Session title

Track **Abstract submission: Physics**

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Abstract title **Statistical motion masks to identify sliding surfaces for motion models used on an MR-Linac**

B. Eiben[1], E.H. Tran[1], M.J. Menten[2], A. Wetscherek[2], D.J. Hawkes[1], U. Oelfke[2], J.R. McClelland[1].
[1]University College London, Medical Physics and Biomedical Engineering, London, United Kingdom.
[2]The Institute of Cancer Research and The Royal Marsden NHS Foundation Trust, Joint Department of Physics, London, United Kingdom.

Purpose or Objective

Respiratory motion is a challenge for precise radiotherapy delivery for lung cancer patients. MR-Linac technology facilitates real-time monitoring of lung tumour motion using 2D cine MR-acquisitions. However, motion of the full 3D patient anatomy including the tumour and organs at risk remains, due to relatively slow 3D MR acquisition and reconstruction techniques, an unsolved problem. In this regard motion models are a promising tool to estimate the full 3D motion of the patient during treatment based on a surrogate signal. Building such models requires motion measurements obtained from image registration. However, respiration causes the lung and more inferior structures, such as the liver to slide along the pleural wall. Sliding is challenging for registration methods which usually regularise motion estimates to be smooth. Hence, in order to efficiently deal with this type of motion, sliding surfaces need to be identified. We present a method that first builds a statistical shape model (SSM) from motion masks, which include the lung and inferior sliding structures, based on 4DCT images. Those shape models can then be fit to a variety of image modalities - including MRI - and different resolutions to delineate sliding surfaces.

Material and Methods

Mid-position images were created by group-wise image registration for 32 lung 4DCT image sets. From each mid-position image a motion mask was calculated which includes organs enclosed by the sliding surface such as the lungs, mediastinum, diaphragm, and liver (see Figure 1). In order to measure the inter-patient variation of the motion masks, these masks need to be aligned. This was done by group-wise registration of the mid-position images and then applying the transformations to each corresponding mask. A population average mask was created and then transformed into a mesh representation. An SSM was built from the average mesh and transformed back to each individual mid-position image where the intensity gradients along the mesh normals were calculated for each node. The gradient information is then used to fit the model to an unseen image.

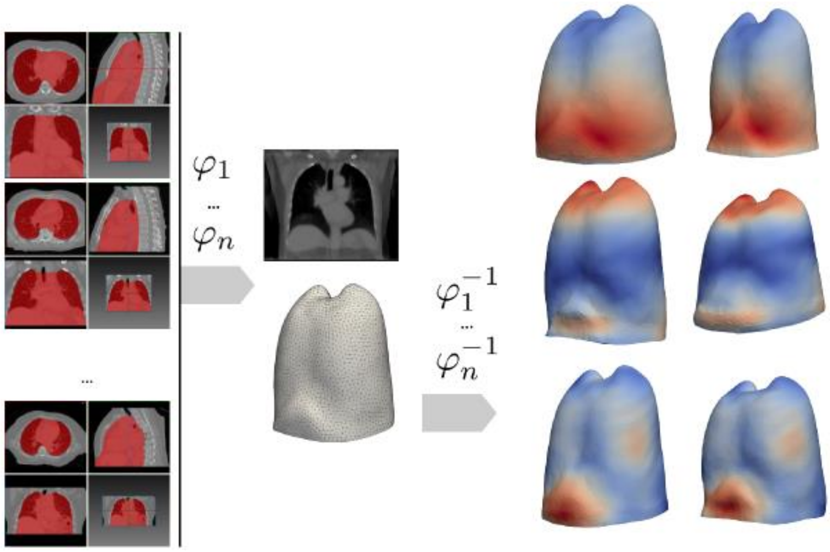

Figure 1: Building a statistical shape model (SSM) from mid-position 4DCT images: First a group-wise registration is performed on the images to obtain a population average image. The transformations are then applied to the CT-based motion masks to create an average mesh representation. The average mesh is combined with the corresponding deformations into an SSM. The first three modes of variation of the SSM are shown on the right.

Results

The performance of the algorithm was evaluated quantitatively using a leave-one-out strategy on the 32 4DCT images. The statistical motion mask with ten modes of variation was fit to the left-out image and then compared to its original mask. The mean Dice coefficient and mean contour distance were calculated as 0.96±0.03 and 3.8±2.8mm, respectively. Furthermore, the algorithm was applied to the first level of a multi-resolution, motion-model based image reconstruction from MR images. The visual assessment shows good positioning of the mask in the low resolution image. For an example of the leave-one-out fitting to a CT dataset and the low-resolution MR image see Figure 2.

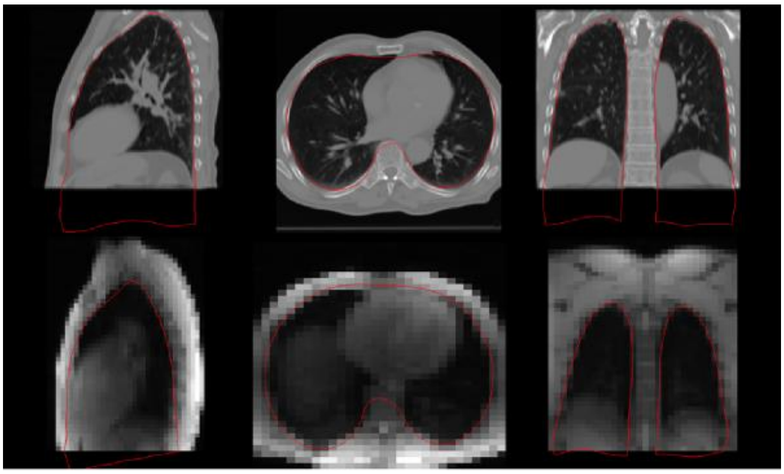

Figure 2: Motion model fitting results. Leave-one-out result (top) and motion-model-based MR image reconstruction (initial, coarsest resolution, bottom). The motion maks (red) delineates the sliding surface.

Conclusion

The method presented here allows good and robust delineation of sliding surfaces in CT and low-resolution MR images and has potential application in registration and motion modelling of images showing breathing motion.

I have no potential conflict of interest to disclose

Keyword **(Deformable) image registration**