Chapter 3

Preprocessing MRS Information for Classification of Human Brain Tumours

C. J. Arizmendi
Universitat Politècnica de Catalunya, Spain & Universidad Autonoma de Bucaramanga, Colombia

A. Vellido
Universitat Politècnica de Catalunya, Spain

E. Romero
Universitat Politècnica de Catalunya, Spain

ABSTRACT

Brain tumours show a low prevalence as compared to other cancer pathologies. Their impact, both in individual and social terms, far outweighs such low prevalence. Their anatomical specificity also makes them difficult to explore and treat. The use of biopsies is limited to extreme cases due to the risks involved in the surgical procedure, and non-invasive measurements are the standard for diagnostic exploration. The usual measurement techniques come in the modalities of imaging and spectroscopy. In this chapter, the authors analyze magnetic resonance spectroscopy (MRS) data from an international database and illustrate the importance of data preprocessing prior to diagnostic classification.

DOI: 10.4018/978-1-4666-1803-9.ch003
INTRODUCTION

In neuro-oncology, diagnosis frequently relies on data acquired through non-invasive techniques of the imaging (e.g., Computed Tomography or Magnetic Resonance Imaging -MRI) and spectroscopy (MRS) modalities. In this chapter, we focus on the latter. MRS generates a wealth of quantitative data that can provide support for medical decision. Due to the complexity and variety of these data, clinicians should benefit from the use of computer-based medical decision support systems (MDSS).

The development and use of MDSS based on pattern recognition techniques holds the promise of substantially improving the quality of medical practice in diagnostic and prognostic tasks. The current chapter deals with the problem of diagnosis of a wide array of human brain tumour types from the biological signal obtained by MRS.

MRS is a signal in the frequency domain that peaks at specific frequencies or frequency bands, most of which are known to correspond to the resonances of specific metabolites present in the analyzed tissue. The signal profile is an indication of the quantities in which the components are present in the tissue. Therefore, those substances with substantial presence will have higher peaks associated than those present in lower concentrations.

One of the main characteristics of MRS data is their high dimensionality, as each measured frequency is considered as a data feature. It is well known that only a few of these frequencies (or short intervals of frequencies) are associated to identifiable metabolites present in the tumour tissue. On the other hand, it is also well known that some of those metabolites are informative as tumour type markers.

Additionally, there are several factors that make the MRS signal acquisition, processing and characterization non-trivial, such as signal degradation related to the sensitivity of the acquisition technique, thermal noise from the sample and noise from the electronic components, technical limitations when measuring the in vitro tissue, as well as time limitation during measurement. In general, in vivo MRS signals are characterized by a low signal-to-noise ratio (SNR), strong overlapping spectral components, and the presence of the residual water peak in 1H-MRS, for which, even after presaturation, the residual water resonance dominates the proton free induction decay, causing baseline distortions in the frequency domain, particularly for resonances closer to the water peak.

To circumvent some of these limitations and provide an adequate representation of the raw signal, techniques in the field of signal processing can be used. In this chapter, we filter the signal and break it up in terms of decomposition coefficients using the Discrete Wavelet Transform (DWT) technique. In order to reduce the dimensionality of the system, a novel filter method called Moving Window and Variance Analysis (MWVA). Its results are compared with a traditional dimensionality reduction technique, namely Principal Components Analysis (PCA). Finally, classification is carried out using Artificial Neural Networks (ANN) with Bayesian regularization.

Classification problems in this context are treated as binary; that is, one tumour class against another. Multiple-class approaches are hindered by the limited number of MRS cases available. Furthermore, and as remarked in (Luts et al., 2007), doctors frequently face situations of doubt between two different diagnosis, (i.e. types of tumour) in medical practice. Binary classification approaches are, therefore, more realistic than either multi-class or one-class-vs-the-rest approaches.

The following sections provide, first, some background on human brain tumours and the MRS data analyzed. This is followed by two main blocks. The first introduces the basics of the MWVA method and the results of a set of preliminary experiments in which ANNs were used as a classifier from a selection of frequencies. The second described the basics of DWT preprocessing and the subsequent classification with ANN from PCA and MWVA reductions of the preprocessed data.