Motion mask segmentation with deep learning approaches

Ludmilla Penarrubia, N. Pinon, E. Roux, D. Sarrut, M. Orkisz,
CREATIS (CNRS UMR-5220 & INSERM U1206), Université Claude Bernard Lyon 1,
INSA Lyon, Villeurbanne, France
ludmilla.penarrubia@creatis.insa-lyon.fr

The segmentation of the regions where lungs and viscera motion occurs in different respiratory phases of CT images (a.k.a motion mask segmentation) helps for registration between those lung thoracic CTs (Vandemeulebroucke et al., 2012). For instance this registration step is useful in radiotherapy planning or local pulmonary ventilation calculation, because it allows to describe the discontinuity of motion altering the registration implementation. However, the motion mask may fail in cases where occlusions are visible due to the patient pathology. To quantify the success rate of the current reference method (Vandemeulebroucke et al., 2012), two experts evaluated the motion mask segmentation obtained by this method on a lung NSCLC cancer database (4DCT of 42 patients). The consensus of the two expert yields a success rate of only 53 %. To address this lack of robustness, we propose a novel approach based on the majority vote of three 2D UNet (Ronneberger et al., 2015), each trained with one specific slicing direction of the CT images – axial, coronal or sagittal. We also exploited the annotations of the two experts to rigorously define the dataset splits used for training, evaluation and testing within a 9-fold cross-validation training strategy. This first approach outperformed the reference in terms of quality and robustness. Additionally, we propose a new method based on the three 2D UNets trained in the first strategy (each one producing a 3D motion mask segmentation) in order to fine tune their predictions with a 3D loss. Both deep learning based approaches provide strongly improved results in terms of performance and in terms of computation ressources and time, considering they are 3D based, for the task of segmenting the motion masks in thoracic CT images. Our perspective is to make the proposed approach more robust and compatible with other datasets (Covid-19 patients for instance).