Unsupervised Detection of Pulmonary Opacities for Computer-Aided Diagnosis of COVID-19 on CT Images

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Background

Diagnosis of COVID-19 on CT Images

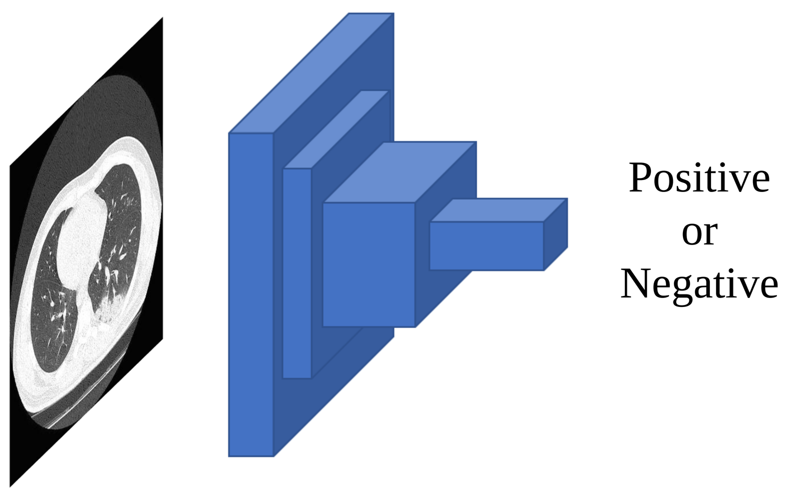

Figure 1: Existing deep learning based methods for COVID-19 diagnosis

- Existing methods tend to extract features from the entire CT images which limits their performances.
- Opacity-awared methods improve the capacity of COVID-19 diagnosis but require human annotation of pulmonary regions on CT images which costs too much time and human labors.

Anomaly Detection

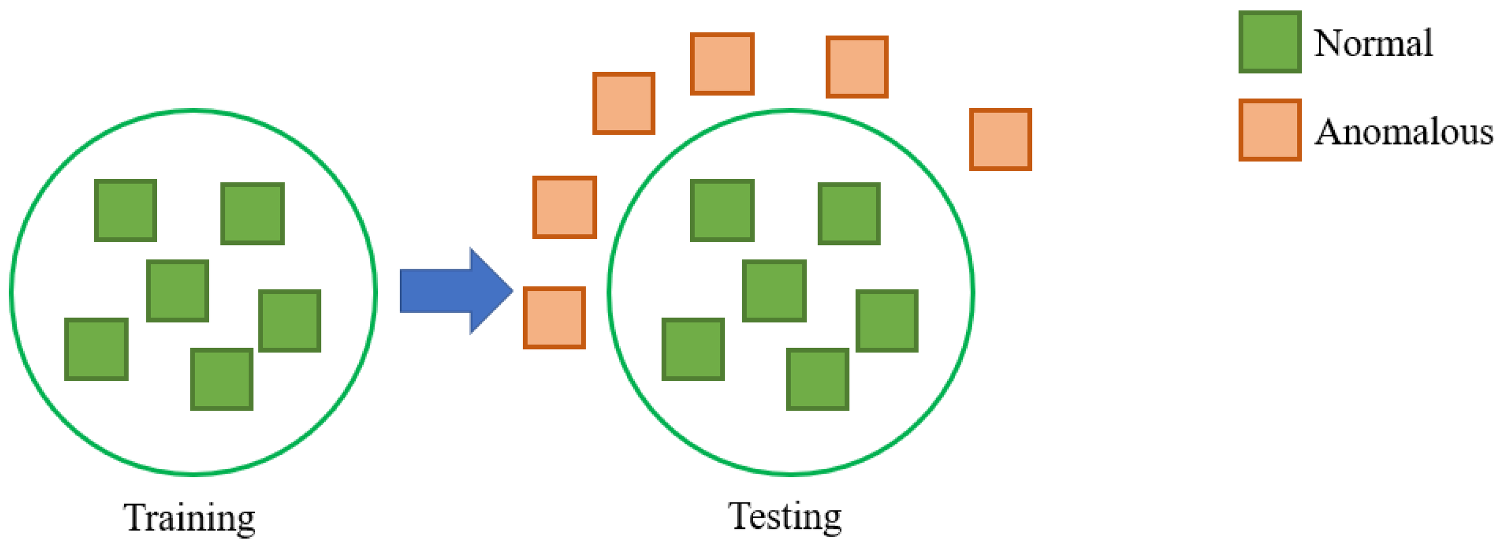

Figure 2: The procedure of anomaly detection

- Anomaly detection aims at identifying abnormal cases by training only on normal data which is suitable for locating regions of pulmonary opacities on CT images

Method

Proposed Method

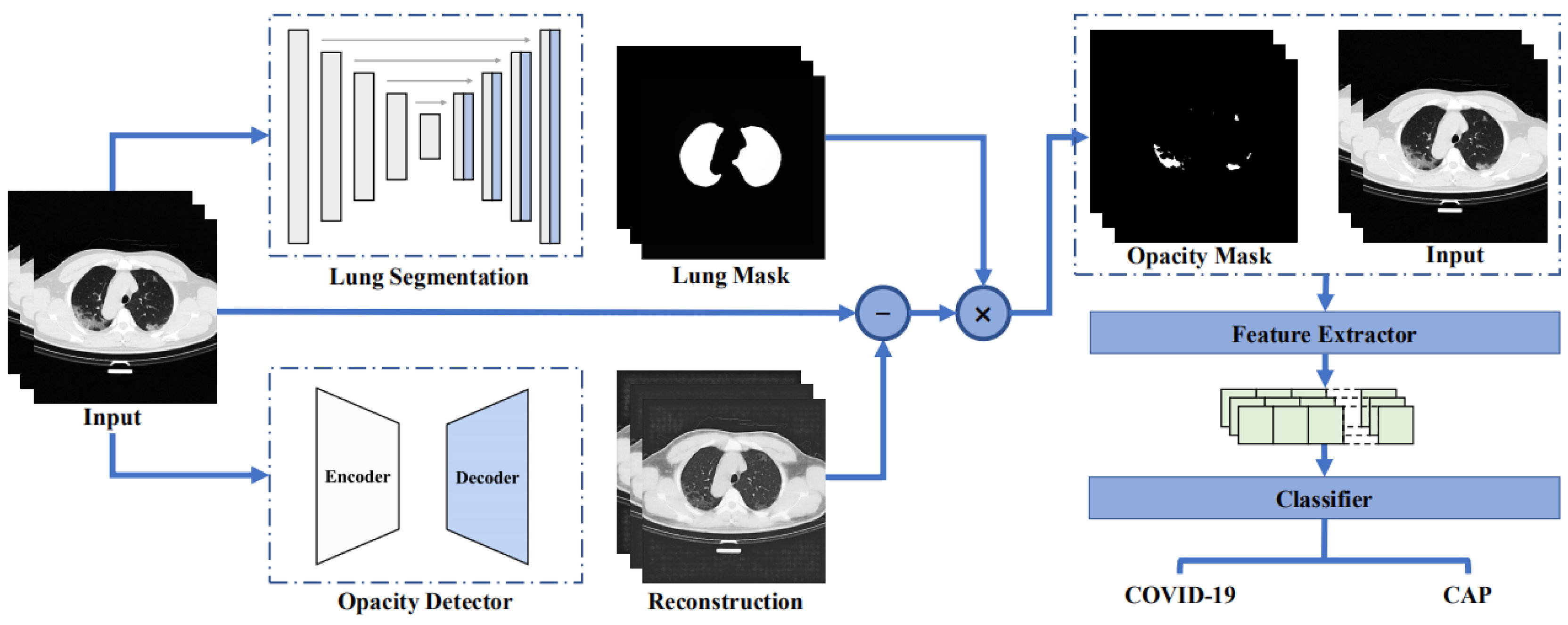

Figure 3: An overview of the proposed method.

1. The input CT slices are fed into lung segmentation model and opacity detector respectively.
2. The differences between the reconstructed images and original images are computed and multiplied by segmentation results.
3. After thresholding, binary masks generated from difference maps incorporate with original images are utilized for feature extraction and classification to get the final results.

Method

Opacity Detector

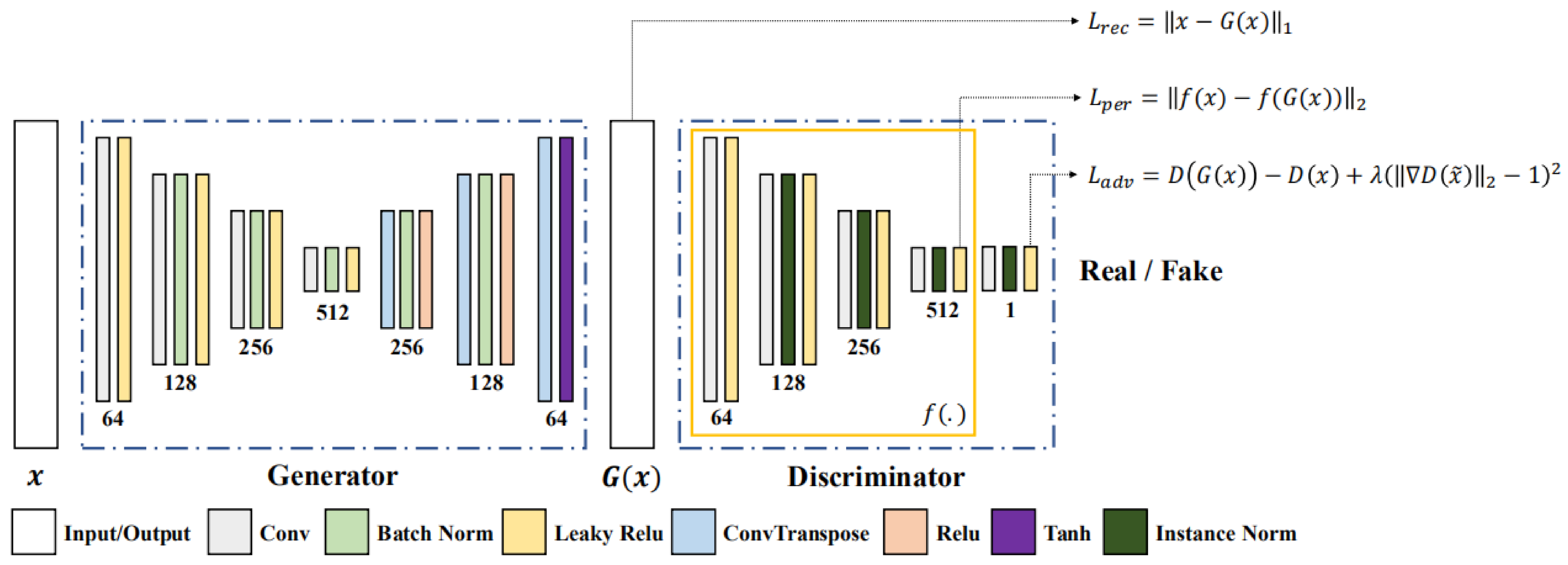

Figure 4: The architecture of the proposed opacity detection model.

- **Inference.**
  1. Get the difference map by computing reconstruction error.
  2. After normalization, thresholding and multiplied by segmentation map, a binary mask of opacity in lung region can be obtained.

Experimental

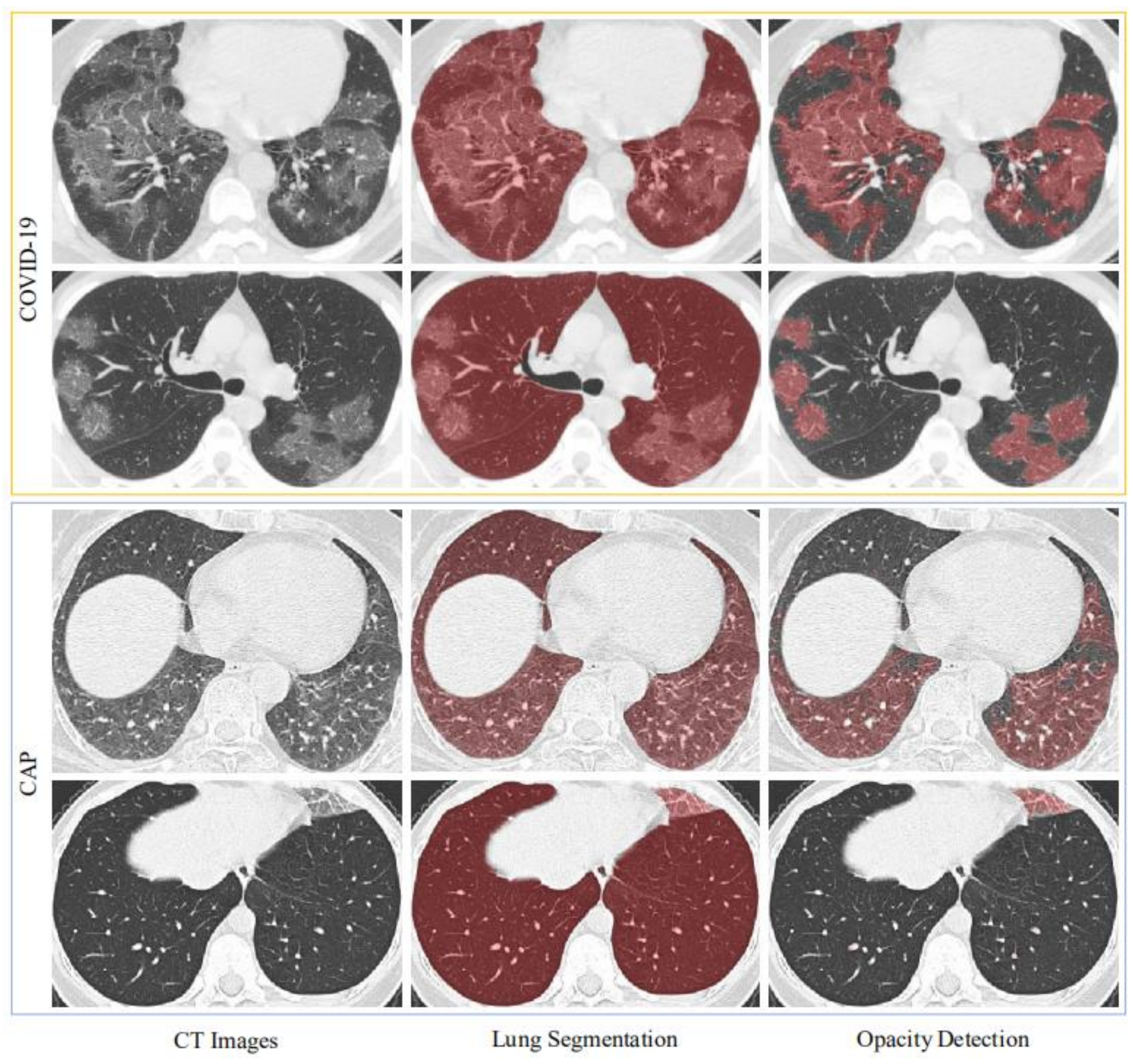

Figure 5: Visualization of segmentation and opacity detection results on COVID-19 and CAP cases.

Methods	Feature Extraction		Evaluation				
	Lung	Opacity	Accuracy	Precision	Recall	F1-score	AUC
Linear SVM	✓		0.9350	0.9674	**0.9000**	0.9302	0.9565
		✓	**0.9400**	**0.9905**	0.8900	**0.9338**	**0.9585**
RBF SVM	✓		0.9350	0.9674	0.9000	0.9302	0.9565
		✓	**0.9550**	**1.0000**	**0.9100**	**0.9510**	**0.9590**
Random Forest	✓		0.9400	0.9889	0.8900	0.9342	0.9640
		✓	**0.9450**	**0.9895**	**0.9000**	**0.9402**	**0.9720**
AdaBoost	✓		0.9200	0.9285	**0.9100**	0.9178	0.9620
		✓	**0.9400**	**0.9714**	**0.9100**	**0.9372**	**0.9640**
XGBoost	✓		0.9200	0.9443	0.8900	0.9155	0.9560
		✓	**0.9450**	**0.9800**	**0.9100**	**0.9416**	**0.9600**

Table 1: Quantitative results of classification.

Conclusion

We propose an opacity detection model for diagnosis of COVID-19. By applying opacity detection, the opacity regions can be segmented in an unsupervised manner which is a key to overcome the bottleneck of insufficient labeled data.