Title: Development of a Computer Aided Diagnosis Model for Prostate Cancer Classification on Multi-Parametric MRI

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Structured Abstract:

Introduction: Prostate cancer (PCa) is one of the most prevalent cancers among men. Diagnosis depends on a trans-rectal ultrasound (TRUS)-guided biopsy to estimate the stage and aggressiveness. The accuracy of this estimate is confounded by a high false negative rate due to a lack of consistent imaging characteristics that make the identification possible in a majority of cases and consequent use of a universal sextant needle targeting scheme for all patients. Multi-parametric magnetic resonance imaging (mpMRI) maps the prostate in 3D, but is relatively complex to interpret and suffers from inter-observer variability in lesion localization and scoring. Computer-aided diagnosis (CAD) systems have been developed as a solution as they have the power to perform deterministic quantitative image analysis. We measured the accuracy of such a system validated using accurately co-registered whole-mount digitized histology [1].

Hypothesis: A CAD system will accurately classify malignant vs. benign tissue at all intraprostatic loci on mpMRI.

Methods: Using a prostatectomy cohort of 40 patients with T2-weighted MRIs and ADC maps, we generated mpMRI texture maps. Twenty-two first and 33 second order texture features were extracted from cancer and healthy tissue ROIs. A logistic linear classifier (LOGLC), support vector machine (SVC), k-nearest neighbour (KNN) and random forest classifier (RFC) were trained in a three-part ROI based experiment as follows: 1) cancer vs. non-cancer, 2) high-grade (Gleason score ≥4+3) vs. low-grade cancer (Gleason score <4+3), and 3) high-grade vs. other tissue components (low-grade cancer and healthy tissue) by selecting the classifier with the highest area under the receiver operating characteristic curve (AUC) using 1-10 features from forward feature selection via 4-fold cross validation. This was performed in both the peripheral zone (PZ) and central gland (CG) for each case. The misclassification rate (MCR), false-negative rate (FNR), and false-positive rate (FPR) were reported at the ROC point with the lowest FPR and highest TPR, depicting ideal classification.

Results: In classification of cancer vs. non-cancer in the PZ, we achieved an AUC of 0.99 ± 0.01 for a 4-feature SVC and in the CG an AUC of 0.99 ± 0.01 for a 6-feature LOGLC. In classification of high-grade vs. low-grade cancer in the PZ, we achieved an AUC of 0.55 ± 0.05 for a 5-feature RFC and in the CG an AUC of 0.56 ± 0.12 for a 3-feature SVC. In classification of high-grade cancer vs. other tissue components in the PZ, we achieved an AUC of 0.73 ± 0.05 for a 1-feature SVC and in the CG an AUC of 0.78 ± 0.10 for a 9-feature SVC.

Conclusion: A computer aided diagnosis system assisting a radiologist has the potential to classify PCa lesions with high accuracy. Once fully validated, the system has the potential to improve treatment selection and image-guided biopsy for PCa patients.