Título: PROBABILISTIC MODELS FOR TISSUE CHARACTERIZATION IN ULTRASONIC AND MAGNETIC RESONANCE MEDICAL IMAGES AND APPLICATIONS

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Resumen: Tissue characterization in medical images is of paramount importance for diagnostic purposes, since it permits physicians to differentiate between healthy and diseased tissues. Several techniques exist for providing such a characterization. Most common ones make use of pattern recognition algorithms, which learn features from textures and their capability of extrapolation allows them to provide a classification of tissues. Other approaches make use of the underlying physical processes of the acquisition and try to characterize the mechanisms that produced the received signals. The main advantage of these techniques is that their performance is not limited by their capability to learn patterns from training sets. Conversely, they depend on the accuracy of the assumed physical models. The Thesis here proposed studies tissue characterization from this perspective. Specifically, it focuses on the probabilistic characterization of tissues in ultrasonic (US) and

magnetic resonance images (MRI), since their underlying physical models give rise to probabilistic models describing the resulting patterns.

The statistical description of US provides an important information of the backscattered echo from tissues, which exhibits a characteristic pattern known as speckle. The parameters of the statistical models allow identifying the features of tissues and provide important descriptors for classification. Many segmentation, filtering, or classification algorithms rely on a Bayesian approach where an accurate statistical model becomes necessary. As a consequence, modeling the statistics of US envelop signals has been a very active area. However, the complex composition of tissues that may show combinations of different kinds of speckle in the resolution cell, and the transformations of data during the acquisition process, make it difficult to provide a proper probabilistic description of signals. This results in the absence of agreement on the probabilistic distributions that characterize tissues in US.

Though the underlying physics that govern the acquisition of MRI and US are completely different, the distributions that model noise in MRI are similar to those of the ultrasonic speckle. In the case of MRI, the presence of noise affects the performance of post-processing techniques such as segmentation, registration, or estimation and, thus, the application of techniques to remove the noise in MRI are of great interest. Hence, tissue characterization techniques used in US can be potentially used for denoising purposes in MRI.

This Thesis aims at characterizing the random nature of tissues in US imaging at different steps of the acquisition process. For this purpose, the main assumptions of the probabilistic models for speckle are revisited, as well as how they are influenced by the different acquisition stages. As a result, new models for the probability distributions of interpolated, filtered, and log-compressed speckle are proposed. The heterogeneity of tissues is also studied and modeled along with other probabilistic distributions that consider the highly impulsive response of speckle. Additionally, new mathematical tools are developed to characterize probability distributions.

The proposed models provide the bases for four new applications within the scope of US and MRI processing: the probabilistic classification of tissues in US; the reduction of speckle via anisotropic filtering; the estimation of the parameters of log-compressing in US acquisition; and the denoising of MRI as an extension of the probabilistic models devised for US.