Segment Anything Model & Medical Imaging

What role do image preprocessing and enhancement techniques play in improving the performance of segmentation models for pneumonia detection in chest x-rays?

Pneumonia, if untreated, can lead to serious complications and adverse health outcomes making early and accurate diagnosis a crucial part in effective treatment. Traditional health methods mainly rely on chest x-rays as their main source of identification. However, interpreting these images sometimes poses challenges due to a few reasons. Human error in diagnosis can lead to inconsistencies in readings or signs of pneumonia can overlap with other conditions like tuberculosis, further complicating the diagnosis process. Such complexities underline the need for an advanced diagnostic process.

While there are supplemental tools like biomarkers that are used to improve the diagnostic accuracy of pneumonia, accurately diagnosing pneumonia simply with radiographic evidence can be challenging and are oftentimes insufficient for a definitive diagnosis. During this research, we will aim to develop and evaluate an AI model based on the Segment Anything Model to segment and highlight pneumonia-affected regions in lung x-ray images. The Segment Anything Model (SAM) is an AI framework designed for high precision analysis. It works to highlight specific features or regions within images, making it highly effective in delineating abnormal areas in images. During our research, we will look at various techniques that can improve the performance of segmentation, ultimately seeking to provide additional support in providing a faster, more accurate, and automated approach to the clinical diagnosis of pneumonia.

Methodology/Timeline/Resources Needed:

As time will be one of our biggest constraints, the research project will be broken down into the following steps to ensure efficiency and effectiveness:

1. Information Gathering/Topic Familiarization
    - Participants will get to familiarize themselves with the necessary information
2. Planning
    - Discuss how project responsibilities will be distributed among participants and over the next few weeks
    - Determine key goals with time constraints and domain knowledge taken into consideration
3. Data Collection and Analysis
    - Since the main platform we will be using is Kaggle, participants will have the choice to find an existing dataset off Kaggle or upload their own dataset.
    - May have to annotate data
4. Model Implementation
    - Implement the SAM-based AI model for pneumonia detection

    - Recommended language: Python
        - Load/Initialize SAM model for Segmentation
        - Set up environments to train model
5. Model Training/Comparisons/Troubleshooting
    - Train the model on the dataset, monitor progress, and troubleshoot any technical issues
    - Try various enhancement techniques
    - Training portion will require a GPU. Kaggle provides free limited access to GPUs
    - Will most likely need a lab computer to train
    - GPUs come in handy when dealing with complex AI models, large datasets, matrix operations, etc. as they are highly efficient at performing parallel computations which can significantly reduce training times compared to CPUs
6. Results Analysis/Review
    - Evaluate the performance metrics of the AI model
    - Compare the different techniques used
    - Document findings, prepare conclusion, and look into future implementations
7. Presentation Prep
    - Prepare presentation summarizing research objectives, results, and conclusions
8. Present!!

Annotated Bibliographies:

Provided below are the annotated bibliographies of the 2 primary sources I used:

Segment Anything

Segment Anything Model for Medical Image Analysis: an Experimental Study

SAM & Medical Imaging: Annotated Bibliographies

Kirillov, Alexander, et al. “Segment Anything.” *arXiv.Org*, 5 Apr. 2023, arxiv.org/abs/2304.02643.

The paper by Meta AI, introduces the Segment Anything Model and discusses the main three components of their Segment Anything project: a task, a model, and a dataset. The task in this case is promptable segmentation which allows for zero shot transfer by using prompts to aid the segmentation process. The model, SAM, consists of an image encoder, prompt encoder, and lightweight mask decoder, enabling it to create segmentation masks in real time. The dataset the paper mentions, SA-1B, is the largest segmentation dataset containing over 1 billion masks from 11 million images. The paper highlights the key features of SAM particularly its ability to handle flexible prompts, generate valid masks even in ambiguous situations, its strong performance in various datasets in comparison to fully supervised methods, and its ability to perform segmentation tasks with minimal additional training.

Mazurowski, Maciej A., et al. “Segment Anything Model for Medical Image Analysis: An Experimental Study.” *arXiv.Org*, 17 May 2023, arxiv.org/abs/2304.10517.

This paper looks into SAM and investigates the potential of using the model for medical image segmentation. The study evaluates SAM on 19 medical imaging datasets, each with varying anatomies. Researchers found that SAM’s performance varied significantly across different datasets suggesting that the model did better for well-defined objects with clear prompts and poorer for more complex segmentation tasks. However, SAM’s overall performance in comparison to other segmentation methods like RITM, SimpleClick, and FocalClick were a lot better making its average performance across different datasets a 0.4595 IoU. The study also found that the model did best with box prompts, especially when a box was provided for each separate part of the object. Overall, the general consensus of their study was that SAM shows promising potential in the realm of medical imaging so long as effective prompting strategies are used for the dataset.