Volume-based vs. voxel-based brain morphometry in Alzheimer's disease prediction
Alexis Roche1,2, Daniel Schmitter1,3, Bénédicte Maréchal1, Delphine Ribes1, Ahmed Abdulkadir2, Meritxell Bach-Cuadra4,5, Alessandro Daducci1, Cristina Granziera6,7, Stefan Klöppel8, Philippe Maeder2, Reto Meuli2, and Gunnar Krueger1
1Advanced Clinical Imaging Technology, Siemens Healthcare IM BM PI, Lausanne, Switzerland, 2Department of Radiology, University Hospital (CHUV), Lausanne, Switzerland, 3Biomedical Imaging Group, EPFL, Lausanne, Switzerland, 4Group of Pattern Recognition and Image Processing, University of Freiburg, Germany, 5Signal Processing Laboratory 5, EPFL, Lausanne, Switzerland, 6Service of Neurology, University Hospital (CHUV), Lausanne, Switzerland

Note: the first two authors contributed equally to this work.

Introduction. Voxel-based morphometry from conventional T1-weighted images has proved effective to quantify Alzheimer's disease (AD) related brain atrophy and to enable accurate automated classification of AD patients, mild cognitive impaired (MCI) patients and elderly controls [1,2]. Little is known, however, about the classification power of volume-based morphometry, where features of interest consist of a few brain structure volumes (e.g. hippocampi, lobes, ventricles...) as opposed to about a million voxel-wise gray matter (GM) concentrations. This work aims to experimentally compare voxel-based and volume-based brain morphometry for automated disease classification.

Materials and Methods. Experiments were conducted on a standardized Alzheimer’s Disease Neuroimaging Initiative (ADNI) analysis set [3,4] consisting of 818 T1-weighted MR scans from different acquisition systems and vendors (667 screening scans acquired at 1.5T and 151 baseline scans acquired at 3T), all from distinct subjects diagnosed as either normal, MCI, or AD based on careful clinical assessment, yielding a total of 229 scans labeled as normal, 401 MCI, and 188 AD. All scans were processed by SPM8 [5], a voxel-based morphometry package, as well as FreeSurfer 5.1.0 [6] and Siemens prototype MorphoBox [7], two volume-based morphometry packages. Extracted features were Jacobian modulated GM concentration maps in the case of SPM, and a set of 10 regional volumes formed by the SPM-based classification was 10-11% lower than that of FreeSurfer and MorphoBox, namely: total GM, left and right tempora...

Results and Discussion. Balanced accuracy values are reported in Fig. 1 for the three considered morphometry methods in three distinct classification scenarios: AD vs. normals (NL), MCI vs. NL, and AD vs. MCI. As verified by McNemar tests, all classifiers performed significantly above chance (p<0.0001). Despite methodological differences, morphometry packages proved fairly consistent across classification tasks. Higher accuracy was observed in all cases for AD vs. NL (85-89%) than for MCI vs. NL (73-76%) and AD vs. MCI (57-68%), reflecting the increasing inherent difficulties of the respective classification problems. Differences amongst methods were found to be the most significant in MCI vs. AD classification, where the accuracy of SPM-based classification was 10-11% lower than FreeSurfer-based and MorphoBox-based classification. This suggests that volume-based morphometry may be relatively more discriminant as the populations to be compared are statistically more similar. Overall, our results provide evidence that volume-based morphometry is a valuable alternative to voxel-based morphometry to assist the diagnosis of Alzheimer’s disease and mild cognitive impairment.

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Fig. 1 Balanced accuracy for multivariate classifiers respectively based on SPM, FreeSurfer and MorphoBox