NovaradAI

COVID-19 AI Diagnostic Assistant

NOVARAD®
ENTERPRISE HEALTHCARE SOLUTIONS

Table of Contents

NOVARAD
ENTERPRISE HEALTHCARE SOLUTIONS

Executive Summary

The COVID-19 AI Diagnostic assistant is a tool designed to help hospitals and doctors in the fight against COVID-19. Many hospitals do a Chest CT as part of the standard protocol for a patient that is in respiratory distress. The COVID-19 Diagnostic Assistant allows them to use CT to quickly triage a patient suspected of COVID-19 and assess extent of involvement. Hospitals can easily download the client to their own hardware and route CT scans from any PACS solution. Once routed, the CT study is anonymized and sent to the cloud for processing through five artificial intelligence (AI) algorithms. These algorithms provide a report that shows both a positive/negative result for being consistent with COVID-19 and the extent of lung involvement. This report can be accessed by both provider and patient using a smart phone or PC. In partnership with Intel, this tool is provided to hospitals and physicians worldwide free of charge as a public service.

Case study:

This story is personal to Novarad. Our chief research and development scientist developed both a fever and a cough. He saw a local Instacare who informed him that the nasal swab test will take a minimum of 2-3 days for a result. Should he quarantine? Was he at risk to his family and others? How bad was his disease? Is this COVID-19 or just a cold? Should he be concerned about hospitalization?

He went to BlueRock Imaging in Provo, Utah and had a Chest CT scan done as part of his diagnostic journey. Blue Rock routed his study to the COVID AI tool. In just minutes, the images were uploaded to the cloud and the Novarad COVID-19 Diagnostic Assistant reported that he was consistent with COVID-19, and the lung involvement was minimal (~13%). He self-isolated and, in 10 days, he felt well again.

COVID-19 Diagnostic Assistant as a Solution

Novarad's COVID-19 Diagnostic Assistant rapidly identifies disease in the lungs consistent with COVID-19. It is intended to be used only as a diagnostic aid to help expedite a diagnosis. It does not replace the reading of the case by a radiologist. Other diseases such as viral or bacterial pneumonia, vasculitis, and other pneumonitis can also exhibit similar findings on a CT scan. Each image of a CT scan is run through all five of the AI models to significantly reduce the chances of a false negative. This tool is meant for facilities who utilize Chest CT scans in the workup of respiratory distress, or patients with symptoms of COVID-19 involvement of the lungs.

The system consists of both a host and a client. The Client lives on premise at the healthcare facility for receiving, anonymizing and routing images to the cloud. The AI model and processing of images live in the cloud.

Why Novarad's AI Tool?

A large training set, a highly sensitive AI model, the ability to measure extent of lung involvement, anonymized transmission to the cloud and the secure, rapid access to this information via an encrypted optical code sets this system apart from all others. The result from scan to results is typically <30 minutes.

- It is common for a patient to have COVID disease yet have a negative nasal PCR swab test
- Up to 40% of patients with COVID-19 will be missed by a nasal swab PCR test
- Most COVID-19 tests using saliva or nasal swab testing entail a delay of 1-3 days for results
- When COVID is present on chest CT, Novarad's algorithm has a <1% false negative detection rate
- 75% of suspected COVID patients with a negative nasal swab will have a positive CT scan
- CTs are often done on patients with respiratory distress. This technology allows the images to be processed within seconds and with a high sensitivity for detection of COVID-19
- Contains key images and shows extent of lung involvement
- Provides an almost instant diagnostic assistance to the provider
- This can be particularly helpful for geographic areas where radiological interpretation is limited or delayed

Machine Learning and AI Details

The Diagnostic Assistant AI was trained using the compute layer of Azure running on Intel technology.

NC12 – Nvidia Tesla K80 + Intel® Xeon® Processor E5-2690 v3

NC6s v3 – Nvidia Tesla v100 + Intel® Xeon® Processor E5-2690 v4

The Intel-based, Azure remote compute system provided needed computing power without Novarad having to physically own/manage the server. As we added thousands of 3D images, the system was extremely scalable and able to pull processing power as needed to keep up with demand. The many different power and size options were tailored to our specific needs. Setup of an instance was easy and quick.

Training Procedure

- A board-certified radiologist highlighted evidence of COVID-19 in ~110 lung CT scans (>44,000 images)
- Ran hyperparameter tuning runs on Azure compute cluster—each run would output about 30 different models. The most accurate models were selected and then tested on thousands of new images to pick the top five models. This was randomly repeated 10 times (the five models were selected from hundreds of evaluated models).
- The pixel data for each annotated scan was uploaded to an Azure storage container
- Uploaded ~200 more non-COVID lung CT scans into a separate Azure storage container blob
- 16 Bit 512x512 PNG images (with DICOM rescale slope/intercept applied) were used as AI training data
- Models were trained on an Azure GPU- STANDARD_DS3_V2

NOVARAD
ENTERPRISE HEALTHCARE SOLUTIONS

- Models were downloaded from Azure cloud and included in Azure Function where inference is performed on uploaded user scans.

Testing Procedure

1. Uploaded 438 scans for testing (using same procedure anonymization as training scans)
2. Ran each through models
3. Saved results as txt files in Azure storage container

The Science Behind the Data

- Number of sites: >40 from four countries
- Total Scans: 755
- Total Images: >75K
- Current Accuracy: 0.86
- Current Sensitivity: 0.99
- Current Specificity: 0.92

Easy to Use

- Either a route rule or DICOM destination from a PACS system or DICOM compliant CT is set up to send studies to the Novarad COVID-19 AI Diagnostic Assistant
- When an axial CT is routed to the Diagnostic Assistant, a QR code is generated (see Figure 5)
- This is a highly secure 3000+ bit encrypted code that is unique for the patient, built on Novarad CryptoChart technology which allows rapid, secure access from the cloud
- Users simply scan the code and the COVID-19 report is generated and displayed
- Can be viewed on mobile devices or PCs
- Multiple copies of the QR code can be printed for both patient and provider

The Report

As soon as the images are sent to the host, the study is run through the AI models and the report is generated real-time. This report can only be accessed through an optical code printed on the access sheet (See figure 5).

The report does not contain any personal health information. The only tie back to the original study is through the case number provided in in the top left corner of the report. This case number matches the one provided on the access sheet.

The report shows the number of images received, if the findings are consistent with COVID-19, as well as the percent of lung involvement. It also gives the confidence level for the result as well as key images taken from areas of the lungs that are involved.

NOVARAD
ENTERPRISE HEALTHCARE SOLUTIONS

Figure 1 Sample report

The Client

The Diagnostic Assistant client is a software package that is quickly and easily installed on a PC. The installation process takes just minutes to install and includes an installation wizard to walk the user through process.

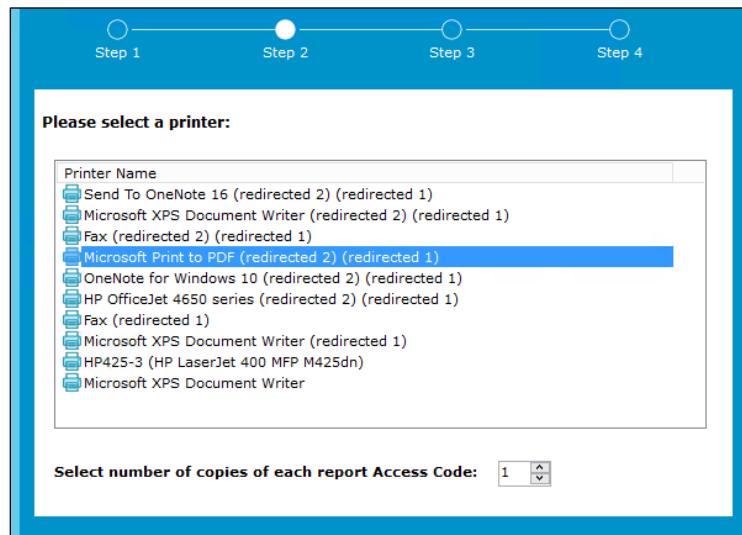**Figure 2: Shows the installation wizard**

Figure 3: Printer selection screen in the installation wizard

The client serves several functions in the tool that include the following:

1. Receive an Axial CT scan from any DICOM compliant PACS or modality
2. Anonymize the study
3. Encrypt and compress the study
4. Send the study to the host and receive the host generated access code
5. Convert the access code to an Optical QR code and send it to the attached printer for printing

NOVARAD
ENTERPRISE HEALTHCARE SOLUTIONS

Images are only temporarily cached on the client. Once routing of the study images has been successfully completed the studies are deleted.
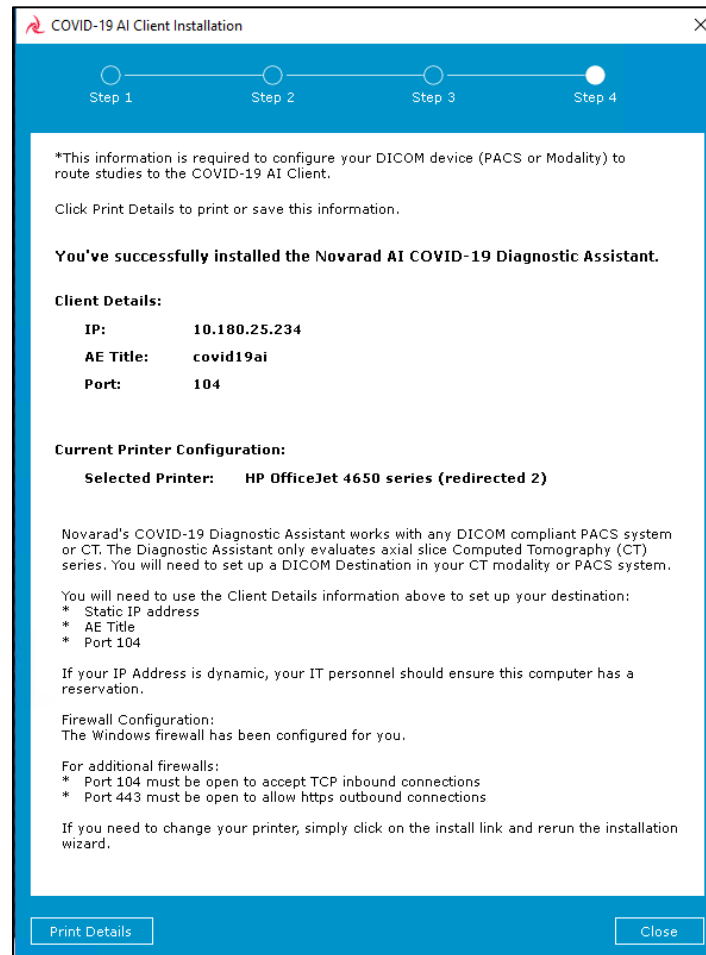

Figure 4 Client Details Page

When the COVID Assistant is installed correctly, a Client Details page is available for print. This page provides all the information necessary to set up a DICOM destination in a modality or DICOM compliant PACS system. A PACS Admin or a site's IT staff should be able to easily set up a route rule or destination

Client Technical Details:

- The client is built on the .net framework
- It receives DICOM files through a DICOM C Store operation
- It automatically filters out anything that is not an axial CT, this includes all other file types and images from other modality types
- The access code is generated by the host but received by the client when it is connected to send the images
- The client runs a proprietary anonymization tool on each image in a study before routing to the cloud
- The client uses HTTPS to transfer images to the cloud
- If a study is sent more than once, a second access page will be printed; but the system won't re-route the study
- The client prints the access page that includes the QR code to a local printer at the facility (this printer is selected during the installation). The access page also includes the Patient ID, Patient Name, Patient DOB, Patient Gender, Study Date, Referring Physician, and a unique case number used to that study/report (see Figure 4)
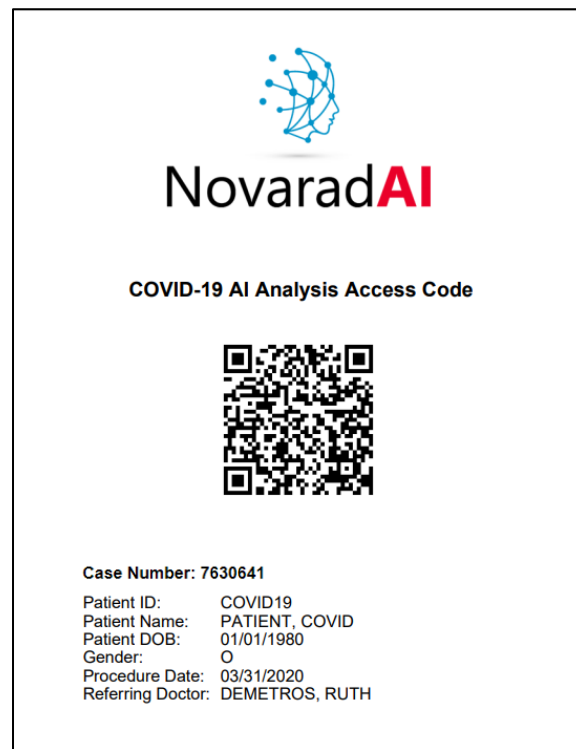

Figure 5: Sample report access sheet

POINT YOUR CELLPHONE CAMERA AT THE CODE TO TRY IT!

COVID-19 AI Diagnostic Assistant

The client is easily downloaded from the Novarad website https://novarad.net/COVIDAI to customer owned hardware. The hardware used can be any workstation or server as long as the receiving hardware meets the appropriate specifications:

- 2 GB of free space on the receiving drive
- Be on a Microsoft-supported operating system
- Be on the same network as your PACS or CT modality
- Have either a static IP address or a dynamic IP address with a reservation
- Administrator access on the receiving machine so the Windows firewall can be configured by the installer
- If it has additional firewalls, have the following ports open:
    - Port 104 must be open to accept TCP inbound connections
    - Port 443 must be open to allow https outbound connections
- The installer comes in the form of a signed .exe file; you may need to accept it as safe in your anti-virus

Host

The COVID-19 AI Diagnostic Assistant host details:

- Any communication to Azure is done over https
- Thumbnails generated for the reports are saved for a minimum 90 days
- Users can click a thumbnail and the images are displayed
- Images besides thumbnails, will be deleted from the host after one week
- A report won't be created until the study has fully uploaded, but the consumer will be notified it is in progress
- Azure instance is very scalable
- The host includes Storage pool, database for results, and end-points to connect
- Training performed in the compute layer of Azure
- Compute of artificial intelligence runs behind the scenes on a background thread

- Processor Details:
    - NC12 – Nvidia Tesla K80 + Intel® Xeon® Processor E5-2690 v3
    - NC6s v3 – Nvidia Tesla v100 + Intel® Xeon® Processor E5-2690 v4
    - Inference models on an image take about 0.19 seconds with processing power provided by Intel
    - The function to download the image data from the Azure storage cloud and write the result takes about 1 second to complete

Algorithm Details

- Technology used for algorithms: Python and Pytorch
- Machine learning details: Adapted Resnet-50 Convolutional Neural Network

NOVARAD
ENTERPRISE HEALTHCARE SOLUTIONS

Product Status

The COVID-19 AI Diagnostic Assistant was officially launched to the world on October 29, 2020.

To-date it has been accessed 89 times by sites in:

- ~18 States in the United States
- Across ~12 countries (Countries include India, Columbia, Dominican Republic, South Korea, Poland, Canada, and Turkey)

This tool has been accessed by hospitals, clinics, and imaging centers.

About Novarad

Novarad was founded in 1988 by a Neurointerventional radiologist with a passion for pioneering imaging solutions that improve the experience of healthcare providers and their patients.

We help practitioners meet the goals of providing world-class healthcare, reducing patient vulnerability, and efficiently managing business. Our 30+ years of success are founded upon several core principles:

Transformative Technology

We leverage artificial intelligence, augmented reality, advanced visualization and more to create truly transformative healthcare solutions.

People-Centered Approach

Innovation alone is not enough. Our products are designed by and for healthcare professionals to make both mundane and extraordinary tasks fit flawlessly into providers' workflows. Ease of use and dependability are key to providing a better experience for both you and your patients.

Service Delivery Excellence

We pair revolutionary software with effective training

- Award-winning products
- 30+ years of technology leadership
- 1000+ installations worldwide
- Scalable solution from imaging centers to large hospital systems
- US-based, 24x7 support (a customer favorite)
- 18 Petabytes and growing, highly available data using object store technology in our cloud.