Physiologically Motivated Image Registration

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Conventional image registration techniques deform the entire image using homogeneous regularization without taking into consideration the physical properties of the various anatomical structures. This homogeneous regularization leads to biologically and physically implausible deformations. To register the EMPIRE challenge lung images, we developed a 3D registration framework based on a fluid transformation model including three physically motivated properties: (i) sliding motion of the lungs against the pleura; (ii) preservation of rigid structures; and (iii) preservation of topology. The sliding motion is modeled using a direction dependent regularization that decouples the tangential and the normal components of the external force term. The sliding boundary conditions are set to 6mm inside and outside the lung boundary, i.e., a total width of 12mm. The lung segmentations are used to calculate the distance maps to enforce the sliding motion at the lung boundaries. The rigid shape of the bones is preserved using a spatially varying filter for the deformations. The spatially varying filter proposed by Staring et. al. [2] is used for this purpose. The filter preserves the local linearity of the deformations. Finally, the topology is maintained using the concept of log-unbiased deformations based on the work of Yanovsky et. al [2]. The method uses statistical distribution of the Jacobian maps in the logarithmic space to produce unbiased transformations.

An initial rigid alignment of the image pairs is achieved using SSD and the code was implemented using ITK. The code has been implemented on a Windows workstation of Intel Xeon CPU AT 2.4 GHz with 12 GB main memory. Non-rigid alignment is achieved using local cross correlation as a similarity measure for the classic fluid method as well as for the proposed method. We have used varying values of Lamé parameters for the different image pairs depending on the magnitude of the deformations. Generally a lower value of Lamé parameter is selected to recover larger deformations and higher values of are used to get improved stability

for smaller deformations. Selecting the Lame parameters makes the process semi-automatic. The algorithm is semiautomatic.

References

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