LA Grid Summit 2011
November 3rd & 4th 2011
Florida Atlantic University

Partnership for International Research and Education
A Global Living Laboratory for Cyberinfrastructure Application Enablement

Improvement of Automatic Brain Masking by Machine Learning

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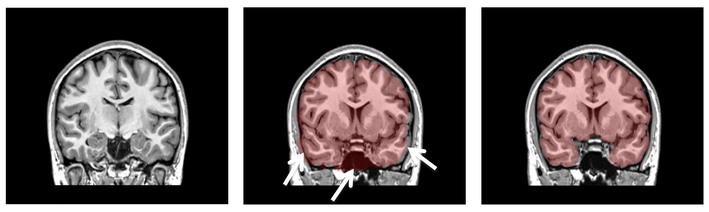
National Science Foundation

I. Research Overview and Outcome

Abstract

Computational MRI image analyses consist of several steps implemented in a pipeline. Brain extraction (masking) is typically among the very first steps. Therefore, several automatic brain segmentation algorithms have been proposed and implemented. These algorithms significantly reduce the time needed to manually extract the brain. Yet, most brain masking algorithms might give imperfect results due to different segmentation standards between the end user and the algorithm developer. Such differences appear to be systematic to the end user and should be manually corrected for every case. Consequently, the manual correction procedure adds to the time needed to accomplish brain masking. Since the discrepancies observed by the end user seems to be systematic, machine learning algorithms (i.e. AdaBoost) can be employed to hone the automatic brain masking algorithm to match the end user standard. This study shows the result of using AdaBoost to improve the automatic masking results and is based on the wrapper method suggested in [1].

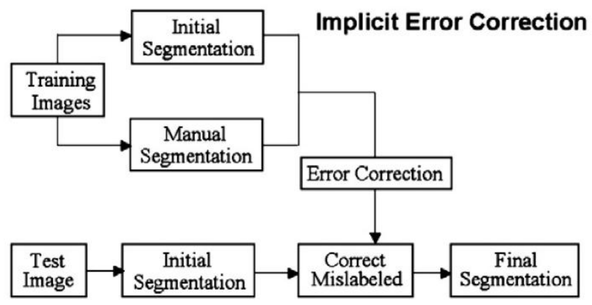
Problem Statement



MRI | Automatic Brain Masking | Manual Brain Masking

- Manual masking is time consuming (several hours per subject)
- Automatic masking produces systematic errors due to discrepancies between the algorithm user and its developer
- The white arrows above indicate the discrepancies in the same slice

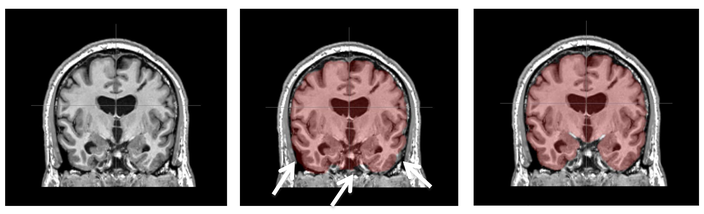
Methods



Implicit Error Correction [1]

- Brain masking is a binary segmentation problem
- Automatic error correction using AdaBoost
- The training process takes as inputs, several original MRI images along their manual and automatic brain masks.
- The classifier is trained using features extracted from the inputs images and masks
- The training process (performed once) is time consuming, took almost 35 hours.
- The implementation process takes as inputs the original MRI image along with its automatic brain mask that it will try to correct.
- Once trained the AdaBoost classifier is very fast and can be used as in extra automatic step (wrapper) in the analysis pipeline

Results



MRI | Automatic Brain Masking | Corrected Brain Masking

- Significant automatic masking improvement
- Corrected brain mask is obtained by a trained AdaBoost classifier
- The automatic correction process only takes a few minutes to finalize
- Manual correction is still needed in some cases
- Automatic machine learning correction reduces the time spent on manual masking to a few minutes
- Adding the image gradient features during training did not improve the results

Conclusion

- Brain masking is a fundamental step in any MRI study
- Several brain masking algorithms are in use
- Different segmentation protocols and standards generate discrepancies between the algorithm developer and the end user
- Discrepancies are usually systematic and can be corrected by machine learning
- This study showed that an AdaBoost classifier can give good correction results [1]
- The AdaBoost classifier is trained using features from the Original MRI image, the Automatically Segmented MRI image, and the Manually Segmented MRI image
- The trained AdaBoost classifier can be used by employing features from the Original MRI image and the Automatically Segmented MRI Image
- Manual brain mask correction is still needed, but the time need to perform the task is minimized

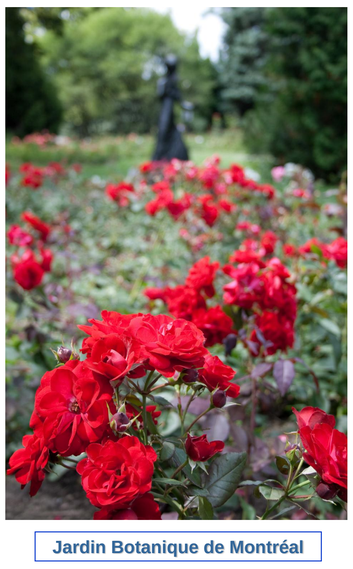
Future work

- Integrate more features to the AdaBoost training set.
- Test the effect of a larger training set
- Collaborate on a new project with the MNI team
- Survey the MRI/fMRI data in the “Multi-Site Pediatric Network for fMRI in Childhood Epilepsy” hosted at FIU
- Categorize the data into groups for for further clinical analysis
- Preprocess the structural MRI and functional fMRI data (Brain masking, segmentation, filtering, acquisition time correction, etc.)
- MRI cortical surface analysis (Patients vs. Controls
- Functional fMRI analyses (Patients vs. Controls)
- Correlation of surface and functional results

References

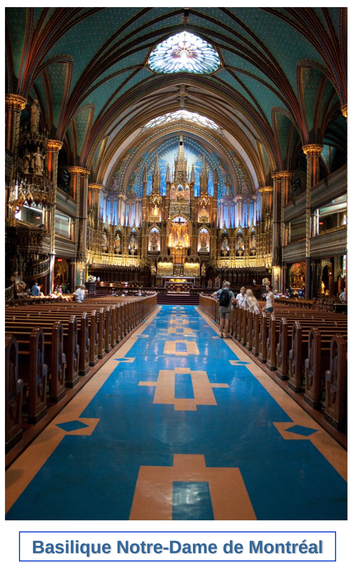
1. Hongzhi Wang, Sandhitsu R. Das, Jung Wook Suh, Murat Altinay, John Pluta, Caryne Craige, Brian Avants, Paul A. Yushkevich, The Alzheimer's Disease Neuroimaging Initiative, A learning-based wrapper method to correct systematic errors in automatic image segmentation: Consistently improved performance in hippocampus, cortex and brain segmentation, NeuroImage, Volume 55, Issue 3, 1 April 2011, Pages 968-985, ISSN 1053-8119, 10.1016/j.neuroimage.2011.01.006.

II. International Experience

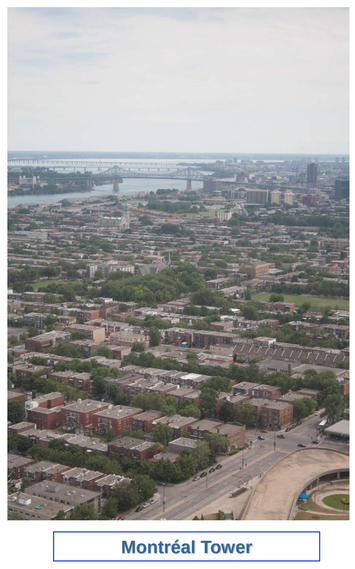


Jardin Botanique de Montréal

Montréal Biodom



Basilique Notre-Dame de Montréal



Montréal Tower

The PIRE international research trip has helped me build a new collaboration with the researchers at the McConnel Brain Imaging Center at Montreal Neurological Institute and Hospital. This collaboration is a crucial step in my research experience, specifically the expertise of the MNI team has helped me learn new academic skills. On the personal level, this trip has showed me how different cultures can coexist in one place. Montreal, is a truly multicultural city, and this shown by the French/English influence in the city.

III. Acknowledgement

The material presented in this poster is based upon the work supported by the National Science Foundation under Grant No. OISE-0730065, CNS-BPC-AE-1042341, CNS-MRI-R2-0959985, HRD-CREST-0833093. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.