Precisely Determining Lung Infected Regions on COVID-19 CT Images Through Artificial Intelligence

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Introduction

- COVID-19 is a contagious disease affecting the world that was declared a pandemic by World Health Organization(WHO) in March 2020
- It is important to segment the CT lung images for diagnosis, determining the severity of the disease, as well as monitoring the disease progression in the lungs
- There have been several approaches proposed to use artificial intelligence (AI) to segment the infected region of the CT lung images
- However, the limitation of their work includes requiring a large amount of labeled training data to achieve competence performance
- There are currently very limited amount of publicly available labeled data in segmentation of the CT lung images affected by COVID-19

Methodology

- To solve problem of requiring lots of training data and motivated by how human brain works, we use self-supervised training on an existing AI, SInfNet
- Our hypothesis is that self-supervised training helps the SInfNet learn the better feature representation of the CT lung images
- The knowledge learned can be transferred to improve on segmentation of the infected region of the CT lung images
- SInfNet is the supervised InfNet we will improve on. Our method is SSInfNet. ”S” refers to supervised and “SS” refers to self-supervised
- To learn the structure of the CT lung images, we will damage the CT lung images and train the AI to predict the actual CT lung images

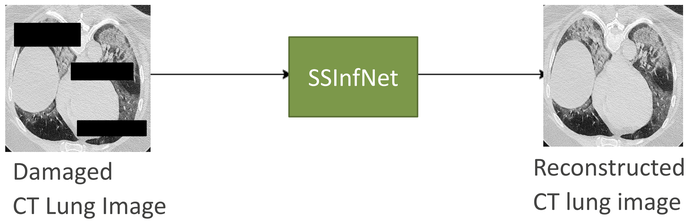

Fig 1: Reconstructing damaged CT lung image with SSInfNet

Data split	Source	Segmented	Images	Patients
Training	Med-Seg	Yes	698	39
	ICTCF	No	6654	1338
Validation	Med-Seg	Yes	114	35
Testing	Med-Seg	Yes	117	35

Table 1: The table shows the distribution between the datasets that we used as evaluation. Med-Seg contains segmented infected region of COVID-19 infected CT lung images.

- We have to carefully damage part of the CT lung images. If the damage is too complex, it will be hard for SSInfNet to learn the structure of the CT lung images. If the damage is too simple, SSInfNet will not learn good structure of CT lung images
- We create another AI, coach AI, that generates the damage for the CT lung images, less damage in the beginning, progressively more damage as the training continues

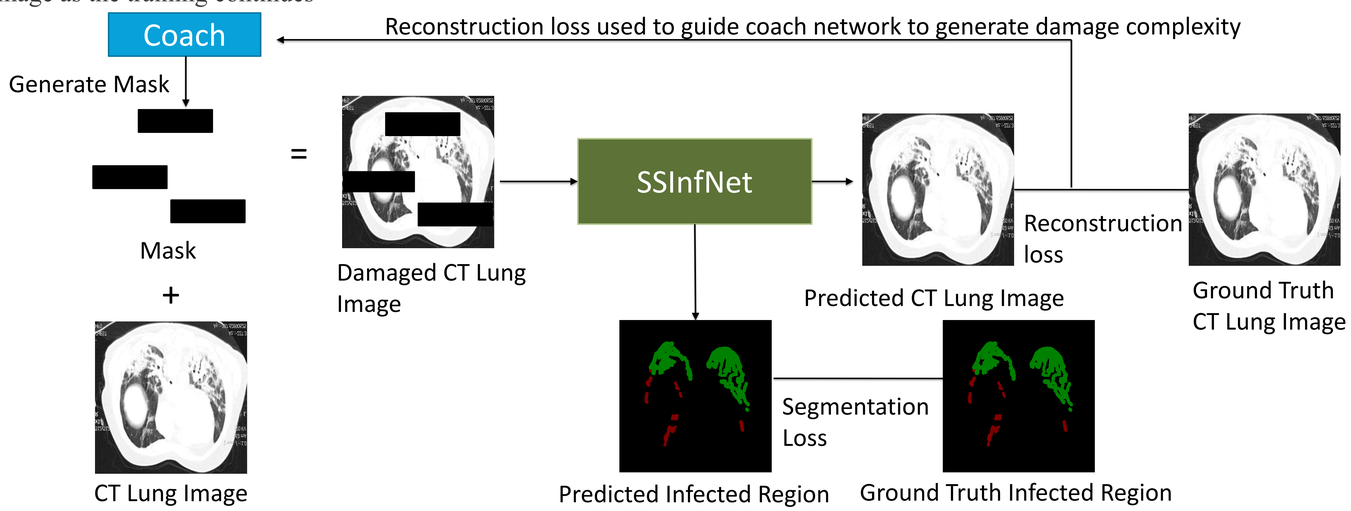

Fig 2: The architecture of SSInfNet. SSInfet receives a damaged CT lung image and learn to reconstruct the CT lung image. The coach AI receives the reconstruction loss and generate more complex mask if the reconstruction loss is low. Otherwise, the coach AI generates easier mask if reconstruction loss is high. Then, the knowledge learned from CT lung images reconstruction are transferred to learning to segment the infected region of the CT lung images.

Results

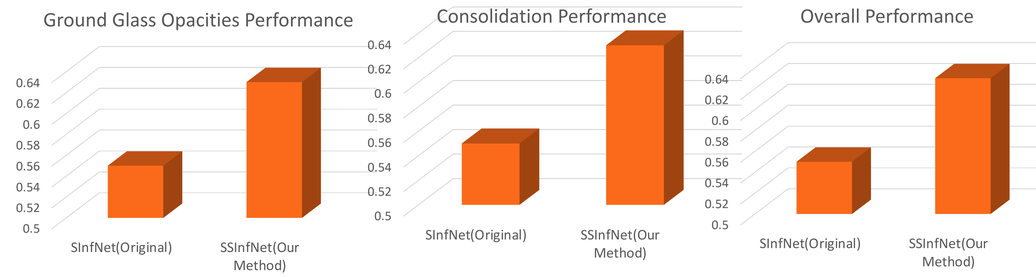

Figure 3: The chart shows F1 score being used to compare between SInfNet (Original) and SSInfNet (our method). Adding self-supervised learning improves in learning better structure and feature representations of the CT lung image. Both the performance of segmenting ground-glass opacities and consolidation improve.

- Ground-glass opacities are abnormal findings in CT lung images
- Consolidation is the region of the lungs that have been filled with liquid instead of air
- The improvement in the performance prevents overestimating the infected region so that patients will not receive unnecessary treatment that could negatively affect their health

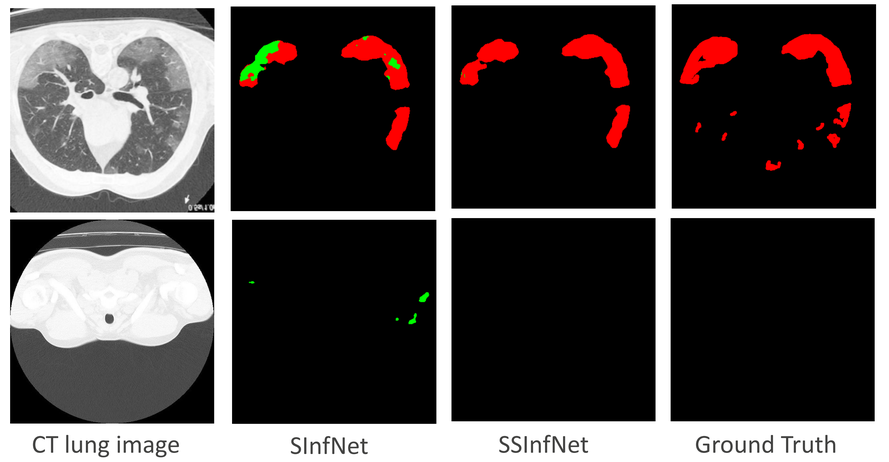

Figure 4: comparison of segmentation of infected region between SInfNet and SSInfNet. Red color is the ground-glass opacities and green color is the consolidation. SInfNet over-estimated the consolidation region in both the CT lung images when there are not suppose to have consolidation infected region.

Conclusion

- Adding self-supervised learning into SInfNet improves its performance in segmenting the infected region of the CT lung images
- SSInfNet learns the important features of the CT lung images and generalizes well during segmentation of the infected region
- The improvement in the performance can help prevent negatively assessing a patient containing irregular pattern in the lungs when the patient is healthy

Acknowledgement

- Dr. Ruppa Thulasiram
- W.S.Ning, S.J. Lei, J.J. Yang, et al. iCTCF: an integrative resource of chest computed tomography images and clinical features of patients with COVID-19 pneumonia, April 2020, PREPRINT (Version 1) available at Research Square. (Dataset)
- http://medicalsegmentation.com/covid19/ (Dataset)