Journal of Nuclear Medicine, published on February 2, 2017 as doi:10.2967/jnumed.117.190397

Machine learning will change medicine

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Why do we need artificial intelligence (AI) algorithms (machine learning) in medicine? Is there not enough “natural” intelligence among physicians? Well, the latter clearly depends on the individual medical education of every single physician. But to be honest: No doctor in the world can be perfectly up–to–date on recent medical advances. To do so, we do need help from the world of technology.

Beside the problem of data overflow, there are additional reasons why we need AI in medicine. One of the main decision problems - in general and not only in medicine - is the so-called optimism bias. That is defined as the difference between a person's expectation and the outcome that follows. And also physicians do have this optimistic approach that biases them: They usually think that the patient´s problem belongs into the specific discipline the physician belongs to. Imagine a patient with pain in his left arm. A cardiologist will always think first, that this patient has a coronary problem. A neurosurgeon will look for a cervical disc problem, the orthopedic surgeon will have a look at the shoulder and an angiologist will exclude a vascular problem. Finally, somebody will figure out, what the disease is, but it can take time. And now imagine that the patient first gets a questionnaire –based on numerous data obtained from patients with pain in the left arm and validated diagnoses. The system will clearly have no optimism bias. Imagine how helpful these tools could be in rural areas with a low number of well-educated physicians. But even in high-end first world countries: Will we still need physicians to diagnose popular diseases or is a well-trained physician assistant enough?

We need AI for rare diseases. Some of the so-called rare diseases are probably not really rare, but just often overseen. And those, which are really rare, are difficult to remember even for specialists. Think of the numerous syndromes. Intelligent systems never forget anything. Regardless whether you look at images, lab values or genetic data: Well-trained intelligent systems will be faster and better than the vast majority of physicians.

Will radiologists or nuclear medicine physicians be replaced by AI? Recently, Obermeyer and Emanuel stated “machine learning will displace much of the work of radiologists” (1).

It will change our daily life. It will remove a lot of the routine work. For AI it will be pretty easy to diagnose simple things like intracerebral bleeding, typical bone fractures and liver cysts. Well-trained systems will become excellent advisers in mammograms, lung problems and early stroke CT reading.

Scientists all over the world are training systems in detecting pulmonary embolism, characterizing micro calcifications of the breast, doing texture analysis of the fetal brain and prostate cancer "(2, 3, 4, 5). And even the very first results are extremely promising.

Those, who do not like that scenario, usually come up with medicolegal aspects. Who is responsible, if the system fails, e.g. the system misdiagnoses? Well, if radiologists all over the world would never fail, then we would have a major problem. But beside that: Look at laboratory medicine. Automatization in lab medicine improved quality dramatically; we are not dependent any more on human skills in counting leucocytes – like we were 30 years ago. And the question: who is responsible, if the machine fails, is clearly defined. As a consequence there are very strict quality control mechanisms in laboratory medicine. The same would become true for radiology: The system will see reference images all the day and the responsible physician will immediately realize when the system is out of order.

An important question will be: Who is on the driver seat for the final decision. It is like the autopilot in an aircraft. If you ask somebody, who is flying the aircraft, the answer will be: the pilot. The reason for that is: the human pilot is finally responsible for the action.

There will be at least two major fields, where AI will have initial problems. Some diseases will not have a 1:1 translation into a specific image pattern. IT nerds could reply that radiologists probably do not see the specific pattern for a given disease right now – maybe this is true for a certain number of diseases. But from a pathophysiologic point of view, it is most likely, that imaging will not always be specific. In these situations the radiologists could be the integrator of imaging findings and other information about the patient. The system will give him a list of "best matches" from the imaging point of view and he has to discuss the different possibilities with the referring physician.

The second major problem will be to define "normal". The spine in a 20-y-o patient looks different compared to a 60 y-o and among the 60 year old patients there is huge variety of degeneration and often no correlation to back pain. Maybe it is not really helpful for a patient if he knows that the degree of his spine degeneration is beyond the 95 percentile of his age. Even if he never had back pain before, he now will get some.

Anyhow, these problems will not prohibit AI to come into radiology. Radiology is pattern recognition and computers can recognize patterns. What many people not realize: The deep learning algorithms are there, in part they are freeware. A couple of months ago, I had a job interview with a young mathematician, who was working in a very active AI lab. And I asked her, why AI is coming so slowly into medicine. Her answer was very simple: There are not enough medical datasets in the cloud to train our systems in medical problems.

If the main problem for AI going into medicine (or radiology) is a data-related problem: We have to re-organize our data. Radiologists all over the world host uncountable numbers of data sets. The problem of these data is that they are not really valid. For learning systems we need valid, annotated data. And that is not only true for radiology. The same is true for pathology, laboratory medicine and – at the end – for all fields of medicine. We need data bases that can deliver these valid data into learning systems and all players in the healthcare field will struggle for these data sets. The exciting question is: Who already owns or has those data sets? And who will earn money with them?

Let´s have a look at the device manufacturer. Well, they have data sets or at least access to them. Let us not look at data privacy protection problems at this point. These problems can be solved quickly. But the main problem is that these data are not valid enough. Data quality will be very heterogeneous. And then you face a well-known IT problem: Garbage in, garbage out.

A second player in this field is clearly radiology itself. Maybe huge institutions – doing 100.000 or more CT scans per year – will have departments for quality control that continuously "feed" learning systems with valid data. Perhaps we will have NIH apps for lung diseases or Harvard apps for breast diseases. Or scientific societies – like the RSNA – will identify AI as a new business area and create a structure allowing to store valid data and train AI systems.

Third players are companies publishing medical textbooks or medical journals. They have a lot of valid data, not only radiological data. And they can read texts, often even unstructured textual data.

I am in radiology since 30 years now and I do not believe that radiology will be on the driver seat when it comes to the decision who will organize the data sets. Device manufacturers will probably decide to deliver more than equipment. They could hire radiologists, create new departments for data quality and image annotation and finally offer – all over the world – software assisted reporting.

The evolution of laboratory medicine during the last 40 years is probably a good template for the development of all diagnostic disciplines, including radiology and nuclear medicine. Maybe this process of industrialization will not be as deep as in laboratory medicine, because there will be no 1:1 correlation between every imaging study and a distinctive disease. And we will have always patients in our departments instead of probes. The patients will have questions; they need explanation of images, need injection of contrast agents and need additional images or sequences. But there will be a substantial process of industrialization. And the need for diagnostic radiologists will probably decrease, like the demand for physicians working in the field of laboratory medicine. I can imagine that there will be "diagnostic physicians", responsible for the integration of all diagnostic information, e.g. "radiopathologists"

Fact will be: We as imaging physicians – radiology or nuclear medicine – will not be asked, whether we like that or not. We just can decide, whether we want to participate in the creation or ignore it. The manufacturers of horse-drawn buggies were also not asked whether they liked the upcoming cars.

Just at the end: Some people hope, that IT in general – and maybe AI also –will reduce costs within the healthcare system. I am not convinced about that. Digitalization of radiology did not really make radiology or nuclear medicine cheaper. We improved our services and we improved our quality.

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