

A feasibility study of tumour motion estimate with regional deformable registration method for 4-dimensional radiation therapy of lung cancer

Radiation therapy uses high energy radiation to shrink tumours and kill cancer cells. For external beam radiotherapy, precise localization of the mobile tumour in the thoracic and abdominal region is critical yet challenging. Therapeutic outcome could be seriously compromised if the tumour motion is not properly taken into account in each step of the treatment procedure. A number of techniques were proposed to better control the motion such as: respiratory gating; incorporating motion into treatment volume; breath holding; and tumour tracking [1]. Four dimensional computed tomography (4DCT) dividing a patient's breathing cycle into multiple phases was introduced a decade ago, providing spatial-temporal information of patient's anatomy that can be utilized for tumour motion estimation. This task is often carried out with deformable image registration based on the entire image region of both input images. In our article we adopted a regional model with multistage deformable registration to estimate the tumour excursion. This choice was made largely because we are only interested in the tumour motion that is regional. There is no need to conduct the calculation on the entire image region. In addition, the registration accuracy may be jeopardized in that the registration can be influenced unnecessarily by the image content distant from the region of interest. The tumour motion can be well represented as the location change of the gross tumour volume (GTV), or the GTV excursion relative to a preselected breathing phase, for example, 0% phase of 4DCT. This can be readily computed with GTV contours. To attain GTV contours on all breathing phases, a straightforward solution is to delineate the tumour on a selected phase and then propagate the GTV contour onto the remaining phases through a deformable registration.

KEYWORDS: Resection margin; surgical accuracy; navigation; patient-specific instruments

Ten patients with various tumour sizes and locations were retrospectively enrolled to assess the proposed technique. Estimating tumour excursion relies exclusively on the deformable registration accuracy. The lack of the ground truth makes objective assessment of the algorithm quite challenging. Commonly utilized evaluation techniques are visual inspection, digitally synthetic image experiments, and physical deformable phantoms [2,3]. We manually delineated the GTV on all slices of 4DCT to evaluate the calculation accuracy. With the multistage regional method better than 2 mm accuracy was achievable. The margin added to GTV impacts the algorithm reliability and accuracy, and is often chosen no smaller than 1.5cm. In the cases where tumour is small but immediately

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Our study demonstrated that the information in the region of interest is sufficient to guide the deformable registration for the tumour motion estimation with high efficiency and clinically acceptable accuracy. Although only the motion magnitude is presented, it is not difficult to derive the three dimensional movements based upon the registration results. The motion obtained could benefit 4D treatment planning [4] and eventually mitigate the deleterious impact the mobile tumour motion can have on radiotherapy of thoracic and abdominal cancer.

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