Improving Small Tumor Volume Estimation Accuracy in Positron Emission Tomography Using Resampling and Regional Blind Deconvolution Restoration

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Introduction

Accurate estimation of tumor volume on Positron Emission Tomography (PET) images is an important requirement in radiotherapy planning and other similar applications in Oncology. Tumors with less than 2 cm diameters are particularly difficult to quantify mainly due to the limited spatial resolution of Positron Emission Tomography (PET) cameras and the large pixel sizes.

Aim

The purpose of the present work is to present a new method for the accurate volume estimation of small tumors and demonstrate its efficacy on real oncological PET images that contain simulated tumors.

Materials & Methods

First, images in three dimensional form were reduced to small volumes incorporating the individual tumors in order to increase the efficiency of the image restoration process and reduce the effects of the varying point spread function (PSF) across the FOV.

A blind deconvolution algorithm based on the Lucy-Richardson method was used to restore the cropped volumes by reducing the effect of the resolution loss[1-2]. Parameters were optimized by the use of a relative difference index [3-4]. The resultant image was then resampled using linear interpolation [5].

After deconvolution, a resampling scheme was applied in order to reduce the pixel size [5]. The tumor in the final image was delineated with the 50% thresholding method. The entire procedure was applied to the [18F] FDG PET images in the ONCOPET database [6].

The ONCOPET image database consists of image sets of 128x128x375 voxels. Real patient scans were used and tumors of different sizes were simulated with spheres of varying activities. Finally, projection data were reconstructed using a filtered back projection algorithm.

The MIPAV image processing platform was used for visualization, cropping and segmentation [7].

Results & Discussion

Initial results were obtained using a small tumor of 14 mm diameter, a signal to background ratio of four and a voxel size of 5.0625 x 5.0625 x 2.425 mm3. The volume estimation error was reduced from 583 % to less than 9 % using linear and B-Spline interpolation methods and a 50% thresholding segmentation algorithm. The initial matrix size needed by the algorithm as well as the number of iterations were optimized by making use of a relative change ratio. The number of iterations was taken as 18 since the relative change reached a plateau at that level and an initial matrix of 6x6 was used to represent the initial PSF since it gave the highest relative change. Work is ongoing for optimizing delineation accuracy and determining confidence intervals for different tumor sizes and signal to background ratios using phantom studies and realistic image sets.

Conclusion

First results indicate that a substantial improvement in accuracy of small tumor volume estimation can be achieved by the use of this method. This may contribute to higher precision in radiotherapy planning and other oncological applications using PET.

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