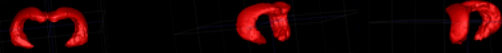


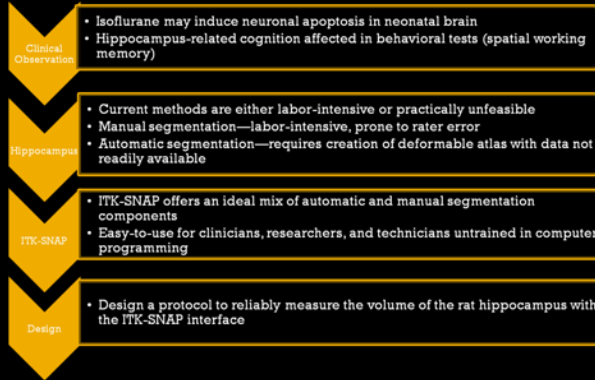
Design of a Semi-Automatic Segmentation Method for Measurement of the Hippocampal Volume in the Rat Brain from Magnetic Resonance Images



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Background



Objective and Design Challenges

Objective: To develop a robust semi-automatic computer method that determines the volume of the rat hippocampus from a magnetic resonance image.

Specifications

- Inter- and intra-rater reliability of at least 0.90, as measured by the Dice's overlap coefficient
- Detection of a rat hippocampal volume difference of less than 25% between image sets
- Segmentation of hippocampus in under 60 minutes

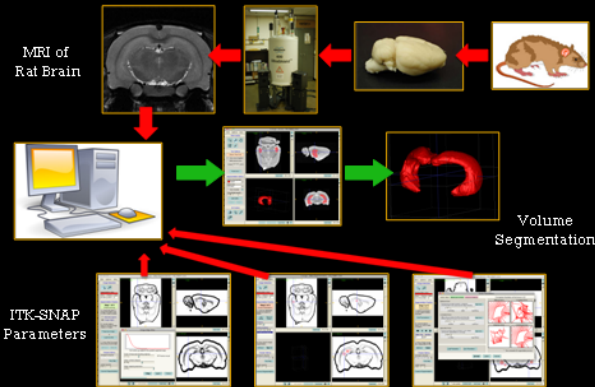
Risks

- Ambiguous anatomical boundaries of the rat hippocampus
- Discrepancies between users due to previous knowledge of hippocampal shape affecting the ability to make final adjustments to the segmented hippocampus

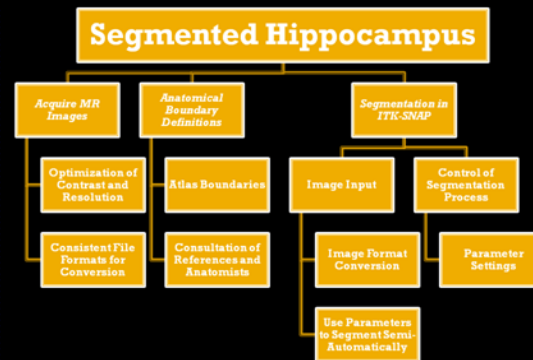
Constraints

- Low sensitivity
- Small sample size (N=4)
- Barriers in software functionality

Project Illustration



Block Diagram



Results: Segmentation Parameters

| Gaussian Blurring | Edge Contrast | Edge Mapping |
|-------------------|---------------|--------------|
| 1.000 | 0.054 | 3.000 |



| Balloon Force | Curvature Force | Advection Force |
|---------------|-----------------|-----------------|
| 1.600 | 0.620 | 0.940 |



Results: Volume Measurements

| Image | Rater 1 Volume (mm ³) | Rater 2 Volume (mm ³) | Rater 3 Volume (mm ³) |
|-------|-----------------------------------|-----------------------------------|-----------------------------------|
| 1 | 75.25±2.51 | 74.16±1.71 | 75.96±0.46 |
| 2 | 76.16±1.89 | 78.71±3.79 | 76.32±3.81 |
| 3 | 74.75±2.91 | 74.97±2.93 | 76.75±0.70 |
| 4 | 78.25±1.44 | 75.69±1.76 | 79.59±0.57 |

Specifications

| Specification | Promised | Delivered | Test Method |
|--------------------------|---|--|--|
| Reliability | Inter- and intra-rater reliability of at least 0.90 | Inter-Rater Reliability: 0.934 Range: 0.907 – 0.959 | Dice Coefficients calculated from ITK-SNAP segmentations using Convert3D |
| | | Intra-Rater Reliability: 0.952 Range: 0.901 – 0.913 | |
| Sensitivity | Detect hippocampal volume difference of less than 25% | Detected 2.62% difference with significance (p=0.0113, two-tailed) | Average hippocampus volumes for each image set (N=4); t-test averages of images with >1.9 mm ³ difference |
| | | Detected 2.66% difference with significance (p=0.0154, two-tailed) | |
| Sensitivity | Detect hippocampal volume difference of less than 25% | Image 1: 3.528% | Average hippocampus volumes for each image set (N=4); find 95% confidence intervals for each set |
| | | Image 2: 6.132% | |
| | | Image 3: 4.680% | |
| | | Image 4: 4.113% | |
| Time Optimization | < 60 minutes | 49.33±1.32 minutes | Average all trials (N=36) across all three raters (Rater 1, Rater 2, Rater 3) |

Conclusions and Recommendations

Conclusions

- A segmentation protocol was developed for segmenting the rat hippocampus in MR images
- The protocol allowed for consistent volume measurements between raters, and between measurements from the same rater

Recommendations

- Modify ITK-SNAP interface to improve manual segmentation portion of the segmentation process
- Use segmentation protocol on MR images from isoflurane-exposed mice

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We would like to thank Dr. Lynnae Schwartz and Dr. James Gee for their guidance and support throughout our senior design project.