

A Comparative Study Between Apparent Diffusion Imaging and Correlated Diffusion Imaging for Prostate Cancer

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Abstract

Prostate cancer is the second most common cancer in men worldwide, with approximately 174,650 new cases diagnosed in 2019 in the U.S. [1]. However, prognosis is relatively good given sufficiently early detection during the non-metastatic stage, motivating the need for fast and reliable cancer screening methods. Diffusion weighted imaging is a magnetic resonance imaging technique that is gaining traction as a noninvasive method for cancer screening. In 2013, a new form of diffusion weighted imaging called correlated diffusion imaging (CDI) was introduced as a potential candidate modality for building computer-aided clinical decision support systems [2]. We perform a large scale study, across 101 patient cases with full PI-RADS score and histopathology, to compare the performance of correlated diffusion imaging in prostate cancer detection and localization to apparent diffusion coefficient maps, the most commonly used diffusion weighted imaging-derived imaging modality in cancer grading. Using threshold-based classification, experimental results showed that CDI achieves higher specificity at high sensitivity values of 90% and 95%, suggesting that CDI is well suited for scenarios where high sensitivity is crucial, such as cancer screening.

1 Introduction

A promising imaging modality for diagnosing prostate cancer (PCa) is apparent diffusion imaging. With the presumed high cellular density of PCa, the associated tissues should exhibit restricted diffusion characteristics and as such, should have lower apparent diffusion coefficient (ADC) values. While ADC maps shows considerable promise in diagnosing PCa [3], delineating between cancerous tissue and healthy tissue in the prostate gland remains a challenge. As such, a new imaging modality called correlated diffusion imaging (CDI) and its variant exponential diffusion imaging (eCDI) were developed to address this issue. While a preliminary study demonstrated the potential of CDI in computer-aided clinical decision support systems for detection and localization of PCa, this study was limited to 20 patients with known PCa [2]. In this study, we investigate the performance of CDI and ADC on a larger scale, with 101 fully-labeled patient cases, 39 with the presence of a cancerous tumour. More specifically, we take a threshold-based classification approach with the goal of identifying thresholds that achieve high sensitivities to show the efficacy of CDI and ADC modalities for the task of diagnosing patients.

2 Method

To assess the potential of CDI in building a diagnostic aid for radiologists, we focus on leveraging a threshold-based classification strategy. First, full CDI and ADC slices are taken, as shown in images b) and c) in Figure 1. Second, to identify which region is cancerous, a tumour mask is labeled by radiologists, as shown in Figure 1(a). After cancerous and non-cancerous regions of the whole slice are identified, a range of threshold values are used to produce a receiver operating characteristic (ROC) curve to quantitatively assess the classification of PCa, similar to what was performed in [2]. The threshold values were chosen based on the minimum and maximum values of all the prostates in the dataset. The ROC curves are obtained from the pooled data of all patients. To quantitatively compare the ROC curves, the area under the curve (AUC) metric is used.

3 Results and Analysis

As shown in Figure 2, CDI performs significantly better than ADC when using threshold-based classification for slices. In Table 1, at high sensitivity, which is desired for scenarios such as cancer screening, CDI achieves a more balanced tradeoff compare to ADC. Although CDI achieve higher specificities for both sensitivities, a

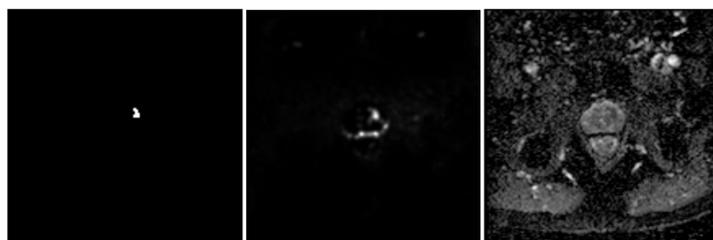


Fig. 1: Sample of data used in the study: a) tumour mask, b) corresponding CDI slice and c) ADC slice

Table 1: Threshold-based classification results on all patient cases

Modality	AUC	Specificity @ 90% sensitivity	Specificity @ 95% sensitivity
ADC	0.265	0.154	0.115
CDI	0.933	0.832	0.597

5.5% increase from 90% to 95% in sensitivity results in a 28.2% decrease in specificity.

Based on the current experimental results, it can be observed that CDI shows strong promise as an important imaging modality for building computer-aided clinical decision support systems. For future work, we plan to leverage discovery radiomics approaches [4] to learn better imaging-driven radiomic sequences from ADC and CDI modalities that can differentiate between healthy and cancerous prostate tissue.

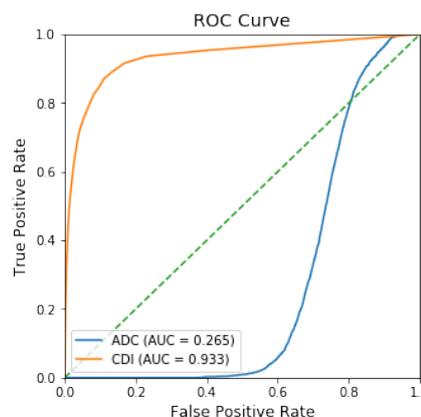


Fig. 2: Receiver operator characteristic (ROC) curves. ROC curves for all patient cases using both ADC and CDI maps.

Acknowledgments

The authors would like to thank Natural Sciences and Engineering Research Council of Canada (NSERC), the Canada Research Chairs program, and the Ontario Institute of Cancer Research (OICR).

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