A Functional Model for Detecting Changes in Evolving Shapes Brain Tumors

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Abstract In this work we propose a dynamic functional model for inspecting the evolution and predicting the deformation of a brain tumor shape. We illustrate the usefulness of the proposed model on real and simulated data.
Abstract *In questo lavoro viene proposto un modello funzionale dinamico per monitorare e predire l'evoluzione di forme tumorali celebrali. L'utilizzo del modello proposto viene inoltre illustrato tramite un'applicazione a dati reali e simulati.*

Key words: functional data, shape, tumor growth, predictive model

1 A functional data analysis approach to brain cancer growth

The study of brain tumor evolution is mainly related to the analysis of Magnetic Resonance Imaging (MRI). MRI is a tool that provides detailed information about the targeted brain tumor anatomy, which in turn enables effective diagnosis, treatment and monitoring of the disease.

Literature on this topic is domain of medical image analysis. It can be divided into segmentation and registration, as well as into several further areas such as enhancement, visualization, quantification and modeling. An extensive review of these methods can be found in (Bauer et al. 2013).

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In this presentation we focus on the registration and modeling of a very invasive tumor where only two images or at least three images corresponding to two or at least three steps of observation are available for subject. In this framework, morphological changes need to be established, and a shape analysis is of an enormous importance. When observing contour profiles, it is difficult to distinguish specific features and changes into two consecutive steps of observation. In this sense Vlad et al. (2013) introduce and describe two geometric approaches based on the Lévy-based spatial Cox processes for computing the growing of tumor. Recently in the functional framework (Ramsay and Silverman 2005) a first attempt in modeling changes has been done in Romano et al. (2012). The contour of the tumor was modeled by a radius vector function and then modeled by a Functional Concurrent Linear Model. However several problems arise in the estimation process and in the model fitting.

The approach presented here is to measure the tumor outline contour as a bivariate functional data and to describe its evolution through a new dynamic functional model (Romano et. al 2014). When comparing tumor contours, the starting point are not the same from an observation to another (the classic registration problem in FDA), the sense of rotation can be different, however the objects are not aligned and of the same size. Thus, at first, we define and analyze carefully functional data object related to the tumor contour functions. Especially after introducing descriptive statistics and plots, we turn into Principal Component Analysis in order to see what primary modes of variation are in the data, and how many of them seem to be substantial. Then, hence our main aims are to analyze the behavior of a set of bivariate functional data replicated into two occasions and to monitor and predict their changes, we introduce and describe a functional -dynamic- model based on the covariation among a deformed and an unreformed functional form. Specifically, we present a functional model with varying coefficients for functions observed sequentially, and being serially dependent. Our proposal offers a systematic approach for building a quantitative model for describing the relationship among tumor contour obtained in two different steps of observation. Illustration of the method are shown on real and simulated data.

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