Spatial Correspondence between Graph Neural Network-Segmented Image

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INTRODUCTION

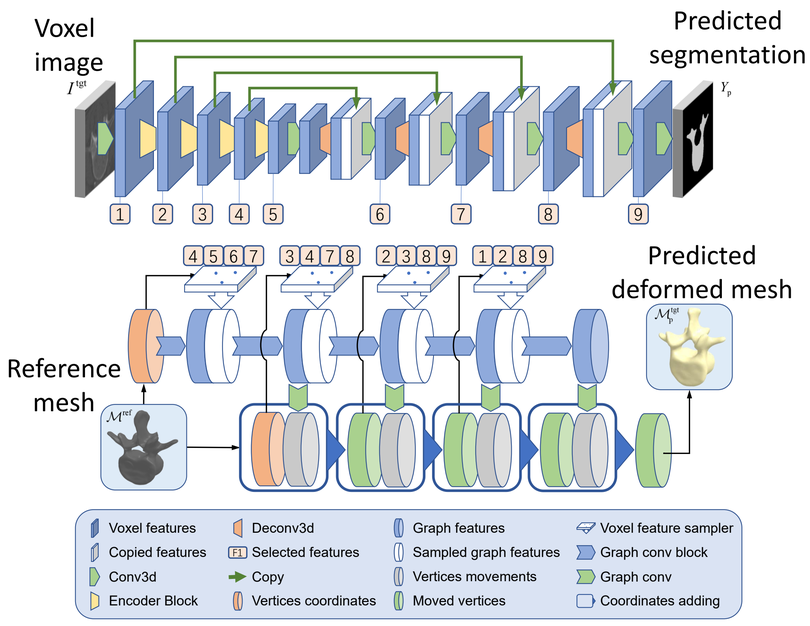
Some recently proposed graph neural networks were trained to deform the predefined template meshes iteratively to fit the object surface in the input image to achieve mesh reconstruction. We observed that the correspondence, defined by the same vertices before and after mesh deformation, pertains anatomically corresponding locations, but was understandably discarded for segmentation tasks. This correspondence is used to register the input image with the predefined template and further register the input image pairs. To demonstrate the application of the proposed registration strategy, we take annotating spinal vertebrae from CT images as an example. Atlas registration can be considered a suitable method in the absence of a sufficient number of labeled data sets. It also has the potential to transfer the planned surgical trajectories from the atlas to new images.

The contributions of this paper can be summarized as follows.

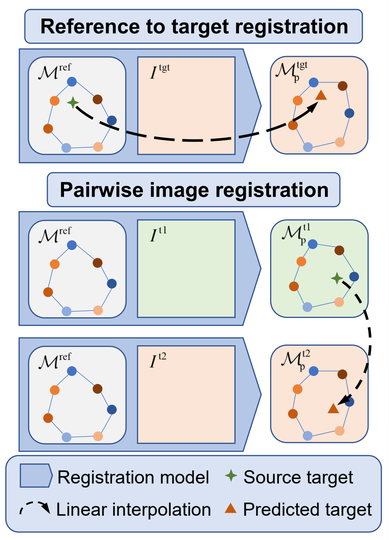
- A previous segmentation network was reused for image registration tasks.
- Based on predefined reference meshes, strategies for a reference to target registration and a general pairwise image registration are proposed.
- The proposed method achieves significantly better performance on both target point localization and atlas segmentation tasks, compared with the tested classical non-learning and other learning-based registration algorithms.

METHODS

The proposed network consists of CNN and GNN modules. The CNN module ingests the input image and predicts a segmentation mask. The GNN module takes the reference mesh as input and performs graph convolution with vertex features extracted from the CNN module to adjust vertex coordinates progressively. This method aims to register a set of predefined surface points in the reference image with those in the target image.

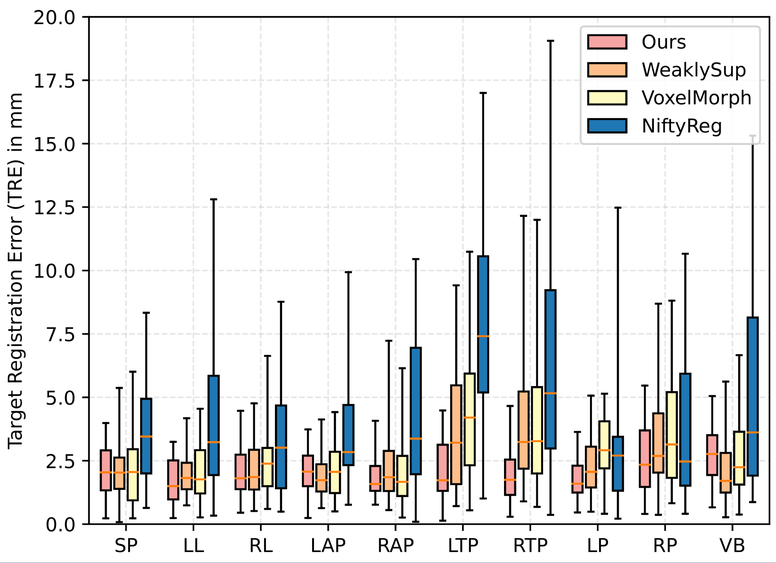


A smoothed surface mesh from the training data sets is used as the reference mesh. The registration task is to predict the displacements for each vertex in the reference mesh. Therefore, a series of corresponding points from the reference image to the target image are generated through the proposed registration method. For a new target point the registered corresponding point for it can be obtained by using the piecewise linear interpolator. More generally, the pairwise registration method registers the set of predefined surface points from one image to a second image. The relative vertex displacement between the two images can be obtained by the difference between the displacements from the reference mesh to the input images.

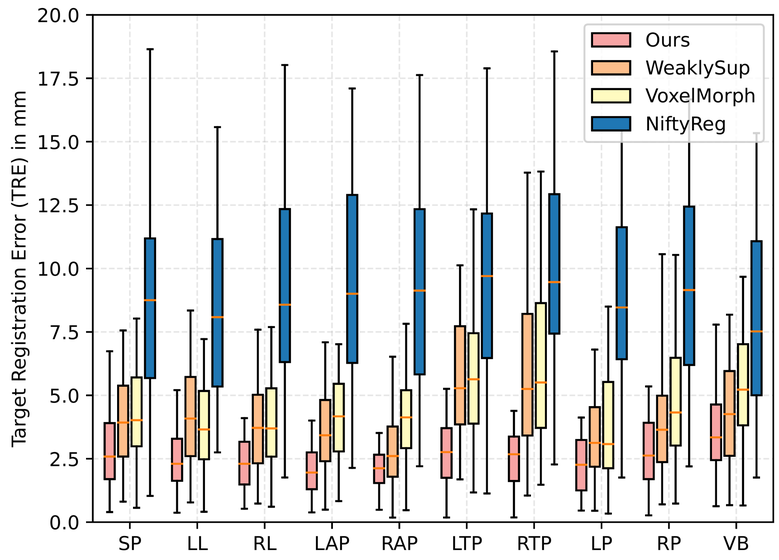


RESULTS

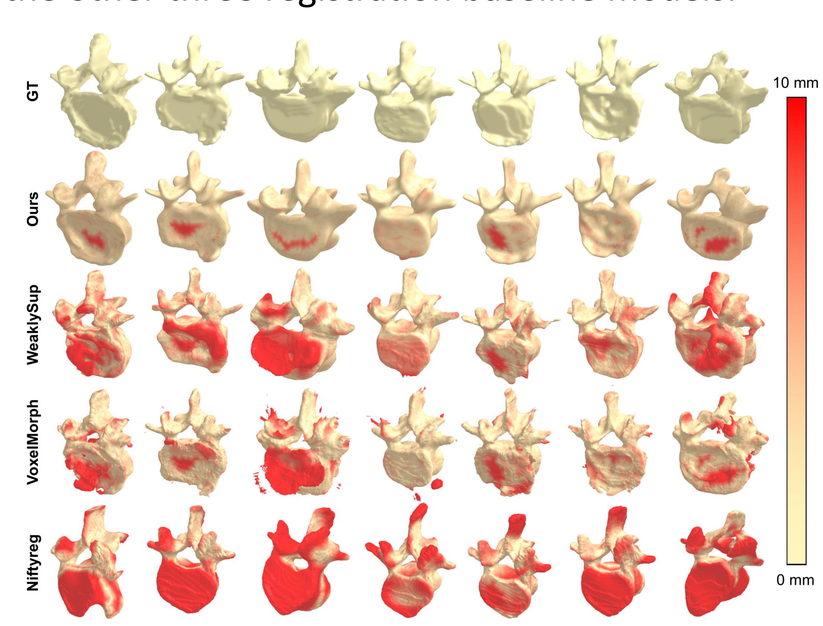
In the task of registration between images and a fixed reference mesh, the proposed algorithm is compared with three registration baselines. The results show that the proposed method can achieve the best registration results.



In the arbitrary image pair registration via reference task, the proposed method has a clear advantage with an average of 2.68mm.



Through this atlas registration, the relationship between the newly input image and the reference image can be established. Using the segmentation result of the reference image, the segmentation result corresponding to the input vertebral block image can be obtained. The figure below compares the segmentation results and segmentation true value of the proposed registration method with the other three registration baseline models.



Further sub-region segmentation on the reference image can also further obtain the sub-region segmentation result of the new input image. This is expected to further be used for rapid surgery planning, etc.