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Reproducible Radiomics Features Enable Robust Habitat Segmentation in Cervical Cancer CT Images

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ABSTRACT

Problem: Most previous studies have focused on feature reproducibility for prognostic modeling, with limited investigation of habitat segmentation. This study assessed radiomic feature reproducibility under clinical variability and developed a stable framework for voxel-level habitat segmentation.

Method: Image perturbation strategies were applied to emulate variability in patient positioning and contour delineation. A total of 1302 radiomic features were extracted from original images, five LoG filtered images, and eight wavelet decompositions. Analyses were conducted across different kernel radius and bin widths. Feature reproducibility was quantified using the bootstrap-based lower confidence limit of the intraclass correlation coefficient. Reproducible features were used to generate voxel-wise feature maps, and habitats were clustered using Gaussian mixture models. Spatial consistency was evaluated using Dice similarity coefficients.

Results: Habitats derived from reproducible features achieved higher spatial consistency than those derived from all features (Dice median[IQR] for Habitat1-3: 0.874 [0.595-0.940], 0.921 [0.696-0.974], 0.913 [0.786-0.977] VS. 0.757 [0.525-0.897], 0.885 [0.756-0.969], 0.897 [0.710-0.967], P < 0.001).

Consluslons: Selection of reproducible radiomic features improves the stability of voxel-level habitat segmentation and supports reliable characterization of intratumoral heterogeneity.

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INTRODUCTION

Radiomics provides a quantitative approach for characterizing tumor and organ heterogeneity from medical images through high-dimensional feature extraction, while habitat imaging extends this concept by partitioning regions of interest into spatially distinct subregions with similar imaging phenotypes. However, voxel-level habitat segmentation remains susceptible to variability introduced by image acquisition, preprocessing strategies, patient positioning, and contour delineation, which may compromise its reproducibility and clinical applicability. Although radiomic feature reproducibility has been widely investigated for predictive modeling, its impact on habitat-based subregional segmentation remains insufficiently explored. Therefore, this study aimed to develop and evaluate a reproducibility-driven CT radiomics framework for stable voxel-level habitat segmentation in cervical cancer.

METHODS AND MATERIALS

- Planning CT images from 356 cervical cancer patients in a two-institution cohort were retrospectively analyzed.
- Three ROIs, including the rectum, bladder, and clinical target volume, were manually delineated and resampled to a uniform voxel size.
- Affine transformation and contour randomization were applied to simulate patient-positioning and delineation variability.
- A total of 1302 radiomic features were extracted from original, LoG-filtered, and wavelet-filtered CT images under different kernel radii and bin widths.
- Feature reproducibility was assessed using bootstrap-based ICC_LCL, and reproducible features were used to generate voxel-wise feature maps.
- Habitat subregions were then obtained using Gaussian mixture model clustering, and segmentation stability was evaluated using Dice similarity coefficients.

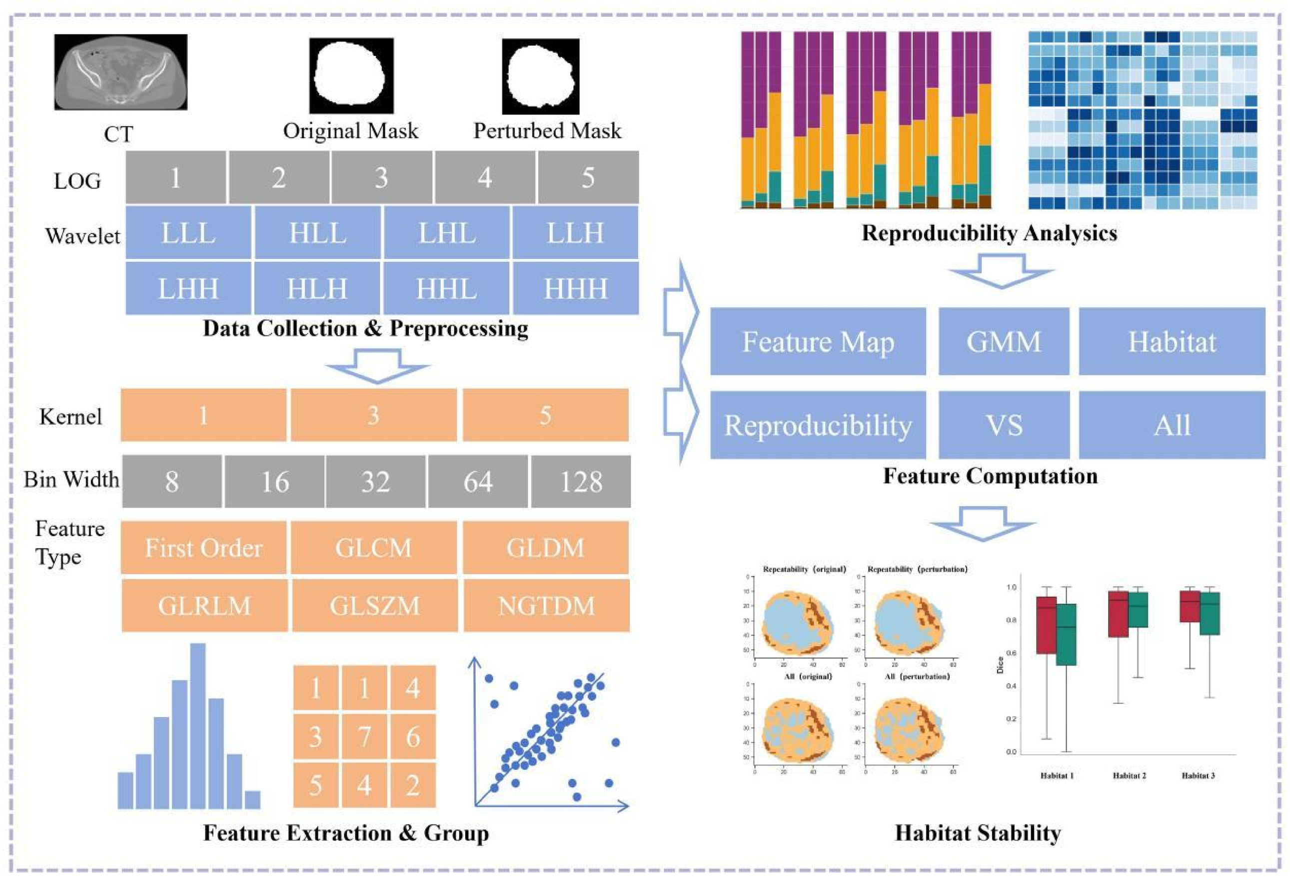

Figure 1. Workflow of the reproducibility-driven habitat segmentation framework.

RESULTS

- Result 1. Perturbation generated clinically realistic ROI variability.Affine transformation and contour randomization produced moderate anatomical and delineation variations while preserving the overall spatial agreement of the ROIs. The Dice similarity coefficients between original and perturbed contours were 0.910 [0.879–0.936] for the rectum, 0.965 [0.952–0.977] for the bladder, and 0.949 [0.931–0.964] for the CTV.
- Result 2. Feature reproducibility depended on spatial scale and intensity discretization.Radiomic feature reproducibility varied across kernel radii and gray-level bin widths. Overall, the highest reproducibility was observed with a kernel radius of 1 mm, while a bin width of 32 HU provided the best balance between texture preservation and noise suppression. Among feature categories, GLDM and GLRLM features demonstrated consistently high reproducibility, whereas NGTDM features showed relatively lower stability.
- Result 3. Reproducible features improved habitat segmentation stability.Habitat subregions generated using reproducible radiomic features showed higher spatial consistency than those generated using all extracted features. The median Dice coefficients for Habitat 1–3 were 0.874 [0.595–0.940], 0.921 [0.696–0.974], and 0.913 [0.786–0.977] in the reproducible-feature group, compared with 0.757 [0.525–0.897], 0.885 [0.756–0.969], and 0.897 [0.710–0.967] in the all-feature group.

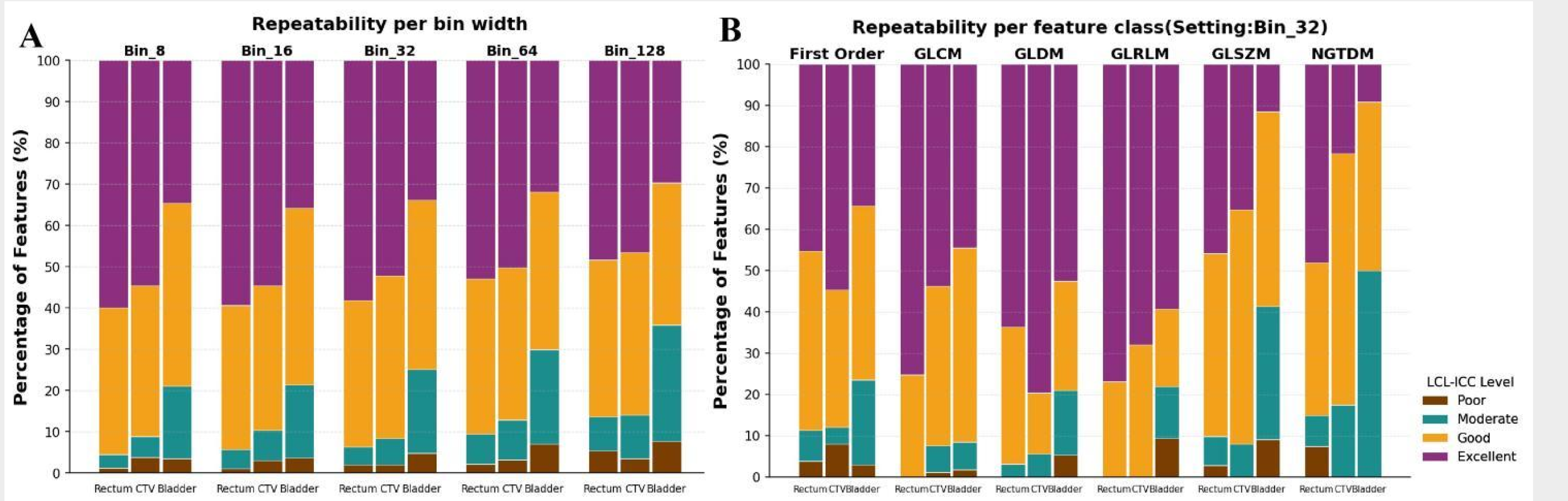

Figure 2. Reproducibility distribution of radiomics features per setting.

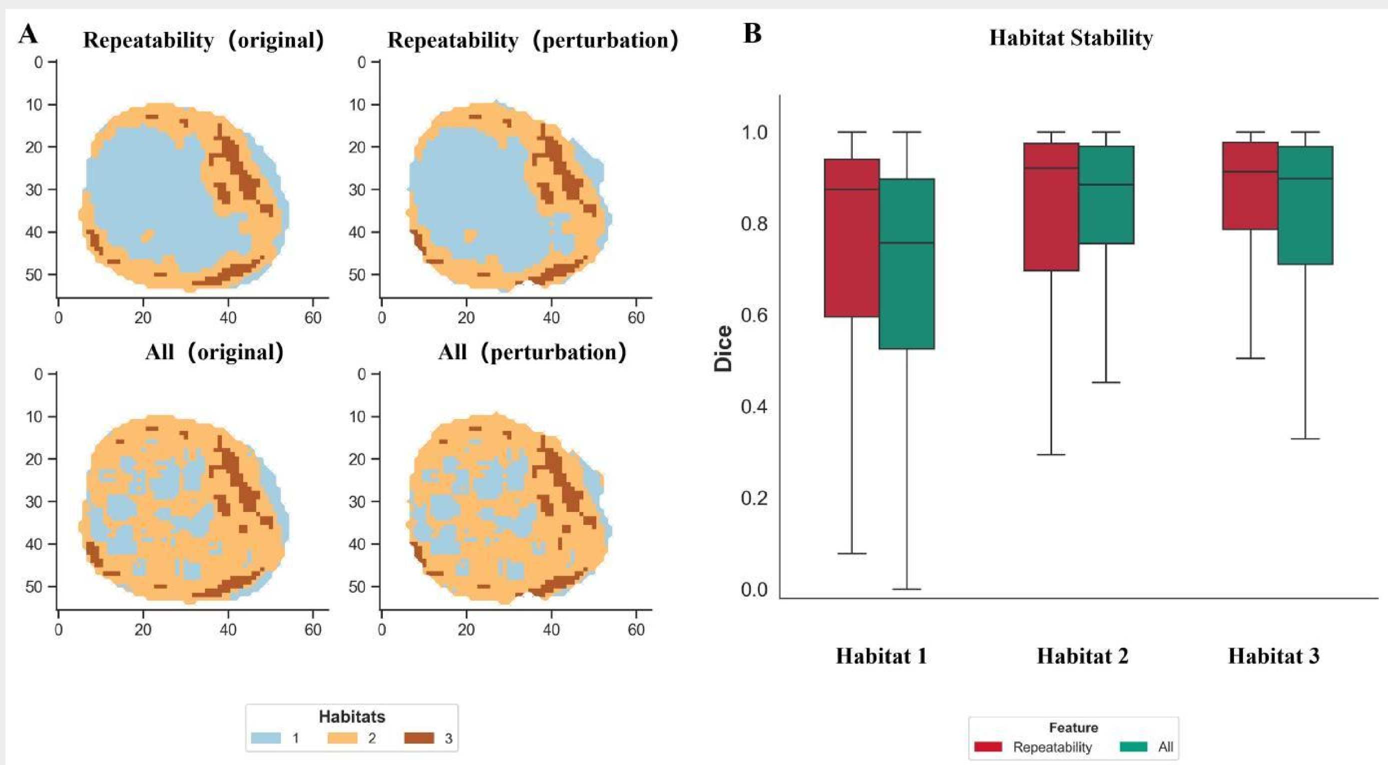

Figure 3. Habitats obtained for the same lesion.

DISCUSSION

These findings suggest that radiomic feature reproducibility is important not only for predictive modeling but also for stable voxel-level habitat segmentation. The higher stability of GLDM and GLRLM features indicates that these texture categories may better capture robust spatial patterns under contour and image perturbations, whereas less stable features may introduce uncertainty into habitat delineation. By selecting reproducible features before clustering, the proposed framework reduces the influence of unstable radiomic information and improves the spatial consistency of CT-based habitat segmentation.

CONCLUSIONS

This study demonstrates that Compared with segmentation using all extracted features, habitat segmentation based on reproducible features achieved significantly higher spatial consistency.

REFERENCES

1. Prior O, Macarro C, Navarro V, et al (2024) Identification of precise 3D CT radiomics for habitat computation by machine learning in cancer. Radiology: Artificial Intelligence 6(2): e230118. https://doi.org/10.1148/ryai.249001.
2. Gong J, Meng F, Liu C, et al (2025) Repeatability and prognostic value of radiomic features: a study in esophageal cancer and nasopharyngeal carcinoma. Insights into imaging 16(1): 166. https://doi.org/10.1186/s13244-025-02044-z.