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Dissertations-Kurzfassung

Performance of an atlas-based autosegmentation software for delineation of target volumes and organs-at-risk for radiotherapy of breast, anorectal and prostate cancer

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The purpose of this thesis was the validation of an atlas-based autosegmentation software for contouring clinically relevant target volumes and organs-at-risk for radiotherapy treatment of breast, anorectal and prostate cancer.

ABAS™ (Elekta CMS Software, St.Louis) is based on the principle that an atlas with defined clinical target volumes (CTV) and organs-at-risk (OAR) serves as a template case to automatically delineate target volumes in other patient CT datasets. For breast cancer, three atlases were generated, for anal cancer four and for prostate cancer a total of 7 atlases, each representing a typical anatomical situation. Atlases were then applied in various permutations to 9 (breast), 12 (anal) and 14 (prostate) patient datasets. Automatic delineation results were compared with structures contoured manually based on the Radio Therapy Oncology Group (RTOG) suggestions for breast, anorectal and prostate cancer. In contrast to other recent studies, atlases and manually created structures were all contoured by the same individual following the same guidelines to exclude inter-observer variations and therefore more precisely quantify the actual performance of the algorithm.

Different target paradigms were studied for the three tumor entities and the impact of using specific atlases matched to the individual patient geometry was evaluated for the first time to our knowledge. In addition, this thesis introduced and validated STAPLE (Simultaneous Truth and Performance Level Evaluation), a novel algorithm of ABAS™, which was designed to improve the delineation outcome.

Dice Similarity Index (DSC), Logit Dice transformation (logit(DSC)) and Percent Overlap (PO) were the selected means of quantification for analysis of results. Dice Similarity Indices > 0.700 and logit(DSC) > 0.847 are considered to be acceptable values when clinical application of autocontouring is considered.

ABAS™ produced the best outcome for CTV and OAR for the breast cancer paradigm, followed by results for the large pelvic component (CTVA) of anorectal targets and finally prostate cancer targets. Delineation of the inguinal lymphatic drainage (CTVB/C) and OAR (Bladder) of the anorectal cancer paradigm was insufficient. Similarly overall results of CTV and OAR (Rectum, Bladder, Penile Bulb) of the prostate cancer paradigm did not meet the required threshold values. DSC for breast CTV were between 0.86 and 0.91 (possible range [0,1]) with a logit(DSC) between 1.82 and 2.36 (possible range [-∞,∞]) and a PO between 75.50% and 82.89%. DSC for CTVA of anorectal cancer was between 0.79 and 0.85, logit(DSC) between 1.40 and 1.77 and PO between 68% and 73.67%. DSC for CTV of prostate cancer ranged from 0.54 to 0.8; log(DSC) were as low as 0.18 with a maximum of 1.42 and PO were between 37.75% and 67.18%.

The results of this thesis provide the basis for stepwise clinical implementation of automatic contouring into the clinical routine, further streamlining radiotherapy workflow and reducing contouring variability. It therefore has the potential to both improve treatment quality and make complex treatments available to more patients. ABAS™ produced satisfactory results for the large clinical target volumes under study that are less clearly defined by tissue interfaces than for example head and neck targets. STAPLE improved contouring outcome for the breast and anorectal cancer paradigm. Small target volumes not clearly defined are yet to be delineated manually. Based on these results, ABAS™ has been clinically introduced for precontouring of CTVs and OARs in breast cancer and CTVA in anorectal radiotherapy treatment. Further developments are necessary before clinical implementation for prostate cancer can be integrated into the clinical workflow.