Purpose: We have developed a system that monitors intra-fractional target motion perpendicular to the treatment beam with the aid of metallic markers by means of separating kV image and MV treatment field on a single flat-panel detector.

Methods: We equipped a research Siemens Artiste linac with a 41x41cm^2 a-Si flat-panel detector underneath the treatment head. The in-line geometry allows kV (imaging) and MV (treatment) beams to share closely aligned beam axes. The kV source, usually mounted directly across from the flat-panel imager, was retracted towards the gantry by 13cm to intentionally misalign kV and MV beams, resulting in a geometric separation of MV treatment field and kV image on the detector. Two consecutive frames acquired within 140ms (the first with MV-only and the second with kV and MV) were subtracted to generate a kV-only image. The images were then analyzed ‘online’ with an automated threshold-based marker detection algorithm. We employed a 2D phantom equipped with either a single metallic marker or three Calypso beacons to mimic respiratory motion. Measured room positions were either cross-referenced with a phantom voltage signal (single marker) or the Calypso system.

Results: A phantom study has demonstrated that our imaging framework is capable of automatically detecting marker positions and sending this information to our tracking tool at an update rate of 7.14Hz. The system latency is 111.35+/-2.6ms for single marker detection in the absence of MV radiation. In the presence of a 7x7cm^2 300MU/min MV field, the latency increases to 117.23+-12.57ms. The position accuracy is -0.19+/-0.21mm (without MV radiation) and -0.26+/-0.27mm (with MV). The detection of three markers increased latency by 10-15ms.

Conclusions: Positional accuracy and system latency strongly indicate that this system is suitable for real-time adaptive applications. In the future, we hope to utilize the full image information and substitute metallic with anatomical markers.

Funding Support, Disclosures, and Conflict of Interest:

Supported by Siemens Healthcare/CR.