Validated Automatic Brain Extraction of Head CT Images

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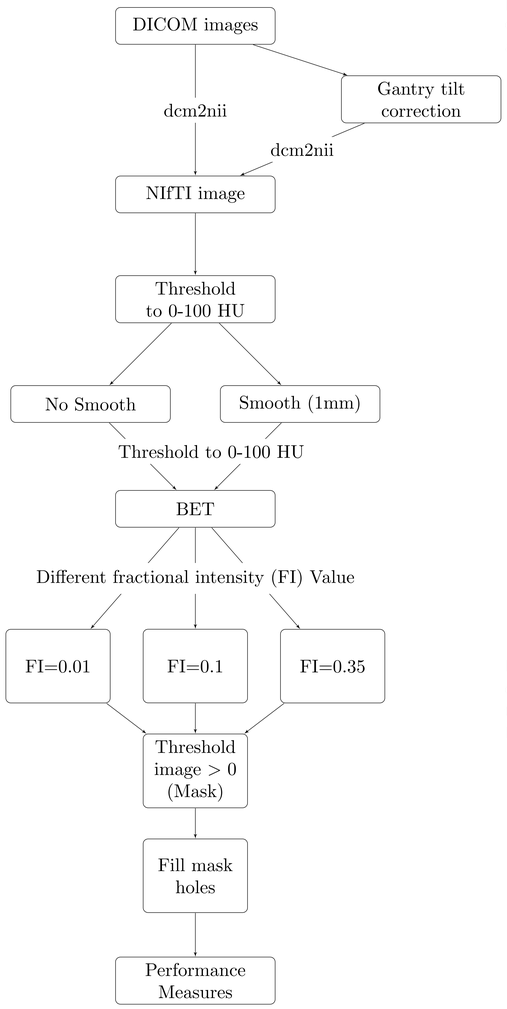
Image Processing Pipeline



Goals and Methods

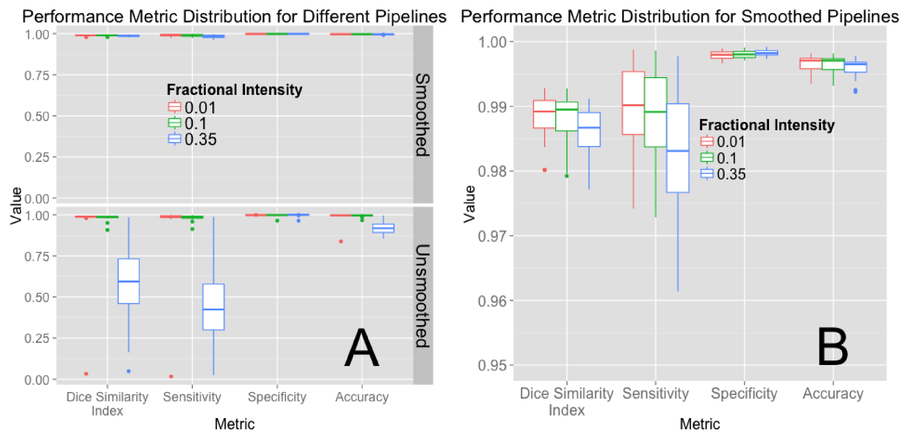
Systematically analyze the performance of the brain extraction tool (BET) [2], a function of the FMRIB software library (FSL) [1], on head CT images of patients with intracranial hemorrhage by varying parameters of BET and the use of smoothing after performing CT-specific preprocessing by:

- Quantitatively comparing the results to the manual gold standard, and
- Estimating the performance using the intraclass correlation of serial CT scans.

Data were from patients with intracranial hemorrhage from MISTIE (Minimally Invasive Surgery plus recombinant-tissue plasminogen activator for Intracerebral Evacuation) stroke trial centers.

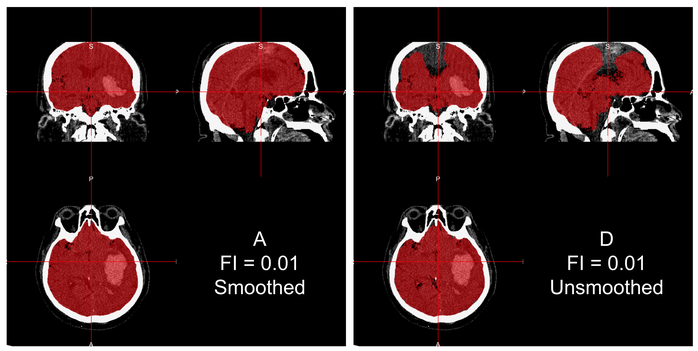
- Sample compared to gold standard: Twenty Two images from 19 patients.
- Intraclass Correlation Estimate: 1062 images from 133 patients, after excluding 115 scans for craniotomy or skull stripping failure (9.8%).

Measuring and Testing Brain Extraction Performance

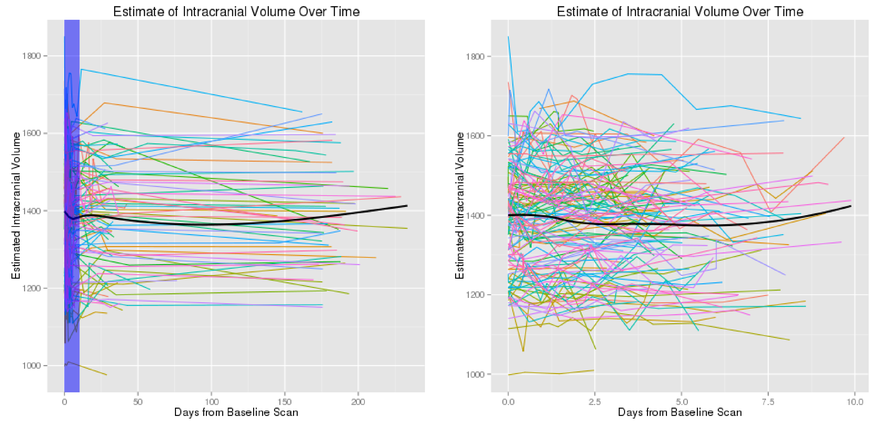


Performance Metric Distribution for Different Pipelines. Panel A displays the performance for brain extraction for the pipelines, panel B focuses on only those using smoothed images. Using an FI of 0.01 or 0.1 performed better than 0.35. Using an FI of 0.01 had a higher median sensitivity (0.9902) than an FI of 0.1 (0.9891, $p < 0.001$), lower specificity (0.998 vs. 0.998; $p < 0.001$), and no difference in accuracy (0.9971 vs. 0.9971; $p = 0.039$) or DSI (0.9892 vs. 0.9895).

Smoothing Images can Dramatically Increase Performance



CT Skull Stripping Leads to Consistent Intracranial Volume Estimates



Intracranial Volume (ICV) Estimate over Time. Each line represents an individual patient's ICV estimate over time. The data presented used an FI $= 0.01$ and smoothed data. The left panel shows all data used to estimate the intraclass correlation coefficient (ICC) of 0.93, (95%CI : 0.91, 0.95).

Where does it fail?

Much more area than the brain is imaged

Patient had a craniotomy

CT ventricles are low intensity or enlarged

We have code to do this!

- R code: `http://bit.ly/CTBET_RCODE`
- bash code: `http://bit.ly/CTBET_BASH`

Conclusions

Smoothing the data using a conservative smoother (1mm Gaussian kernel) and using an FI of 0.01 provides good brain extraction.

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References

[1] Mark Jenkinson et al. "FSL". In: *NeuroImage* 62.2 (Aug. 15, 2012), pp. 782–790.
[2] Stephen M. Smith. "Fast robust automated brain extraction". In: *Human Brain Mapping* 17.3 (2002), 143–155.