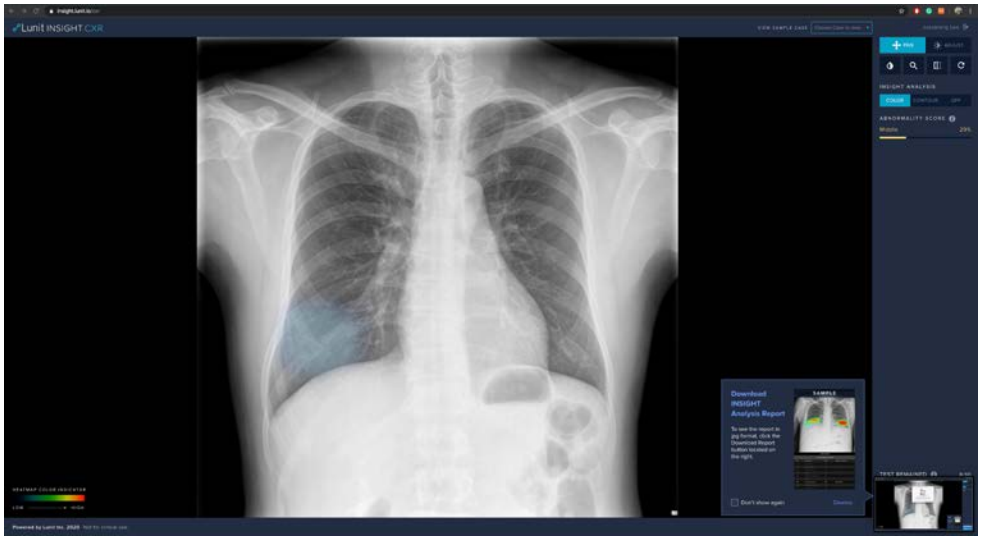
Lunit

USING AI TO HELP DETECT COVID-19

Lunit, a medical AI software company that develops AI-powered detection of lung diseases via chest x-ray images, has been closely monitoring the situation around COVID-19 and the rapid escalation of its cases around the world. Given the fact that COVID-19 is known to cause pneumonia and that our AI is capable of accurately detecting lung diseases, including pneumonia, from chest x-ray images, we have been investigating possible ways to contribute to the battle against COVID-19 with what we have at hand: our advanced medical AI technology.



ABOUT Lunit INSIGHT CXR

The software, developed by Lunit, is a state-of-the-art AI solution for chest x-ray analysis, detecting 10 different radiologic findings including lung nodule, consolidation, and more with 97-99% accuracy. Lunit INSIGHT CXR is designed to help radiologists detect more and better, alleviating the burden coming from routine chest x-ray interpretations. The software has received CE mark and has been featured in major publications such as Radiology, JAMA Network Open, European Radiology, and Clinical Infectious Diseases. As of March 2020, Lunit INSIGHT CXR has analyzed more than three million chest x-ray images from over 80 countries around the world.

LUNIT INSIGHT CXR IN THE DETECTION OF COVID-19

As an effort to examine the efficacy of the performance of Lunit INSIGHT CXR when employed to detect COVID-19-infected pneumonia, we have conducted a preliminary study summarized below.

In our study, anteroposterior chest X-rays (CXRs) of 6 patients confirmed to have coronavirus disease-19 (COVID-19) at the time of admission were retrospectively analyzed by Lunit INSIGHT CXR.

All six patients had pneumonia on chest CT. On CXR, the lesions were clearly visible in three patients, subtle in one patient, and non-visible in two patients.

Both radiologists and AI correctly detected CXR abnormalities from x-ray images of three patients with clearly visible lesions. Neither radiologist nor AI was able to detect subtle or non-visible lesions from the other three patients. When compared with the undetected cases, detected cases had longer interval from symptom onset to admission.

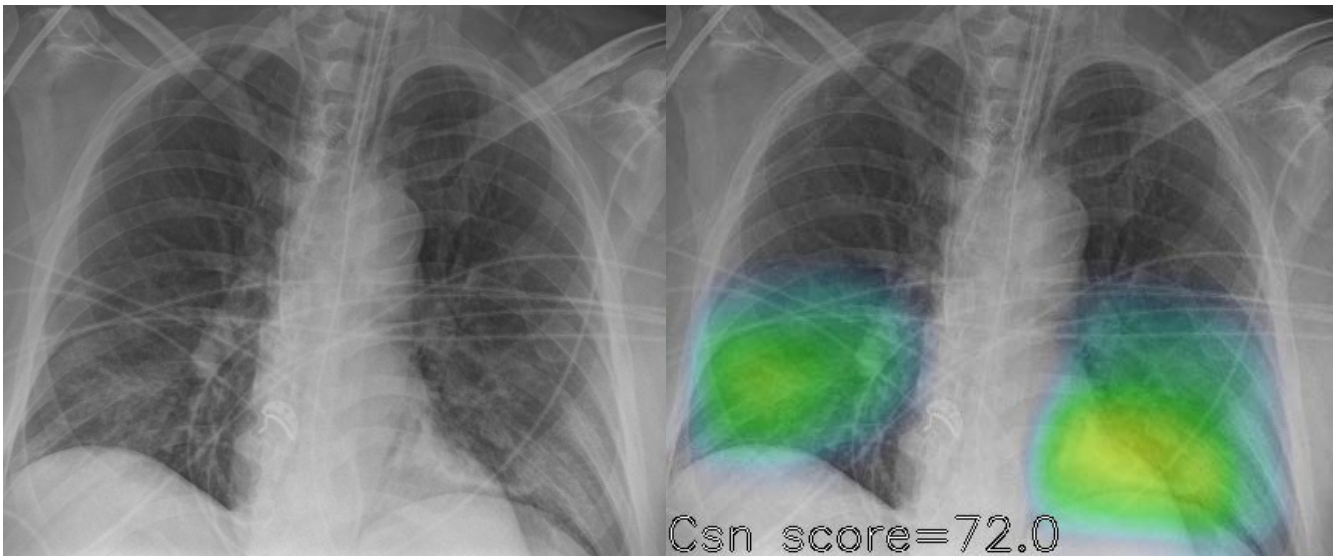
Additionally, we also used CXR data from the previous outbreak in 2015, the Middle East Respiratory Syndrome (MERS) for further validation. Both AI and radiologists detected all cases of pneumonia in CXRs of 4 patients who were diagnosed with MERS in June 2015.

The preliminary study results showed that Lunit INSIGHT CXR can be considered as a clinical support tool to interpret CXRs, performing at a similar detection rate as radiologists.

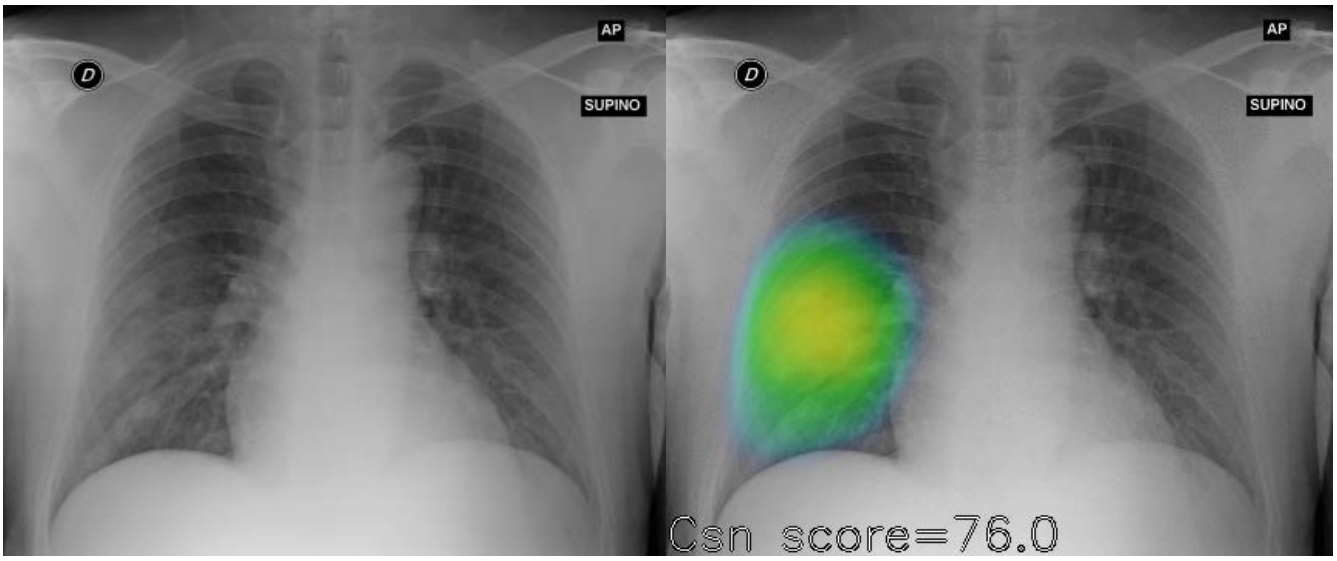
SAMPLE COVID-19 CASES

The COVID-19 cases that had radiologic abnormalities on CXRs could be detected by Lunit INSIGHT CXR. These samples were all RT-PCR positive at admission and had long interval from symptom onset to admission (mean interval: 16.3 days). On chest CT, the detected cases all had bilateral lung involvement, large number of affected lobes (median affected lobes: 5), and high lung severity score. Also, linear opacities (67%) and “crazy-paving” pattern (67%) were observed. The three sample cases detected by Lunit INSIGHT CXR are presented below.

[CASE 01] There is an ill-defined patchy increased opacity in the left mid to lower lung zone, which may be unclear for interpretation. The Lunit INSIGHT CXR has correctly detected the lesion with the abnormality score of 34.0%.



[CASE 02] The plain CXR taken on the patient in ICU care shows patchy ground-glass opacities in the bilateral lower lung zones. The Lunit INSIGHT CXR has correctly detected the lesions with the abnormality score of 72.0%, even in the setting with many tubes, central line, and external devices overlapped on the image.



[CASE 03] There are multifocal patch/nodular consolidations and ground-glass opacities around the right mid to lower lung zone. The Lunit INSIGHT CXR has correctly detected the lesions with the abnormality score of 76.0%.

SUGGESTED USE OF LUNIT INSIGHT CXR IN COVID-19 TESTING

- Use as a supportive tool during case overload, which can likely lead to low reading quality
- Use with portable x-ray devices to fast-track test results and decision making in advance to the PCR results
- Use when regular monitoring is required among patients showing mild symptoms, in order to identify and/or triage patients by the progression of symptoms

The current COVID-19 epidemic is burdening health care providers around the world and straining the system, with massive demands for tests, diagnosis, and treatment. While PCR is generally being used to test and identify COVID-19, CXR can also be a fast, effective, and affordable modality to evaluate COVID-19 related pneumonia. However, limitations remain as the massive shortage of interpreting radiologists exists as a hurdle for extensive conduction of test and diagnosis of COVID-19 via CXR.

We have discovered that with Lunit INSIGHT CXR, detection of COVID-19 pneumonia in the level of radiologists is viable, with the AI instantly interpreting CXRs to select suspicious cases

that warrant further action to whether or not isolate the patient even before PCR confirmation. Therefore, the use of Lunit INSIGHT CXR may be beneficial as a triage tool for non-radiologists, or even for non-doctors in extreme cases.

NOTES: USE OF LUNIT INSIGHT CXR IN COVID-19 CASES

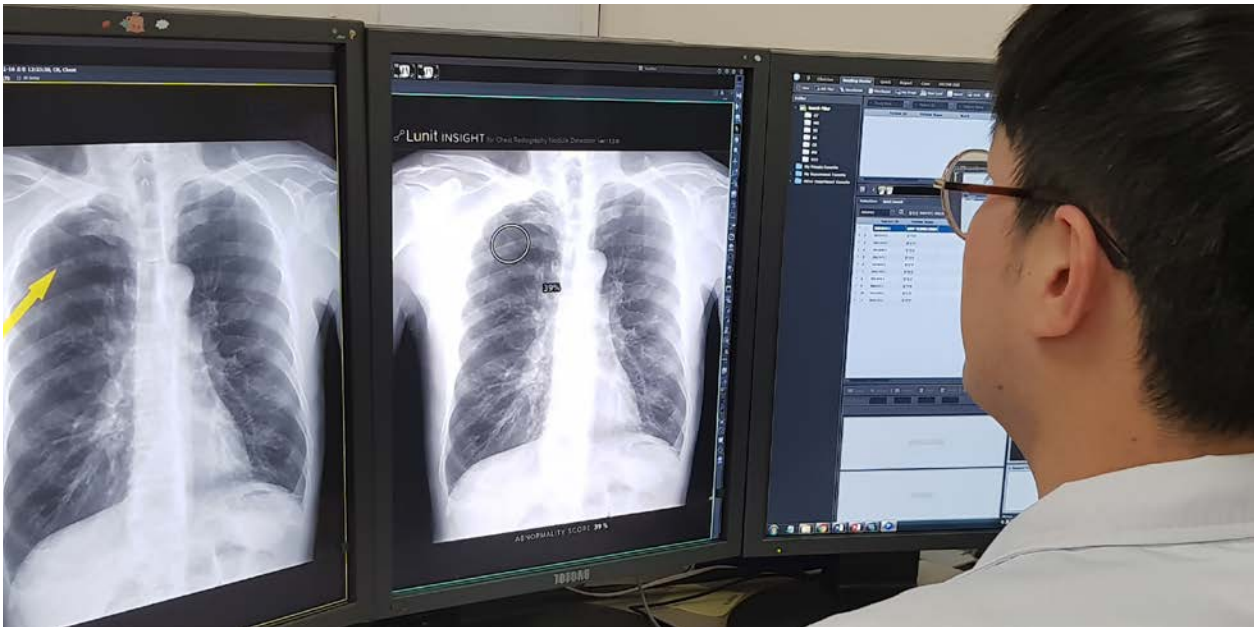
According to the recommendations by American College of Radiology (ACR), chest radiography, especially a fixed radiography or a CT scanner installed in an enclosed space, is not recommended for the diagnosis of COVID-19 as it may increase the risk of infection spread (1).

However, ACR states that when considered medically necessary, facilities may consider deploying portable radiography units since it relatively has lower risk of infection, as the surfaces of these machines can be easily cleaned, avoiding the need to bring patients into enclosed radiography rooms (1).

Recent use cases at major hospitals in the US, such as University of California San Francisco Hospital, New York University Langone Health, and University of Wisconsin Hospital shows that portable x-ray machines are used at respiratory clinics under strict infection control to screen suspected COVID-19 patients for further evaluation (2).

USE CASES OF LUNIT INSIGHT CXR FOR COVID-19 DETECTION IN SOUTH KOREA

In South Korea, Lunit INSIGHT CXR has been deployed to assist the diagnosis of COVID-19 patients from Daegu, the hardest-hit city where 7,431 patients—87% of the entire domestic cases—has been diagnosed. Seoul National University Hospital has built a healthcare center in Daegu, where physicians remotely examine patients via video call. The patients' chest x-ray images are sent directly to radiologists in Seoul, where Lunit INSIGHT CXR is used for the instant detection and diagnosis of COVID-19. The system enables prompt and early discovery of severe patients who are then sent directly to larger hospitals for proper treatment.



A radiologist at Seoul National University Hospital is examining a patients' chest x-ray using Lunit INSIGHT CXR.

LUNIT INSIGHT CXR COVID-19 RELEASED ONLINE

Lunit has been providing free demo service of Lunit INSIGHT CXR analysis at insight.lunit.io. In light of the current outbreak, we have released a special version of Lunit INSIGHT CXR specific for COVID-19, at www.lunit.io/covid19. Anyone can upload chest x-ray DICOM image files and get real-time detection results conducted by Lunit INSIGHT, with COVID-19-related findings displayed by the algorithm as a "consolidation."

PUBLICATIONS OF LUNIT INSIGHT CXR

1. Nam JG, Park SG, et al. Development and Validation of Deep Learning-Based Automatic Detection Algorithm for Malignant Pulmonary Nodules on Chest Radiographs. *Radiology.* 2018 Sep 25:180237 https://pubs.rsna.org/doi/10.1148/radiol.2018180237

2. Hwang EJ, Park SG, et al. Development and Validation of a Deep Learning-Based Automatic Detection Algorithm for Active Pulmonary Tuberculosis on Chest Radiographs. *Clinical Infectious Diseases.* 2018 Nov 12. https://academic.oup.com/cid/advance-article/doi/10.1093/cid/ciy967/5174137

3. Hwang EJ, Park SG, et al. Performance Validation of a Deep Learning-Based Automatic Detection Algorithm for Major Thoracic Abnormalities on Chest Radiographs, *JAMA Network Open* 2019 https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2728630

4. Hwang EJ et al. Deep Learning for Chest Radiograph Diagnosis in the Emergency Department, *Radiology.* 2019 Oct 22 https://pubs.rsna.org/doi/10.1148/radiol.2019191225

5. Kim HJ et al. Test-retest reproducibility of a deep learning–based automatic detection algorithm for the chest radiograph, *European Radiology.* 2020 Jan 03. https://link.springer.com/article/10.1007%2Fs00330-019-06589-8

REFERENCES

(1) American College of Radiology. (2020). ACR Recommendations for the use of Chest Radiography and Computed Tomography (CT) for Suspected COVID-19 Infection. Retrieved from https://www.acr.org/Advocacy-and-Economics/ACR-Position-Statements/Recommendations-for-Chest-Radiography-and-CT-for-Suspected-COVID19-Infection

(2) Mossa-Basha M, Meltzer CC, et al. Radiology Department Preparedness for COVID-19: Radiology Scientific Expert Panel. Radiology. 2020 Mar 16:200988