Clinical implementation of an automatic mask generation framework for use in radiotherapy patient positioning with 2D/3D image registration to achieve hybrid inter- and intrafractional patient position monitoring and multi-component adaptive beam delivery based on bony anatomy

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The spatial alignment of pre- and intra-interventional data plays an important role in image guided radiotherapy (IGRT) to correct for day-to-day variations of the target location in the body and/or the patient on the couch, in order to guarantee an efficient treatment and to avoid adverse effects. We recently developed, evaluated and employed a (semi-)automatic intensity-based 2D/3D registration approach to correct translational and rotational displacements in the pelvic region [1-3]. It rigidly registers a computed tomography (CT) with two X-rays by maximizing the agreement in pixel intensity between the X-rays and corresponding reconstructed radiographs from the CT. To limit the metric evaluation to the anatomical structure of interest, we implemented an automated approach to construct regions of interest (masks) in the X-rays based on 3D segmentations from the pre-planning stage [4].

The next steps of clinical application are hybrid inter- and intra-fractional 2D/3D patient position monitoring (HPPM) and multi-component adaptive beam delivery (MCBD) based on bony anatomy, which are both in a preparatory stage. HPPM is performed during treatment and based on mega-voltage (MV) X-ray images to detect intra-fractional patient movement. Image-guided setup is performed, where prior to each treatment fraction the patient's anatomy is imaged and compared to the planned reference setup. The deviation is computed with rigid 2D/3D registration and corrected to bring the patient into alignment with the planned reference. Irradiation is started and a background patient position verification (gating/adaptation), without fiducial markers (e.g. gold-seeds) is performed through MV intensity information that represents bony anatomy. The goal is to automatically detect if a patient moved between the acquired images.

MCBD based on bony anatomy independently registers multiple regions of interest and results in multiple rigid transformations to correct the alignment of individual anatomical structures. Indications are large target volumes where the spatial location of distinct parts correlates with nearby bony anatomy. Each split volume is registered to the corresponding bony anatomy.

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