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Transitioning to Fully-Supervised Pre-Training with Large-Scale Radiology ImageNet for Improved AI Transferability in Three-Dimensional Medical Segmentation

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Abstract:
***Purpose:** Fully-supervised pre-training has experienced long-standing success in the realm of computer vision, largely attributable to the extensive annotated ImageNet dataset. This research examined the transferability of medical AI fully supervised pre-trained on a similarly sized Radiology ImageNet.
***Methods and Materials:** We first constructed a large-scale dataset by assembling 3,410 publicly available abdominal CT scans with partially annotated 25 organs and 6 tumors. We then completed the missing annotations using an efficient human-in-the-loop approach, resulting in Radiology ImageNet. This dataset enabled us to pre-train an AI model using full supervision. Segmentation, partitioning an image into multiple segments, can be viewed as a per-voxel classification. Therefore, the per-voxel annotations in our Radiology ImageNet (2,109 million annotated voxels) provided an order of magnitude larger than the per-image annotations in ImageNet (14 million images). AI transferability was evaluated on three medical segmentation tasks, i.e., 19 cardiovascular structures, 22 muscles, and 18 organs, using two external datasets, i.e., TotalSegmentator and JHH, comprising 6,062 CT scans. Dice Similarity Coefficient (DSC) was used as the evaluation metric. For a comprehensive comparison, we benchmarked fully-supervised pre-training against three dominant AI models pre-trained on 5,050, 5,022, and 888 unlabeled CT scans, respectively.
***Results:** Fully-supervised pre-training demonstrated improved transfer learning performance compared to self-supervised counterparts, with increases from 86.5% to 90.9%, 89.9% to 94.4%, and 85.8% to 90.4% for the segmentation of cardiovascular structures, muscles, and organs in CT scans, respectively, using the TotalSegmentator dataset. As the annotated CT scans became more limited, fully-supervised pre-training achieved substantially better performance than self-supervised pre-training, with improvements of 17.5%, 12.1%, and 16.6% for 5-shot, 10-shot, and 20-shot transfer learning in the JHH dataset.
***Conclusions:** We created Radiology ImageNet and demonstrated its importance in the field of medical image analysis. Pre-training medical AI on this dataset led to an improved transferability for segmenting various anatomical structures in the human body. Our investigation suggested that fully-supervised pre-training mitigated the marked difference between self-supervised and segmentation tasks. This highlighted the potential of fully supervised pre-training to advance precision medicine.
***Clinical Relevance/Application:** Medical AI, pre-trained on our Radiology ImageNet, excelled in the segmentation of anatomical structures, executing its vast potential in robotic surgery and treatment planning.

Category (Complete): Imaging Informatics -> INMLIB - AI and Machine Learning: Image-based
Format Preference (Complete): Oral Paper
Questions (Complete):
Trainee Research Prize: Not Applicable
Disclosure of "Off-Label" usage: No, I do not intend to discuss off-label uses
IRB / IACUC Response: Not applicable/None of the above (explain)
If needed, please explain: : Public datasets were used.
Has this work been previously presented or published?: No
2nd Format Opportunity: Yes, I would be interested if accepted to showcase my work in an additional format (2 meter Hardcopy Backboard).

Attached Files: Fully-supervised pre-training using a large-scale Radiology ImageNet outperforms existing self-supervised pre-trained models in 3D medical segmentation tasks. (PDF, 304739 bytes)

Status: Complete