A Radiomics Based Approach for Predicting Prostate Cancer in PIRADS 3 Lesions on Multi-Parametric MRI

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Background

Prostate image reporting and data system (PIRADS) 3 lesions are considered indeterminate. The decision to biopsy depends on individual factors as opposed to objective guidelines. Herein we proposed both a radiomics and combined radiomics and clinical data-based approach to determine the risk of clinically significant prostate cancer (csPCa) (ISUP>1) using multi-parametric MRI (mpMRI) in this cohort.

Hypotheses

- Radiomics-based feature analysis can be used to predict the presence of csPCa on PIRADS 3 lesions from mpMRI
- Age at biopsy (age), prior biopsy, prior positive biopsy, prostatic specific antigen density (PSAD), and zone of the lesion are clinical features that will increase the model's predictive power

Methods

- Retrospective analysis of mpMRI in patients who underwent targeted biopsy with index PIRADS 3 lesions between 2015 and 2025
- 5-fold training/validation (80%) splits and a testing (20%) splits were generated at the patient level by the presence of csPCa.
- Radiomic features were extracted using PyRadiomics.
- A Random Forrest Classifier was trained using radiomic features (M1) or radiomic features and clinical data (M2).
- ElasticNet was used for feature selection with 30 total features chosen.

Results

		Cohort 1	Cohort 2	Total
Patient (Lesion)	Count	204 (259)	118 (142)	322 (401)
csPCa	Count (%)	43 (21.1%)	40 (33.9%)	83 (25.8%)
Age at biopsy	Mean (SD)	66.49 (6.87)	63.58 (6.98)	65.42 (7.04)
PSA	Mean (SD)	8.37 (7.18)	9.32 (8.78)	8.71 (7.80)
Prostate Volume	Mean (SD)	73.30 (40.61)	60.11 (41.22)	68.47 (41.27)
PSA density	Mean (SD)	0.15 (0.37)	0.18 (0.16)	0.16 (0.31)
Prior Biopsy	Count (%)	125 (61.3%)	103 (87.3%)	228 (70.8%)
Prior Positive Biopsy	Count (%)	86 (42.2%)	82 (69.5%)	168 (52.2%)
Lesion Locations	CZ	5 (2.5%)	2 (1.7%)	7 (2.2%)
	PZ	69 (33.8%)	52 (44.1%)	121 (37.6%)
	TZ	147 (72.1%)	76 (64.4%)	223 (69.3%)
Lesions per patient	1	157	96	253
	2	40	20	60
	3	6	2	8
	4	1	0	1

Table 1: Demographics. CZ = central zone; TZ = transition zone; PZ = peripheral zone

Model	M1	M2
Sensitivity [CI]	0.51 [0.28, 0.72]	0.5 [0.28, 0.72]
Specificity [CI]	0.78 [0.65, 0.86]	0.86 [0.75, 0.93]
Accuracy [CI]	0.72 [0.60, 0.81]	0.78 [0.68, 0.86]
PPV [CI]	0.38 [0.21, 0.60]	0.5 [0.28, 0.72]
NPV [CI]	0.85 [0.73, 0.92]	0.86 [0.75, 0.93]
F1	0.43	0.5
AUC	0.67	0.75

Table 2: Model Performance. CZ = central zone; TZ = transition zone; PZ = peripheral zone

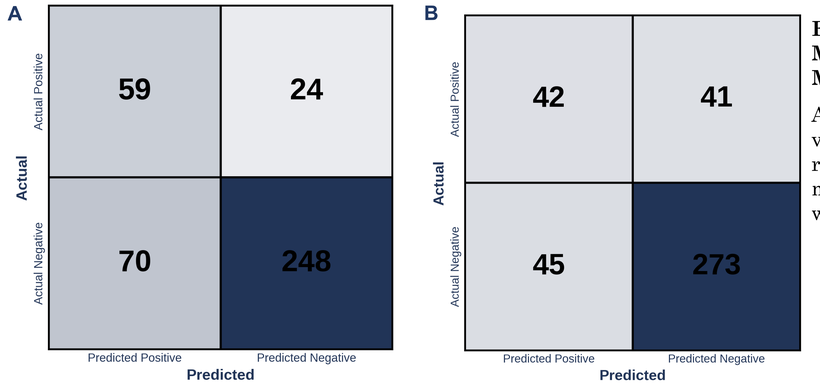

Figure 1: Confusion Matrices for A) M1 and B) M2.

Actual represents the true values and predicted represents the classification model's prediction of if a lesion was csPCa or not.

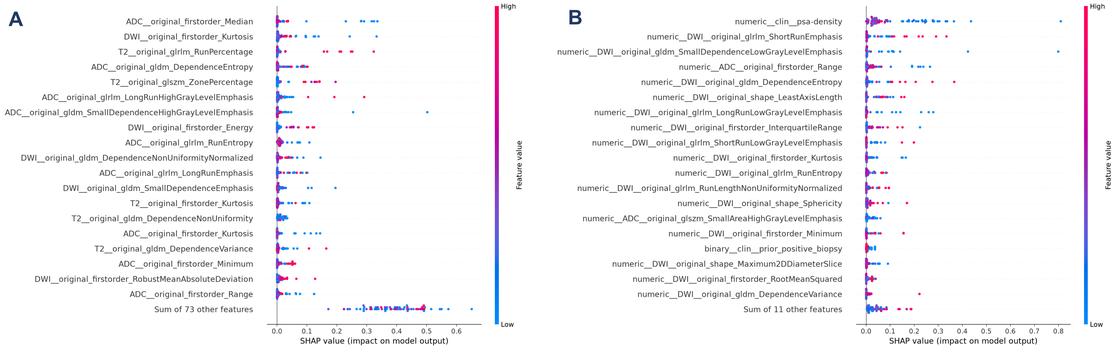

Figure 2: Bee Swarm Plot for the Top 20 Contributing Features by Mean SHAP Value for A) M1 and B) M2. The y-axis represents each feature. The x-axis represents each SHAP (SHapley Additive exPlanations). Each point represents a case. Blue points represent low values for a particular feature at that SHAP value. Red points represent high values for a particular feature at that SHAP value. The density of points represents the association for that feature value/SHAP value relationship across patients.

Conclusion

- The addition of clinical values increased the predictive power of the model
- The model's performance would benefit from an increased training set size due to the lack of PIRADS 3 lesions with biopsy confirmed csPCa in our cohort

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