frontiers

Supplementary Material

Predicting Gleason Score of Prostate Cancer Patients using Radiomic Analysis

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1 Supplementary Tables

Supplementary Table 1: PCa patients (n=99 cases)

ProstateX-0000	ProstateX-0026	ProstateX-0055	ProstateX-0094	ProstateX-0110	ProstateX-0123	ProstateX-0139	ProstateX-0164	ProstateX-0183	ProstateX-0195
ProstateX-0001	ProstateX-0028	ProstateX-0067	ProstateX-0095	ProstateX-0111	ProstateX-0124	ProstateX-0141	ProstateX-0165	ProstateX-0184	ProstateX-0196
ProstateX-0002	ProstateX-0031	ProstateX-0069	ProstateX-0097	ProstateX-0114	ProstateX-0125	ProstateX-0142	ProstateX-0168	ProstateX-0186	ProstateX-0197
ProstateX-0004	ProstateX-0035	ProstateX-0071	ProstateX-0099	ProstateX-0115	ProstateX-0126	ProstateX-0143	ProstateX-0169	ProstateX-0187	ProstateX-0198
ProstateX-0005	ProstateX-0037	ProstateX-0076	ProstateX-0101	ProstateX-0116	ProstateX-0127	ProstateX-0145	ProstateX-0172	ProstateX-0188	ProstateX-0199
ProstateX-0014	ProstateX-0040	ProstateX-0077	ProstateX-0102	ProstateX-0117	ProstateX-0128	ProstateX-0148	ProstateX-0173	ProstateX-0190	ProstateX-0200
ProstateX-0015	ProstateX-0041	ProstateX-0078	ProstateX-0103	ProstateX-0118	ProstateX-0129	ProstateX-0150	ProstateX-0174	ProstateX-0191	ProstateX-0201
ProstateX-0016	ProstateX-0046	ProstateX-0082	ProstateX-0104	ProstateX-0119	ProstateX-0131	ProstateX-0152	ProstateX-0179	ProstateX-0192	ProstateX-0202
ProstateX-0018	ProstateX-0053	ProstateX-0084	ProstateX-0105	ProstateX-0121	ProstateX-0133	ProstateX-0153	ProstateX-0181	ProstateX-0193	ProstateX-0203
ProstateX-0019	ProstateX-0054	ProstateX-0092	ProstateX-0106	ProstateX-0122	ProstateX-0136	ProstateX-0162	ProstateX-0182	ProstateX-0194	

Supplementary Table 2: Patients characteristics and Gleason score

Gleason (n)	Gleason score		PCa zone	This study
Grade Group 1 (30)	≤ 6		PZ=10; AS=14; TZ=6	G1 (30)
Grade Group 2 (39)	3+4 = 7		PZ=19; AS=15; TZ=5	G2 (39)
Grade Group 3 (17)	≥ 7	4+3=7 or	PZ=6; AS=8; TZ=3	G3 (30)
Grade Group 4 (7)		4+4=8; 3+5=8;5+3=8	PZ=3; AS=3; TZ=1	
Grade Group 5 (6)		9 or 10	PZ=2; AS=4; TZ=0	

Supplementary Table 3: Description of features computed within the sub-volume of PCa tumor

Features	Description
Histogram (first order features): These features are derived from the first order statistics and provide information related to the gray-level distribution of the ROIs	
Average (Mean)	The average gray level intensity
Variance	Measures the spread distribution about the average
Skewness	Measures the asymmetry of the distribution of values about the average value
Kurtosis	Measures the peakedness of the distribution of values in the image
Energy	Measures the magnitude of voxel values
Entropy	Describes the randomness in the image values
Grey-level co-occurrence matrix (GLCM): These texture features use second order statistics to characterize the spatial relationship between intensity values within ROIs	
Angular second moment	Measures the textural uniformity that is pixel pair repetitions. It detects disorders in textures
Contrast	Measures the local intensity variation
Correlation	Describes the linear dependency of gray level values to their respective voxels in the GLCM
Sum of squares variance	Measures the distribution of neighboring intensity level pairs about the average of intensity level in the GLCM
Homogeneity	Measures the closeness of the distribution of elements in the GLCM to the GLCM diagonal
Sum-average	Measures the relationship between occurrences of pairs with lower intensity values and occurrences of pairs with higher intensity values
Sum-variance	Describes the weights elements that differ from the average value of the GLCM.
Sum-entropy	Represents the sum of neighborhood intensity value differences.
Entropy	Describes the randomness in the GLCM
Difference variance	Measure of heterogeneity that places higher weights on differing intensity level pairs that deviate more from the mean.
Difference entropy	Measure of the randomness/variability in neighborhood intensity value differences.
Information measure of correlation 1	Measures the differences of randomness (entropy)
Information measure of correlation 2	Measure the differences of randomness using exponential formula
Autocorrelation	measure of the magnitude of the fineness and coarseness of texture
Dissimilarity	Describes the contrast of local region
Cluster shade	Measure of the skewness and uniformity of the GLCM
Cluster prominence	Measure of the skewness and asymmetry of the GLCM
Maximum probability	Represents the occurrences of the most predominant pair of neighboring intensity values.
Inverse difference	Measures of the local homogeneity of an image
Neighborhood grey-tone difference matrix (NGTDM): These features use higher-order statistics to measure intensity differences between neighbor voxels	
Coarseness	Describes the texture uniformity
Contrast	Describes the spatial intensity change and the overall gray level dynamic range.
Busyness	Measures the change from a pixel/voxel to its neighbour.
Complexity	An image is considered complex when it has several rapid changes in gray level intensity.
Texture Strength	An image is considered strength when it has a slow change in intensity but more large coarse differences in gray level intensities.
Grey-level zone size matrix (GLSZM/ GLZM): These texture features characterize the size of uniform voxel regions, called zones.	
Small zone size emphasis	Describes the fine textures.
Large zone size emphasis	Describes the coarse textures.
Low gray-level zone emphasis	Measures the distribution of lower gray-level size zones, with a higher value indicating a greater proportion of lower gray-level values and size zones in the image
High gray-level zone emphasis	Measures the distribution of the higher gray-level values, with a higher value indicating a greater proportion of higher gray-level values and size zones in the image.
Small zone / low gray emphasis	Describes the joint distribution of smaller size zones with lower gray-level values.
Small zone / high gray emphasis	Describes the joint distribution of smaller size zones with higher gray-level values.
Large zone / low gray emphasis	Describes the joint distribution of larger size zones with lower gray-level values.
Large zone / high gray emphasis	Describes the joint distribution of larger size zones with higher gray-level values.
Gray level non-uniformity	Measures the variability of gray-level intensity values in the image, with a lower value indicating more homogeneity in intensity values.
Zone Size Non-Uniformity	Measures the variability of size zone volumes in the image, with a lower value indicating more homogeneity in size zone volumes.
Zone Size Percentage	Measures the coarseness of the texture by taking the ratio of number of zones and number of voxels in the ROI

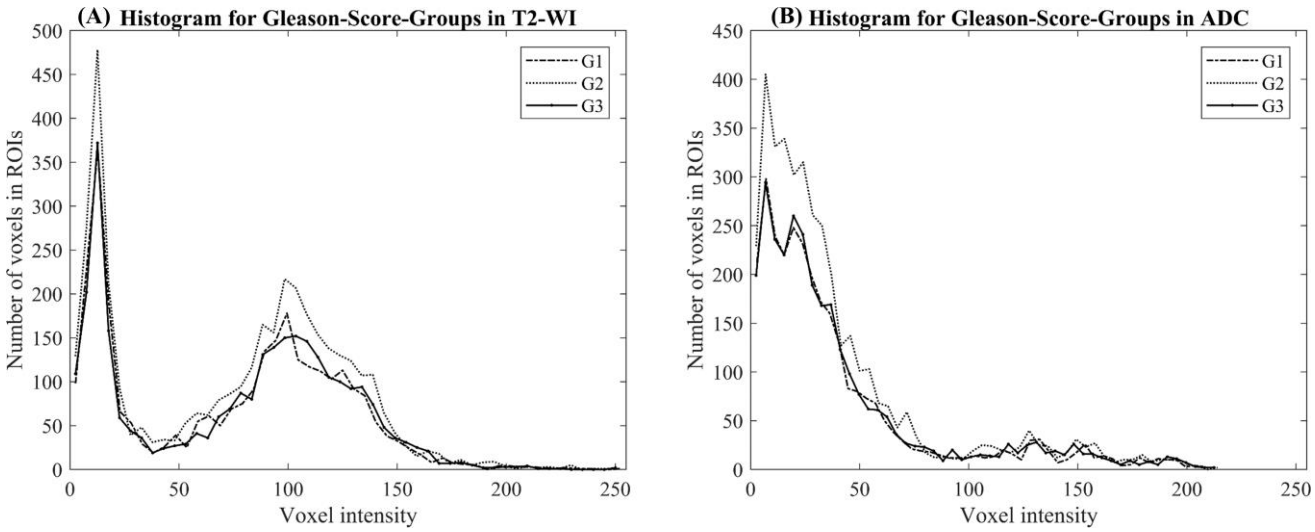
Supplementary Table 4: Performance metrics (%) for predicting the groups of Gleason score

Metrics	G1 vs. all	G2 vs. all	G3 vs. all
Classifier accuracy	81.82	66.67	74.75
NPV	75.00	57.89	80.56
PPV	84.00	72.13	59.26
AUC	83.40	72.71	77.35

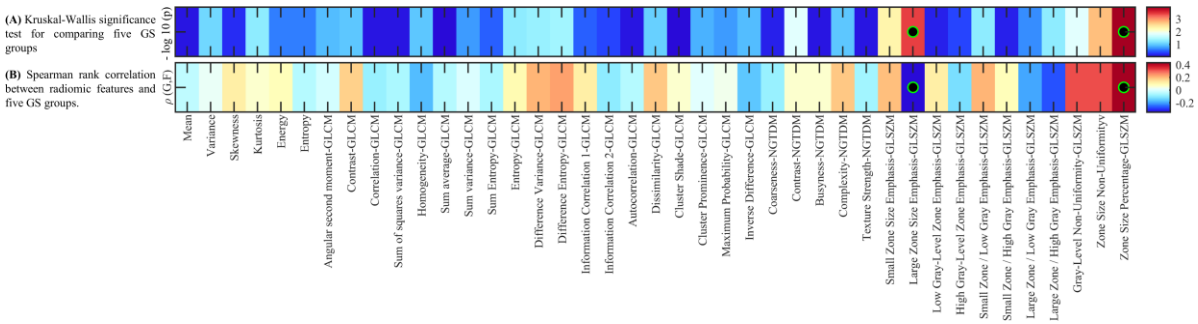
Supplementary Table 5: The confusion matrix for a binary classification

	G1 (n=30)	G2-G3 (n=69)		G2 (n=39)	G1-G3 (n=60)		G3 (n=30)	G1-G2 (n=69)
G1	18	12	**G2**	22	17	**G3**	16	14
G2-G3	6	63	**G1-G3**	16	44	**G1-G2**	11	58

2 Supplementary Figures



Supplementary Figure 1. Histogram of ROIs derived from the Gleason Score Groups (i.e. G1, G2 and G3) of PCa patients. (A) T2-WI and (B) ADC.



Supplementary Figure 2. (A) Heatmap of the Kruskal-Wallis significance test p values (-$\log_{10}$ scale) using radiomic features to identify patients of five groups of Gleason scores. (B) Spearman rank correlation between features value and five groups of Gleason score, color-coded from minimum (dark blue) to maximum (dark red). In (A) and (B), significant features are labeled with a black-green circle (corrected $p < 0.05$).