Chapter 25
Multivariate Functional Data Discrimination Using ICA: Analysis of Hippocampal Differences in Alzheimer’s Disease

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Abstract Recently, independent component analysis (ICA) has been successfully used for classification of univariate curves, Epifanio (2008). Extending this methodology to the multivariate functional case, an analysis of hippocampal differences in Alzheimer’s disease is carried out.

25.1 Introduction

Early diagnosis of Alzheimer’s disease (AD) is a topic of great importance. As more effective pharmacological therapies become available, the administration of these agents to individuals who are subtly impaired may render the treatments more effective. Mild cognitive impairment (MCI) has been proposed and commonly accepted as a diagnostic entity within the continuum of cognitive decline towards AD in old age [Grundman et al. 2004, Petersen, 2004]. Longitudinal studies suggest that hippocampal volume loss predicts cognitive decline [Jack, et al. 1999, Mungas et al. 2001]. Volumetric measurements are simple features, but structural changes at specific locations cannot be reflected in them. If morphological changes could be established, then this would enable researchers to gain an increased understanding about condition. This explains why shape analysis has thus become of increasing interest to the neuroimaging community, Styner et al. (2003).

We analyse the information extracted from magnetic resonance (MR) scans in 28 subjects for three groups: controls, patients with MCI, and patients with early AD. The main objective is to understand the way in which their hip-
pocampi differ. The available information is translated in a (multivariate) functional form, as explained in Section 2, and used in a functional discriminant analysis. This methodology uses ICA, and is explained in Section 3. Finally, results are presented in Section 4, together with some conclusions and future developments.

25.2 Brain MR scans processing

Twenty-eight subjects participated in this study: 12 healthy elders (five males and seven females, mean age 70.17±3.43), 6 patients with MCI (two males and four females, mean age 75.50±3.33), and 10 patients with early AD (one male and nine females, mean age 71.50±4.35). All subjects were recruited from the Neurology Service at La Magdalena Hospital and the Neuropsychology Service at the Universitat Jaume I. All experimental procedures complied with the guidelines of the ethical research committee at the Universitat Jaume I. Written informed consent was obtained from every subject or their appropriate proxy prior to participation. Selection for the participant group was made after careful neurological and neuropsychological assessment. The neuropsychological test battery involved Digit Span, Similarities, Vocabulary, and Block Design of the WAIS-III; Luria’s Watches test, and Poppelreuter’s Overlapping Figure test. MRI studies were performed on a 1.5T General Electric system. A whole brain high resolution 3D-Gradient Echo (FSPGR) T1-weighted anatomical reference scan was acquired (TE 4.2 ms, TR 11.3 ms, FOV 24 cm; matrix = 256×256×124, 1.4 mm-thick coronal images).

Hippocampi are traced on contiguous coronal slices (or sections) following the guidelines of Watson et al. (1992), and Hasboun et al. [Hasboun et al., 1996]. Each hippocampus is described by around 30 slices. The hippocampus segmentation was done by a double tracer, blinded to the clinical data of the study subjects. The first tracing was done manually by an expert rater with the VOXAR program (v4.2) and the second tracing was done manually with the MRicro software by other expert tracer, giving nearly equal segmentations. So, we consider only one of the segmentations, the second one. Total time for the segmentation of one hippocampus was approximately 40 minutes. Fig. 25.1 (a) shows an example of one coronal slice, with the right and left hippocampus drawn in white, whereas Fig. 25.1 (b) displays a sagittal view of one of the hippocampi.

As aforementioned, volume is a discriminatory feature for this problem. Therefore, we think that area could be a good descriptor for each slice. Area of right and left hippocampus in each slice is computed (it can be estimated as the number of pixels of each hippocampal segmented slice). Therefore, for each subject we have two functional data, where the argument is not time, as usual, but the space, the coronal axis. We observe the right and