Improving geometric accuracy in radiation delivery using helical tomotherapy

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Highly conformal radiation delivery demands very accurate target localization at each treatment fraction. The daily goal is to match the optimized treatment plan as closely as possible. Refining the initial setup to the room lasers depends equally on accurately determining any setup errors and correcting for them. If the patient anatomy is deformable and the registration/correction methods are limited to rigid-body adjustments, setup verification involves subjective, priority-based decisions. Having determined the needed adjustments, re-positioning the patient can be an error-prone process that may necessitate further setup verification; thus, it is more accurate to make adjustments to the couch or otherwise modify the delivery, with minimal disruption to the patient. The entire process must also be conducted quickly in order to maintain accuracy.

Helical tomotherapy is a rotational IMRT modality with CT scanning capabilities. Tomotherapy's unique helical scanning geometry has opened the way for new strategies to ensure geometric delivery accuracy, both prior to treatment and in real time. Some of these techniques are incorporated into the commercial system, while others are still under development. Pre-treatment setup verification is accomplished by registering a daily megavoltage CT image to the planning image. The setup is verified automatically using priority-based registration algorithms. While automatic registration is faster than manual registration and sometimes more accurate, a human observer must evaluate the registration results to ensure clinical acceptability. For registration techniques that do not require image reconstruction, one way to manually verify the registration results is to display selected rows of the CT sinogram as a scout view (after re-sorting to parallel, projections). Translational and roll setup corrections are implemented by precise adjustments to the couch or gantry start angle, respectively. However, to correct for pitch and yaw rotational setup errors, no simple mechanism is currently available, so the patient must be re-positioned about a designated rotation center. We propose a dynamic couch translation during treatment to approximately; correct for pitch and yaw rotational offsets. Such an approach would also be useful to correct for piece-wise rigid translations or rotations (bending), or differences in couch sag between the planning CT image set and the delivery.