2D and 3D assessment of radiomic features stability in patients with rectal cancer

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Purpose

Evaluate in rectal cancer primaries, using high-resolution T2-weighted MR images (T2w), which radiomic feature are stable to:

- Inter-observer variations in manual segmentation
- A shift from volume-of-interest (VOI) to region-of-interest (ROI)

Material and methods

Twenty-four patients with oblique axial T2w staging MRIs were retrospectively retrieved from our rectal cancer database.

Two radiologists manually segmented the rectal cancer primaries.

For each VOI, the ROI corresponding to the largest cross-section was obtained.

2247 radiomic features for VOI and 1969 for ROI, comprising the following feature classes: shape, first-order, and GLCM, GLRLM, GLSZM, GLDM, NGTDM matrices, were extracted from each VOI for the original and filtered images – exponential, logarithm, square root, two levels of wavelet and, in VOIs, Laplacian of Gaussian with 1-, 3-, 5-mm – using the PyRadiomics (v.1.3.0).

Statistical Analysis

The agreement between the two radiologists' VOIs was evaluated using the Jaccard Similarity Index (JSI), as shown below:

$$JSI = \frac{S_{reader1} \cap S_{reader2}}{S_{reader1} \cup S_{reader2}},$$

where $S_{reader1}$ is a segmentation of Reader 1 and $S_{reader2}$ is the corresponding segmentation of Reader 2.

The Intra-class correlation coefficient (ICC) was calculated to assess the stability of radiomic features when using manual segmentation. Features with an ICC value ≥ 0.81 were considered to have excellent stability.

Results

Inter-observer manual segmentation agreement

Mean JSI	Range	95% CI
0.64	0.42-0.95	0.58-0.70

484 (21.5%) of 2247 VOI features presented excellent stability to inter-observer variations in manual segmentation.

VOI stable features by image filter

Filter Name	Number of robust features
original	26 (23%)
exponential	7 (7%)
logarithm	51 (53%)
square	19 (20%)
square root	56 (58%)
LoG $\sigma = 1$ mm	23 (24%)
LoG $\sigma = 3$ mm	43 (44%)
LoG $\sigma = 5$ mm	52 (54%)
wavelet	100 (13%)
wavelet2	108 (14%)

VOI stable feature by feature class

Filter Class	Number of robust features
shape	9 (56%)
first-order	90 (20%)
GLCM	87 (15%)
GLDM	86 (25%)
GLSZM	83 (23%)
GLRLM	81 (22%)
NGTDM	49 (43%)

The comparison between ROIs showed excellent stability for 826 (42%) features.

The number of features with excellent stability common to ROIs and VOIs was 186 (9.5%)

Between VOIs and corresponding ROIs

	Number of robust features
Reader 1	37 (1.9%)
Reader 2	42 (2.1%)
Reader 1 $\cap$ Reader 2	19 (48% between readers; 0.9% of total)

Conclusion

Tumour indistinct border on T2w images lowers agreement between observers' segmentations.

Considering inter-observer variations in manual segmentation:

- the percentage of radiomic features with excellent stability is higher for ROIs than VOIs.
- a very low percentage of radiomic features with excellent stability "survive" shifts from VOI to ROI
- of these, an even lower percentage overlaps between readers.