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AbdomenAtlas-8K: Human-in-the-Loop Annotating Eight Anatomical Structures for 8,448 Three-Dimensional Computed Tomography Volumes in Three Weeks

Author Block: Chongyu Qu; Tiezheng Zhang; Hualin Qiao; JIE LIU; Yucheng Tang; Alan Yuille; Zongwei Zhou, PhD

Abstract:
***Purpose:** Segmenting anatomical structures can facilitate precise robotic surgery, personalized treatment planning, and improved patient outcomes, but it is a highly cumbersome and time-intensive process. We seek to expedite this process using an efficient human-in-the-loop approach.
***Methods and Materials:** We first pre-trained an AI model on 14 publicly available datasets using the partial labels provided by each dataset. The model was then used to generate pseudo labels of 8,448 three-dimensional CT volumes for segmenting eight critical structures in the abdominal region, including the spleen, liver, kidneys, stomach, gallbladder, pancreas, aorta, and IVC. The quality of the pseudo labels was assessed by inconsistency, uncertainty, and overlapping measurements. The integration of these three measurements resulted in a list that prioritized the CT volumes and regions in the volume that required medical professionals to review and revise the pseudo labels. The revised labels were used to fine-tune the model. This process was repeated until the professionals confirmed that the highest-priority CT volumes on the list did not require further revision. From the human-in-the-loop approach, we summarized a taxonomy of common errors made by AI and medical professionals, which minimized the duplication in human revision and improved the efficiency of continuous refinement of AI models and organ annotations. A commercial software called Pair was used by the medical professional for revising the annotations. Finally, the professional confirmed the annotation of all the CT volumes by visual inspection.
***Results:** AbdomenAtlas-8K is a high-quality dataset consisting of 8,448 CT volumes with eight anatomical structures annotated in detail. 99% of the annotations were generated by AI algorithms and the remaining 1% by a medical professional. We demonstrated high sensitivity and precision (0.78 and 0.83, respectively) in detecting AI errors, highlighting the efficiency of human revisions.
***Conclusions:** Our human-in-the-loop approach can significantly reduce annotation effort while maintaining high-quality annotations. With this approach, we have annotated 8,448 CT scans within three weeks. The annotations were of superior quality, ensuring precision and dependability in segmenting critical abdominal structures.
***Clinical Relevance/Application:** AbdomenAtlas-8K will be made publicly available to advance medical research, providing doctors, researchers, patients, and students with a comprehensive understanding of human anatomy and facilitating early cancer detection. It will enable researchers to identify abnormalities associated with various diseases and provide insights into imaging characteristics of cancer, diabetes, and heart disease.

Category (Complete): Imaging Informatics -> INISDM - Image Sharing and Data Management
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: A. Attention map generation, which facilitates the localization of areas with the highest probability of prediction errors. B. Examples of AbdomenAtlas-8K labels. C. AbdomenAtlas-8K stands out from other datasets due to its annotated images and organs. (PDF, 871269 bytes)

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