Hypothesis 5: Predicting Multiple Labels with a Unified Model

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Outline

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.

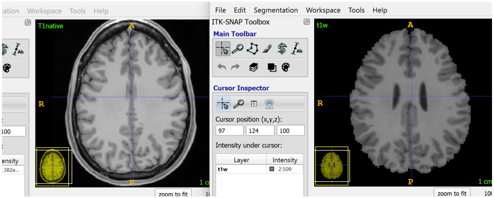


Figure: Example of pre-processing steps: Min-max and z-score normalisation, skull stripping, and image registration.

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.

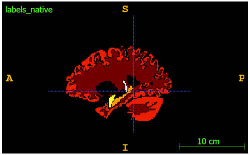
Results: Overlapping Subtraction

Table: Impact of Overlapping Subtraction on DSC and HD

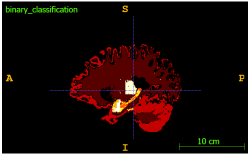
	DSC		HD	
	-	OS	-	OS
GM	**0.51 (0.02)**	0.34(0.01)	**3.54 (0.38)**	4.78(0.32)
WM	**0.73 (0.02)**	0.58(0.01)	**6.06 (0.35)**	6.17(2.06)
HP	**0.37 (0.02)**	0.33(0.01)	**21.81 (3.74)**	23.02(4.21)
TH	**0.66 (0.03)**	0.64(0.01)	36.92(8.01)	**35.17 (7.32)**
AM	**0.41 (0.02)**	0.38(0.01)	28.13(4.74)	**27.72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

Discussion

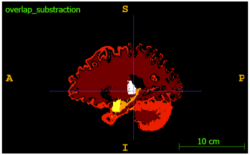
- Multi-label classification performs well for certain structures.
- Binary classification shows promising results, particularly for GM and WM.
- Overlapping subtraction improves overall performance.
- Challenges include handling complex structural boundaries and overlapping regions.



(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 same 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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