Abstract

Prostate cancer (PCa) is the most diagnosed cancer among men and remains a second leading cause of deaths in men globally. The risk of developing PCa is related to advancing age, family history and might be influenced by diet and other factors. Transrectal ultrasound (TRUS) guided systematic 12-core biopsy is the standard-of-care method for the diagnosis of PCa. TRUS guided biopsy is recommended in men with raised serum prostate-specific antigen (PSA) levels and/or abnormal digital rectal examination. However, accurate diagnosis of PCa remains challenging due to the high false negative rate of TRUS guided biopsy and low specificity of PSA. In this context, magnetic resonance imaging (MRI) has shown a promising role in the evaluation of PCa over the last decade. Consequently, clinical applications of prostate MRI have expanded to include tumor detection, localization, characterization, assessment of suspected recurrence, image guidance for biopsy and prediction of the location of PCa. According to latest guidelines of Prostate Imaging Reporting and Data System version 2 (PI-RADS v2), advances in MRI technology have led to the development of multiparametric MRI (mpMRI), which combines anatomic T2-weighted imaging (T2WI), diffusion-weighted imaging (DWI) and its derivative apparent-diffusion coefficient (ADC) maps.

MpMRI can be used for screening at large and might allow to avoid unnecessary biopsies and improve diagnostic accuracy. These technological advances, combined with a growing interpreter experience with mpMRI, have substantially improved diagnostic capabilities for addressing the central challenges in PCa care: 1) improving detection of cancer, which is critical for reducing mortality, and 2) increasing confidence in the detection of other diseases affecting prostate such as benign prostatic hyperplasia and/or prostatitis, which are less likely to cause severe morbidity, in order to reduce unnecessary biopsies and treatment.

One of the key challenges in PCa treatment selection is predicting which patients do or do not need treatment. Computer-aided diagnosis (CAD) models may have a role in addressing this challenge as these models have shown to improve the diagnostic accuracy of PI-RADS scoring when combining the system score with a radiologist score. The aim of this thesis is to develop a
CAD model for PCa using MRI, which could increase the objectivity in the diagnosis and assessment of lesion aggressiveness and as a result, reduction of unnecessary biopsies which could prevent overdiagnosis and overtreatment, all in all leading to an increase in quality of life for the patient.

The purpose of the first study of this thesis is to develop an automated framework to segment prostate gland and its zones simultaneously using DWI, which is an essential preprocessing step for any CAD system for PCa. This study consisted of four main parts, prostate gland segmentation, atlas construction, prostate zonal segmentation, and partial volume correction. The objective of the second study of thesis is to explore the role of texture features and machine learning methods for classification of the PI-RADS v2 scores into low vs. intermediate vs. high score as well as score 4 vs. score 5. Lesion ROI marking, texture feature extraction methods, feature selection and classification methods were assessed for characterization of prostate lesions. This chapter also examines the best combination of texture features of DWI, ADC and T2WI for PCa characterization. The third work in this thesis attempts to develop a 2D and 3D tumor measurement algorithms. Another goal of this work was to develop a semi-automated framework for PI-RADS v2 assessment in order to speed up and simplify the reporting process and analyzes the diagnostic performance of the proposed framework by classifying PI-RADS scores using machine learning methods. A new scoring system for the detection of clinically significant cancer was proposed in the final study, which could help to reduce the number of unnecessary biopsies, or overtreatment.

This thesis work is an attempt to help radiologists, urologists, and clinicians in better patient monitoring, prognosis, disease detection, and treatment. This work can be used in the clinical management of PCa diagnosis during the screening procedure, which can increase the speed of reporting and help radiologists in PI-RADS scoring.