OD26 - Inverse consistency error as a validation metric for deformable image registration: preliminary implementation research

However, the sensitivity to deep morphological modifications is still under study and more data are needed to be conclusive. Moreover, a more refined 3D data analysis is ongoing to fully exploit the available information. The clinical trial will end in 2021 and other 10 patients will be monitored starting from the next summer.
Keywords: particle therapy, inter-fractional monitoring, DP

OD25

Analysis of the plan complexity produced by a knowledge-based planning system for head and neck cancer

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Purpose: Knowledge-based planning (KBP) techniques aim to reduce variations in plan quality among operators and among centers. KBP extracts data from a library of different patient plans to train and produce a model that can predict achievable dose-volume histograms (DVHs) for new patients. Is generally reported that those models can produce generally better plans respect to the manual ones, at the cost of an increased plan complexity. In this work we present the results for a Head and Neck (HN) model.
Materials and Method: A commercial KBP solution (RapidPlan, Varian) has been used to train a general purpose Head and Neck model. We used a total of 194 plans to train the model, and a total of 60 plans to validate it. The model was validated through a closed- and open-loop process [1,2]. For the planning of the RapidPlan plans (RP) no manual intervention was made. Each RP has been compared to the clinical manual plans (MP). To simplify the overall scoring of plans and to limit the subjectivity of judgment, the Plan Quality Metric (PQM) was adopted as a global measure of quality [1,2]. For each VMAT plan we computed a number of complexity metrics related to the degree of modulation and the plan deliverability, a complete list of which has been reviewed in literature [3,4]. A total of 120 plans has been evaluated in terms of plan quality and complexity. A Wilcoxon paired test has been use to check differences.
Results: RapidPlan plans outperforms manual planning in terms of PQM (p=0.002). In terms of plan complexity, the results for some parameters is reported with his own p-value: Modulation Complexity Score (MCS) (p = 0.841) and its adaptation to VMAT (VMCS) (p = 0.009); the equivalent square field (EFS) (p = 0.912); the total monitor units normalized to the prescription dose in cGy (MU/cGy) (p = 0.881); the total modulation index (MI_t) (p = 0.062).
Conclusions: The assistance of RapidPlan during the optimization of Head and Neck cancer treatments induces a significant increase of plan quality without a contextual increment of plan complexity. In this work we show that RapidPlan has proven to be a valuable tool for producing high quality RP (at the same level or better than MP), ensuring an acceptable level of complexity of the plan, ensuring a better quality of the treatments delivered.

References:
[1] doi: 10.1016/j.ejmp.2018.08.016
[2] doi: 10.1002/mp.12896
[3] doi: 10.1016/j.phro.2018.02.002
[4] doi: 10.1002/acm2.12908
Keywords: Knowledge-Based Planning, Automatic planning, Plan Complexity, Plan Quality, Head and Neck

OD26

Inverse consistency error as a validation metric for deformable image registration: preliminary implementation research

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Purpose: The aim of this work is to develop a novel automatic voxel-based quantitative measurement approach to evaluate the registration accuracy of a Deformable Image Registration (DIR) algorithm in clinical practice. As the Inverse Consistency Error (ICE) can be computed directly from the deformation vector field (DVF) generated by the Treatment Planning System (TPS), it appears to be a valid surrogate of standard quality assurance metrics to assess the spatial error in the registration process.
Material and Methods: The ground truth scenario was provided by digital phantoms, based on real Head-Neck patient data, with known and clinical relevant DVFs produced by ImSimQA. They were then imported and registered in RayStation's TPS obtaining DIR DVFs. All generated DVFs were exported and they were made comparable by rescaling the deformation grids and the intensity values. The ground truth spatial registration error (GTE) was computed by composing the backward RayStation DVF with the forward ImSimQA DVF, whereas the ICE of the DIR was estimated by composing the backward and the forward RayStation DVFs. The ICE was also compared within regions of interest (ROIs) with widely used metrics like Conformity Index (CI) and Mean Distance to Conformity (MDC).
Results: Both ICE and GTE maximum values were below the tolerance limit of 3 mm corresponding to sub-voxel accuracy. In particular, for the three deformation levels, the maximum ICE within the body area resulted 1.16 mm, 2.27 mm and 2.39 mm, respectively, whereas the maximum GTE was 1.48 mm, 2.16 mm and 2.68 mm.ICE was slightly a dependent from the magnitude of the applied DFV. Correlation has been evaluated with MDC and CI for each ROI: strong correlation of 0.89 between MDC and mean value ICE has been found, as well between CI and mean value of ICE (0.80).
Conclusions: The results show that in presence of clinically consistent spatial distortions ICE is consistent with GTE. Both errors grow as the deformation increases with similar magnitudes, indicating good agreement between the two metrics. Furthermore, ICE was shown to be correlated with well-known and used metrics for the validation of DIR performances. Future developments will focus on validating the robustness of the metric through the analysis of a larger and different clinical dataset.
Keywords: deformable image registration, inverse consistency error, quality assurance, deformation vector field, radiotherapy

OD27

The investigation of RBE-weighted dose and LETd distribution for skull base patients in proton therapy and correlation with observed necrosis regions

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