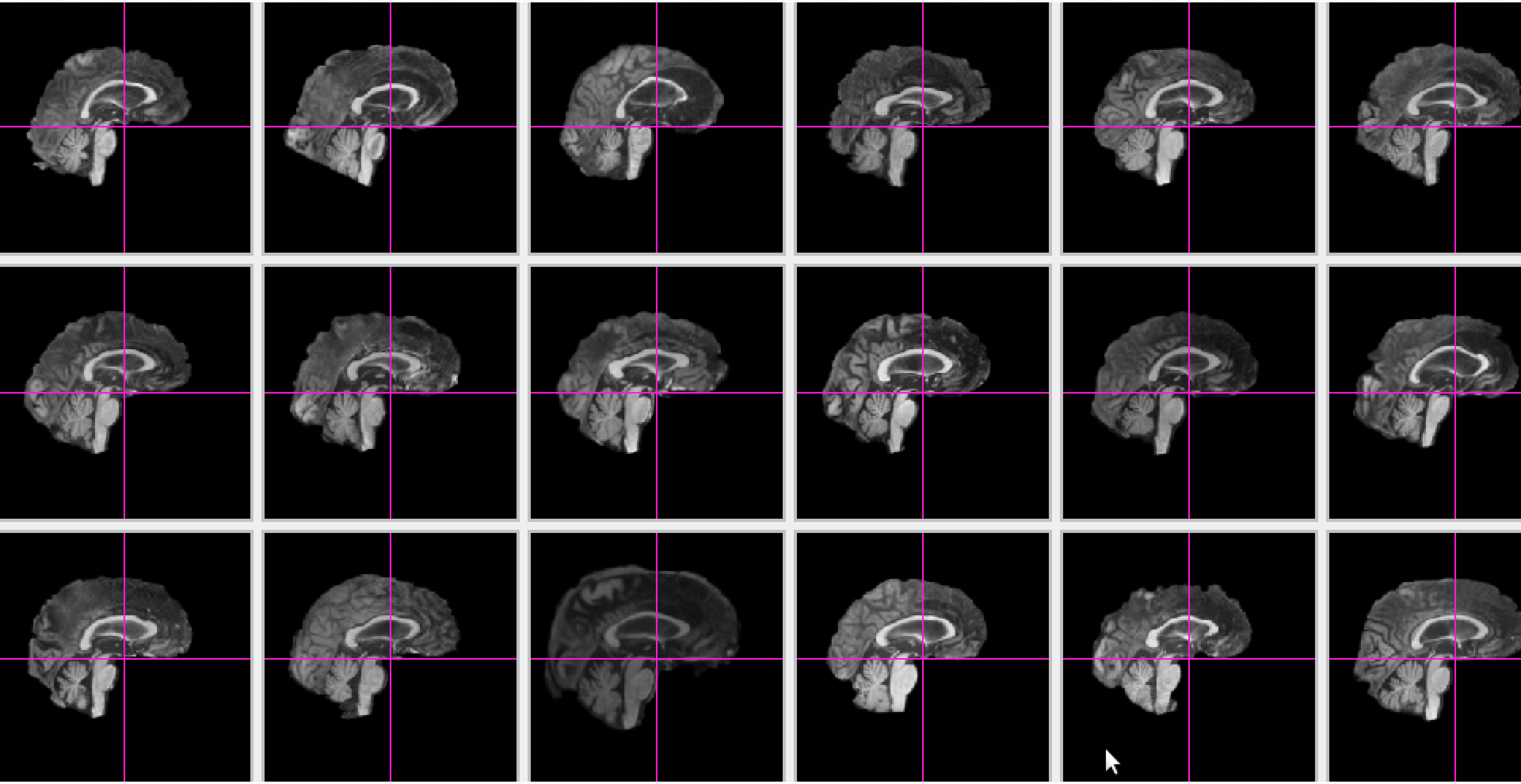
Radiotherapy treatment planning of the prostate from CT and MR images (Oyen et al.)

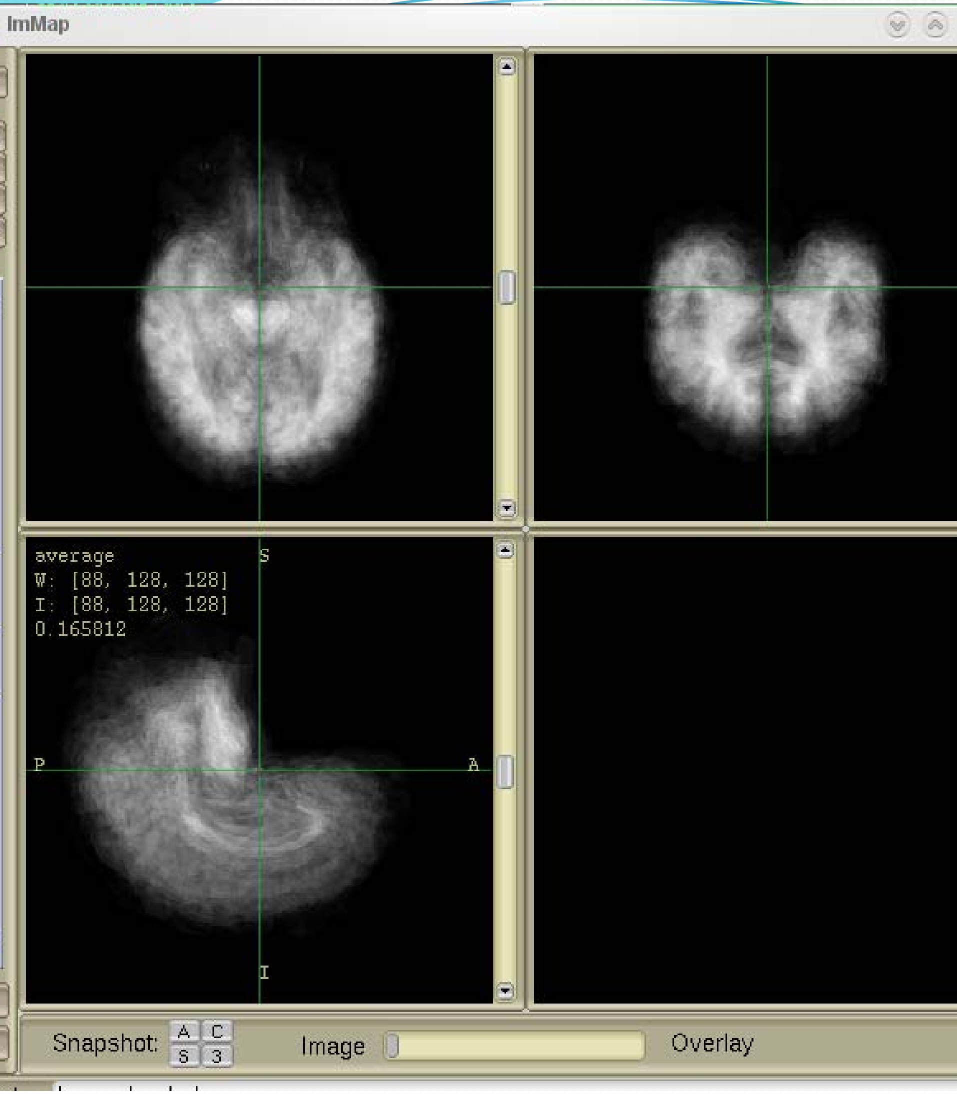


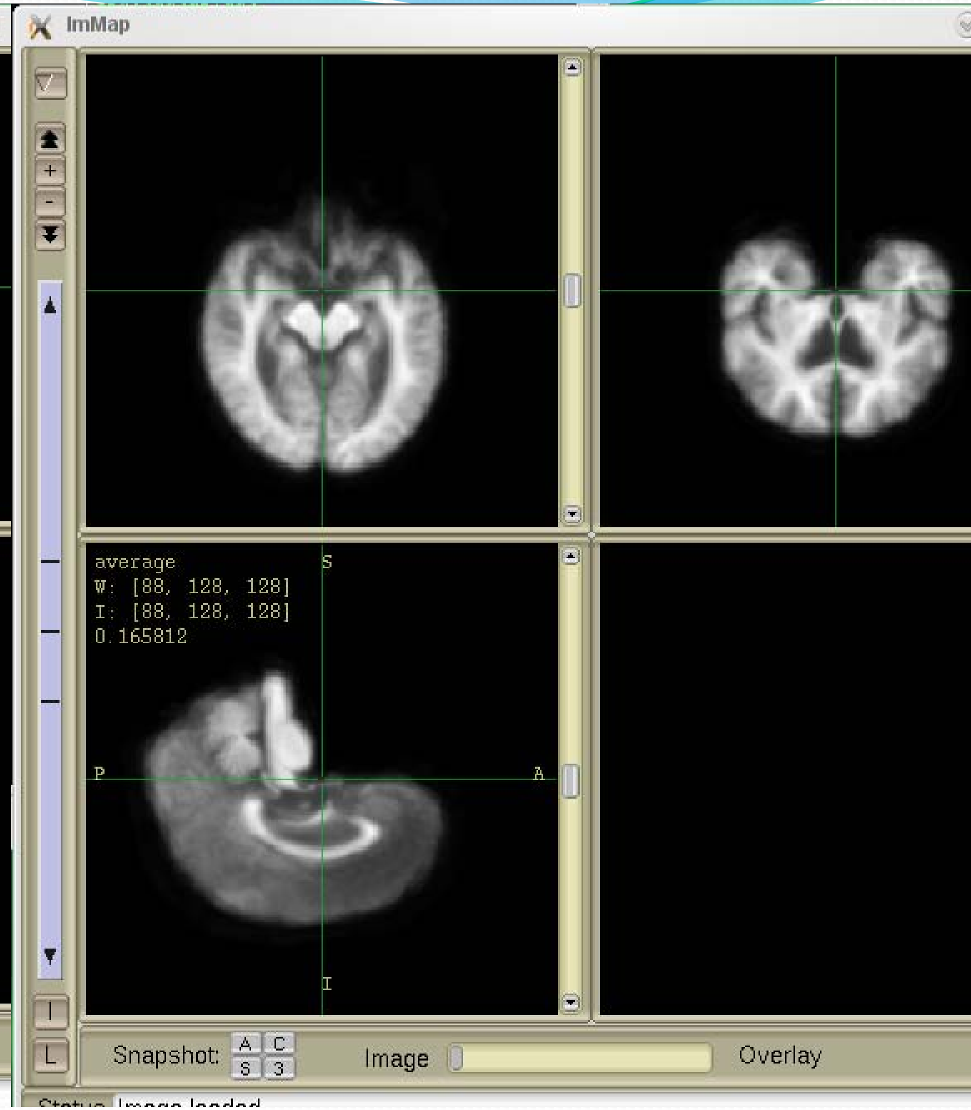
- summary

Groups






ImMap
average
W: [88, 128, 128]
I: [88, 128, 128]
0.165812
S
P
A
I
Snapshot:
A C
S 3
Image
Overlay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