Real-Time Volumetric Image Guidance From a Single Projection View Via Deep Learning: A Preliminary Study

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PURPOSE

To investigate a novel real-time volumetric tumor tracking strategy using a deep learning model from a single kilo-voltage (kV) X-ray images in image-guided radiation therapy (IGRT).

METHOD

Here, we show that a deep-learning model was trained to map 2D projection radiographs of a patient to 3D tumor segmentation of the patient from a single projection view. To generate a sufficient number of the training 2D projection images, we introduced a different scenario of patient position and/or anatomy distribution made by synthetically changing the planning CT image. The changes, including translation, rotation, and deformation, represent vast possible clinical situations of anatomy variations during a course of radiation therapy (RT). We demonstrated the feasibility of the approach with a 4D thorax phantom in 2800 projection views. Results of the 3D tumor contours were compared between the model prediction and the reference, which was from the preset phantom. Dice similarity coefficient and center-of-mass distances were evaluated.

RESULTS

The mean Dice similarity coefficients between proposed 3D tumor contours and reference contours for test data were 0.86 ± 0.06 (range, 0.68-0.95). The mean error of the center-of-mass distances was 1.26 mm ± 0.90 mm. The execution of the prediction model took less than 90 ms, which is well suited for real-time tracking of the 3D tumor in IGRT.

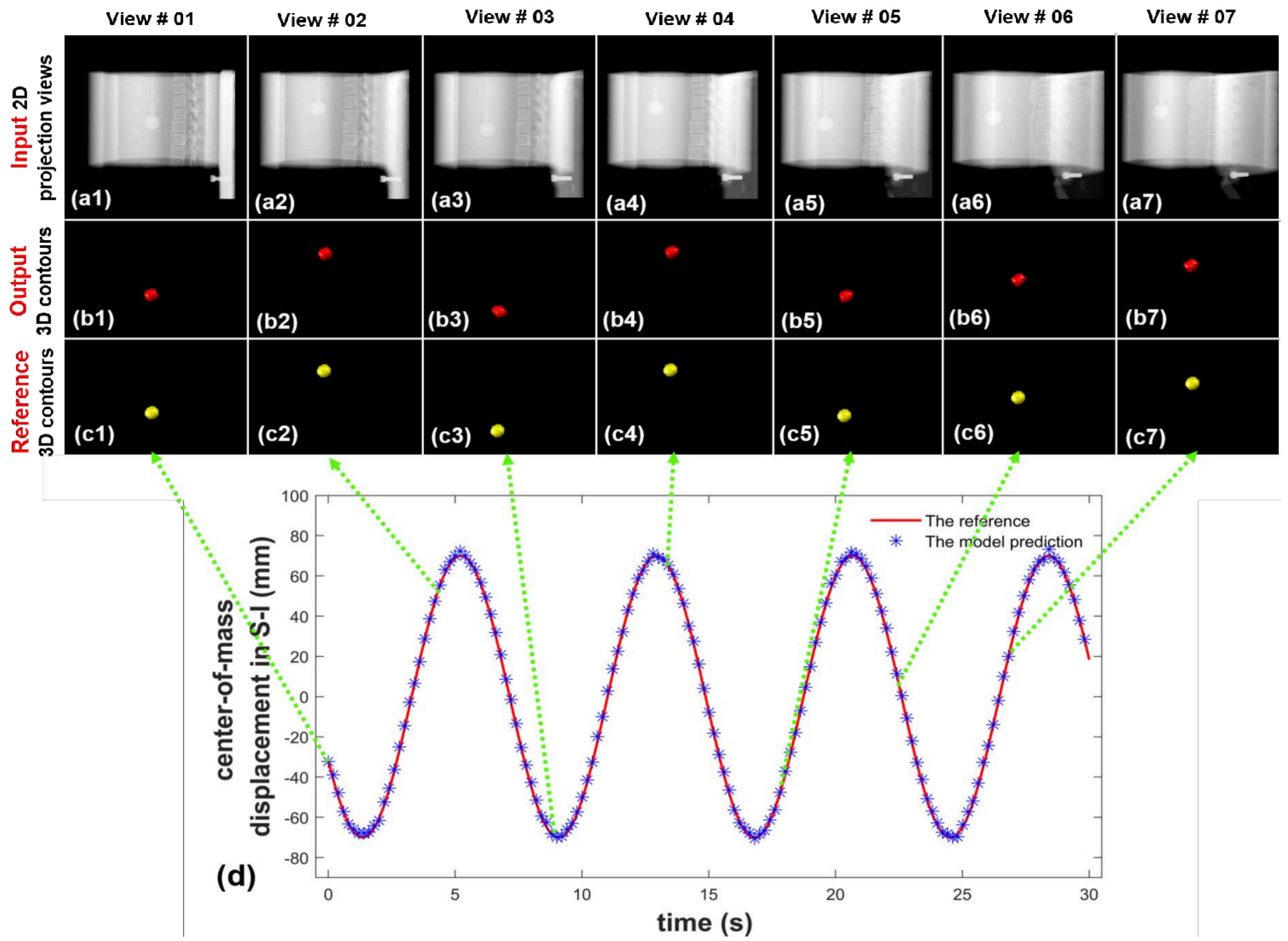

Figure 1. results of the proposed method in the 4D thorax phantom study. Row (a), (b), and (c) show the input 2D projection views, the output 3D tumor contours from the proposed method, and the reference 3D contours, respectively. Columns 1 to 7 show the different images in different views. (d) shows the displacement of the tumor center-of-mass in the S-I direction. The mean Dice similarity coefficients between proposed 3D tumor contours and reference contours for test data were 0.86 ± 0.06 (range, 0.68-0.95). The mean error of the center-of-mass distances was 1.26 mm ± 0.90 mm. The execution of the prediction model took less than 90 ms, which is well suited for real-time tracking of the 3D tumor in IGRT.

CONCLUSIONS:

We proposed a novel real-time volumetric tumor tracking strategy using a deep learning model from a single kilo-voltage (kV) X-ray images. To mitigate the nuance associated with the clinical implementation of deep learning algorithms in training data collection, we propose a novel personalized model training strategy based on synthetically generated digitally reconstructed radiographs (DRRs) without relying on the use of a vast amount of clinical images. Real-time volumetric image guidance from a single projection view via deep learning could be useful in image-guided radiation therapy, and might help simplify the hardware of the on-board imaging systems. Real-time volumetric image guidance from a single projection view via deep learning could be useful in IGRT, and might help simplify the hardware of the on-board imaging systems.

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