Problem Statement
- Goal: automated segmentation of hippocampus in brain MRI images

Hippocampus Anatomy
The hippocampus is located in the medial temporal lobe of the brain.

Clinical Significance
- Epilepsy is the most common serious brain disorder worldwide.
  - Prevalence of epilepsy worldwide (WHO): 7 sufferers in every 1,000 people
  - 3 new sufferers in every 10,000 people each year
  - People with epilepsy are at increased risks for status epilepticus (life-threatening)
    - One continuous, unremitting seizure lasting longer than five minutes or recurrent seizures without regaining consciousness between seizures for greater than five minutes.
  - Prevalence of status epilepticus in US (NIH): 195,000 new patients of status epilepticus each year
  - 42,000 deaths caused by status epilepticus each year

Clinical Research
- Hippocampal volume reduction >10% of “normal” size indicates
  - “normal”:
    - People with the same age
    - Bilateral hippocampus comparison
    - Personal changes in more than
  - Over 90% sensitivity + 98% specificity for MRI image measurement diagnosis, [5-7]

Issues for Segmentation
- Low contrast to neighboring brain structures
- No clear boundary between hippocampus and amygdala


AUTOMATED HIPPOCAMPUS SEGMENTATION OF BRAIN MRI IMAGES
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May 1st, 2014
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Hippocampus Anatomy
*Modified from a case of a plate of “Posterior and inferior cornua of left lateral ventricle exposed from the side” in Gary’s Anatomy

What is its function?

Clinical Research
- CAD Significance

Issues for Segmentation
- OK but reference? Missing details
- Only low contrast??

Hippocampus
Previous work

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<th>Method</th>
<th>Result</th>
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<tr>
<td>Tu et al. 2008</td>
<td>Same as our dataset</td>
<td>Hybrid generative/</td>
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<td>Aljabar et al. 2007</td>
<td>Same as our dataset</td>
<td>Min/max Filtering</td>
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<td>Van et al. 2008</td>
<td>518 cases (20 manually marked)</td>
<td>Adaptive threshold, probability map</td>
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<tr>
<td>Fiorina et al. 2012</td>
<td>56 cases</td>
<td>Enhance image contrast</td>
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Our algorithm based on Somasundaram:

- OK 1. Nice graphics
- ✗ 1. Too many overlays
- ✗ 2. Inverted Image for comparison!!

Algorithm Overview

- OK 1. Nice graphics
- ✗ 2. Does not show algorithm details
- ✗ 3. Squashed images

Hypothesis

- OK 1. Clear goal
- ✗ 1. Missing explicit reference to previous work
Dataset

- Data Set\(^1\) (with manual markings)
  - C1:
    - GE 1.5T Coronal T1W MR
    - voxel size=0.78x0.78x2mm  image dim=256x256x124
  - C2:
    - GE 3.0T Coronal T1W MR
    - voxel size=0.39x0.39x2mm  image dim=512x512x112

- 15 C1
  - 10 epilepsy (E) & 5 non-epilepsy (N)

- 10 C2
  - 5 epilepsy (E)


Experiment

- For C1
  - Training set: 8 C1 (5 E & 3 N)
  - Testing set: 7 C1 (5 E & 2 N)
- For C2
  - Training set: 5 C2
  - Testing set: 5 C2

Parameters tuning

- Noise removal
- Min/max filtering
- Thresholding
- Middle-block selection
- Largest connected component
- Mean filter size \(w_1\)
- Filter size \(w_2\)
- Block control points \(P_1, P_2\)

Changes (algorithm modifications)

- Mean filter deleted
  - Reason: Data with low resolution, lose edge information when using mean filtering
- Thresholding method changed
  - From Balanced Histogram Thresholding (BHT) to local thresholding
  - Reason:
    1. Low contrast between hippocampus and neighboring regions
    2. Non-uniform intensity for interested regions
- Erosion-Region growing added
  - Reason: gain a more accurate boundary

Results-parameter

- Optimal Parameters
  - For Dataset C1 (1.5T):
    - \(w_1: 3\)
    - \(w_2: 20\)
    - \(P_1: (w/3,h/2-20)\)
    - \(P_2: (2w/3,h/2+20)\)
  - For Dataset C2 (3.0T):
    - \(w_1: 4\)
    - \(w_2: 23\)
    - \(P_1: (w/3,h/3)\)
    - \(P_2: (2w/3,h/3+60)\)

Results-evaluation

- Dice Coefficient for C1 (1.5T)
  - Mean dice coefficient: 0.6
- Dice Coefficient for C2 (3.0T)
  - Mean dice coefficient: 0.672

Changes

- 1. Clear
- 1. Missing details on how parameter space will be explored

Discussion

- Poor outcomes:
  - HF015
- Good outcomes:
  - HF009

1. Local variations inside hippocampus
2. Errors caused by transferring from coronal to sagittal view

1. Does show a poor and a good example
2. Explanations not understandable
3. Better visualization to use 3 color segmentation image and original image
Summary

- Min/max filtering and local filtering can correct non-uniform backgrounds and enhance boundaries
- Comparing with and without Max/min filter would have been a GREAT and easy to do experiment, i.e. explore max/min width, a width of 1 == no filtering
- Parameters for MR imaging highly affect the performance of image analysis algorithms
- This does not appear to be true from presentation
- Our method is sensitive to middle-block selection
- Our result didn’t meet our expectation but close
- Negative AND imprecise!

We achieved an average DC of 0.6 and 0.672 for our two datasets which was 86% and 96% of the target goal of 0.7. Our algorithms achieved promising results compared to published algorithms.

Questions

picture from: www.timothy-carter.com