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[Stochastic modeling, control and applications]

[Stochastic Modeling and MRI Data Analysis of Patients with Alzheimer's Disease]

[Dominique Duncan]

[Department of Mathematics, University of California, Davis, USA]

[dominique13@gmail.com]

Abstract:[The goal of this study is to classify magnetic resonance imaging (MRI) of brains of patients with Alzheimer's Disease (AD) and of patients without AD and then to identify changes in brain MRI in early stages of AD. Neuroimaging has been shown to be a powerful tool for studying changes in the progression of AD. MRI scans are useful for identifying features that can help predict which patients will develop AD. In MRI data, we assume that there are certain features in the brain images of patients with AD. Our goal is to discover these features to distinguish brains of patients in early stages of AD from brains of healthy patients. Diffusion maps are used in many problems of data analysis. This method (1) is a useful tool in reducing the dimensionality of the data as well as in providing a measure for pattern recognition and feature detection. Since diffusion mapping may detect abnormal behavior in data, it can be used to determine differences of brains of patients with AD compared to healthy brains. However, diffusion maps assume access to the underlying process that it aims to reveal. In MRI data, the relationship between the pixels of the images and the underlying brain activity may be stochastic, and the data are assumed to be noisy due to the calibration. Hence, diffusion mapping is not the most suitable approach to use with MRI data. Based on some initial results, a recently developed algorithm, which is an extension of diffusion maps, is more applicable in the case of classifying AD (2,3). This new algorithm assumes a stochastic mapping between the underlying processes and the measurements; the mapping is inverted, and a kernel is used to recover the underlying activity (2). The proposed method has already proved to be effective in identifying preseizure states in intracranial EEG data by providing a distinction between interictal and preseizure states of a patient with epilepsy (4). The important difference in our method and other methods that have been used to classify and detect early onset of AD in patients is the nonlinear and local network approach, which is necessary to eliminate the calibration differences of MR images of patients with different shapes and sizes of brains as well as different scanners and centers collecting data. The presentation is partially based on joint work with Thomas Strohmer from UC Davis.
References:

(1) Coifman RR and Lafon S: Diffusion Maps. Appl. Comp. Harm. Anal.2006, 21:5-30.
(2) Talmon R and Coifman RR: Differential stochastic sensing: intrinsic modeling of random time series with applications to nonlinear tracking. PNAS 2012.
(3) Talmon R, Kushnir, D, Coifman RR, Cohen I, Gannot S: Parametrization of linear systems using diffusion kernels. IEEE Trans.Signal Process 2012, 60.
(4) Duncan D, Talmon R, Zaveri HP, Coifman RR: Identifying preseizure state in intracranial EEG data using diffusion kernels. Math Biosci Eng 2013, 10(3):579-90.
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