Summary of Research: Image Guided Therapy and Surgery

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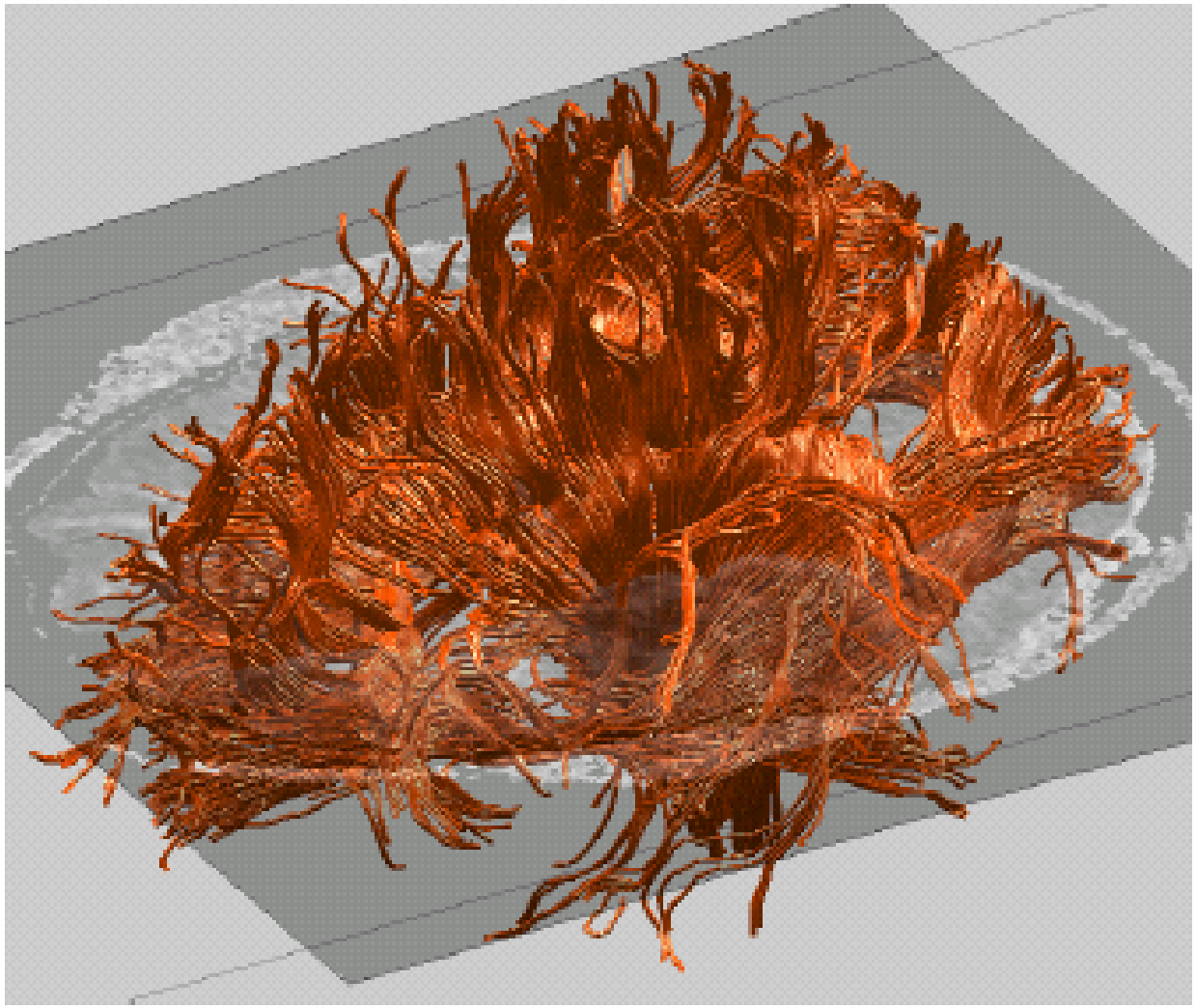
Medical Applications: IGT and IGS

- Biomedical Engineering principles to develop general-purpose software methods that can be integrated into complete therapy delivery systems.
- Four main components of image-guided therapy (IGT): localization, targeting, monitoring and control.
- Develop robust algorithms for:
  - Segmentation - automated methods that create patient-specific models of relevant anatomy from multi-modal data.
  - Registration – automated methods that align multiple data sets with each other and with the patient.

DT-MRI Tractography



fMRI and DTI for IGS

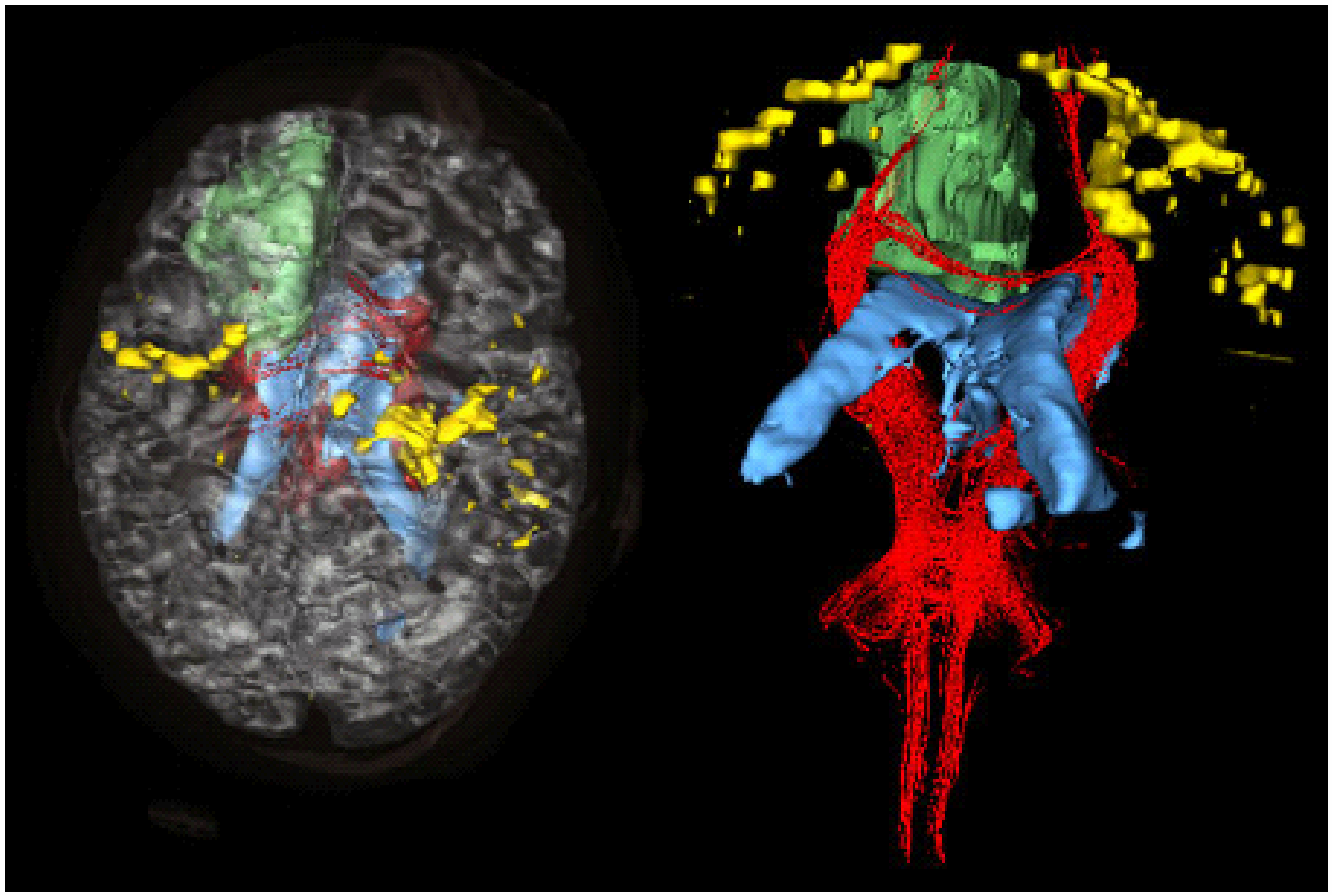


Figure 8.4.6-1. Retrospective Example of fMRI for Neurosurgical Application
62-year-old female patient with left frontal hyperintense non-enhancing mass lesion
Skin, Brain, Ventricles (blue) and Tumor (green) models from conventional MRI; fMRI activations (yellow) from pre-operative finger-taping experiment. Fiber tract indications (red) from Diffusion Tensor MRI.
Imaging suggests that the tumor is in front of motor strip with involvement of supplementary motor area, with fibers from SMA piercing tumor in its posterior aspect.

Data Fusion

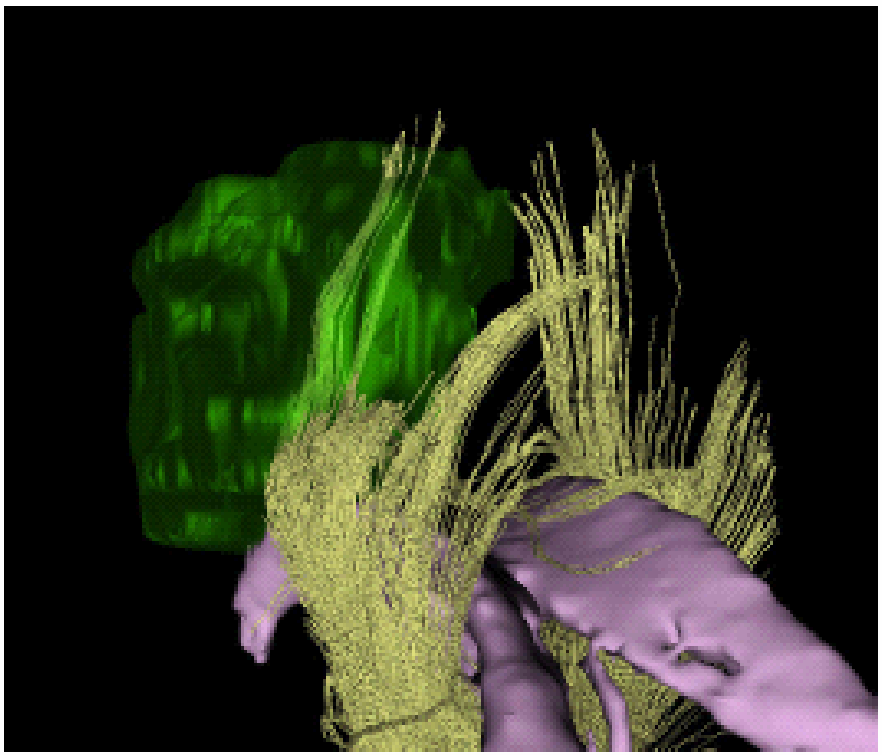


Figure 8.4.3-4. Results from DT-MRI tractography
Tractography results in the cortico-spinal tract are shown in gold. Note that some of the tract is passing through the tumor (green).

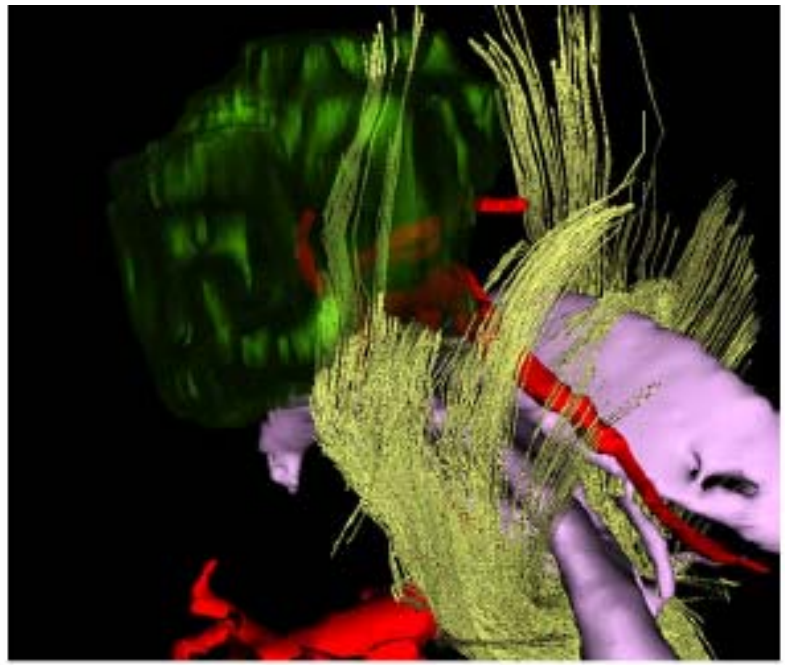
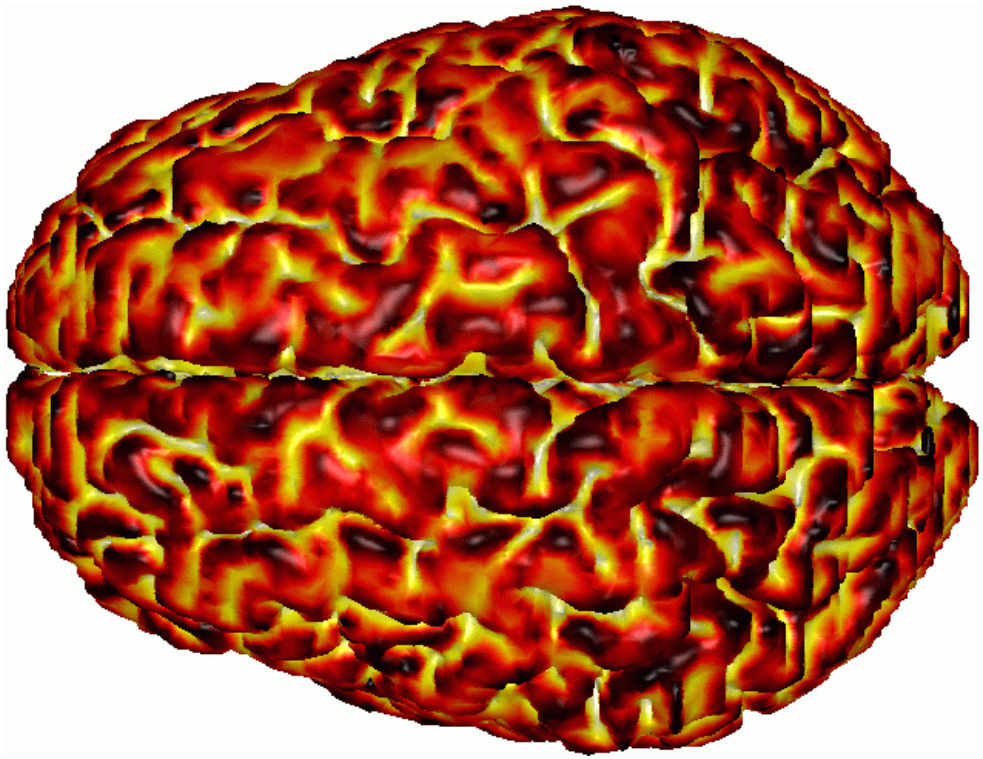


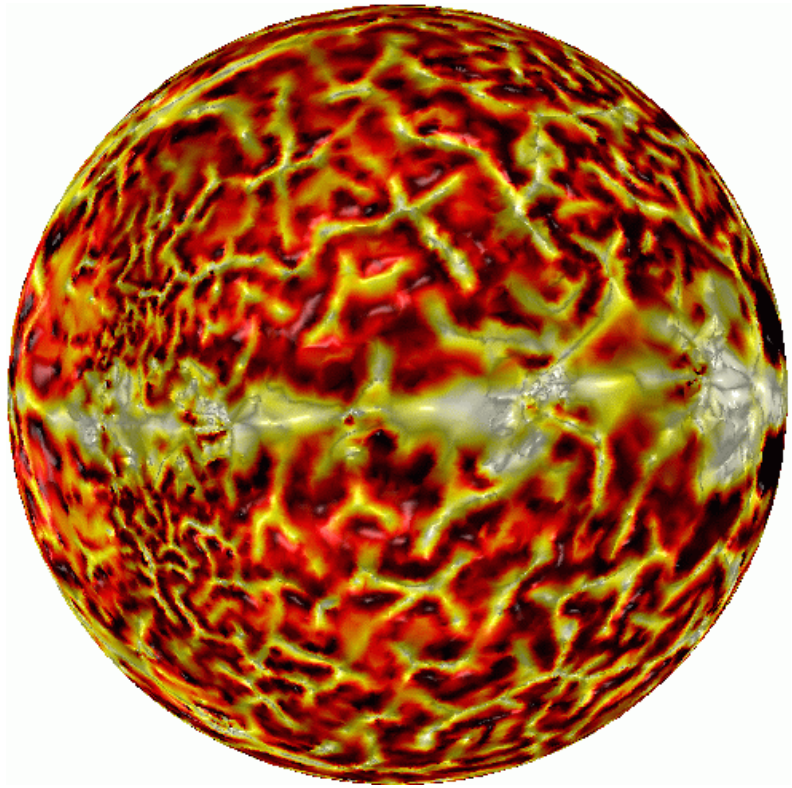
Figure 8.4.4-4. Case 1
Left postero-lateral view of a three-dimensional reconstruction of the tumor (transparent green), lateral ventricles (pink), cerebral arteries (red) and white matter tracts adjacent to the tumor (yellow) in the same case as in Figures 2 and 3. A 3D-SPGR dataset was used for the tumor and ventricle reconstruction and MR angiography was used to create the vessel 3D-model. The same line scan diffusion dataset as in Figure 8.4.4-3 was used for the three-dimensional reconstruction of the fiber tracts.

Surface Deformations and Flattening

- Conformal and Area-Preserving Maps
  - Optical Flow
- Gives Parametrization of Surface
  - Registration
- Shows Details Hidden in Surface Folds
- Path Planning
  - Fly-Throughs
- Medical Research
  - Brain, Colon, Bronchial Pathologies
  - Functional MR and Neural Activity
- Computer Graphics and Visualization
  - Texture Mapping

Cortical Surface Flattening-Normal Brain





White Matter Segmentation and Flattening

Conformal Mapping of Neonate Cortex

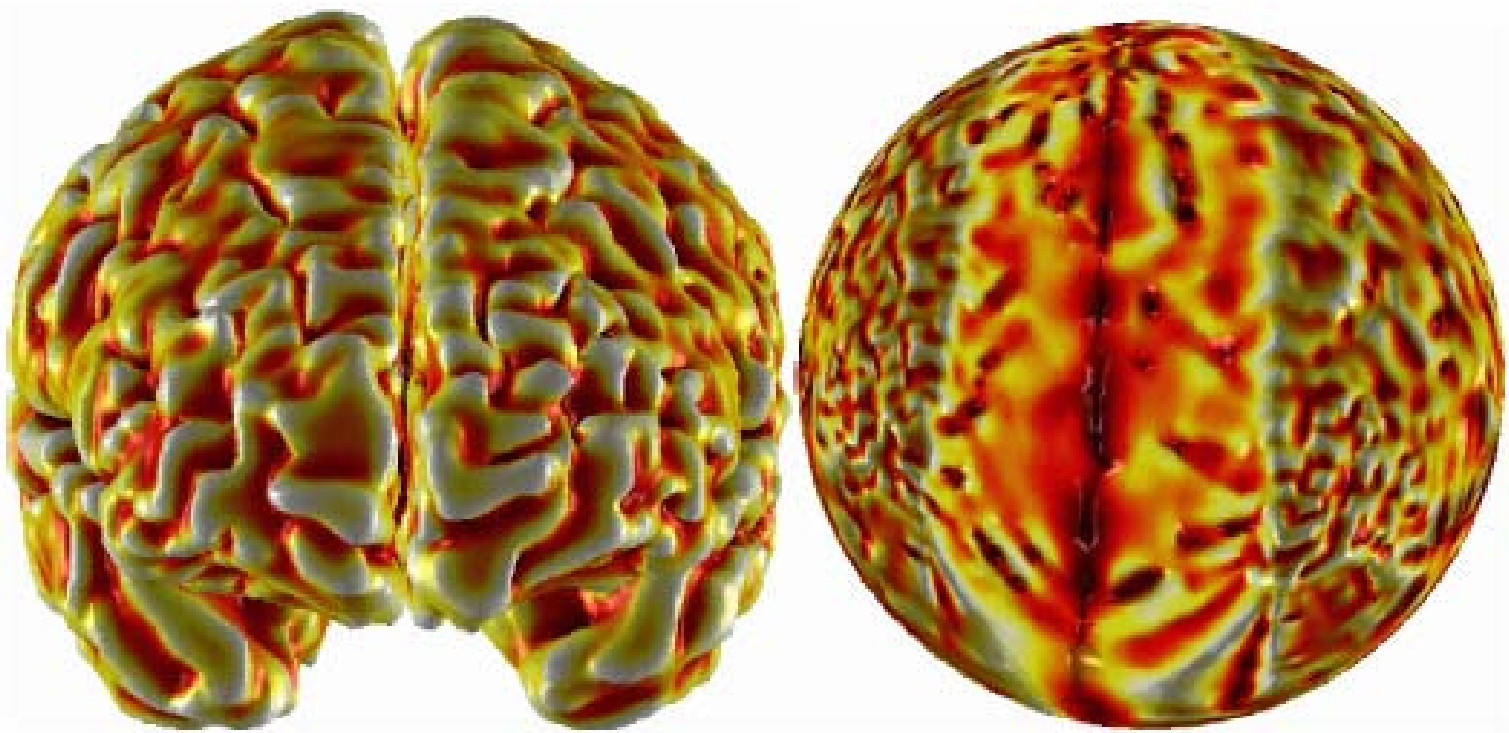


Figure 8.4.5-12
Conformal mapping of the neonate cortical surface to the sphere. The shading scheme represents mean curvature.

Coordinate System on Cortical Surface