Clinical use-based evaluation of SmartFuse: an AI-powered registration software by TheraPanacea

Purpose: Image registration plays a central role in treatment planning and delivery. The goal of this study is to evaluate the accuracy of a rigid and a spline based free-form deformation registration tool offered by TheraPanacea.

Methods and materials: Validation of registration software systems remains a challenge due to the lack of standard mathematical formalism to perform real-world evaluations where noise, distortion, and complex anatomical variations can occur. In [1], different evaluation methods and criteria were suggested depending on the clinical use of the registration. Following these guidelines, in this study we evaluate the usability of SmartFuse for each of the major fusion clinical uses cases in the radiotherapy workflow related to replanning, contouring assistance, electron density transfer and 4D-CT: a) replanning in case of MRgRT(MR-MR), b) CT-based replanning (CT-CT), c) planning on MR with CT as a secondary image (CT-MR), d) planning on CT with MR as a secondary image (MR-CT), and e) planning on 4D-CT. For each clinical case, a mix of abdominal, pelvic, H&N, brain, and thoracic patient images (n=36 per case) were evaluated.

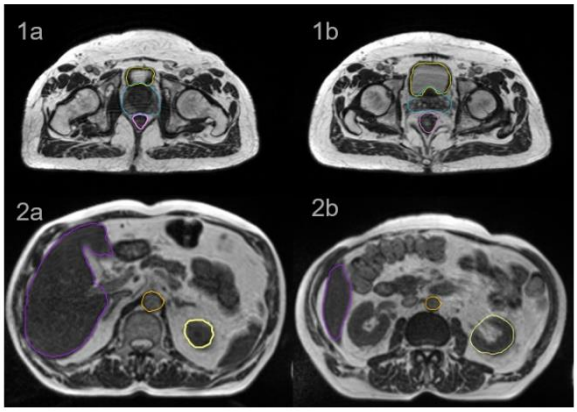

Fig. 1- Example of contour propagation after deformable registration from planning (1b/2b) to the daily MR images (1a/2a) for prostate (top) and abdominal cases for MRgRT. Organs like the PTV (blue), kidney (yellow) and aorta (orange) were used to assess the quality of the propagated contours.

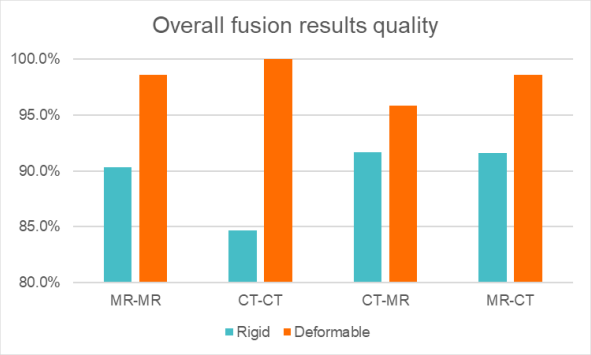

Fig. 2- Qualitative assessment of rigid/deformable registration per clinical case, with the deformable outperforming the rigid registration for all cases. For the case of 4D-CT, 91.7% of the fusion results exceeded/met the evaluator's expectations.

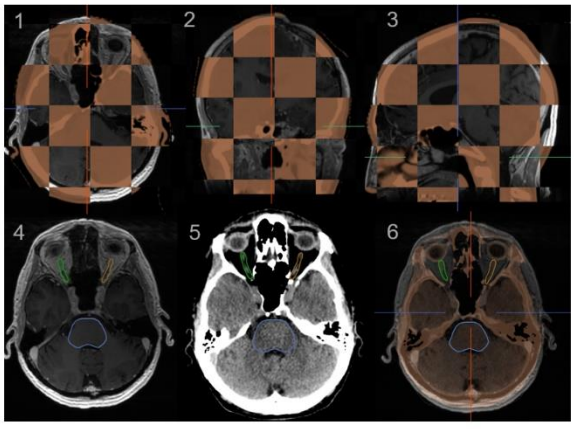

Fig. 3- Qualitative assessment of rigid registration between an MR (4) and a CT (5) image for a brain case. The overlap using the checker-board function are shown in the axial (1), coronal (2) and sagittal (3) views. Landmarks like the nose, optical nerves (green and orange) and brainstem (blue) shown good overlap of the images, especially when superimposed.

DSCs were computed between the registered contours of the source and the target images for both types of fusion. In addition, external medical experts visually evaluated the quality of fused images and propagated contours through a scoring system with a) contour is acceptable for clinical use without any modification/fusion results exceed expectation, b) contour would be acceptable for clinical use after minor modifications/fusion results meet expectation, c) contour requires major modifications/fusion results do not meet expectation.

Results: The average mean DSC for the cases where contour propagation is needed for replanning purposes was 0.74 and 0.89 for rigid and deformable registration, respectively. Example of cases of MR-Linac for both the pelvic (T2) and abdominal areas (TrueFisp) are shown in Fig.1. For the cases where no propagation of the contours is needed, following the guidelines outlined in [1], Fig.2 presents the qualitative evaluation results. In Fig.3, an example of a fusion between MR and CT brain images after rigid registration is shown. Qualitative evaluation of the fusion results led to a global acceptance of 90% for the rigid and 98% for the deformable registration, respectively.

Conclusion: The accuracy and performance of the registration algorithm for both deformable and rigid registration suggests its utility for the different clinical purposes outlined in [1] including the integration into an adaptive radiotherapy protocol of MRgRT.

References:

[1] Brock KK, Mutic S, McNutt TR, Li H, Kessler ML. Use of image registration and fusion algorithms and techniques in radiotherapy: report of the AAPM Radiation Therapy Committee Task Group No. 132. Med Phys. 2017; 44:e43–e76

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