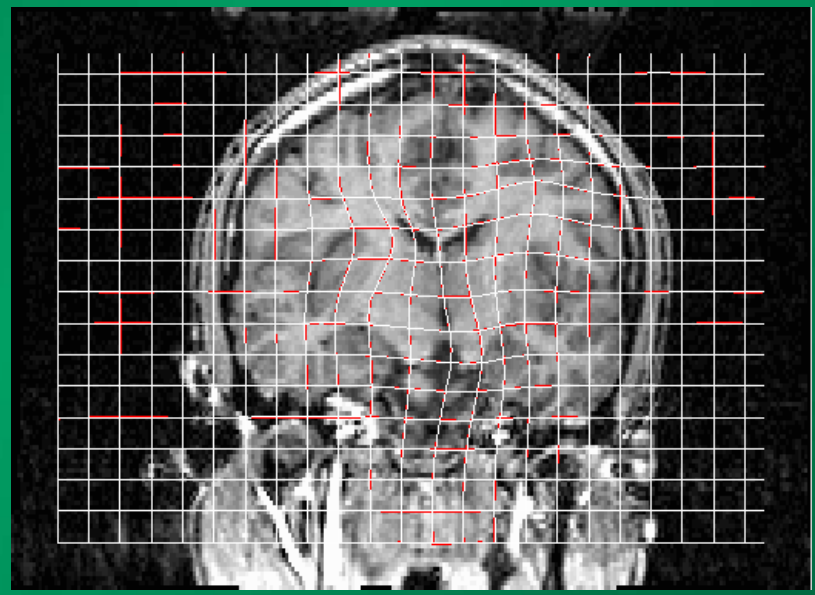
Nonrigid Image Registration in Image Guided Intervention Applications

Oskar Skrinjar
Department of Biomedical Engineering
Georgia Tech and Emory University

Supported by NIBIB R01 EB 002957

Non-rigid Image Registration

1. Goal: find geometric transformation between two images that aligns corresponding features
2. Applications:
   - Pre- to post-operative registration
   - Pre- to intra-operative registration
   - “Time 1 to time 2” registration (tumor growth, MS, cardiac deformation recovery)
   - Patient-to-patient and patient-to-atlas registration
   - Multimodality registration
   - Organ specific: brain, lung, breast, heart
   - Non-medical applications



Challenges:

- Choice of image similarity measure
- Transformation folding
- Topological nonequivalence
- Transformation representation, parameter setup
- Assumptions, properties, and prior-information
- Validation

Max. displacement: 7.6 mm Max. error: .74 mm

Approach:

- define spatial transformation on a set of nodes by means of interpolation/approximation (cubic B-spline)

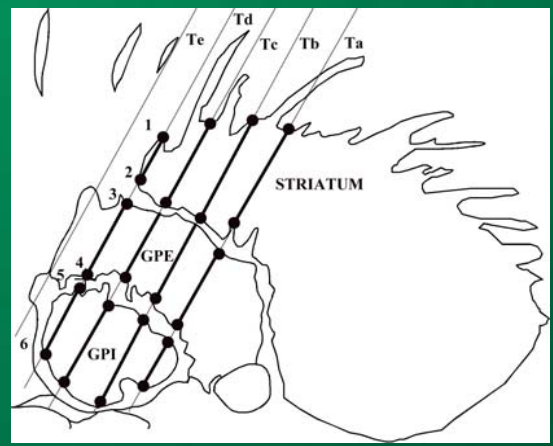
- optimize node locations to maximize image similarity measure (and transformation smoothness)

Augmentation of Accuracy for Image-guided Neurosurgery

Micorelectrode-guided surgery for treatment of movement disorders (e.g. Parkinson's disease, essential tremor, and dystonia)

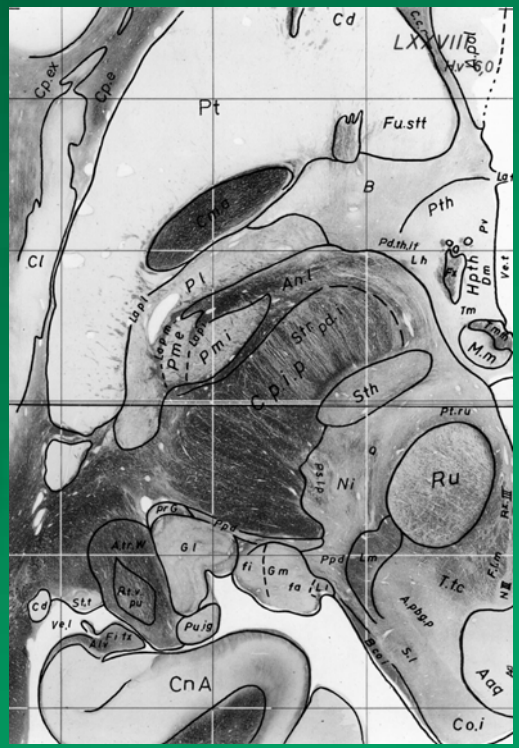
The goal is to improve the navigational accuracy for placement of the permanent stimulator in the midbrain for deep brain stimulation surgery. Funded by NIH.

For the success of the surgery, the DBS lead must be implanted precisely in the target structure, the internal globus pallidus or the subthalamic nucleus.

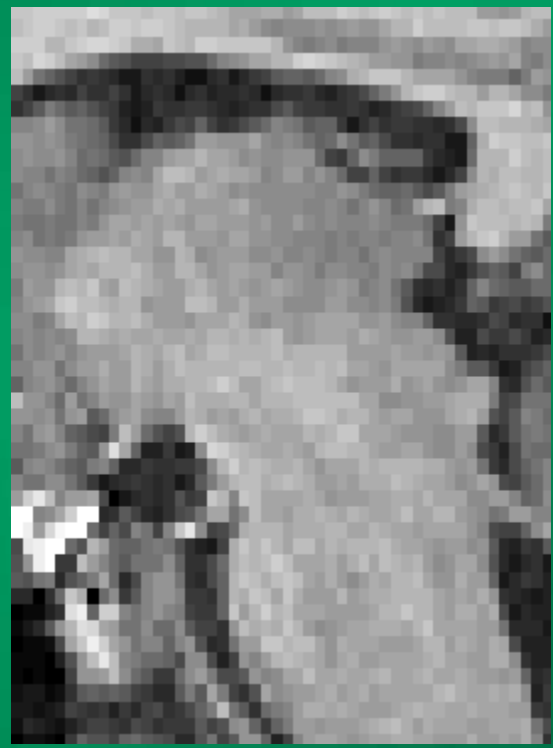


The procedure involves listening to the neuronal signals as a recording microelectrode is penetrated into the deep brain in small steps.

Atlas-to-patient Nonrigid Image Registration

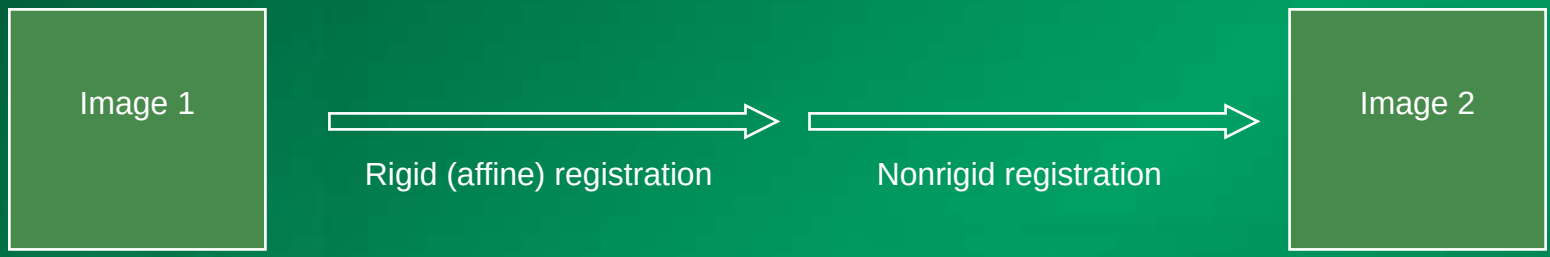


A sagittal histology section



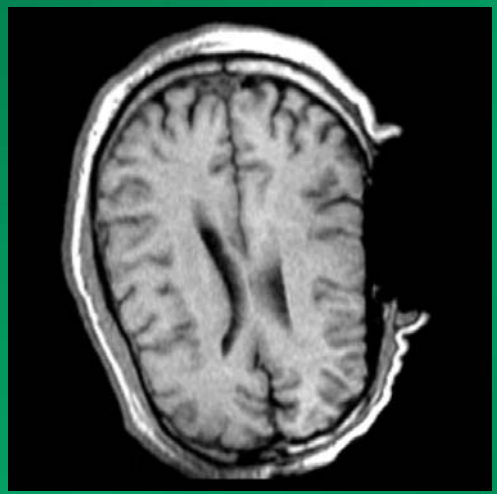
A sagittal MRI section

Pre- to Post-operative MRI Registration for Brain Shift Analysis



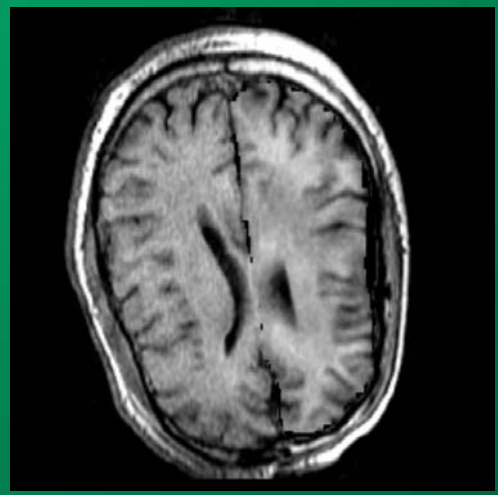
Brain shift analysis: DEMO

Brain shift compensation: a biomechanical model-based approach



Intraoperative

Intraoperative MRI data provided by Surgical Planning Lab., Harvard U.



Model-updated

Image-guided Constitutive Modeling of the Brain Tissue

The goal is to develop reliable (mechanical) constitutive models of the in-vivo brain tissue. The long-term goal is to use the models to predict brain deformation during any kind of mechanical excitation. Funded by NIH.

Pre-shunt

Post-shunt

THE END

- Nonrigid image registration
- Augmentation of accuracy for image-guided neurosurgery
- Atlas-to-patient registration
- Pre-to-post operative registration for brain shift
- Image-guided constitutive modeling