

Hypothesis 5: Predicting Multiple Labels with a Unified Model

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December 20, 2023

Outline

Introduction

Methodology

Results

Discussion

Medical Diagnostics and Brain Imaging

- ▶ Precise brain region delineation is vital in medical diagnostics.
- ▶ Brain imaging plays a crucial role in identifying debilitating conditions.
- ▶ Neocortex, limbic system, and smaller structures are essential for various functions.
- ▶ Magnetic Resonance imaging is commonly used in medical diagnostics.

Motivation

- ▶ Manual segmentation is laborious and time-consuming.
- ▶ Automated solutions, especially machine learning, have been explored.
- ▶ Utilizing a Random Forest classifier for segmentation.
- ▶ Challenges in handling intricate structural boundaries, especially for smaller structures.

Data Acquisition & Framework

- ▶ Utilizing the Human Connectome Project dataset.
- ▶ 30 unrelated healthy subjects divided into training and test.
- ▶ Atlas references.
- ▶ MIALab pipeline includes pre-processing, feature extraction, voxel-wise tissue classification, and evaluation.

Pre-processing

- ▶ Min-max and z-score normalisation applied.
- ▶ Skull stripping and image registration for spatial alignment.

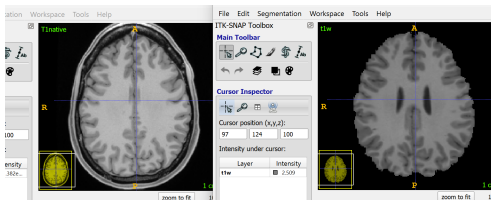


Figure: Example of pre-processing steps: Min-max and z-score normalisation, skull stripping, and image registration.

Feature Extraction

- ▶ Extracting atlas coordinates features.
- ▶ Employing neighbourhood feature extraction with statistical measures.

Model

- ▶ Utilizing the Random Forest model.
- ▶ Exploring both binary and multi-label classification approaches.

Parameter Optimization and Model Configuration

- ▶ Utilizing grid search to find optimal parameters.
- ▶ Tuning parameters, including the number of estimators and the maximum depth of the tree.

Evaluation Metrics

- ▶ Employing Dice Similarity Coefficient (DSC) and Hausdorff Distance (HD).
- ▶ DSC measures the similarity between two sets.
- ▶ HD measures dissimilarity between two sets.

Overlapping Subtraction (OS)

- ▶ Applying the OS technique to address potential overlaps between different brain structures.
- ▶ Systematically subtracting overlapping regions from larger structures.

Results: Classification

Table: Comparison of DSC and HD for Brain Structures Classification.
MC: Multi-label classification (baseline), BC: Binary Classification

	DSC		HD	
	MC	BC	MC	BC
GM	0.42(0.02)	0.52 (0.02)	3.65(0.29)	3.13 (0.26)
WM	0.67(0.03)	0.75 (0.02)	4.26 (0.38)	5.67(0.38)
HP	0.38 (0.02)	0.38 (0.01)	19.41 (0.80)	20.85(1.66)
TH	0.65(0.03)	0.66 (0.02)	39.51(1.02)	31.17 (7.94)
AM	0.42 (0.04)	0.42 (0.05)	15.39(2.76)	14.55 (3.16)

- ▶ Grid search for parameter optimisation.
- ▶ WM, GM overperformed.
- ▶ Similar results for smaller structures.

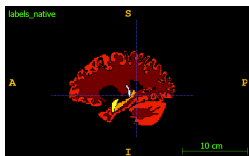
Results: Overlapping Subtraction

Table: Impact of Overlapping Subtraction on DSC and HD

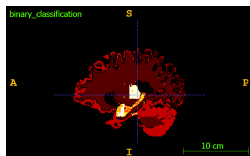
	DSC		HD	
	-	OS	-	OS
GM	0.51 (0.02)	0.34(0.01)	3.54 (0.38)	4.78(0.32)
WM	0.73 (0.02)	0.58(0.01)	6.06 (0.35)	6.17(2.06)
HP	0.37 (0.02)	0.33(0.01)	21.81 (3.74)	23.02(4.21)
TH	0.66 (0.03)	0.64(0.01)	36.92(8.01)	35.17 (7.32)
AM	0.41 (0.02)	0.38(0.01)	28.13(4.74)	27.72 (4.57)

Discussion

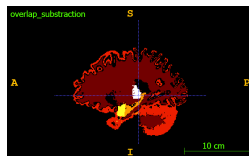
- ▶ Multi-label classification performs well for certain structures.
- ▶ Binary classification shows promising results, particularly for GM and WM.
- ▶ Overlapping subtraction improves overall performance.
- ▶ Challenges include handling complex structural boundaries and overlapping regions.



(a) Ground Truth



(b) BC



(c) BC with OS

Figure: Magnetic Resonance (MR) Images Sagittal Views

Comparison: Comparison of MR images sagittal views from Ground Truth (a), Binary Classification (b), and Binary Classification with Overlap Subtraction (c).

Conclusion

- ▶ Predicting multiple labels with the multiple binary model is favourable.
- ▶ Binary classification and overlapping subtraction enhance segmentation accuracy.
- ▶ Further refinement and exploration of model architectures are warranted.
- ▶ Incorporating advanced neural network architectures.

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