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Characterizing Bladder Filling Physiology with Long-Axial-FOV Dynamic PET/CT

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Introduction

During dynamic PET imaging, the urinary bladder accumulates tracer excreted by the kidneys, causing expansion that displaces adjacent organs. Since CT is typically acquired after PET, the bladder is often delineated at its largest volume, creating positional inconsistencies for neighboring organs. We therefore track bladder expansion and evaluate its frame-by-frame shape.

Methods

In 23 patients, bladder masks from automated multi-organ segmentation frameworks (TotalSegmentator and MOOSE) were used to define an approximate bladder region as initialization for a custom region-growing algorithm. Starting from the final PET frame, the algorithm propagated the mask backward through the dynamic PET frames using voxel intensity normalization, distribution-based correction, and region growing to capture temporal changes.

Results

The result of the algorithm is a collection of segmentation masks for each PET frame, starting from the last PET frame and ending whenever the bladder is no longer visible in PET. It failed in 2/23 cases because of anomalous uptake near the bladder. In the remaining 21 patients, the volume growth over time followed a linear pattern (coefficient of determination $R^2 = 0.94[0.88,0.97]$), while the fractional anisotropy (a shape quantifier) showed a decreasing trend, i.e., the bladder became closer to a sphere as it filled (Spearman correlation $\rho = -0.86[-0.96,-0.61]$). To assess the accuracy of existing state-of-the-art models, we calculated Dice–Sørensen coefficients (DSC) using the masks generated by our method as reference segmentations, resulting in 0.40 ± 0.37 for TS and 0.70 ± 0.26 for MOOSE.

Conclusion

We developed and evaluated a custom algorithm for urinary bladder segmentation in dynamic FDG PET imaging. Unlike existing state-of-the-art segmentation models, which demonstrated limited accuracy for bladder delineation, our method successfully traces the bladder over multiple PET frames. This approach enables reliable tracking of bladder expansion, allowing the reduction of potential misalignment of adjacent organ masks.

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