



LLE Based TRUS Image Features Dimensionality Reduction for Prostate Cancer Diagnosis

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Abstract

This paper focuses on the construction and analysis of prostate image features from Trans-Rectal Ultra-Sound (TRUS) for tissue characterization. One of the principal contributions of this investigation is the combined use of the information in the images' frequency domain features and spatial domain features to attain an accurate region of interest identification (ROI) which leads to a more accurate diagnosis. Next, from each ROI, two different feature sets are constructed; the first set includes the Fractal Dimension obtained using three different methods and the second set consists of the Laws Energy Measure features. To remove the redundancy among the constructed features as well as to overcome the curse of dimensionality, we apply the recently developed Locally Linear Embedding (LLE) technique to the above set of features which produces a low dimensional, neighborhood preserving embeddings of the high dimensional data. For comparison purpose, another set of low dimensional features is also produced using the classical Principle Component Analysis (PCA). The discriminatory power of the constructed feature set, and the reduced-dimensional feature sets, are compared using the Support Vector Machine classifier. The classification accuracy ranges from 62.5% to 82.3%, where the performance of the LLE-based features outperforms that of the PCA-based ones.

Keywords: Prostate Cancer, Locally Linear Embedding, TRUS images, Dimensionality Reduction, Fractal Dimension, Laws Energy Measure.

1. Introduction

TRUS imaging system is one of the most dominant image modalities used for prostate cancer diagnosis. Due to the fact that prostate cancer is only curable at an early stage, an accurate diagnosis is crucial [1]. The diagnosis scheme consists of consecutive stages that start with clinical data analysis and Digital Rectal Examination

(DRE). The following stage is usually TRUS images and then usually a biopsy operation is conducted. The common factor between DRE and TRUS is the dependence on the skills of the conducting physician and radiologist. Experienced doctors achieve more accurate prediction rates than inexperienced doctors due to the fact that prior knowledge is correlated to the success of applying these methods. Therefore the biopsy operation is the only way for accurate diagnosis. In an aim to guide the biopsy operation, TRUS images are analyzed which leads to highlighting the most suspicious regions.

To achieve this task, the work in this paper relies mainly on improving the Computer Aided Diagnosis (CAD) techniques. When CAD is adopted as a tool in ultrasound imaging, features are constructed from the echoes after the echo processing to identify the tissue type present in the image. Two feature sets are used in this work: the Fractal Dimension (FD) [2] and the Laws Energy Measure (LEM) [10]. Both features were applied successfully for fetal lung maturity determination using ultrasound images [3]. The proposed system in this work is shown in figure 1.

The first stage is identifying the high risk Regions Of Interest (ROI) in the image. In the second stage, the features are constructed from these ROIs. Three different methods are used in this work for FD estimation while 25 LEMs are produced for each region of interest. It is clear that these features may have some redundancy and correlation among them. To reduce this problem and to overcome the curse of dimensionality, we apply the newly developed Locally Linear Embedding (LLE) technique to the above set of features which produces a low dimensional, neighborhood preserving embeddings of the above high dimensional data. For comparison purpose, another set of low dimensional features is also produced using the Principle Component Analysis (PCA) algorithm. The discriminatory power of the original constructed feature set, and the reduced-dimensional feature sets, is compared using the Support Vector Machine classifier.

