Integrating diagnostic B-mode ultrasonography into CT-based radiation treatment planning.

Abstract:
This paper presents methods and a clinical procedure for integrating B-mode ultrasound images tagged with position information with a planning computed tomography (CT) scan for radiotherapy. A workflow is described that allows the integration of these modalities into the clinic. A surface mapping approach provides a preregistration of the ultrasound image borders onto the patient's skin. Successively, a set of individual ultrasound images from a freehand sweep is chosen by the physician. These images are automatically registered with the planning CT scan using novel intensity-based methods. We put a particular focus on deriving an appropriate similarity measure based on the physical properties and artifacts of ultrasound. A combination of a weighted mutual information term, edge correlation, clamping to the skin surface, and occlusion detection is able to assess the alignment of structures in ultrasound images and information reconstructed from the CT data. We demonstrate the practicality of our methods on five patients with head and neck tumors and cervical lymph node metastases and provide a detailed report on the conducted experiments, including the setup, calibration, acquisition, and verification of our algorithms. The mean target registration error on nine data sets is 3.9 mm. Thus, the additional information about intranodal architecture and fulfillment of malignancy criteria derived from a high-resolution ultrasonography of lymph nodes can be localized and
visualized in the CT scan coordinate space and is made available for further radiation treatment planning.

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