Usage of Artificial Intelligence in Future Pandemics

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Abstract

In [1], researchers found that radiologists have relatively mediocre sensitivity rates compared with specificity rates when diagnosing COVID-19 cases via CT scans. AI has the potential to make the diagnosis process more efficient, effective, and economical. In [3], a group of researches examines the possibility of using deep learning to analyze CT scans, and [5] presents a brilliant cloud-deep-learning framework that combines data gathered from embedded smartphone sensors to give a COVID-19 diagnosis. However, [4] warns that the lack of training data will prevent any practical application of these solutions during this pandemic.

Background

Many people still regard AI merely as an element of science-fiction, exclusively existing in the writers' imagination. Unbeknownst to those people, AI has already slipped under our noses into much of our daily lives. From life-saving machines to more subtle gadgets, AI continues to transform numerous industries, and healthcare definitely won't be an exception.

The medical industry has seen some amazing innovations recently fueled by the pandemic. These developments have shed some light on AI's great potential to aid with detecting, preventing, responding to, and recovering from future disease outbreaks.

The Problem

In epidemiologists' talk, sensitivity refers to the portion of positive cases who were correctly identified as such, or the TPR (True-Positive-Rate). On the other hand, specificity refers to the portion of negative cases that were correctly identified as such or the TNR. (True-Negative-Ratio). Both terms are shown in figure #1.

During a study conducted in [1], seven radiologists were asked to differentiate between 219 COVID-19 pneumonia chest CT scans and 205 non-COVID-19 pneumonia scans. Overall, the group displayed fairly good specificity rates, but on the other hand, sensitivity rates were rather mediocre; in some cases, there could be only minuscule differences between COVID-19 pneumonia and some other types of pneumonia, which occasionally leads medical experts to erroneously rule out positive cases as negatives, hence the lackluster sensitivity. Imperfect sensitivity rates threaten to overwhelm healthcare facilities, causing cross-infection, putting vulnerable patients' lives in danger, and inflicting even more economic damage. Besides, CT testing can be time-consuming, and COVID-19 test kits are at short supply, which further hinders the diagnosis of patients.

Clearly, this is an urgent problem with far-reaching consequences. However, it also happens to be a very good opportunity for AI systems to prove their worth.

The Solution

Deep learning is a form of machine learning inspired by the human brain, where artificial neural networks use gigantic amounts of data to learn how to do a specific task by repeating it countless times, slightly optimizing itself every time until it masters that task [2]. Deep-learning algorithms have become advanced to the point where they could be used reliably to diagnose COVID-19 patients, which is exactly what many researchers have already done. A group of researchers developed a ResNet-50 Convolutional Neural Network (CNN) model which is able to distinguish COVID-19 pneumonia cases from other pneumonia cases. The model, namely "COVNet", has an AUC-ROC rating of 0.96, which is outstanding for a binary classification system. There have been several other neural networks developed in addition to COVNet, with AUC-ROC ratings as high as 0.99 and accuracies up to 98% [3]. Moreover, it's important to predict which patients are likely to need Intensive Care Units (ICU) because their capacity is limited to very high-priority patients. Fortunately, researchers have developed a prognostic prediction algorithm which is able to calculate the mortality risk of COVID-19 patient. Other researchers have developed an AI which is capable of predicting whether a patient would develop Acute Respiratory Distress Syndrome (ARDS) with 80% accuracy [4].

These results clearly show that ML algorithms have become immensely useful against disease outbreaks.

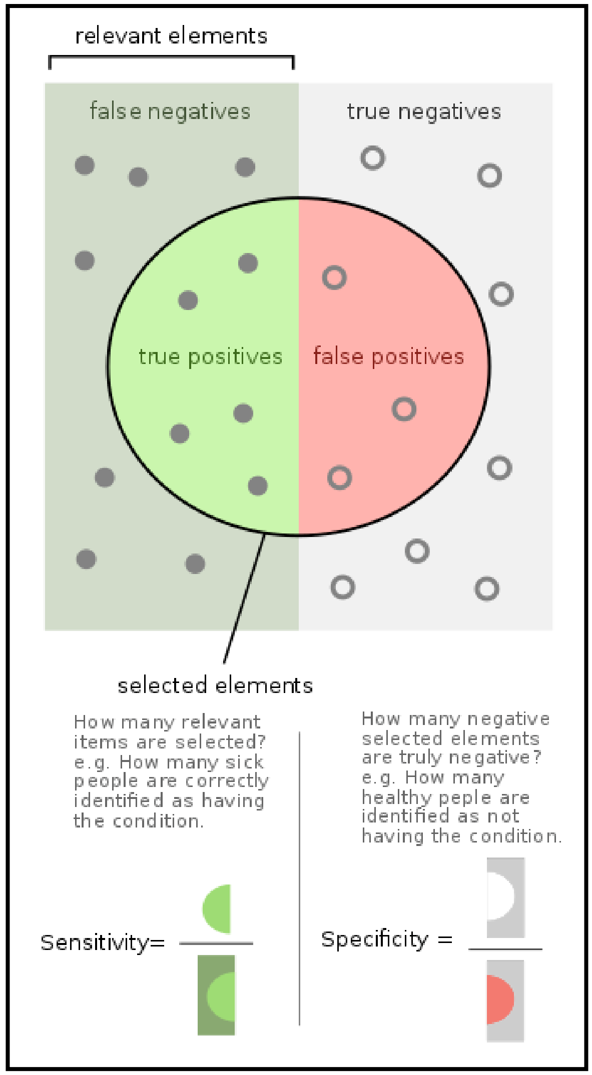

Figure #1: An illustration of sensitivity vs. specificity.

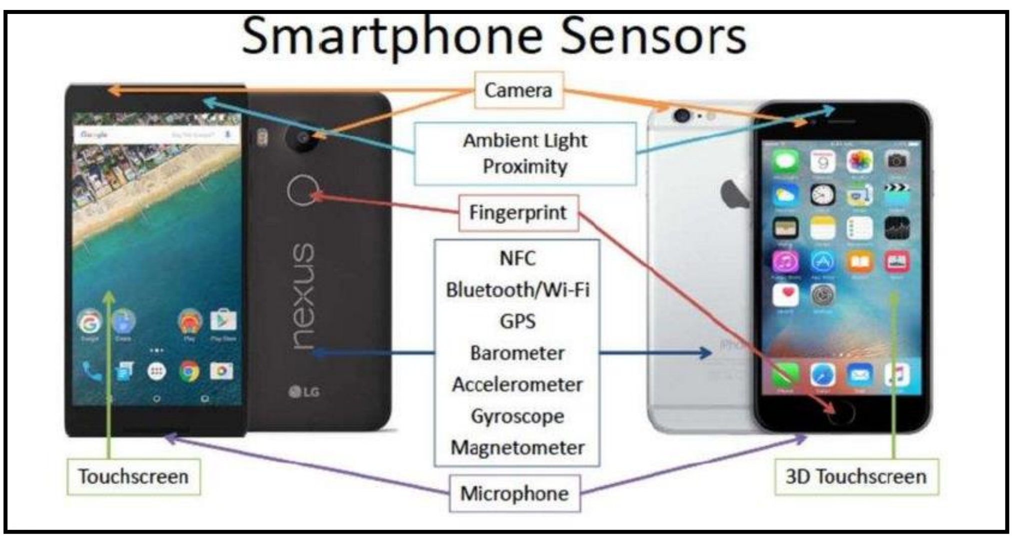

Figure #2: A diagram showing where many of the modern smartphone sensors are embedded. [6]

However, X-ray generators and CT scans won't be available everywhere, every time: Consider developing countries with poor healthcare systems and hospitals, where there are often "peak" times when said facilities are completely overloaded with no capacity to receive more patients. Those situations require novel approaches that enable rapid and effective testing using whatever equipment is at hand.

Luckily, smartphones have a lot of embedded sensors, **as shown in figure #2**, which can be exploited and turned into a means of diagnosis. In [5], a brilliant framework incorporating these sensors is presented, which would allow for quick, cheap, and effective testing. The framework works by aggregating input from different sensors, and uploading that data to a cloud deep learning model that analyzes it to predict what symptoms the patient might have and the severity of each of them; and based on the result of said analysis, the model will yield the probability of the patient having COVID-19. Each sensor collects information about a certain behavior, according to the sensor's functionality: The temperature-fingerprint sensor is used to predict the level of fever; the camera and the accelerometer are used to detect fatigue, nausea, posture, and headache; and finally, the microphone chipset is used to analyze audio data and indicate the type of cough the patient has. This mobile-based framework is considerably accurate, as data is collected from many different sources, and is also far cheaper and less time-consuming than CT scans and X-rays.

Challenges & Conclusion

Although both of the frameworks discussed above are very promising, they are currently undermined by many challenges, the biggest of which is lack of data; Thus, AI systems need billions upon billions of bytes for training, and in this context, data must be acquired through expanded testing and CT scans, most of which as of yet have come from Chinese hospitals which implies the possibility of selection bias [5]. It would take years to collect enough volumes of random, unbiased data for properly training AI, which means we probably won't be seeing AI-powered COVID-19; instead, we'll probably be seeing AI deployed in areas with the most short-term potentials, such as social control via surveillance (e.g, checking citizens' temperature with IR cameras, using facial recognition to check if they're wearing masks, etc.). To conclude, maybe AI won't be a huge player this pandemic, but we have surely learned invaluable lessons and gained crucial insight as to how it may be used against future pandemics and disease outbreak.

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