Population classification using global brain shape features inferred from massive T_1-MRI registration

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Abstract

Brain morphometry has received a lot of attention during the past few years with the emergence of specific algorithms and corresponding computational power. Brain morphometry studies generally proceed by choosing features in the brain (cortical thickness for voxel-based morphometry (VBM) methods, sulcus size, etc.) specific to the problem at hand, which are then used to classify the population into the desired categories.

The method reported here takes a different path as it makes no assumption on what measure should be extracted from individual brains. Instead, the information used is a *distance between brains*, measured as the amount of energy necessary to deform one brain into another. The computation of all brain pair distances enables to project the brains as points in a standard *d*-dimensional Euclidean space via Multi-Dimensional Scaling (MDS) [1], which can then be classified using standard methods. The axes on which brains are projected are the first *d* features that best explain measured distances. Furthermore, its reliance on massive comparisons suggests that it is intrinsically robust.

We have used 142 brain MR images coming from the ICBM database [2]. It is composed of healthy young adults that were scanned on a Philips Gyroscan 1.5 T, yielding T_1 MR volumes of about 150 slices and having 1mm isotropic resolution. The volumes are individually corrected for intensity inhomogeneities, and spatially registered to a template using an affine transform [2].

We have non rigidly registered all of the 20022 MRI pairs using the PASHA algorithm [3], running on a network of about 40 computers. The algorithm did not complete on approximately 2000 images. This left us with a subset of 100 volumes (41 females and 59 males) for which we have all pairwise registrations. The result of the registration is a dense displacement field, of which we computed the Dirichlet membrane energy. This energy is taken as a measure of dissimilarity between the volume pair at hand. The matrix containing all the pairwise dissimilarities is then processed by an MDS algorithm, yielding a point set representation of the brains in Euclidean space. Furthermore, the axes of this projection are ranked according to their capacity to explain measured brain dissimilarities.

We have used this point set to classify male and females. The result of the leave-one-out (LOO) training of suport vector machines (SVM) classifiers is shown as a receiver operating curve (ROC) in Fig.1. At a particular area of the curve, it shows that about 96% of males and 88% of females can be correctly classified. As a side note, the first two features alone yield a classification rate of about 80%. Given the lack of assumption of the method, it shows that gender has a major impact on brain shape. By contrast, laterality, an information also present in the database, could not be deduced as precisely.

Although the volumes were linearly registered, there might still be a bias towards the subject's size.

In other words, a larger brain may not simply be akin to a linearly dilated smaller brain. A specific study collecting this information should help to confirm if gender or size differences is what is really found.

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[2] K. E. Watkins *et al*. Cerebral Cortex:11, 2001

[3] P. Cathier *et al*. CVIU:89(2-3), 2003

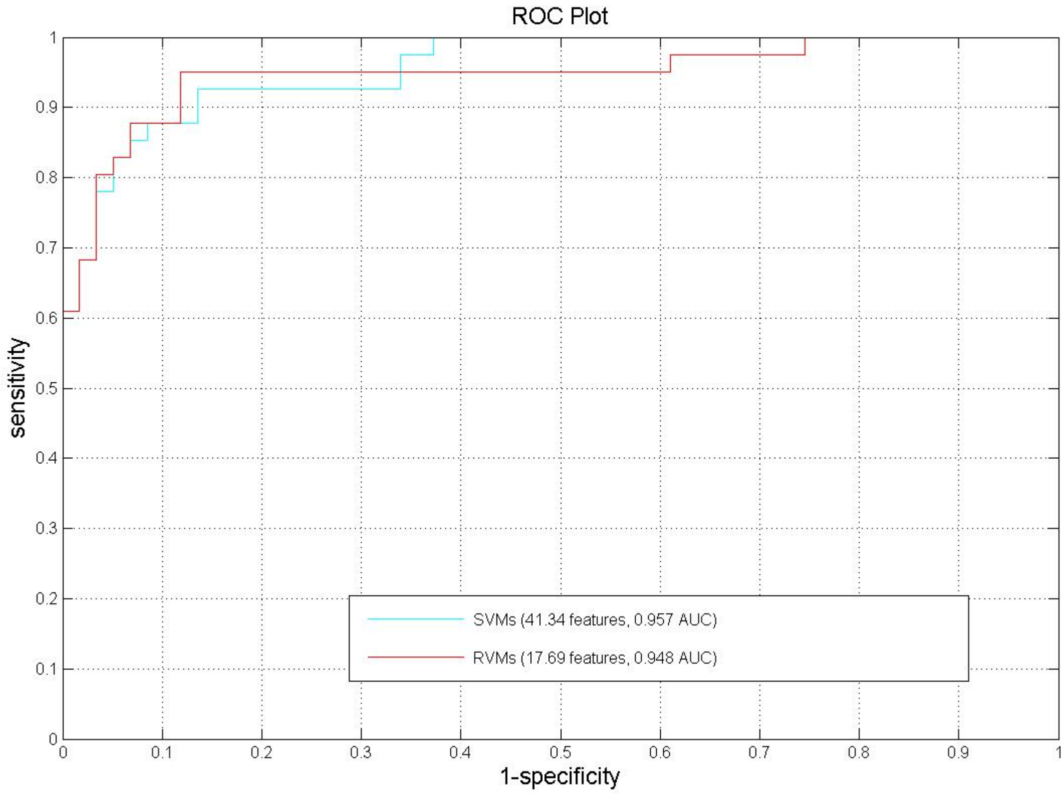

Fig. 1: ROC plot of male/female classification using two classification strategies