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Artificial intelligence and radiology

Human-machine collaboration is key

Should radiologists be buying into the hype about artificial intelligence? HealthManagement spoke to Prof. Paul Chang about AI, deep learning and the advantages of intellectual arbitrage.

Paul Chang
Professor of Radiology
Vice Chair, Radiology Informatics
Medical Director, Enterprise Imaging
University of Chicago
USA

pchang@radiology.bsd.uchicago.edu

How are artificial intelligence (AI) and deep learning shaping radiology?

In healthcare in general, and radiology in particular, we tend to buy very early into the hype surrounding any new potentially disruptive technology, whether that's Picture Archiving and Communication Systems (PACS), speech recognition or big data. But it takes us much longer to appropriately consume and actually influence 'real-world' radiology. Because we are behind other business verticals in achieving human-machine cybernetic harmony we tend to buy into the hype where we think that AI is going to either save us or replace us as radiologists. We tend to overpromise the technology benefit or overestimate the potential harm or threat. For example, we heard similar arguments when we talked about PACS—"we are now hamsters in wheels, we've lost the ability to collaborate with our patients and our clinicians", and so on.

We have always had human-machine cybernetic collaboration. Cybernetics is essentially how humans work within complex systems to achieve their goal, and it predates AI and even computers. I could not function as a radiologist without PACS, speech recognition and the electronic medical record (EMR). These are information systems that are examples of human-machine cybernetic collaboration to achieve something positive. AI, machine learning and deep learning are evolutionary (and I believe necessary) next steps to these systems.

Today radiologists and physicians are knowledge workers, who work with electronic information systems and other machines in a very complex collaboration to try to achieve desirable patient outcomes. Unfortunately, frequently we have impedance mismatches; we have inefficiencies and immaturities in the system and immaturities in how we work with information technology.

In other business verticals deep learning is ubiquitous and has been used for several years to achieve efficiencies, reduce variability and improve quality. And despite the misconceptions people have, it tends not to replace people but augments people.

We will eventually learn to appropriately consume AI and deep learning technology and work together in a cybernetically balanced way. It just takes us a lot longer in radiology.

Why do you think radiology needs to embrace AI and not fear it?

AI is neither a saviour nor a horrible threat. It's like any other disruptive technology. We will learn to appropriately consume it after going through the hype curve. In the USA radiologists are barely managing their workload, and are susceptible to burnout. Our datasets are becoming much larger, and the challenges are not just the number of images but their complexity and multispectral nature. It's a good problem from one perspective, as we can obtain much more actionable and relevant information to help positively impact patient outcomes. One of the reasons radiologists embraced PACS, even though in many ways it was more disruptive than AI, was that film-based analogue image interpretation made the application or interpretation of MRI, CT, PET, the modalities we take for granted now, impossible. That's one of the reasons we embraced PACS and take it for granted now.

Unfortunately, PACS and just the electronic distribution, management and display of images are no longer sufficient as there is so much more complexity in the image dataset. Radiology is more than interpreting images, it's about managing the role of imaging in a highly complex environment where our clients are much more demanding. Extra demands from the healthcare enterprise are putting an incredible burden on radiologists, resulting in burnout, inefficiency and variability in quality. Whatever we embrace, whether it's AI, machine learning or deep learning, we are going to need some help from advanced IT.

Because we are ten years behind other industries in adopting these technologies, by the time radiology and healthcare adopt them appropriately we will have taken them for granted in other parts of our lives. Amazon, Google, Siri and Alexa are getting much smarter now. Why? Deep learning and AI. The application of machine intelligence in other parts of our lives is already ubiquitous. My refrigerator will soon be more intelligent than my PACS and tell me if the vegetables are spoiled and ask if it would like me to reorder them.

> “DEEP LEARNING IS LIKE HAVING THE FASTEST RACE CAR IN THE WORLD. BUT EVEN RACE CARS NEED GASOLINE AND ROADS; WE HAVE NEITHER AT THIS TIME”

In medicine, by the time we actually adopt AI and deep learning it will be so pervasive in other parts of our lives that we will perceive it as ‘no big deal’. It’s going to take a lot longer than many anticipate to appropriately embrace it in radiology; unfortunately, because we buy early into the hype, that gives us plenty of time to ride the hype curve. I don’t think we should fear AI. The status quo where the bulk of the task is left to the human knowledge worker is no longer viable.

“Intellectual arbitrage is the best risk mitigation strategy”. Please explain.

With intellectual arbitrage, we can use the experience of other industries that have adopted AI and deep learning to apply it to radiology. Arbitrage exploits incomplete distribution of information or experience. Radiology and healthcare’s future is the past or present of other industries. When we look at other business verticals, without exception they bend over backwards to build human-machine cybernetically optimised IT collaboration workflow. They ensure that humans work on what they do best and reduce the system’s vulnerabilities and dependence on what humans do poorly. As humans we can do extraordinary things, we can make incredible judgments with incomplete or inaccurate information, and we can have true insight. But we are terrible at remembering, and at initiating workflow. For example, you never want to rely on a human to do things like remember to follow up a nodule that might be cancer, or remember that a patient is being seen in clinic today so their study needs to be interpreted now. Other business verticals make sure that humans are not placed in that position. Machines can do the “left brain” stuff better.

The whole idea of human-machine cybernetic collaboration is that IT takes over what humans are bad at, such as remembering things. That leaves the human to do what they do best, and that is to understand what needs to be done for the patient, prioritise what is important, gain insight and help patients. That’s not a threat to a radiologist, that's being complementary and other industries do it very well. People who are threatened by AI need to understand that this is a natural evolution of human machine collaboration, even predating computers. For example, eyeglasses and slide rules are both examples of human-machine cybernetic collaboration, so it’s nothing new.

The problem with healthcare and IT is that we tend to force knowledge workers to initiate workflow. That's an example of an impedance mismatch or suboptimal human-machine cybernetic collaboration or harmony. Our IT systems still require humans to do the right thing. If you look at PACS and our other IT systems, we use the same computer and monitors as other industry verticals; we have very similar software and databases as other industry verticals. But we are behind by ten years in optimised human-machine cybernetic collaboration where the IT and machine parts do what they do best and where humans do what they do best.

Being ten years behind other industries on AI and deep learning is not a bad thing. The reason we got away with it is that before shared risk and capitation, with fee for service there was no true competition. It upsets me when physicians say that hospital IT is “stupid.” We’re not stupid. We’re actually quite rational. In the days of fee for service it was irrational to invest any resources to have a differential advantage in IT. However, now that we have shared risk and capitation, we’re competing in earnest, and IT has to be more strategic, and our managers have to be more aggressive in looking at how we can achieve a differential competitive advantage by leveraging and optimising human-machine cybernetic collaboration.

To understand how best to achieve human-machine cybernetic balance all I need do is look at other industries. It’s the best way to mitigate risk. The problem is we don’t do it. We tend to recapitulate the errors of early adopters, including buying into hype. For example, much of the hype is coming from data scientists who, with the help of hardware graphics processing unit (GPU) assistance, can now

create very impressive deep learning systems. Some are even boldly claiming that human radiologists will soon be obsolete, replaced by these powerful creations. However, building the best deep learning system in the lab is not enough. Even if you assume that it is possible to create a deep learning system that will be a better radiologist then humans (a very strong and I believe suspect assumption), it is like building the best race car in a world without gasoline or roads. Even the best race car needs gasoline and roads.

What is the "gasoline" for AI? It is vetted annotated data (ground truth) required to train these algorithms. And the "roads" for AI is optimised integration into our existing operational workflow. Currently, we aren't even close to providing either the "gasoline" or "roads" to supply AI at scale or clinical relevance. This is one of the reasons I believe we are still very early in this journey.

I think another reason that contributes to the hype is how folks attempt to explain how AI, especially deep learning, works. Here's a drinking game for you: the next time you hear someone give a lecture on deep learning, you get to drink a beer whenever they show a picture of the neuron and then attempt to describe neural networks in some spooky magical anthropomorphic way. For many, that just adds to the level of discomfort folks have in trusting these systems. The way I teach deep learning is explaining that the methods involved have less to do with our modern neurobiological understanding of the neuron but are more related to traditional data mining statistical methods. In fact, a number of experts in the AI field have stated that deep learning is "logistic regression on steroids." This is of course an over-simplification, but a useful way to introduce deep learning to many of us in radiology.

Another way to introduce folks to deep learning is to start with traditional machine learning. In radiology we've had computer-aided detection (CAD) for a decade in breast and lung imaging. Did we hear any hype about CAD replacing us? No. These tools have always been viewed as augmentation helpers to the human radiologist. CAD is a classic example of machine learning and of traditional artificial intelligence. The key point about traditional machine learning is that these approaches typically require a very clever human being to come up with an a priori feature model that ideally differentiates between, for example, cancerous lesions versus benign ones. For instance, Dr. Maryellen Giger with her team from the University of Chicago was one of the pioneers to come up with machine learning algorithms for breast CAD. She, working with radiologists, developed an a priori feature model and based on that model used image processing methods (convolutional filters, etc.) to extract those features from images and then used statistical methods to come up with a prediction model.

In a way, deep learning is actually the dumber, brute force cousin to CAD. There is no preconceived feature model; it is replaced by lots (and I mean LOTS) of annotated training data. By using lots of vetted ground truth data and applying methods similar to traditional statistical methods (logistic regression, gradient descent, etc.), the deep leaning system can come up with an acceptable prediction model the same way feeding data to a linear regression model can come up with an acceptable prediction model. The real "deep" power comes from the ability to "chain" these statistical methods together to form multiple layers of analysis, powered by hardware graphic GPUs.

This dependence on LOTS of vetted training data (the "gasoline") is one of the reasons other industries have invested significant resources to build scalable and interoperable IT infrastructures to feed these AI systems. This is one of the most important "intellectual arbitrage" opportunities for us in radiology: we need to do the same: it is a great "hedge" strategy for health IT administrators.

You have said that you would advise CIOs in healthcare systems to move away from an EMR-centric view. Please comment.

Radiologists, CIOs and CEOs ask me what they should do on AI. I say that it's too early to pick a winner in AI, but in the meantime you can start "drilling for gas, and building roads." The strategy should be to build up IT infrastructure to be more strategic, interoperable, scalable and capable. Our IT infrastructure in hospitals is very primitive relative to other industries. It tends to be EMR-centric, PACS-centric and siloed, with no interoperability. We need to apply intellectual arbitrage and look at how other industries have built their IT stacks.

Without exception every other business vertical, whether it's Amazon, the military, banks or the pizza shop over the road, does not do it the way we do. What we have is a monolithic EMR and PACS. What they have is service-oriented architecture or microservices. They have much more agile and capable strategic IT infrastructure with better interoperability; as a result they have the ability to "appropriately consume" AI, big data and other advanced IT applications. We need to do the same. ■