Morphological classification of brains via high-dimensional shape transformations and machine learning methods

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Subject: Modeling and Analysis

Abstract

***Introduction*:**
Developing image analysis methods for quantification of subtle anatomical and physiological group differences is becoming increasingly important. In particular, early detection of subtle morphological and physiological brain changes could ultimately lead to early diagnosis and classification of patients bound to develop disease. We present an approach that uses the entire set of morphological measurements obtained from all voxels in a brain image, to build a brain classifier. Our classification scheme operates in a very high-dimensional space, and therefore can determine subtle population differences with complex spatial patterns, which often cannot be identified via voxel-wise statistical analysis.

***Method*:**
Our approach is based on a mass-preserving framework called the Regional Analysis of Volumes Examined in Normalized Space (RAVENS) [1, 2] and a high-dimensional elastic registration [3]. A RAVENS map is created by warping individual images into conformation with a template, while preserving the total amount of tissue in any brain region. Volume compression results in an increase of tissue density, so that the total amount of tissue is preserved, and vice versa. Therefore, regional volumetric analysis is performed by applying statistical analysis methods on the RAVENS tissue density maps. Analysis of the RAVENS maps involves three major steps. First, we apply a wavelet decomposition to hierarchically decompose a RAVENS map in a scale-space way. Second, we use a feature selection method [4] to focus on the most discriminating aspects of the wavelet transformed RAVENS maps. Third, we use the selected features and apply a Support Vector Machine (SVM) pattern recognition method to achieve morphological classification.

***Results and Discussion*:**
Three experiments are used to demonstrate the performance of our approach. All testing images are obtained from the Baltimore Longitudinal Study of Aging study [5], where MR brain images of over 150 older adults have been collected yearly over 9 years. The first experiment is on age classification. We divided 150 subjects into 4 age groups: 50~59, 60~68, 69~79, 80+, and test our classification performance, using the leave one out method. The result in Fig 1 shows that the more separated two groups were, the better the classification was. The second experiment was on normal and pathology classification. We used 10 normal subjects and 10 subjects with simulated atrophy of different levels. For 5% atrophy, the leave-one-out classification rate was 95%, whereas it was 100% for higher atrophy levels. In our final experiment we tested the morphological classification into male/female, and found a 98.9% classification accuracy, using the leave one out method. We intend to use our morphological classification scheme in order to determine early brain changes that predict dementia.

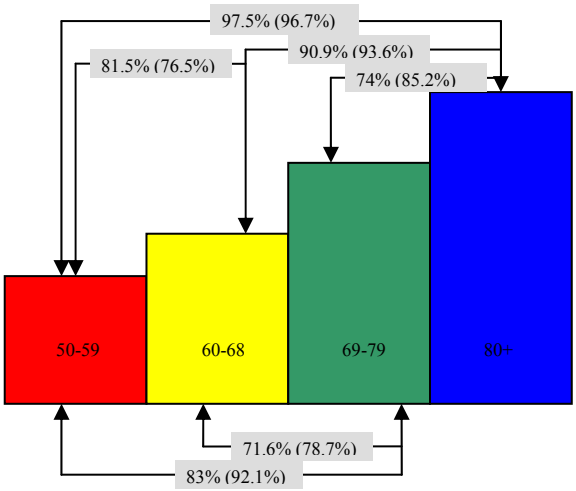

Fig 1 Morphological classification success rates for groups of different ages. The numbers in parentheses were obtained by using Year1 vs. Year5 longitudinal data, which in effect separated the groups further by 4 years.

References:

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