GREYC Image - UMR 6072

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Automatic statistical shape model building from a priori information

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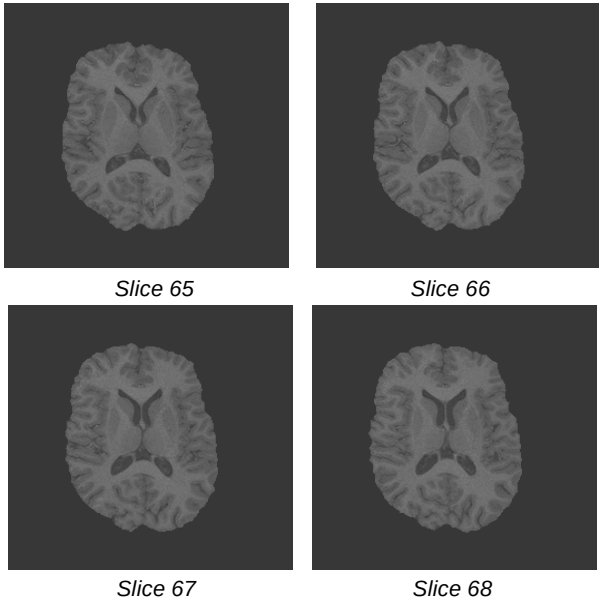
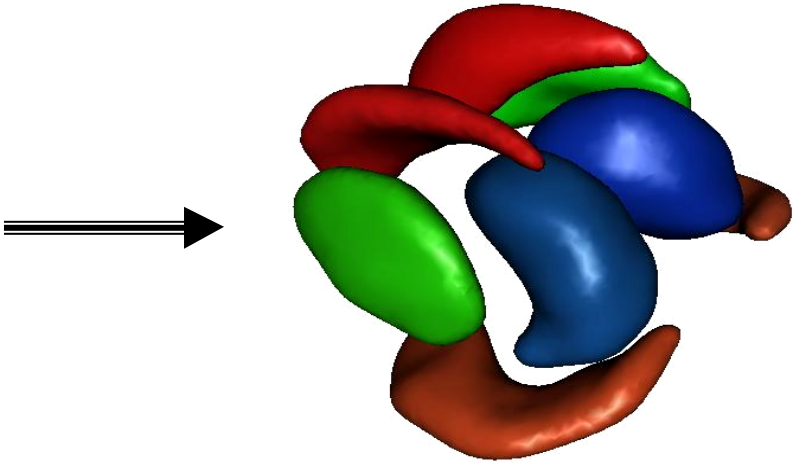
Practical Target

Automatic detection of anatomical structures from brain MRI.



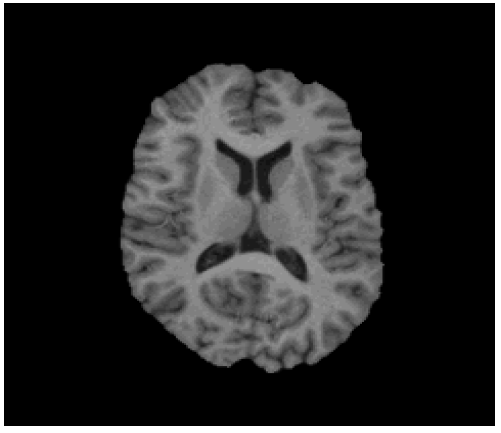


Clinical applications:

- Structure volume quantification
- «Digital Atlas»
- Fonctional Brain mapping

Main difficulty

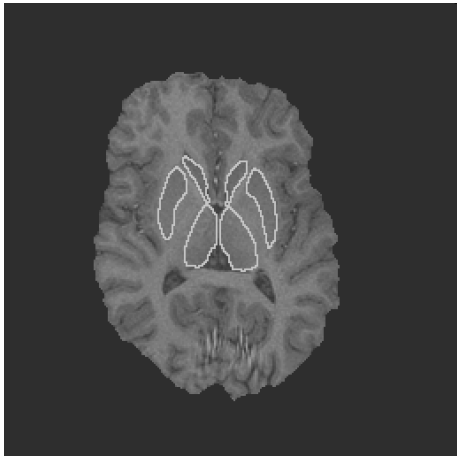
Low constrast at boundaries of structures



sample MRI slice

Associated gradient image (Sobel)

Need for a priori information to guide the delineation process

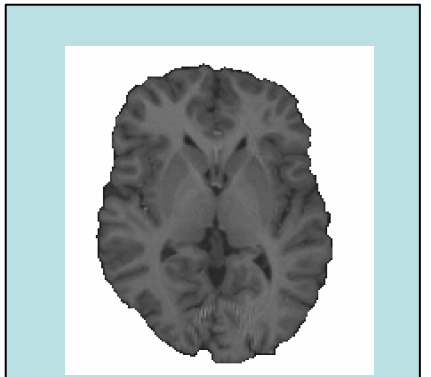


Automatic statistical shape model building from a priori information

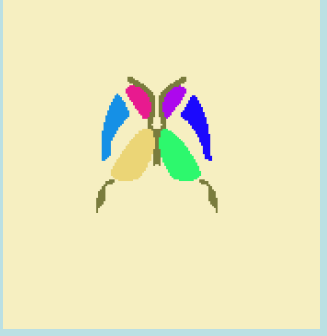
1. ***Region-based 3D segmentation method***
2. 3D Shape Model of internal brain structures.
3. Application to brain MRI structures segmentation

Region-based method

Step 1: projection of a priori knowledge into patient MRI



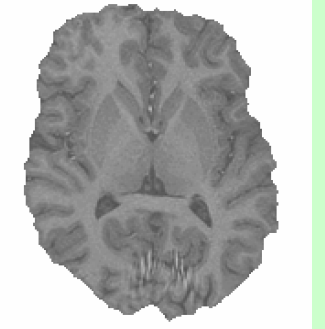
reference MRI



associated anatomical atlas

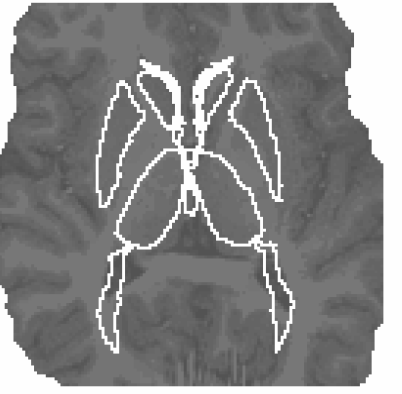
a priori information

Warp registration (AIR 5, Woods.)



Patient MRI

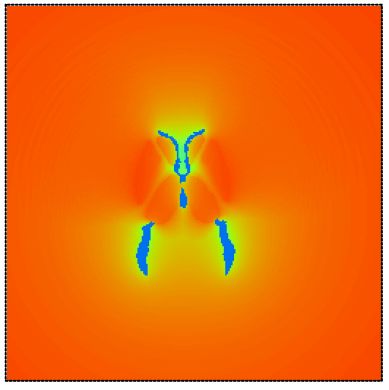
registered atlas



a priori knowledge projected onto patient MRI

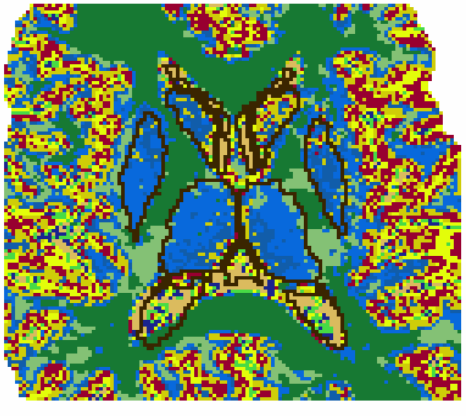
Region-based method

Step 2: use of fuzzy information to determine structure contours

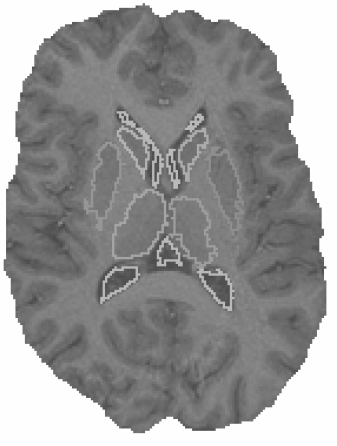


distance-based fuzzy fields

+

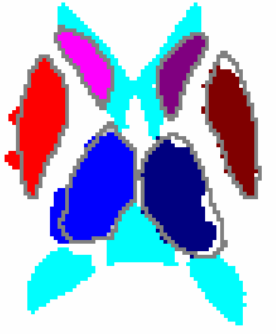


FMRF oversegmentation



structure « seeds »

constrained
morphological growing



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Need for a shape model enforcing explicit geometric constraints

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2. ***3D Shape Model of internal brain structures.***
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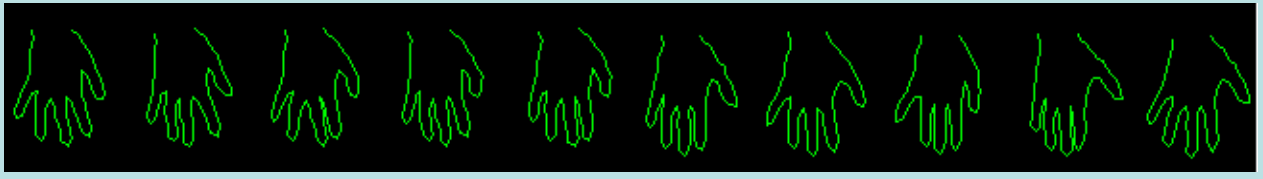
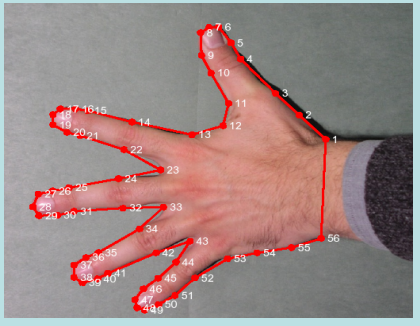
Multi-dimensional Shape Model

Overview of the Point Distribution Model (PDM)





Input data: landmarked training set of studied shape

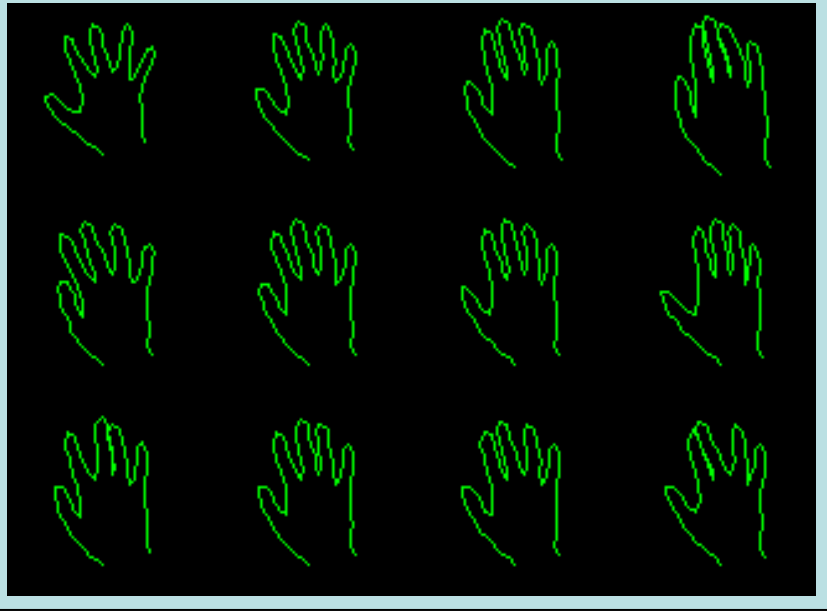
Output data: an Allowable Shape Domain (ASD) for studied shape:

$$s_a = \overline{s} + \sum_{m=1}^{n_p} p^m b_i^m$$

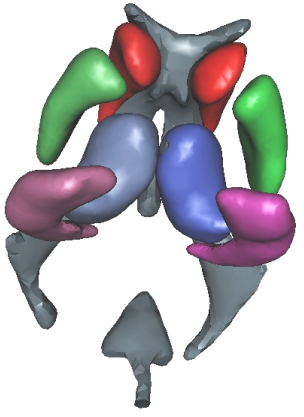
first mode

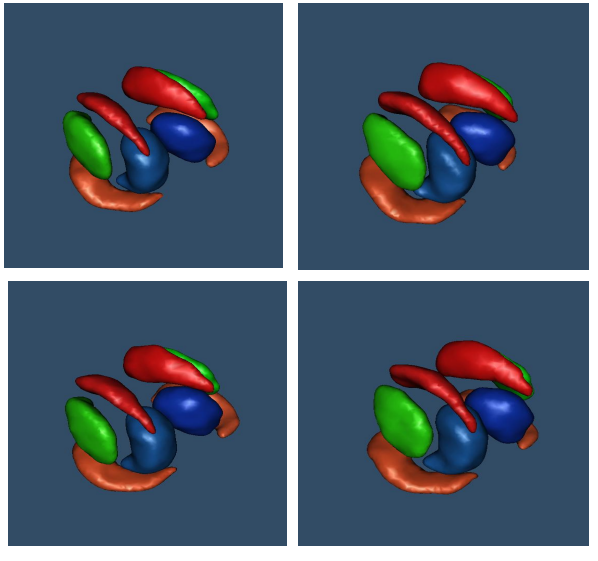
2nd mode

3rd mode



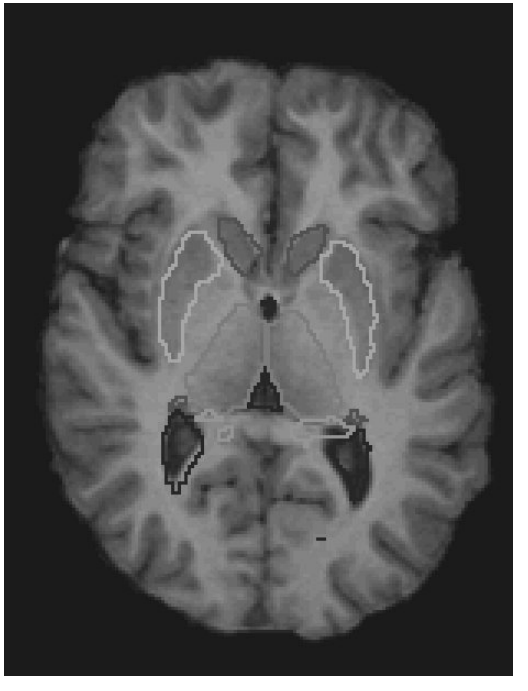
3D Brain Structures Training Set Building





Warp registration of the anatomical atlas onto a wide set of patient MRIs

- Acceptable quality
- Variability ***vs*** mean shape precision
- Further iterative refinement opportunities



Automatic 3D Landmarking

Step 1: Annotation as an optimization process

Simplex minimization framework:

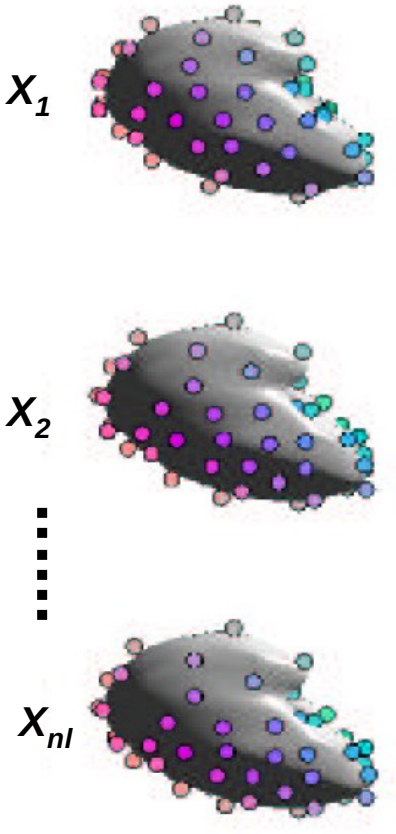
- Generate many annotation hypothesis.
- Compute the derived PDM and ***quantify*** its relevance.

$$s_a = \overline{s} + \sum_{m=1}^{n_p} p^m b_i^m$$

Objective function outline:

MDL(PDM) =

MDL(X_m) + MDL(*significant modes*) + MDL(*residual modes*)



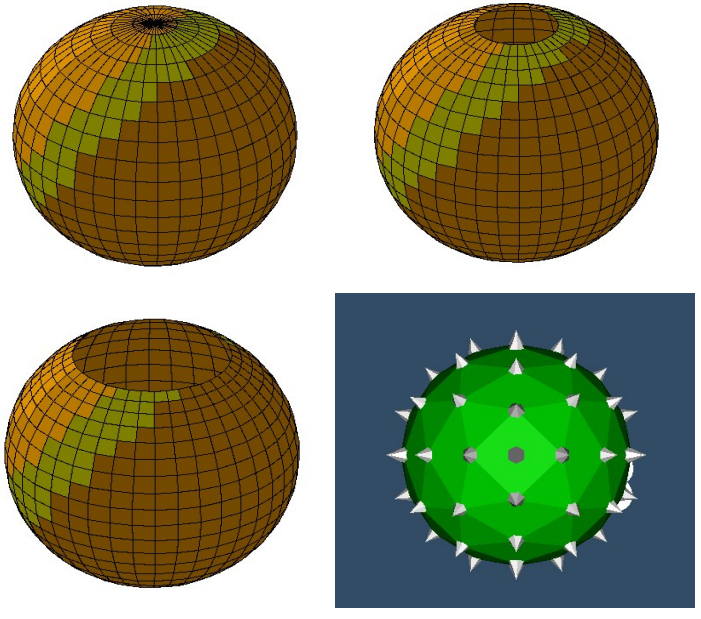
picture from Dr. Rhodri Davies

Automatic 3D Landmarking

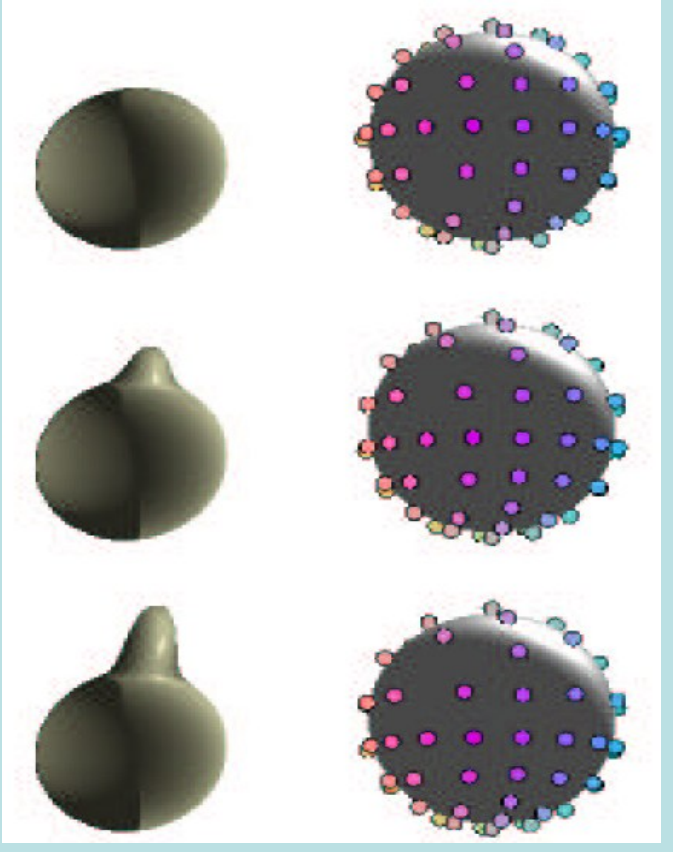
Step 2: generation of various landmarking hypotheses

Sphere reparameterization by cumulative distribution fonction of Cauchy Kernels.

$$f(\theta) = \frac{1}{1+A}\left(\theta + \arccos\left(\frac{(1+\alpha^2)\cos\theta - 2\alpha}{1+\alpha^2 - 2\alpha\cos\theta}\right)\right)$$



Effect of optimizing one kernel on a landmark sphere

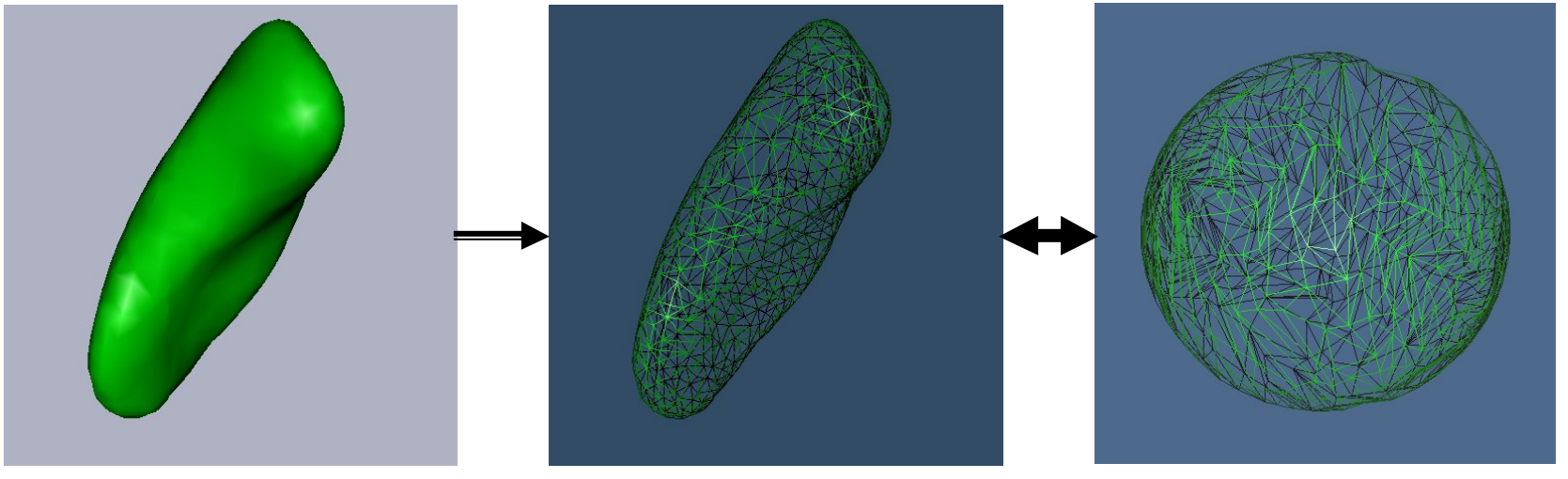


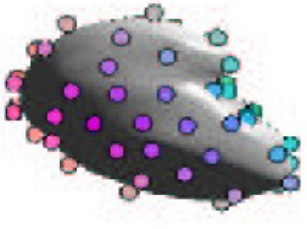
picture from Dr. Rhodri Davies

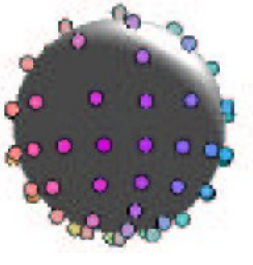
Automatic 3D Landmarking

Step 3: Projection of landmarks on the structures

- Conformal mapping optimizing angle preservation
- Vertices position optimization to also preserve surfaces



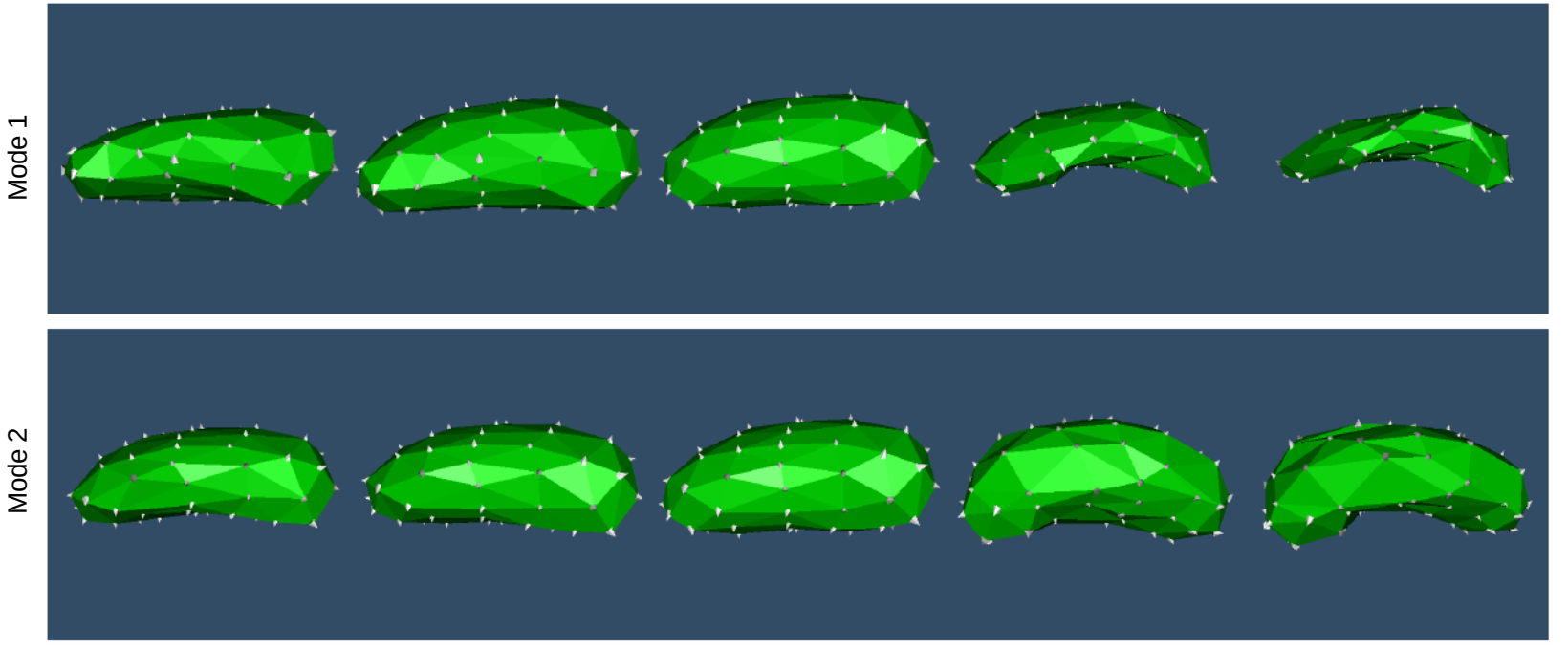




Automatic 3D Landmarking

Results

Example of PDM variation modes



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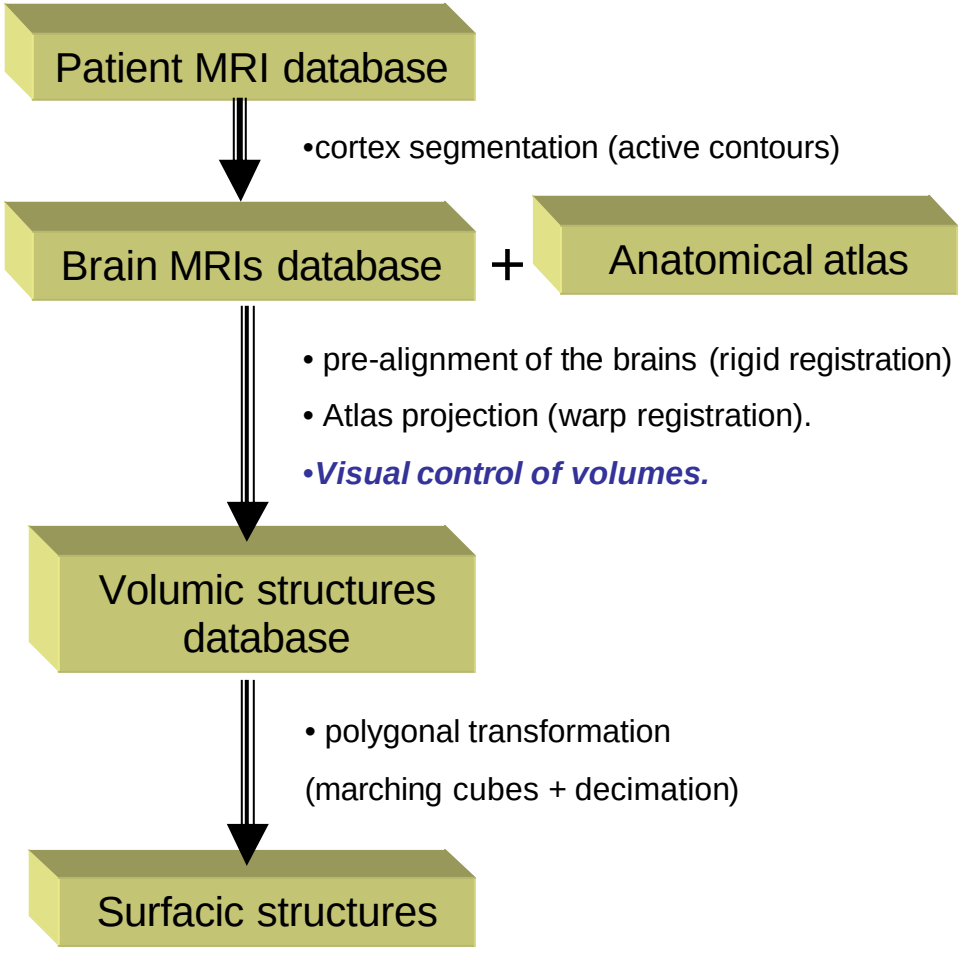
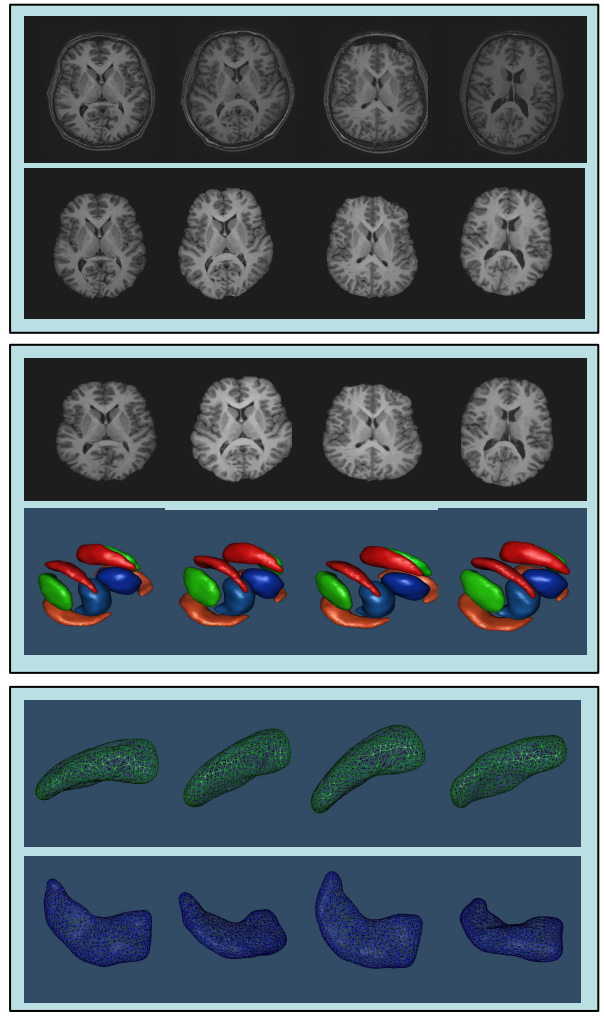
Automatic 3D PDM Building

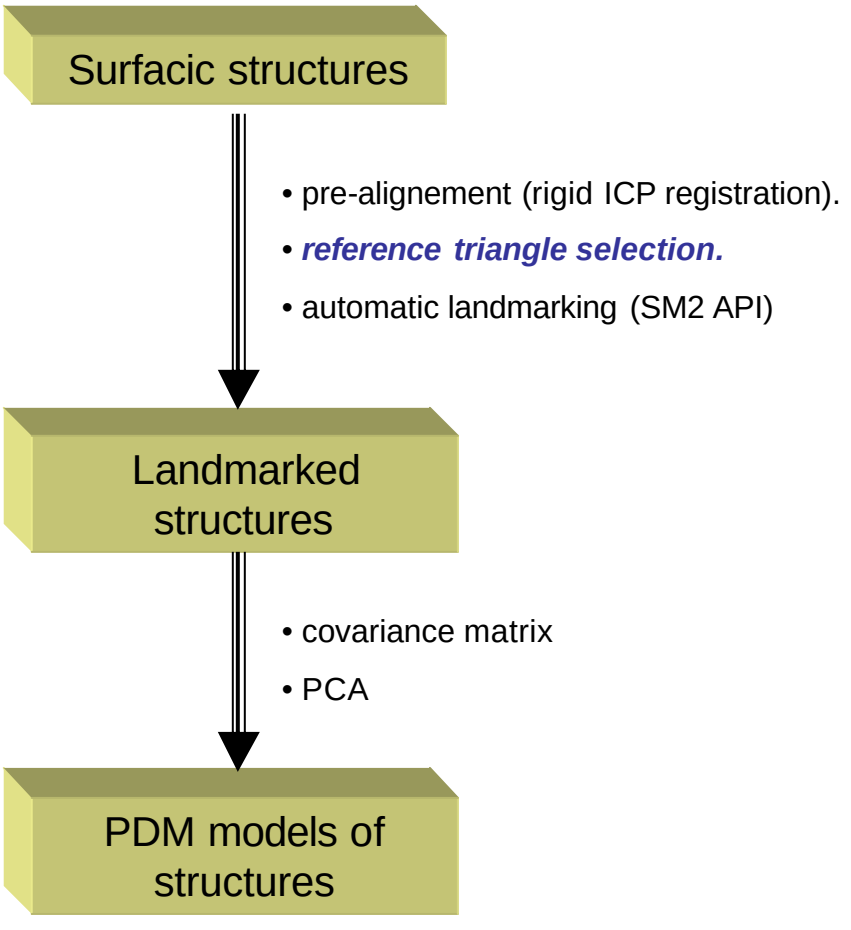
Overview

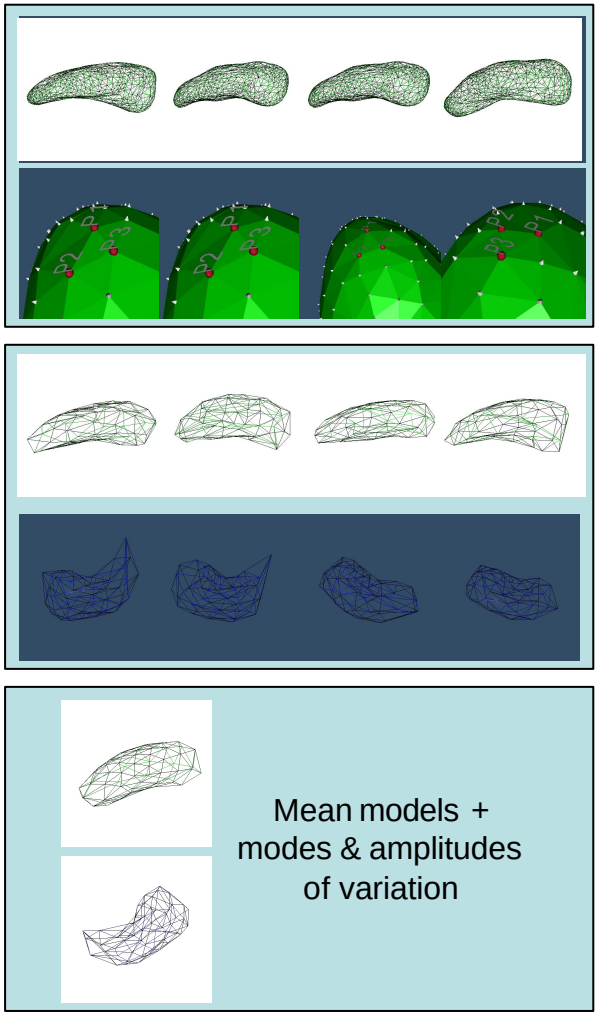




Automatic 3D PDM Building

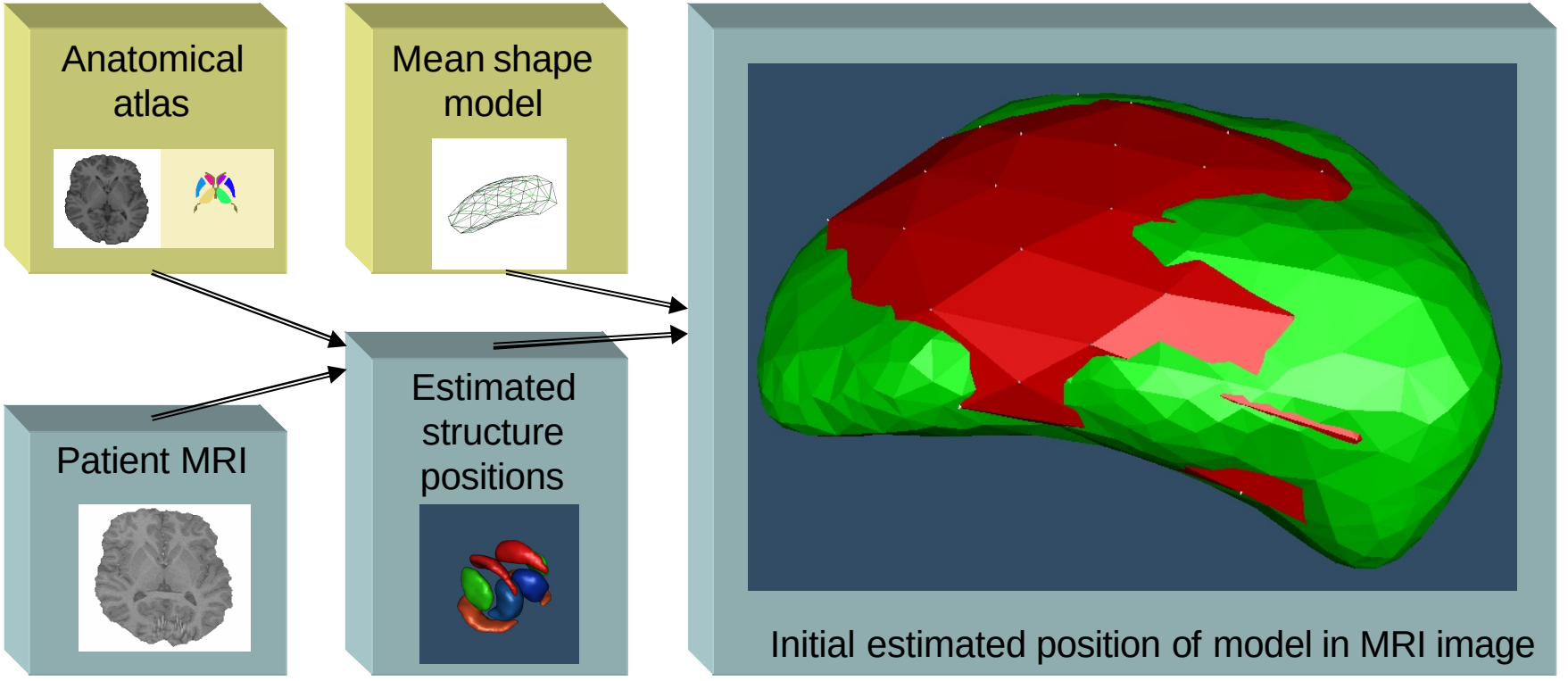
Overview





Brain MRI segmentation

Step1: Mean model positioning

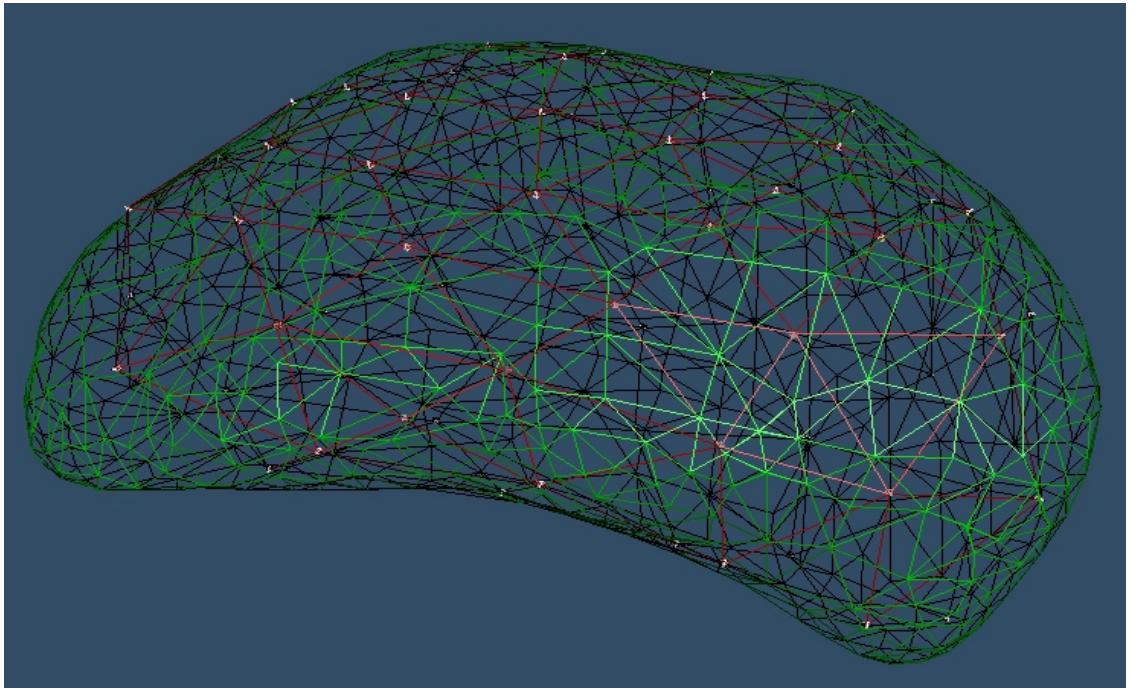


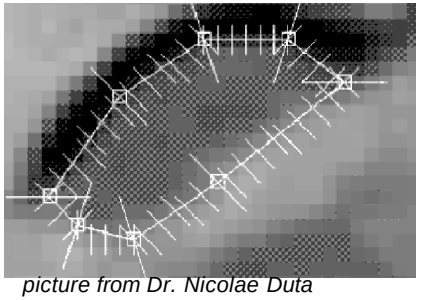
Brain MRI Segmentation

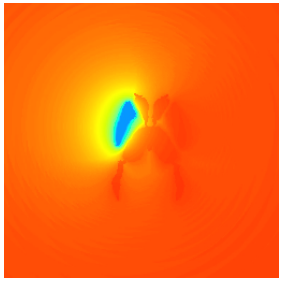
Step 2: Fitting the model to patient MRI (Prospective)

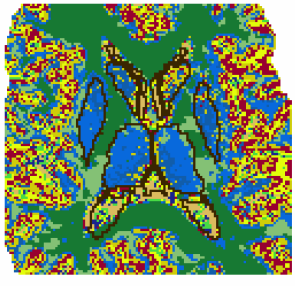
Iterative move of each landmark along its normal

- matching learned gray-level profile onto MRI.
- move constrained by fuzzy distance field.
- move constrained by anatomical tissue
- global regulation of the shape model









picture from Dr. Nicolae Duta

The end…

Contacts:

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