Automated Extraction of Subdural Electrodes from Post-operative MRI for Epilepsy Surgery

by Max Pozdin
gtg470j@mail.gatech.edu

Overview

- Introduction to epilepsy surgery
- Post-operative MRI, subdural electrodes
- Extraction of subdural electrodes
  - Exhaustive search for spherical shapes
  - Modeling of the 3x3 electrode grid
- Future work

Medical Background

- Epilepsy is a condition in which person has recurrent seizures
  - Seizure – abnormal, disorderly discharging of the brain’s nerve cells, resulting in a temporary disturbance of motor, sensory, or mental function
  - Cause: tumor, chemical imbalance, head injuries, certain toxic chemicals or drugs of abuse, stroke (hemorrhage), birth injuries

Medical Background (con’t)

- 1% of US population affected
- Cure:
  - Medications
  - Brain surgery
- Epilepsy surgery is one of the safest types of brain surgery
  - Doctors need to know what part of a brain to remove
    - Make sure that it is a gray matter not a functional

Post-op MRI images

- Post-op MRI images taking after electrodes have been implanted
- 3 weeks to monitor brain activity and identify abnormal areas
- Map electrodes with abnormal readings to the patients brain
- Check function of abnormal areas with functional MRI

Sample of electrode grid

(a)
Search for spherical shapes

- Search for ‘dark’ spheres
  - Threshold of MRI
  - Brain Segmentation
    - Advantages and Disadvantages
  - Skull Segmentation
    - To minimize search space

Search for spherical shapes (con't)

- Filtering with a sphere of R=2.5mm
- Filtering with a sphere of R=3.5mm

Output: list of coordinates of dark spheres

Defining a measure

Need of quantitative measure to describe each black sphere

Smart Search

- Based on the fact of being ‘dark’ sphere and high measure value
- Works well for electrodes strips
- Fails to detect grid of electrodes

- Apply constraints:
  - Distance and relative position = plane

Finding closest neighbors

Modeling 3x3 electrode grid and growing

- User manually specifies electrode center on the grid
- From the list of dark spheres find 8 or less points with relative high measure
- Use those points to compute vector pairs and normals
- Choose 8 best normals and their corresponding points
- Use that information to model plane of 3x3 electrode grid
Modeling 3x3 grid as a plane

Green circle – position of electrodes
Blue vectors – 8 good normals
Yellow vector – average of good normals
Cyan points – best fit of model
Red crosses – points whose vector pair results in good normal
White vectors – two orthonormal vectors within a plane

Modeling 3x3 grid as a part of a cylinder

- Plane model
  - preserves the distances, recovers electrodes
  - does not work if a grid or part of a grid is curved
- New approach
  - model as a part of cylinder
  - preserve the distance
  - make sure new center is a ‘dark’ sphere
  - recover missing electrodes

Future Work

- Best method to register model in MRI
- Growing and smoothing the electrode grid
- Validation against CT/MRI and manual

Questions?