A Patient-Specific Model for Tracking Lung Tumor During Radiation Therapy

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INTRODUCTION

The main goal of a radiation therapy treatment plan is to deliver the maximum radiation dose to the tumor, while sparing the healthy organs at risk. Precise determination of the tumor location is crucial to achieve this goal. Respiratory-induced motion makes the measurement and tracking the exact tumor location more difficult during the radiation delivery. We present a patient-specific correspondence model to track lung tumors during radiation therapy using surface displacement as a surrogate signal.

METHOD

A CIRS Xsight® Lung Tracking Phantom kit was used to model the respiratory motion (Fig.1). A 2.5 cm diameter spherical target moves linearly and rotationally in the phantom. The iso-center was placed at the center of the sphere. A large skin-like silicone pad was placed on the phantom to cover the surrogate platform and connect it to the phantom. While a 4DCT scan was acquired from the phantom, displacement of two points on the silicone pad were recorded as surrogate signals. Using the C-RAD Sentinel system, the primary signal point was placed on the surrogate panel and the secondary point was placed on the part connecting the platform to the phantom (Fig.2).

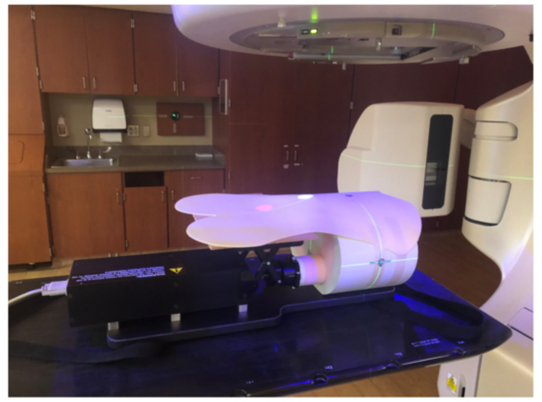

Fig.1: Representation of the CIRS dynamic phantom set up for the study.

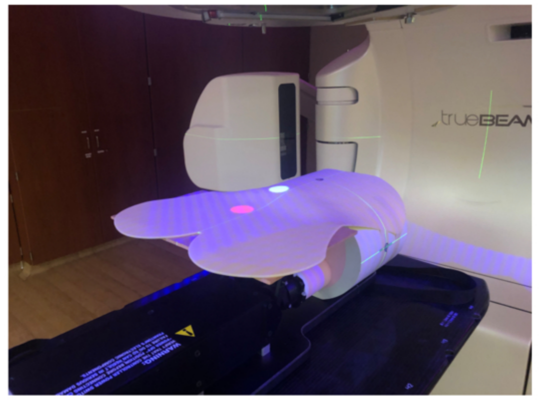

Fig.2: Representation of the location of the primary signal (red circle) and secondary signal (green circle) on the silicone pad.

The primary signal was used to reconstruct 4DCT images into 10 respiratory phases. The data of internal motion was calculated by performing deformable image registration (DIR) algorithm on the 4DCT images with end-exhalation (EE) phase as the reference. Horn and Schunk optical flow algorithm was selected for DIR. Principal component analysis (PCA) was used to fit the correspondence model to the internal data and surrogate signals. In the treatment room the primary and secondary signals were recorded by C-RAD CatalystHD and placed into the model as an input. The model's output was the motion of the iso-center along X, Y and Z direction. The flowchart in Fig.3 shows the steps of the construction and application of the correspondence model.

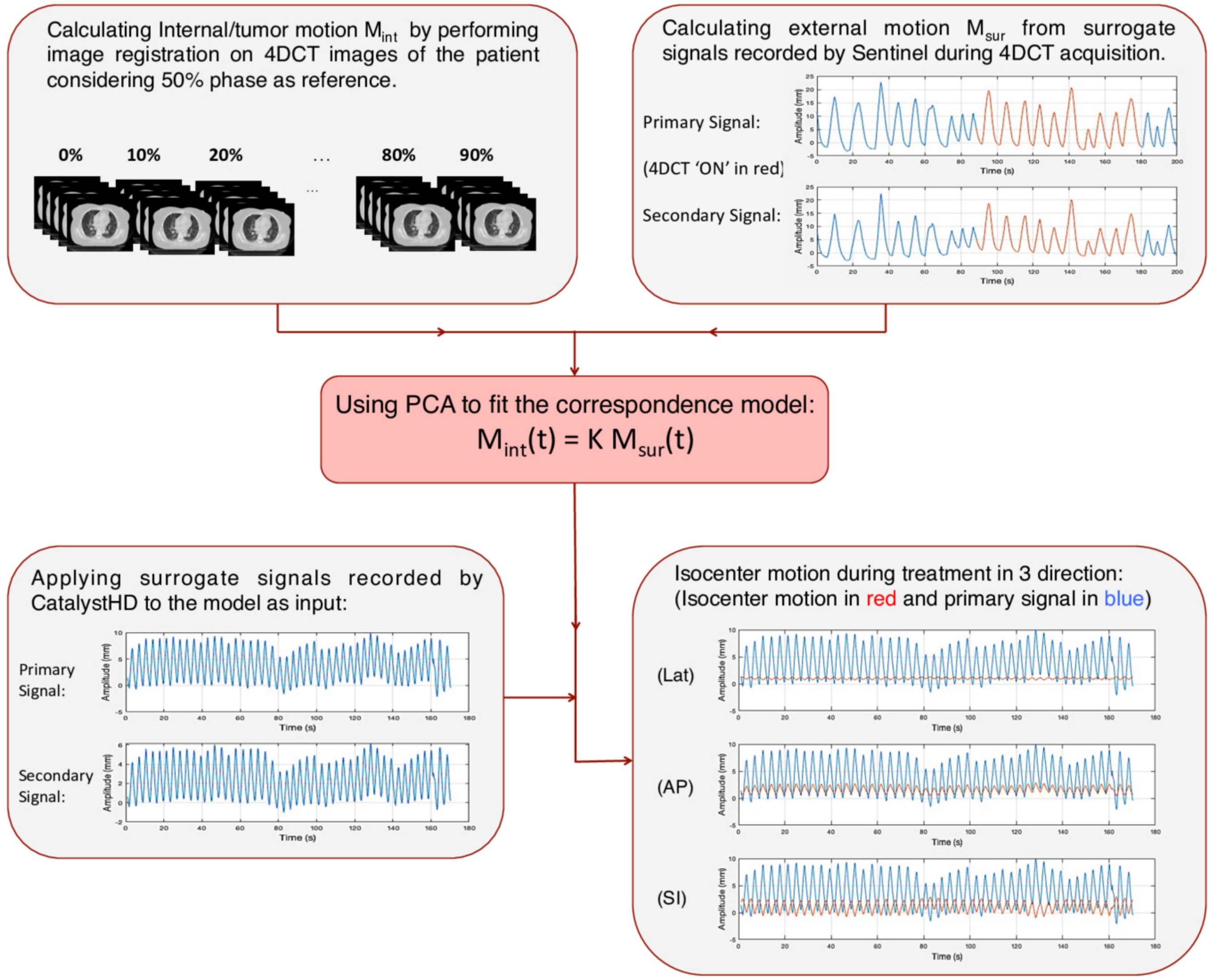

Fig.3: The flowchart of the process of model construction and application.

RESULTS

There was sub-millimeter agreement between the actual and calculated target motions, with differences of 0.08 mm along X (RL), 0.51 mm along Y (AP) and 0.33 mm along Z (SI). The direction of the motion matches the true direction of the target motion along all three axes ((Fig.4)

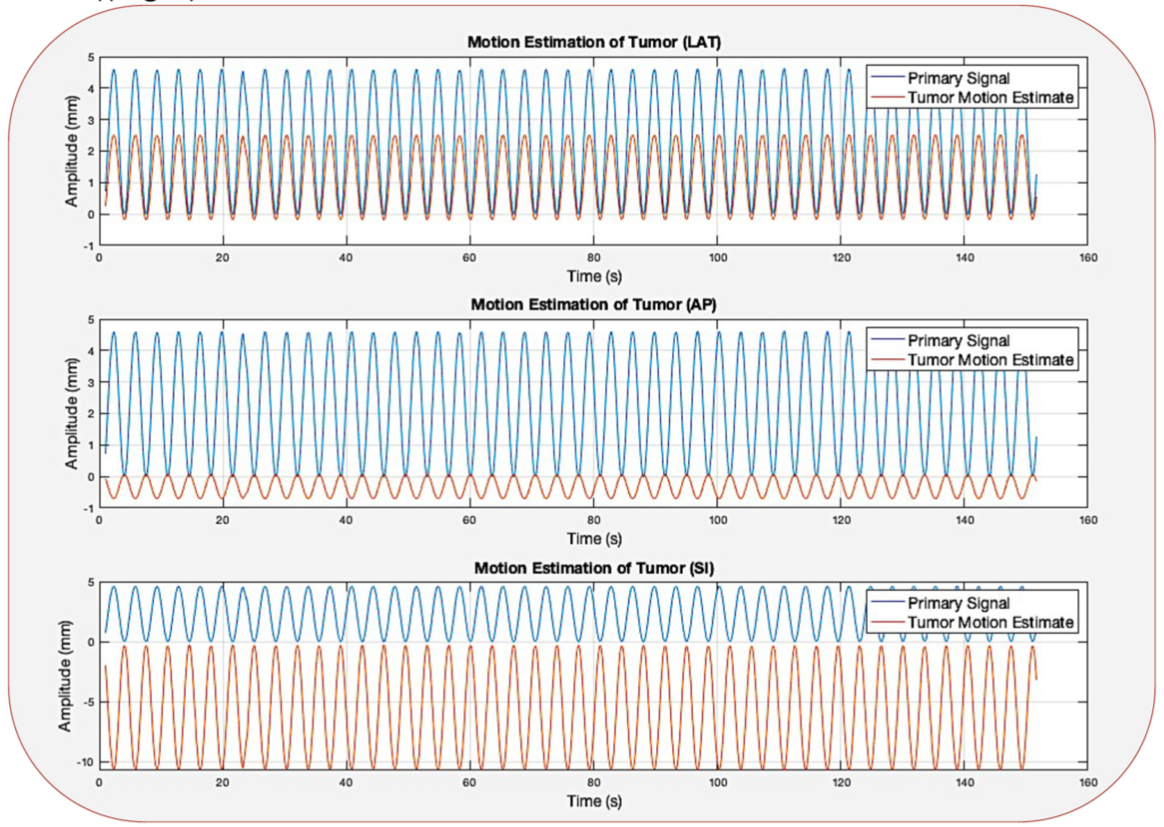

Fig.4: Comparing calculated isocenter motion with primary signal. The isocenter motion moves in the opposite direction of the primary signal in AP and SI directions.

CONCLUSION

Application of the correspondence model designed in this study is a non-invasive and dose free technique to track the location of the tumor during radiation therapy. This model can locate lung tumors during the treatment sessions or can be used as comparison of the tumor range of motion between treatment fractions. The SIGRT system used for recording the surrogate signals (C-RAD Sentinel and CatalystHD) is a commercial systems currently being used in the clinics for patient positioning and patient motion monitoring. Therefore, the model has the potential to enter the clinical use easily. Application of the model to patient images is currently underway.

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