MRI-Based Pattern Recognition Methods for Dementia Diagnostics

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It is estimated that the number of people that will suffer from dementia by 2020 will be more than 40 million, with an increasingly higher proportion coming from developing countries [8]. Historically, brain imaging with CT or MRI has largely been used to rule out alternative and especially structural causes of the dementia syndrome. This approach is consistent with established diagnostic consensus criteria such as those published by the NINCDS-ADRDA [14]. Recently, there has been a realisation that MRI may add positive predictive value to a diagnosis of Alzheimer's disease (AD) [9]. Several studies demonstrate that using MRI to evaluate atrophy of temporal lobe structures can contribute to diagnostic accuracy [2, 22], but these findings have yet to be applied to routine clinical radiological practice, let alone in the general practice or internal medicine setting [22]. Recent developments in machine-learning analysis methods and their application to neuroimaging [4–7, 10, 11, 13, 15, 18–21] are very encouraging in relation to the levels of diagnostic accuracy achievable in individual patients. These multivariate methods promise fully-automated, standard PC-based clinical decisions, unaffected by individual neuroradiological expertise which strongly affects diagnostic accuracy (Fig. 1). They are sufficiently sensitive to successfully separate those with mild cognitive impairment (MCI [16]) from the cognitively normal [3] or identify those cognitively normal subjects who will convert to MCI [4]. So far, computational anatomy has been used to characterise differences between the brains of patients and normal age-matched volunteers at the group level. What is needed in the clinical setting is a diagnostic method applicable to each and every individual. Multivariate classification methods such as linear support vector machines (SVM) integrate information from the whole brain. In the context of machine learning, individual MR images are treated as points located in a high dimensional space. Figure 2 illustrates this procedure in an imaginary two-dimensional space: In this example the two groups to be classified are represented by circles and triangles. It can be seen that the groups cannot be separated on the basis of values along one dimension only and that

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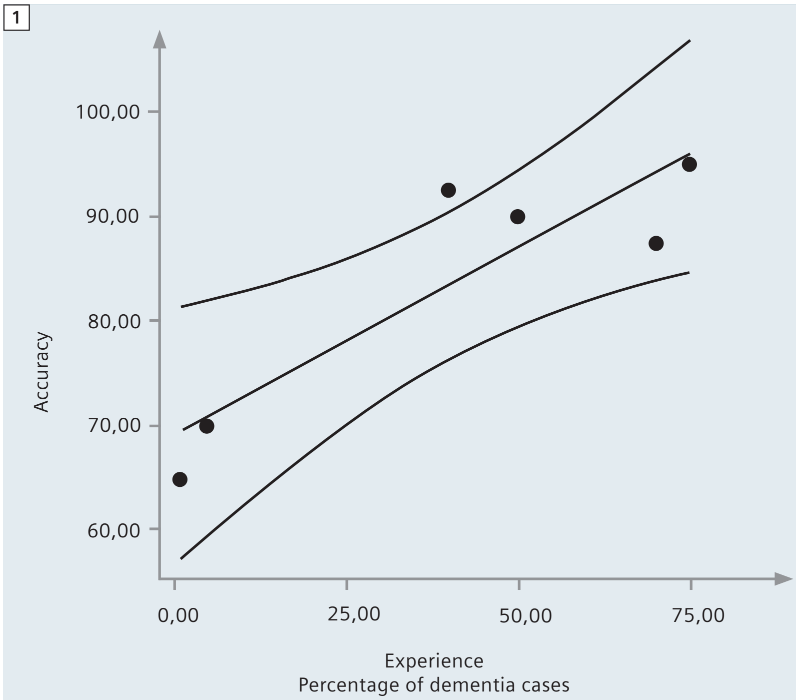
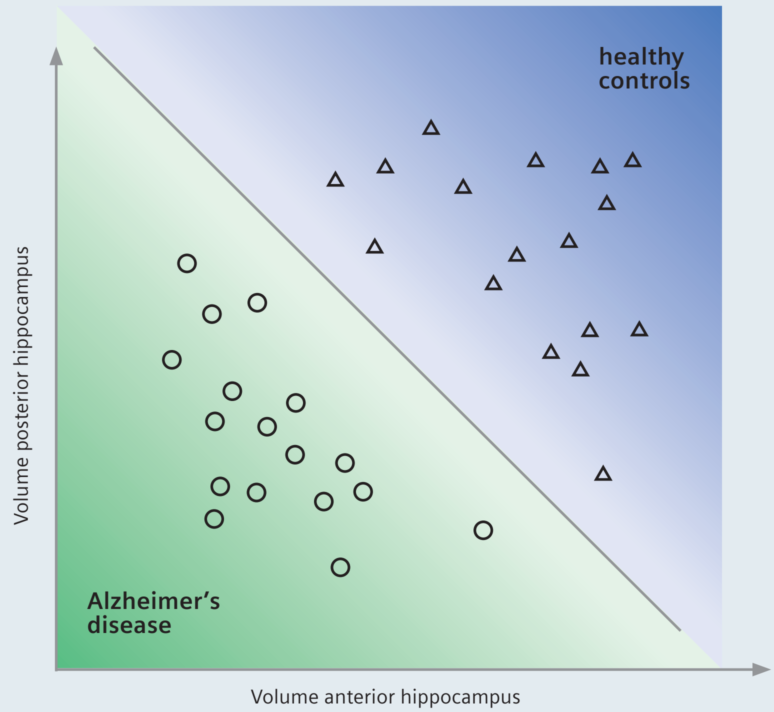


1 Shows an increasing accuracy of radiologists more experienced in the diagnosis of dementia [10].

2

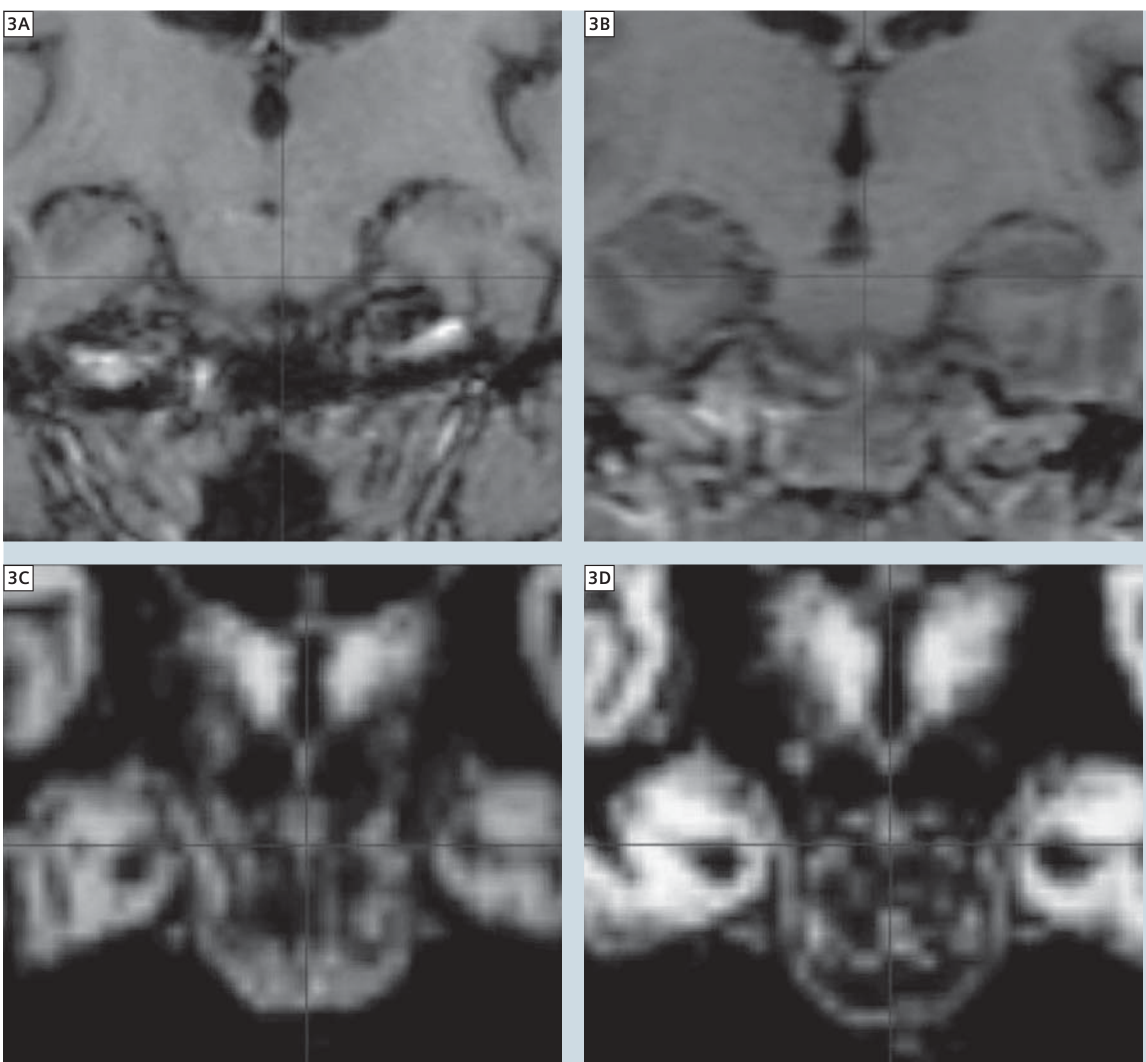


2 Concept of multivariate classification methods in a 2D example.

only a combination of the two leads to adequate separation. The space used for classifying image data is of much higher dimension; the total number of dimensions is determined by the numbers of voxels in each MR image. Related methods have been introduced to aid in breast cancer screening where they are applied to 2D X-rays and are now part of the diagnostic workup. With the advent of faster computer hardware, an accurate spatial transformation of the individual scan to a standard template is possible within minutes.

Image processing pipeline

To apply classification methods successfully it is critical to extract relevant information from the MRI-scan. Figure 3 magnifies the hippocampus area in



3 The hippocampus region is displayed in two example cases before (top row) and after (bottom row) image processing.