SIEMENS Healthineers

Case study

Using imaging and AI to help diagnose and manage covid-19 patients

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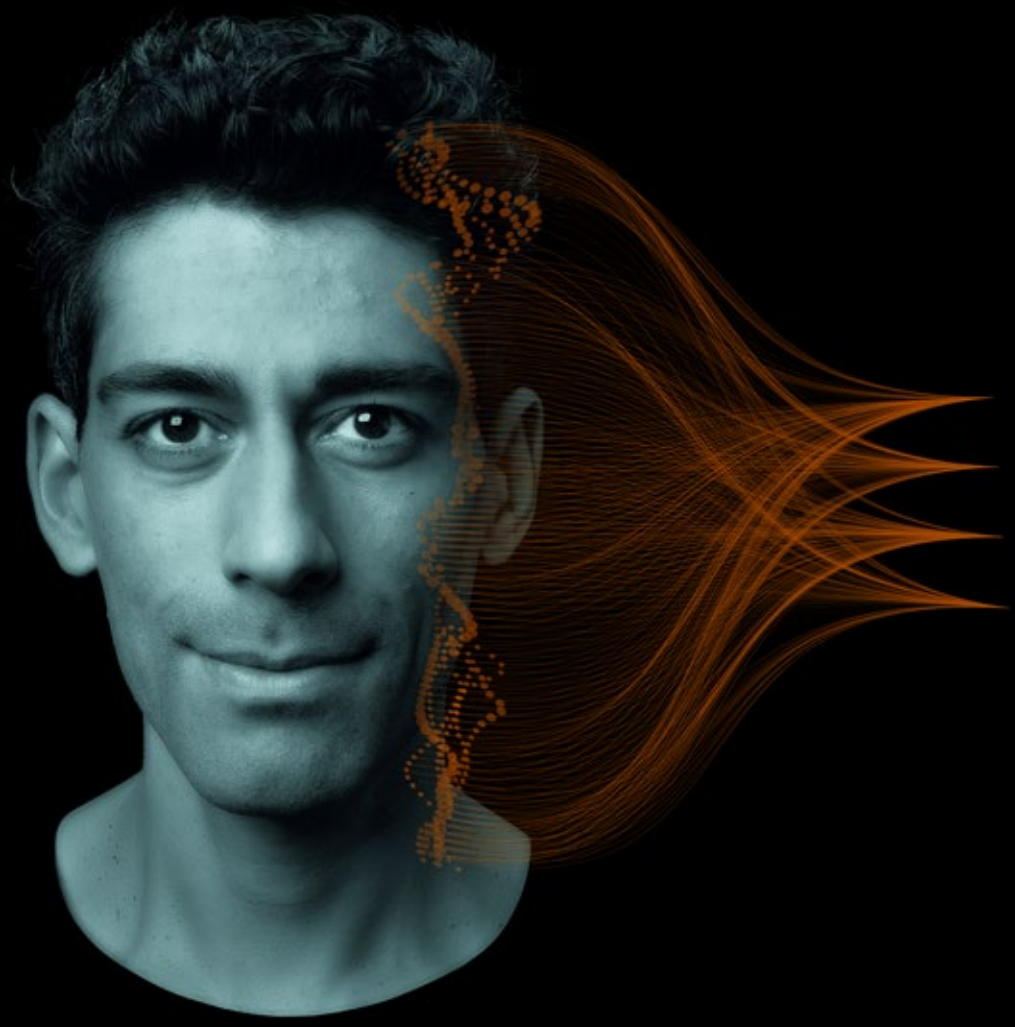

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Foreword by Siemens Healthineers

The nature of how healthcare is provided and operated has been disrupted by the COVID-19 pandemic. Digitalizing healthcare has become front and centre as a key component in the shifting healthcare landscape during these turbulent times. At Siemens Healthineers we believe that becoming a digital healthcare enterprise should happen in four gradual steps, from managing data as a strategic asset which empowers data-driven decisions, and connecting care teams and patients to collaborate better with one another, in order to evolve into a learning health system which is built for continual improvements. COVID-19 has brought attention to the power of good quality data to bear and its subsequent impact on systems such as algorithms and AI which can exponentially impact the quality and speed of the decision-making process.

The pandemic has compelled all of us in the healthcare industry to dramatically rethink what we can achieve with digitalizing healthcare. A digital first mind-set is here to stay and it is important to recognize that for the next five to ten years, we will be making higher quality, more accurate and faster decisions with the help of a decision support system that is built on the foundation of best-in-class data and taken from an ever growing number of sources. Healthcare leaders should focus on strengthening their data position to guide the transition of their organizations to digital enterprises.

This article is the first in a series that will present original insights based on exclusive research and interviews with global healthcare leaders, prepared by the Economist Intelligence Unit. For more information on Siemens Healthineers Insights, please visit: **siemens-healthineers.com/insights-series**

Dr. Ralph Wiegner,
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Executive summary

Opportunities

- AI-supported imaging tools can help hospitals undertake better planning. For example in bed/ward allocations and the need for ventilators and other equipment. They could help plan workflow and the allocation of healthcare workers, especially staff in intensive care units.
- These tools could help diagnose patients faster and manage them more appropriately. They could help healthcare systems manage a second wave of covid-19, where demand could increase dramatically. They could support radiology in identifying potential covid-19 cases and the most serious cases quickly, from patients with other conditions.
- These technologies could be adapted to support the diagnosis and management of patients for other conditions in future. The performance of AI-supported tools could be improved by incorporating data on symptoms from patient questionnaires as well as other clinical indicators.
- Successful tools can act as lighthouses to create awareness of what AI can offer and to help build trust by illustrating that such tools are effective, efficient, and safe. This will improve acceptability of AI, encourage hospitals to engage with the technology and share images in the future.

Challenges

- The effectiveness of these AI-supported tools relies on machine learning so their accuracy will depend on the data used to train them. A large and diverse range of images from different sources are required to train the algorithm and these must be annotated accurately which is a laborious process.
- Hospitals have low awareness of the advantages of data sharing rules, exactly what they are allowed to share and how, and how data sharing legislation is more flexible during a public health emergency. Clear communication is needed from government or another official source to increase awareness and challenge misconceptions.
- Hospitals are wary of sharing images because of data protection issues, so trust will need to be built. After this, contracts will need to be negotiated and signed. Images need to be anonymised or pseudonymised because of data protection laws.
- Hospital IT infrastructure is complex and varied and it may prove challenging to incorporate these tools into some existing systems. For such tools to be widely accepted, it is important to build trust. AI needs to be explainable and transparent and the accuracy of such tools needs to be verified by checking performance against a common validation dataset.
- Imaging has the potential to enable some patients to be diagnosed far more quickly than PCR testing but acceptance and usage of imaging for covid-19 is variable which in turn could be a barrier to making full use of covid-19 imaging AI tools. Official recognition of a role of imaging accompanied with guidelines for clinicians on when to use it are needed.
- There are no universal standards outlining how CT scanners and X-ray machines should be decontaminated after use with patients with confirmed or suspected covid-19.

Using imaging and AI to help diagnose and manage covid-19 patients

Faced with rapidly escalating case numbers soon after covid-19 emerged in the city of Wuhan at the end of 2019, China quickly sought ways to support the rapid diagnosis and evaluation of patients.

Computed tomography (CT) features were included in covid-19 diagnostic criteria and the country began using artificial intelligence (AI), to analyse CT images.[1]

However, as the pandemic spread outside China, health services became more cautious about using CT scanning for the diagnosis and risk stratification of covid-19 patients, with many radiological societies, including the American College of Radiology, the UK's Royal College of Radiologists, the Canadian Society of Thoracic Radiology and the Canadian Association of Radiologists, actively discouraging the use of CT scanning for screening patients.[2, 3, 4]

As well as reflecting uncertainties around accuracy and concerns about cross-contamination, the reluctance to use CT also arose from a need to conserve limited resources in terms of both scanners and radiologists for non-covid-19 patients, explains Professor Alexander Wong, University of Waterloo Canada Research Chair in AI and Medical Imaging: "CT systems are not moveable, they're not portable, you cannot isolate them well."

But now healthcare systems are increasingly seeing a role for imaging in covid-19 diagnosis.[5] The standard method for diagnosing covid-19 is the reverse transcription polymerase chain reaction (RT-PCR) assay, but this method has some limitations. These include long turnaround time (tests often take a day or so to yield results) and sensitivity of tests are never 100%, which can mean false negatives (when a patient is given the all-clear when they actually have the infection).[6] Not only can CT scans provide results quickly, a study in France showed that their use alongside RT-PCR can also improve testing accuracy; the same study also found that they could have a role as an effective standalone diagnostic tool, particularly in areas with relatively high disease prevalence.[7]

Some hospitals are using CT scans in patients with clinical signs of covid-19 to aid diagnosis and/or to support patient management, while others are using it only for follow up or in severely ill patients, says Erik Ranschaert, a radiologist and AI project leader at Elisabeth-Twee Steden Ziekenhuis, a hospital in the Netherlands city of Tilburg. "There's no homogeneous policy on the usage of CT for the disease so you can see a lot of different approaches, and it's kind of dependant on the area where the disease is active," says Dr. Ranschaert.

According to Dr. Ranschaert, hospitals have dealt with the risk of cross-contamination in various ways, including allocating certain CT scanners and teams to assessing covid-19 patients and implementing more robust cleaning procedures. "Regarding the cleaning, there are a lot of different opinions," he adds. Some hospitals insist that the whole room is cleaned after a covid-19 patient has been scanned, which can take half an hour, while others insist that it is enough to wipe the inside of the scanner and the table, which takes only a few minutes.

The most important benefit for patients is having access to fast screening. Mr. Wong explains: "PCR in general still takes a very long time – at least a day or two – and what do you do with a patient with a respiratory complaint or more serious complications while they wait for those results? If they have a chest X-ray or chest CT, a doctor will have a much better idea of the patient's condition and how to deal with the situation while they're waiting for the PCR results."

The benefit of using CT scans can be furthered by employing AI to assist in interpreting them. Research has confirmed that AI algorithms can distinguish covid-19 from other respiratory conditions on CT scans, and numerous projects are underway to harness AI in this way.[8, 9, 10, 11]

Although there were initial fears that AI would threaten the future of radiologists, Mr. Wong says radiology societies now realise that AI "is a technology not for replacing [radiologists] but for augmenting their ability to screen better, faster and more consistently."[12]

Radiological societies are now "embracing this new technology" and interest in its potential applications is increasing exponentially, says Dr. Ranschaert, who is president of the European Society of Medical Imaging Informatics.

At times it can be quite difficult to interpret CT scans to diagnose covid-19, Dr. Ranschaert explains, and a well-trained algorithm could give a probability score – for example, "this is a covid-19 infection with 80% certainty" – and it could estimate the extent of the damage to lung tissue. "This could influence the decisions that are being made regarding where the patient needs to be," Dr. Ranschaert says. "For example, if a decision needs to be made about moving the patient to another ward or the intensive care unit."

It is much easier to get an accurate estimate of the percentage of lung tissue affected using AI, Dr. Ranschaert emphasises. "If you do this without AI you have to estimate by scrolling the eyeballs, so that is more subjective."

AI is also helpful for determining if the disease is improving or getting worse at follow-up, he adds. In addition, the same AI tools can be used to screen CT scans created to check for other conditions, such as cancer, or to assess trauma to pick up unexpected cases of covid-19.

Julien Guiot, head of clinics in the Department of Respiratory Medicine at the CHU of Liège, a university hospital in Belgium, is involved with several AI CT imaging projects. Dr. Guiot says that AI systems could be set to automatically flag any images with signs of covid-19 to help reduce cross transmission of covid-19 between patients and imaging technicians or medical staff. Suspected cases can then be isolated immediately to protect staff and other patients while a PCR test is conducted to confirm infection and the CT scanner is disinfected before the next patient arrives.

Using AI to assess all CT scans for signs of covid-19 could also help to identify atypical signs of the disease. For example, unexplained abdominal pain was found to be a symptom of covid-19 after patients presenting to hospitals were assessed by chest CT, which revealed lung damage.[13, 14]

AI tools also have wider benefits for hospitals and health systems. Mr. Wong points out that these include not only the potential to ease the burden on radiology departments in terms of assessing scans, but also predicting upcoming demand for general hospital and intensive care beds, and demand for equipment such as respirators and ventilators, medicines, masks, and ventilator mouthpieces, as well as aiding workforce planning.

However, although these tools offer clear benefits, decontaminating equipment is not the only hurdle that needs to be overcome in their development and implementation.

It can sometimes be challenging to integrate AI tools into existing IT systems unless they are designed by their respective IT system vendors. Integrating an algorithm can be time consuming and tedious because of technical hurdles, says Dr. Ranschaert.

The accuracy of AI tools also depends on how well the underlying algorithms are trained – a process essentially reliant on the quality of data used. For best results, a large number of good-quality images are needed for both covid-19 and other respiratory conditions, and these must come from a diverse range of patients and a variety of sources.

AI specialists liken the process to educating a child.

"If you want to explain what an elephant, a lion or a penguin looks like, the better the image is coloured or designed, the easier it is for the child to understand. That's actually the same with deep learning: if you provide bad quality images to train an algorithm, the results will be bad," says Dr. Ranschaert.

Preparing the images required to train the underlying algorithm is an extremely laborious process, he explains. "There is a joke among developers, they say 85% of the work is preparing the data – curation of the data – and another 25% is further preparing the data."

Dr. Ranschaert is co-leading the Imaging AI Covid-19 programme, a collaborative research project launched by the Netherlands Cancer Institute to develop a European-focused AI tool.[15] Two companies – Quibim and Robovision – are involved on a pro bono basis, providing a platform for hospitals to upload images and datasets, alongside expertise in algorithm development. The AI tool developed will be made freely accessible to all participating hospitals.

So far, CT images of almost 3,000 patients have been collected from 20 different hospitals in seven countries (Belgium, the Netherlands, Germany, Luxembourg, Italy, Spain and Greece). Each CT scan comprises around 150 images, and the first phase of the project required 1,000 scans of 1,000 patients to be processed manually, which involved annotating the images by colouring abnormal areas in the lung and assigning the diagnosis. Some of the scans were taken from patients with covid-19, others from patients with pneumonia, tuberculosis or other respiratory infection, and some from healthy patients.

The remaining 2,000 scans are gradually being processed by the algorithm automatically and then checked and corrected manually. "Sometimes the algorithm colours areas that are not relevant, or it goes outside of the margins, or it forgets to segment or colour a specific area in the lungs," Dr. Ranschaert explains.

The source of the images is important, because the scanner used and the technique can impact on quality, he adds. "Garbage in is garbage out." Hospitals must use CT scans with images of no greater than 3mm slices, and annotators will also reject images considered poor quality – for example, those that are blurred or have artefacts because the patient moved or was breathing heavily.

At the same time, it is important not to use images from only a single scanner or institution, because the algorithm will only recognise the disease on scans prepared there, Dr. Ranschaert says. "If you want to make an algorithm that's capable of analysing images from any hospital, from any scanner, then you need a lot of images from different origins. At the moment, there is no legal requirement to prove this, that your algorithm has been trained with a lot of different images and to prove that the algorithm is really effective in any clinical environment."

An international group of stakeholders has recently developed guidelines aimed at improving the quality of clinical trials evaluating health interventions involving machine learning or other AI systems.[16, 17] However, Dr. Ranschaert says that what is really needed are reference validation datasets that are applied to every algorithm developed for diagnosing covid-19, so that their performance can be scored and compared.

While preparing the data is laborious, obtaining the images in the first place can be an even more time-consuming job. For example, data protection rules require images to be anonymised or pseudonymised before they are shared. As hospitals are nervous about sharing any data, trust has to be built with stakeholders before negotiations can start, and then contracts must be agreed and signed.

IT departments have to install software or even hardware, and radiologists need to be trained in how to use it. For the most seamless workflow, the AI tool has to be integrated into the PAC (picture archiving and communication) system, and this involves communication with the vendors of that system.

COVID-Net, a free-to-use, open-source initiative developed by a technology start-up called Darwin AI and the University of Waterloo in Canada, has trained its screening and severity assessment algorithms using around 14,000 chest X-rays and 100,000 chest CT images.[18, 19] Images were sourced from a variety of repositories, including the Radiological Society of North America, The Cancer Imaging Archive, various institutes across North America and through crowd-sourcing efforts with industrial partners.

Sharing data is a long and tough process, says Mr. Wong (he is the co-founder and chief scientist of Darwin AI). "To encourage institutions to share data, I have had to put a lot of effort in working with them to get past the hurdles involved with sharing data and to help make sure that they see the global benefits outweigh the struggles with the actual data-sharing process, which is a tremendous amount of work. The only thing I really had to offer them was to support them and work with them to get past the hurdles with sharing clinical data."

Chest X-rays have proved easier to obtain, says Mr. Wong. They are being used widely for complimentary screening alongside viral testing, as they can be useful for assessing disease severity, information on which is not provided by a PCR test. Mr. Wong says that chest x-rays are also routinely used where patients show pneumonia-like respiratory symptoms – "so why not leverage them to also screen for covid-19?" X-ray machines are more portable than CT machines, easier to isolate to reduce cross-contamination and more widely available, even in low-income settings, he notes.

Having worked on a range of previous AI-powered diagnostics tools, including for cancer and skin diseases, Mr. Wong decided to develop an open-access diagnostic tool for covid-19. COVID-Net training tools are freely available, so users can customise the algorithms to fit their local population.

Transparency and trust around how an algorithm is built and makes decisions are important, says Mr. Wong; the open source nature of COVID-Net engenders a lot of trust, he adds. Some of the early internal prototypes of the COVID-Net algorithm had appeared effective in distinguishing covid-19, but closer examination using Darwin AI's explainable AI platform revealed that the algorithms were making decisions based on embedded text and other artefacts in the image, and even the particular type of bed that the patient was lying on. "It was finding a way to cheat the system," he says, so these prototypes had to be abandoned early in the development process.

"Every technique has its advantages and disadvantages," says Dr. Ranschaert. Chest x-rays can be used on a wider scale, because they can be done quickly and cheaply and the equipment is readily accessible, but a chest x-ray is not as specific nor as sensitive as a CT scan, certainly in the early phases of the infection, he explains. However, as each CT scan is made up of hundreds of images, they require a lot more work at the outset to annotate so that the algorithm can be trained to evaluate them.

The performance of AI algorithms in assessing imaging could be further improved by integrating clinical data and information from patients about their symptoms. Dr. Guiot is working on several projects under the COVIA banner (from the French *coronavirus intelligence artificielle*) that are attempting to do just that. The COVIA initiative has Icometrix and Oncoradiomics as AI partners and its research partners include Dr. Ranschaert's Imaging AI Covid-19 project.

The aim of the initiative is to build tools that can estimate the probability of covid-19 infection based on changes on the chest x-ray and clinical symptoms, or that combine clinical and biological markers and information from chest CT scans to assess severity and prognosis, thus helping hospitals to triage covid-19 patients.[20] Overall the aim is to develop an AI tool with extremely high sensitivity to help reduce viral transmission in hospitals.

"The idea is to just to have an automated flag of possible positive covid-19 patients to reduce the risk of cross transmission of the virus between patients and from the patient to the technicians or medical staff," Dr. Guiot says.

What is certain is that if there is a second wave of covid-19 where cases reach similar levels to the first wave, AI and imaging tools will be able to take some of the strain off hospitals.

"During the [first-wave] pandemic phase so many patients had covid-19, it was an easy diagnosis for radiologists to make," Dr. Guiot explains, "but for the next few months and years we will have to manage to live with the disease, like influenza [...] AI can automatically find a patient with possible covid-19. This will be a way to reduce the risk of cross-infection and the under-diagnosis of patients."

As Europe enters winter and the flu season, covid-19 cases are beginning to climb once more. As both flu and covid-19 cause similar symptoms, AI tools could have a key role in helping clinicians to quickly discern between them. "We have developed a new [AI-based] tool that is able to discriminate specific influenza/covid patterns," Dr. Guiot says. "Therefore, we will use this AI tool to help clinicians."

And the learning that arises from developing AI tools for covid-19 will have benefits in terms of developing tools for other conditions. "AI is being used already in many other sectors, but in healthcare, implementing such a disruptive and innovative technique takes more time," Dr. Ranschaert says. "The pandemic is an exceptional situation. It has been a bit easier to obtain the data, so we could learn a lot about how to train an algorithm to distinguish between different pathologies in the lungs. We are still in the early phase of developing AI tools, and so every experience is certainly welcome to make it proceed faster and to make such tools more easily available."

This article was edited by Elizabeth Sukkar of The Economist Intelligence Unit.

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According to US FDA, only in vitro diagnostic testing is currently the definitive method to diagnose COVID-19.

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