Two-dimensional CT Image Prediction from tracking with optical flow and linear regression for X ray lung radiotherapy

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During lung cancer with radiotherapy, the radiation delivered to healthy tissues around the tumor need to be minimized which is difficult because of the breathing motion and the treatment machine latency. This work presents a new method for predicting chest images from limited information based on multiple points position tracking and prediction through optical flow and linear models.

Keywords : Optical flow, Linear Regression, Lung Cancer, Radiotherapy

1. Introduction

During the treatment of lung cancer with radiotherapy, positioning the X-ray beam correctly to minimize damage to healthy tissues is difficult because of the tumor motion due to breathing. Image-guided radiotherapy systems, such as the Elekta Synergy XVI, can provide chest images during the treatment but they are subject to a latency of approximately 100ms due to signal acquisition, etc. As a consequence, the real tumor position at a certain time and its position as shown in the image acquired at the same time differs, which entails uncertainty in the radiation delivery. This in turn reduces the efficiency of the treatment as well as increases irradiation to sound tissues. In this work, we present a method to predict two-dimensional chest images of a breathing patient with a lung tumor, to compensate such latency.

2. Materials and Method

The algorithm described below is used with $n = 10$ 4D-CBCT (cone beam computed tomography) images of a patient's moving chest with lung cancer, corresponding to different breathing phases, acquired by the Elekta Synergy therapy machine in The University of Tokyo Hospital. First, we calculate the optical flow between two successive images of the sequence, using the pyramidal Lukas-Kanade technique [1]. Then, linear regression is used to relate the relative motion of any pixel in the initial image to the motion of three selected pixels near the tumor. The displacement of the latter during one breathing cycle is shown in Fig. 1. The image sequence is repeated to compensate for the scarcity of available data, and a linear predictor [2] is trained to predict the coordinates of the selected points. The linear predictor and the linear relationship between the motion of any pixel and the selected pixels is used to predict the motion of any pixel. Finally, predicted images are reconstructed from the initial image and the predicted motion using forward-warping with a Gaussian kernel. Prediction results are evaluated using 10 successive images of the repeated sequence.

3. Results and Discussion

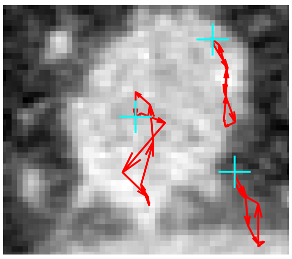
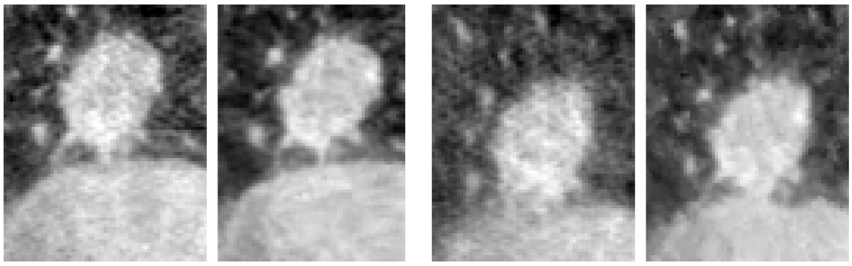


Fig. 1. Selection of three initial points around the tumor and their trajectories based on optical flow



Real t = 22 Predicted t = 22 Real t = 27 Predicted t = 27

Fig. 2 Comparison between real images and images predicted using the 3 trajectories in Fig. 1.

The position of the tumor in the predicted images is similar to its position in the original images (Fig. 2), but we notice difference in their texture and brightness. The high cross-correlation between the initial and predicted images is equal to 0.968 ± 0.017 also indicates a good similarity between the two sets of images. Predicting 10 chest images with Matlab takes 2.38s on a computer with Intel Core i3 3.7 GHz with 12 Gb RAM.

3. Summary

We presented an algorithm which predicts successive 2D cross-section images of the chest of a patient with lung tumor using only the first image of the sequence and the trajectories of a few points, obtained through optical flow. This is a step towards latency compensation in lung cancer radiotherapy.

References

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