Evaluating Patient Setup Accuracy Using a Subset of CBCT Projections in Fiducial Tracking of Abdominal SBRT

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JULY 12–16 2020 VIRTUAL JOINT AAPM | COMP MEETING

UC San Diego Health
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INTRODUCTION

In image guided radiotherapy (IGRT), on-board kilovoltage (kV) cone-beam computed tomography (CBCT) has increasingly been integrated into clinical practice over the past decade for accurate patient positioning and tumor targeting (1-2). Pre-treatment CBCT imaging has been more prevalent in abdominal tumor radiotherapy where respiratory induced motion is dominant. It provides 3D anatomical information of the patient just before the treatment, which is used for patient setup and tumor localization (3). In addition, there have been feasibility studies on the tracking of internal tumor/fiducial motion in CBCT projections using various algorithms (4-5).

A tracking algorithm based on template matching and sequential stereo triangulation algorithms has been used to track the fiducials in CBCT projections. However, the image quality of the CBCT projections can be deteriorated by noise, contrast, and marker occlusion at the specific projection angles. In this study, we hypothesized that the accuracy of the real-time tracking with full-CBCT projections can be improved by using the selective angle projections.

AIM

To show that tracking only a subset of the projection images acquired for pre-treatment CBCT can be more effectively used for positioning the patient. The less noisy subset are the projections acquired near AP and PA kV imaging directions.

METHOD

Short anteroposterior arc beam (SAPAB) projection angles of 0-45^0, 135-225^0, and 315-360^0 were extracted from the pre-treatment CBCT projections of 8 pancreatic and 5 liver SBRT patients (41 treatment fractions) with implanted fiducials. The fiducials were tracked in both the SAPAB and full-CBCT (0-360^0) projections using an offline research software (RapidTrack, Varian Medical System). Figure 1. shows the workflow of the RapidTrack algorithm. The tracking results were compared based on:

(1) Fiducial and external breathing signal correlation as shown in Figure 2.

(2) Internal tracking margin between 5th and 95th percentiles in each cardinal direction.

(3) Predicted couch shift for clinical decision, which also compared with the actual clinical decision.

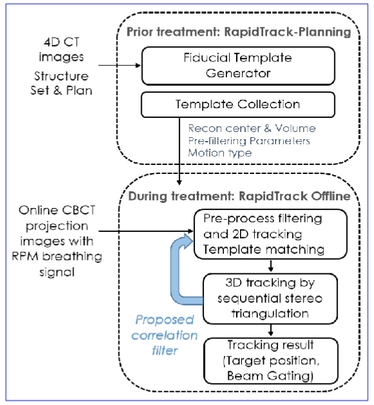

Figure 1: The workflow of RapidTrack algorithm with the blue arrow for the proposed correlation

RESULTS

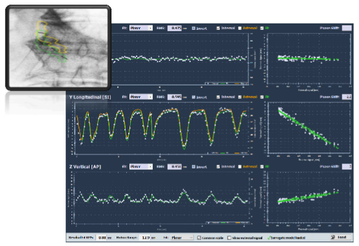

Figure 2: Example of externa-internal motion correlation model generated from fluoro pair (a tracked frame inserted).

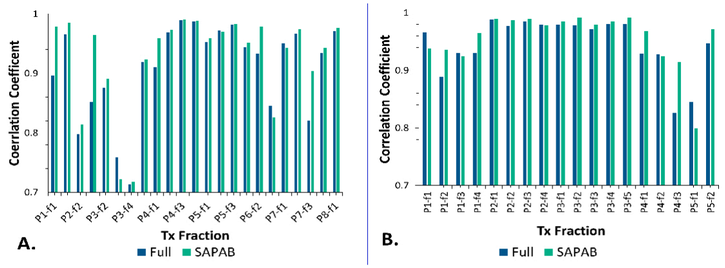

Figure 3. Internal-external correlation coefficients between Full CBCT and SAPAB projections. A) Pancreatic data and B) Liver data

As shown in Figure 3, the average correlation coefficient (coeff) (±SD) for full and SAPAB CBCT projections were 0.93±0.07 and 0.95±0.07, respectively, with root mean square errors (RMSEs) between 0.01 and 1.08 mm. These RMSEs could cause the mean fiducial motion error between full and SAPAB CBCT projections up to 0.07±0.67, 0.19±1.32 and 0.22±1.17 mm in LAT, SI and AP directions, respectively as shown in Figure 4. Comparing the tracking results from full projections with SAPAB projections (Figure 5), the mean predicted couch shifts deviate by 0.08±0.49, 0.32±1.25, and 0.08± 0.27 mm in LAT, SI, and AP directions. In this study, the predicted couch shifts agreed with the clinical couch shift with a mean deviation of 0.88±0.72 mm.

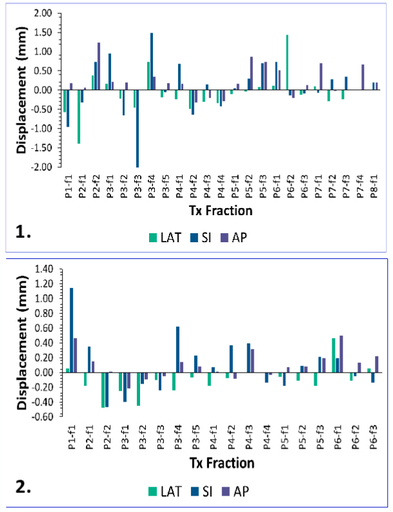

Figure 4: Motion error between full CBCT and SAPAB projection 1) Pancreas and 2) Liver cases

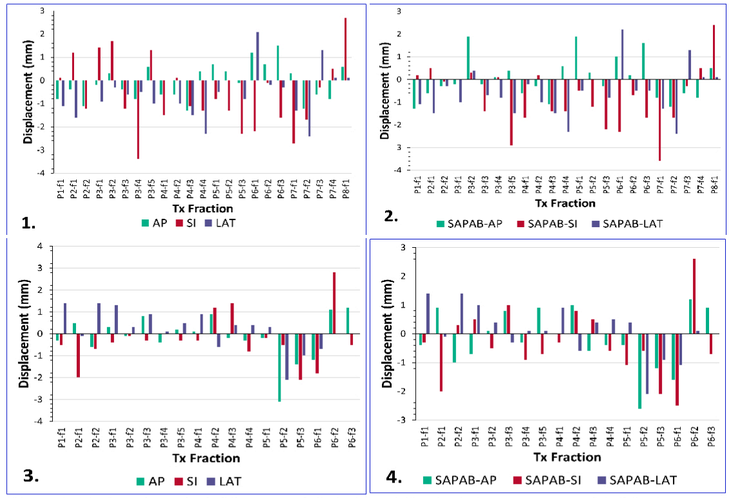

Figure 5. Predicted couch shift between full-CBCT and SAPAB CBCT projections. 1) Full-CBCT images for Pancreatic cases, 2) SAPAB images for Pancreatic cases, 3) Full-CBCT images for Liver cases, and 4) SAPAB images for Liver cases

CONCLUSIONS

This study has shown that the internal-external correlation coefficient is improved in the absence of lateral arc CBCT projections, which also influence the motion margins and predicted couch shifts. However, the full CBCT projection is needed for producing the 3D image that provides positional information about the organs at risk as well as the tumor.

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ACKNOWLEDGEMENTS

This study was funded by Varian Medical Systems, Palo Alto, California, USA.

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