



Classification of Alzheimer's disease subjects from MRI using the principle of consensus segmentation

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Plan

Introduction

Contributions : Proposed classification model

- Dataset description
- > MRI data preprocessing
- Prototypes NC and AD
- > Hybrid classification
- Experiments and results
- Conclusion and perspectives

Introduction : Alzheimer's disease (AD)

Neurodegenerative and progressive disease

- **Deterioration of cognitive functions** *
- Memory, language and behavior disorders *
- **Progressive loss of autonomy** *
- Disorientation in time and space *



Difficulty in doing

problems



simple tasks

changes

elaborate thoughts

of objects

Loss



Disorientation

in time and space

Behavioural

changes



Loss of reasoning capacity



Loss of initiative







Introduction : Statistics of Alzheimer's Disease¹

In 2050:

115 million in the world, a new case every 7 seconds 10 million
13.5 million in the USA (245454 new cases per year)

- Global economic impact: \$ 600 billion in 2010
- Urgent issue:
 - Early diagnosis of AD
 - Implementation of a therapeutic
 - Slow down the neurodegenerative process



1 Association Alzheimer's disease International

Introduction : Magnetic Resonance Imaging (MRI)

- Brain analysis: structural, functional and non-invasive
- Contributing to the early diagnosis of AD
 - Structural alterations
 - Metabolic alterations
- Detecting changes

Macro-structural IRM Anatomic/Structural Micro-structural Diffusion Tensor Imaging



AD diagnosis methods

Volumetric analysis / Area of interest

Study the variation of the volume of a region
Manual: time-consuming, depends on the observer (clinician)
Automatic / semi-automatic: suffers from errors



(Chupin 2009)

- voxel analysis / Voxel
 - To detect significant differences in Grey Matter (GM) between two groups of subjects by voxel-to-voxel tests
 - Do not require a priori assumptions about the location, the size or number of ROIs to be analyzed, since they provide voxel wise measures determined in the entire brain
 - Help to detect structural changes in MRIs
 - Do not depend on the clinician abilities

Methods for group analysis: Individual diagnosis?



(Lehericy 2007)

Problematic

Individual diagnosis = visual assessment of a new case

- Learn about similar cases?
- Detection and characterization of pathological targets?

NC?

- To which class of known subjects can it be associated?
- Lists of similar images?

AD?

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Use recent advances made in segmentation and multimedia Indexing² and classification for Content Based Visual Information Retrieval (CBVIR). More precisely, use the concept of consensus segmentation to build two segmentation prototypes (Prototype Normal Control and Prototype Alzheimer's Disease)

Tools

- Indexing by visual content of images
- Principle of consensus segmentation based atlas
- Using "Domain Knowledge" in:
 - Image acquisition MRI
 - Diagnosis of AD

2 A.Khlif and M.Mignotte (2017). Visualisation et mise en cluster des données de segmentation. Outils et applications multimédias , 76 (1), 1531-1552.

principle of consensus segmentation

- A consensus segmentation is conceptually the compromise (in terms of level of details, contour accuracy, number of regions, etc.) exhibited by each segmentation map (or spatial clustering) belonging to a set of segmentations
- ✤ In our case, the principle of consensus segmentation allows us to build two reliable segmentation-based prototypes, one corresponding to healthy individuals and the second one corresponding to unhealthy subjects (with AD)
- The segmentation into three kinds of regions has the merit to efficiently reduce the information content of a brain image and to suppress noise and artifacts which are not relevant for the AD detection
- These two consensus segmentation-based prototypes allow us to suppress undesired components in the brain image (to be classified) such as the anatomical variability existing between individuals which are not relevant for the detection and quantification of AD

Data description

- OASIS (Open Access Series of Imaging Studies: <u>www.oasis-brains.org</u>)
- Worldwide project
- Sharing data for research in the treatment and diagnosis of Alzheimer's disease
- We will consider a subset of the complete cross-sectional OASIS dataset, with 49 controls and 49 AD patients

	Very mild to mild AD	Normal Controls
No. of subjects	49	49
Age	78.08 (66-96)	77.77 (65-94)
Education	2.63 (1-5)	2.87 (1-5)
Socioeconomic status	2.94 (1-5)	2.88 (1-5)
CDR (0.5/1/2)	31/17/1	0
MMSE	24 (15-30)	28.96 (26-30)

Table 1: Demographic information of the subjects in the two classification classes

MRI data preprocessing



Construction of prototypes



Prototype_NC

Prototype_AD

Proposed classification model



Pott distances is the normalized number of labels differences in percentage

Comparison with morphometric methods (NC vs. AD)

Classifier type	Accuracy	Sensitivity	Specificity
MDC-KNN (our approach)	0.86	0.85	0.87
rbf-DAB-SVM	0.85	0.78	0.92
LVQ2	0.83	0.74	0.92
LVQ1	0.81	0.72	0.90
LC-KNN	0.80	0.80	0.79
rbf-AB-SVM	0.79	0.78	0.80
MLP-BP	0.78	0.69	0.88
PNN	0.78	0.62	0.94
Linear SVM	0.78	0.72	0.88
Indep-rbf-SVM	0.75	0.56	0.95
Kernel-LICA-DC	0.74	0.96	0.52
Indep-Linear-SVM	0.74	0.51	0.97
KNN-Pott-MV	0.73	0.61	0.85
Linear-AB-SVM	0.71	0.54	0.88
RBF	0.66	0.65	0.68



Conclusion

- Our approach is automatic and does not require the intervention of the clinician during the disease diagnosis
- It is extensible to other diseases that can be diagnosed by brain MRI such as Schizophrenia and brain tumors

Perspectives

- The method could be extended by combining axial, coronal, and sagittal MRI data for improving the classification accuracy
- Generalize the approach for the 3D case and compare it with 2D
- Classification in four classes (NC, Very mild AD, mild AD, moderate AD)
- Generalize the approach for other criteria for the consensus segmentation (e.g., VOI, GCE, PRI, FCR)



Questions

