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EASTERN TIME [GMT-4]

Real-time image guidance with single panel Xray imaging system during radiation treatment delivery

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INNOVATION/IMPACT

- Real-time image guidance during radiotherapy delivery (RT-IGRT) is a trend for intrafractional motion management. Low-frequency X-ray RT-IGRT (LFX-RT-IGRT) is promising for this purpose because it ensures accuracy with a reasonable low imaging dose.
- Existing techniques rely on double panels/tubes, with ceiling and floor mounting approach which needs extra hardware and not feasible for ring-gantry based device with an enclosed treatment space.
- It is ideal to develop a X-RT-IGRT technique using single panel/tube pair that is already used for image guided patient setup on most RT devices. This technique monitors patient's motion during rotational treatments by taking and analyzing some x-ray images.
- We have developed such an LFX-RT-IGRT system for intra-fractional motion monitoring. It is realized in a recent-launched whole-body rotational gamma knife (CybeRay®). Its basic idea is sequentially capturing two projections within a certain interval during rotational treatments. By comparing with the initial treatment location with 2D-3D registration, the 3D patient displacement is derived.
- The proposed LFX-RT-IGRT work establishes a universal framework. It is especially significant to rational RT device with existing pair of panel/tube. It provides intra-fractional motion monitoring with accuracy level of ~1mm and a response time <2.3s.

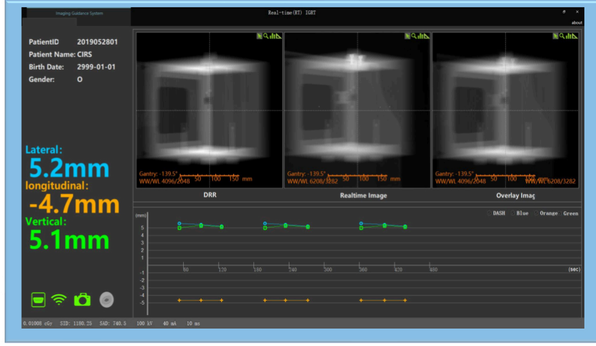
MATERIAL AND METHOD

X-ray images are captured at different gantry angles during rotational treatments. The angle interval is between 45° to 135°, and the default setting is at 90°. The 3D displacement is derived from image registration with DRR for the two images taken at adjacent gantry angles.

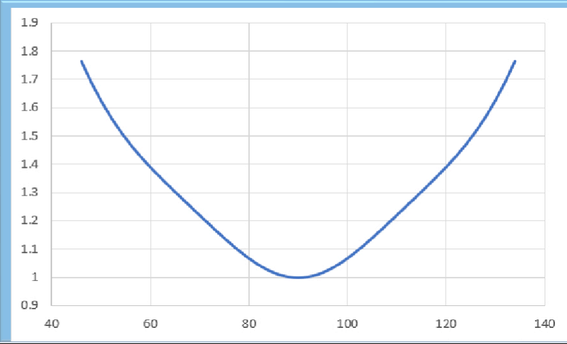
A head anthropomorphic phantom and an inhouse-designed box phantom were setup with cone beam CT based positioning. The derived displacements in 3D during treatment were recorded and analyzed statistically for both still phantoms without (for head phantom) and with a man-set offset of (5mm, -5mm, 5mm, box phantom) .

RESULTS

- Preset offset: 0mm, 0mm, 0mm
- The average biases are **{-0.16mm, 0.08mm, -0.3mm}** in lateral, longitudinal and vertical directions, respectively.
- The standard deviations are **{0.04mm, 0.11mm, 0.10mm}**.
- The average and maximum biases in 3D are **0.56mm and 0.81mm.**



- Preset offset: 5mm, -5mm, 5mm
- The average biases are **0.23mm, 0.13mm and 0.35mm** in three directions.
- The standard deviations are **{0.11mm, 0.12mm, 0.05mm}**.
- The average and maximum biases in 3D are **0.65mm and 1.12mm.**



The performance of X-RT-IGRT system is optimal while the gantry angle gap between two adjacent angles is 90°, it will be degraded along with the deviations from 90°. Suppose that the amplified coefficient is **1.0** while the gantry angle gap is **90°**. When the gantry angle gap is **80° or 100°**, the amplified coefficient is **1.06**, when the gantry angle gap is **45° or 135°**, the amplified coefficient will reach to **1.76**.

KEY RESULTS

- Interval Tuning: we have set 90° as the default setting.
- Response Time: The 2D-3D registration time is tested as below as 2.3 seconds using an Intel Core i7-7700HQ processor (4 CPU cores, 2.8 GHz) with 16GB of DRR3 memory.
- Output and dose: Take a 1RPM treatment gantry speed as an example, every 17.3 (15+2.3) seconds, a motion signal can be detected, indicating the average patient motion over the past 15 seconds. For an SRS non-invasive fraction of 30 minutes, roughly 120 projections are needed. The associated imaging dose is less than the dose from a standard cone beam CT.
- Accuracy: For the head phantom, the average and maximum biases in 3D are 0.56mm and 0.81mm. For the box phantom, the average and maximum biases in 3D are 0.65mm and 1.12mm.

CONCLUSIONS

A new RT-IGRT system using the single panel X-ray image system has been developed for intrafractional position check. These results indicate that LFX-RT-IGRT system is precise and efficient for monitoring target motion during patient treatment.

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