Lesion volume Estimation from PET without Requiring Segmentation

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Introduction

Tracking cancer progress and treatment efficacy requires quantifying tumour burden, which in turn benefits from estimating metrics based on total lesion volume, i.e. via the PET Response Criteria in Solid Tumors (PERCIST). This typically requires lesion delineation from a 3D volume, which can either be performed manually or using (highly) automated segmentation methods. The former approach is time-consuming and suffers from inter and intra-rater variability, whereas the latter can require computationally intensive processing, parameter tweaking and may result in 'leaking' or under-segmentation.

Methods

We propose the first quantification method for lesion volume estimation that does not require segmentation. Our approach, at a high level, relies on training a machine learning system using a set of (image patch, volume value pairs). The image patch is a quick-to-draw, box-like 3D region of interest (ROI), i.e. not a delineation. In practical usage scenarios, given an ROI containing a lesion from a novel PET image, the trained model infers the volume (in mm^3) of the lesion within the ROI, without segmentation. We use regression Random Forests as the machine learning "engine".

Data

We trained our machine learning on a set of 140 phantom images, for which exact geometry and volume of lesion-like regions is available. The data included backgrounds of air, water and hot-background and had Signal to Background (SBR) values of 4:1 and 8:1, respectively. We tested our method on 52 clinical PET images from the Quantitative Imaging Network (QIN) Head and Neck collection in The Cancer Imaging Archive (TCIA). These images come from 3 scanners with different acquisition parameters and are accompanied by 3 expert segmentations for each lesion.

Results

We used our method to estimate the volumes of 195 lesions from the 52 clinical PET images. Then we calculated the pairwise disagreement in volume estimations between the three experts and our method (i.e. disagreement between expert1 and expert2; expert2 and expert 3; expert1 and proposed method; etc.). Our preliminary results show that our method (i) achieves lower (by around 10%)

disagreement with two of the experts (expert1 and expert3) than what the third expert (expert3) achieves, and (ii) has a level of disagreement with expert1 and expert2 similar (within 0.5%) to that of expert3.

Conclusion

Quantifying lesion volume in clinical practice is important for managing cancer. In the past decades, numerous image segmentation-based methods were proposed in an attempt to automate this process. However, it remains difficult to choose a segmentation method and set its parameters. We presented the first machine learning-based model to directly estimate the tumor volume in PET images without applying segmentation. We show promising results in terms of close agreement with expert segmentation-based estimates.