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AN INTEGRATED PATIENT POSITIONING AND BEAM GATING SYSTEM FOR RADIATION THERAPY

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In radiation therapy it is recognized that margins are required around the CTV to ensure adequate minimal dose to the target tissues (ICRU 50). The margin between the PTV and CTV is a direct function of intra and inter fraction target and patient motion as well as daily setup deviation. In this work we describe a machine-vision respiratory-gating system, based on our reported photogrammetric patient position measurement technique[1]. This system offers a means of providing digital direction for automatic patient setup as well as a real time gating signal to mitigate against patient motion during each fraction. The system comprises a minimum of two CCD cameras, each permanently mounted approximately two meters from the machine isocenter. Inherent contrast of retro-reflective markers on the patient's skin is achieved through illumination by infra-red lasers combined with infra-red band pass filters on the cameras. Any two cameras will then provide a stereo view of the markers and provide a basis for triangulation. The system includes a mechanism for automatic calibration and co-ordinate transformation into the linac frame (IEC) of reference providing a temporally invariant metric for patient position. Emphasis on image processing (e.g. image deformation and corrections for radial and decentering lens distortion) allows absolute marker positions to be reported in the linac frame of reference with an accuracy of +/- 0.5 mm, a precision of 0.2 mm and a temporal resolution of better than 150 ms. Integrating these functions provides a system that is simultaneously capable of monitoring mean patient position and real time variations due to patient motion and respiration. Duplicate systems in the simulator and treatment room allow direct referencing of patient treatment position to simulator films. The system in the simulator also allows simultaneous video capture of fluoroscopy video, time-synchronized to the vector position of radio-opaque reflective markers on the patient surface. The clinically relevant parameter is target motion in a plane perpendicular to the beam. Our system provides a tool to set the gating thresholds for each treatment field mapped from spatial boundaries determined in this plane (the beam's eye view). Performance of the system will be reviewed, and new applications will be discussed.

[1] LH Gerig, et al. "The Development and Clinical Application of a Patient Position Monitoring System." Videometrics III. Proc. SPIE 2350, Nov. 1994.