Purpose:

Gaussian smoothing reduces noise in PET images but blurs edges impacting the achievable accuracy in radiotherapy target segmentation. Bilateral filters both provide smoothing while simultaneously preserving edges. We compared the accuracy of four methods used to segment objects in filtered images.

Methods:

Five spherical volumes (1.1-26.5 ml) were imaged for 1, 2 and 5 minutes at high (8:1) and low (4:1) contrast. Four filters were used to smooth images: two Gaussian kernels of 3 mm and 6 mm spatial FWHM, and two bilateral filters with the same FWHM but with an adaptive intensity kernel. Segmentation methods of 40%-max (40%), adaptive thresholding (ADP), K-means (KM) and region-growing (SRG) segmented the volumes. Accuracy was judged comparing segmentations to a known ground truth via Jaccard coefficients (JC) (values closer to 1 better) and symmetric mean average surface distance (SMASD) error. Models describing the impact of filtering and segmentation method were fit using generalized estimating equations.

Results:

Median JC and SMASD results indicated the 6mm FWHM Gaussian filter was the most accurate across all segmentation techniques (JC=0.72, SMASD=0.68mm). ADP and KM were tied for accuracy across all filters (JC=0.68, SMASD=0.73mm). Model estimated accuracy was significantly higher for each Gaussian filter relative to its corresponding bilateral version and for ADP compared to 40% (p<0.0001). For the 13mm, 4:1 object with 1-minute scan duration a 6mm FWHM Gaussian kernel with ADP was best (JC=0.59, SMASD=0.95mm). For the 37mm, 8:1 object with 5-minute scan duration a 6mm FWHM Gaussian kernel with 40% thresholding had the highest JC (0.91) but KM had lower SMASD (0.42mm), vs. 40% (0.51mm).

Conclusion:

Choosing the optimal filter for segmenting radiotherapy targets is a complex relationship between object size, contrast and noise. Object size has the biggest impact. For small low-contrast objects, Gaussian kernels slightly larger than scanner resolution showed higher accuracy.

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