SEARCHING FOR NEW DEMENTIA-RELATED FEATURES WITHIN MRI: KEYPOINT DETECTION AND DESCRIPTION

Elisabeth Stühler[1]
[1]*Department of Computer and Information Science, University of Konstanz, Konstanz, Baden-Württemberg, Germany*

TARGET

This study aims at developing dementia-related features and advancing computer-aided diagnosis of Alzheimer's disease by exploring new approaches to extract such features from structural images (MRI of the human brain).

PURPOSE

Current methods to extract features from structural neuroimaging data (MRI) comprise mainly two approaches when employing MRI: voxel-based methods, where mostly variants of the Support Vector Machine (SVM) are employed for classification, and ROI-based methods, where uptakes or volume measures from previously segmented regions-of-interest are combined in a classifier. The success of both methods relies heavily on the quality of prior registration, which is difficult to validate due to context-free similarity measures and arbitrary transformation models.

METHODS

A novel image processing workflow is presented, which bypasses this problem by extracting features independent of image orientation, and thereby renders a prior non-rigid registration unnecessary. Scale-space extrema, i.e. landmarks are detected automatically as described in Fig. 1, and characterized by following attributes: (1) the scale on which they are found, (2) their maximum or minimum value, and the (3) brain region associated to their position using anatomical brain segmentations. The (4) distribution of voxel-values in a landmarks' spherical neighborhood is also assessed by its first four statistical moments.

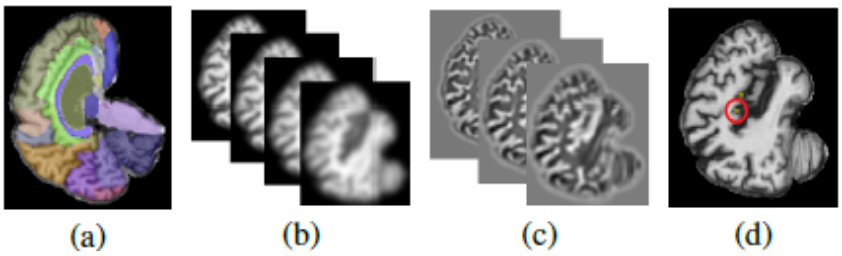

Fig. 1. Scale-space extrema detection: The original and segmented scan (a) is Gauss-convoluted with increasing σ (b) and a stack of Difference-of-Gaussian (DoG) images is produced. An exemplary scale-space maximum corresponding to a local minimum in the original image is depicted in (d).

DATA AND STATISTICAL ANALYSIS

Landmarks are extracted from 382 1.5T MRI scans published by the Alzheimer's disease Neuroimaging Initiative (ADNI), i.e. from scans of 135 healthy controls, 148 patients affected by mild cognitive impairment, and 99 Alzheimer's cases. As we aim at differentiating these groups within the data collection, we test if the characteristics of landmarks are already statistically significant using ANOVA ($p<0.05$, with Levene's test $p_L>0.05$).

RESULTS AND DISCUSSION

On average 711.3 landmarks are detected within each scan, where most are scale-space minima (77.3%) and hence are corresponding to bright areas within the original MRI scan. This is consistent as white and grey matter cover most of the whole-brain area. Already the amount of scale-space maxima is linked to disease progression (disregarding scale), i.e. an increased occurrence of maxima correlates with disease progression ($p=0.004$). This effect describes the enlargement of ventricles and advanced atrophy, and is observed on lower scales, mostly within the frontal lobe. Mean and variance contribute the most consistent results, i.e. decreasing mean of minima neighborhood and increasing variance correlate with increasing disease progression. The significance of skewness is distinct as well, whereas kurtosis does not contribute consistent effects: especially when analyzing brain regions they turn out to be random.

CONCLUSION

The approach proved not only to be very efficient for processing large datasets, but also successfully differentiates various stages of Alzheimer's by using occurrence and first order statistics of landmarks. It presents a first validation that automatically selected points of interest are feasible to describe dementia-related changes in structural images.