3D Volume Estimation from X-Ray Images Using Implicit Neural Representation

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1. Project Purpose

Reconstruction of 3D Structures from few x-ray images is a non-trivial task. A common technique used in orthopedic procedures involve intra-operative fluoroscopy, that is taking the x-ray images of the target during the operation and assessing the progress. This requires thinking and localizing in 3D mentally from the x-ray images. Our aim is to relax the mental burden on surgeons posed by ambiguous depth information in the image, through 3D reconstruction and registration of the image with a pre-operatively obtained 3D model from the CT scan. The initial plan was to incorporate implicit neural representations for generating the 3D structure however we find that learning such a representation of the same volume but with different orientation for each image is redundant and inefficient. Therefore, we opted for a scene coordinate based approach where a scene coordinate map containing 3D point locations of the surface points for each corresponding image pixel is regressed using a U-Net architecture. This allows for a partial point cloud reconstruction from the image as well as registration with a pre-obtained 3D model (Fig. 1).

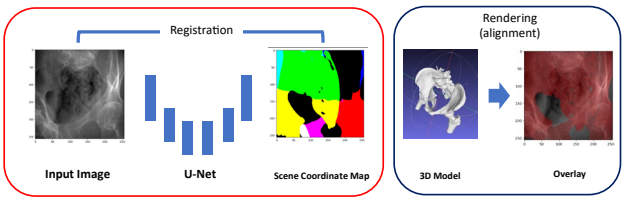

Fig. 1 Overview of our proposed method. Scene coordinate regression (red box) and registration (blue box).

2. Results

We evaluated the registration accuracy for the reconstructed scene coordinate maps. With a simulated dataset of 2700 DRR images which were taken in different orientations, The rotation error was 3.96 +/- 2.26 deg and translation error was 23.07 +/- 19.29 mm. Example overlays of 3D model aligned to the X-Ray are shown in Fig. 2. Since the registration result is close to the ground truth pose, intensity-based optimization method could be applied for further refinement.

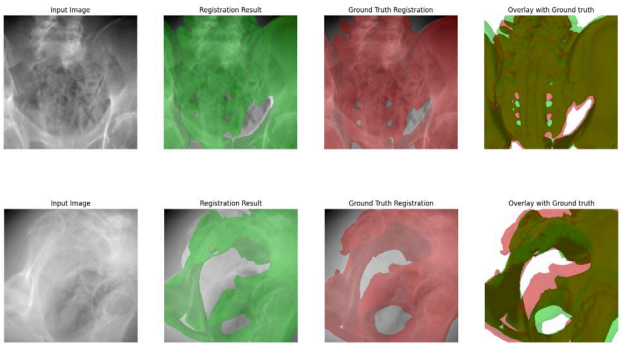

Fig. 2. Examples of registration results. Case with low aligned error (top) and high alignment error (bottom)

3. Roles of the MCRP and its significance

The computing resource is crucial in developing a deep learning system. MCRP provided the essential resource for training our proposed model. The main contribution however was during the generation of simulated x-ray images from the CT-scan data. It has been shown in previous researches that training a model on simulated images using domain randomization produces as good result as those trained on real x-ray images. The medical community usually has limited amount of data available for public use. Therefore, generating a simulated dataset is of great importance to the field and can be accelerated using resources from MCRP.

4. Future plan

As mentioned above, we would like to create and share a dataset for x-ray image reconstruction and registration tasks. Currently, there very few public datasets available in the community and those that are available contain few hundred images for each patient. To create a common benchmark dataset, we plan to generate realistic simulation images in the order of thousands for each patient anatomy and train large models for reconstruction as well as registration tasks.

5. Publications and conference presentations

Presentations

Pragyan Shrestha, Xie Chun, Hidehiko Shishido, Yuichi Yoshii, Itaru Kitahara, "X-Ray to CT Registration Using Scene Coordinate Regression Network", International Forums on Medical Imaging in Asia (IFMIA2023), 2 pages, (2023/1)

Supercomputer	Use	Allocated resources*	
		Initial resources	Additional resources
Cygnus	Yes	4050	0
Oakforest-PACS	No		
*in units of node-hour product			