The Promise of Clinical AI: An Adaptive Future

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Although some may believe the promise of artificial intelligence (AI) lies primarily in self-driving cars or automated fraud detection, AI also holds limitless potential for health care, ranging from personalized medicine based on genomics, to clinical decision support for optimized cancer treatment plans, to predictive analytics for population health management, and beyond. While challenges remain with regard to regulatory approvals, insurance reimbursement, and data sharing, healthcare experts are beginning to understand how AI can improve routine care tasks, support advanced analytics, and identify and collect the right data for the right application. With the costs of data storage decreasing and the amount of clinical data increasing, AI can serve as a transformative technology, enabling providers to identify opportunities for greater operational efficiencies, reducing care disparities, and achieving better patient health outcomes. Homer Pien, PhD, Chief Scientific Officer at Philips, recently discussed the company's Adaptive Intelligence approach to clinical AI and explained how Philips is developing the tools necessary to move health care, and radiology in particular, into the future.

***Applied Radiology* (AR): Why does radiology need artificial intelligence?**

Dr. Pien: Imaging exams are ordered to detect or track the progress of specific diseases. The pixel data captured in the exam is reconstructed into an image that is meaningful to the human brain. Radiologists have been educated to recognize, understand, and analyze the shapes, shades, and colors of these reconstructed images in order to render their diagnoses. Given the advances made in the various imaging modalities, and the high levels of sensitivity and specificity that are now possible, the limitless ways to process pixel data can generate staggering numbers of images for a radiologist to review. The potential for training a computer algorithm to recognize shifts and patterns in data more quickly than a human can help provide clinical decision support. As human beings, we're only able to utilize five to ten pieces of significant information in our decision making. Given the sheer amount of data in radiology, and the rest of medicine into which it is integrated, the user now has thousands and thousands of pieces of data to integrate. That's one of the main reasons that radiology needs AI.

The second major reason radiology needs AI is efficiency. An imaging department is relatively expensive to operate, and because of the repetitiveness of tasks and the large amounts of data, there are numerous opportunities for AI to help eliminate these inefficiencies. The need for operational efficiency in health care is critical; leaders are being pressured to do more with the huge volumes of data being collected—some of our customers

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generate more than 2 million images a week—but just a fraction of that data is being used to improve the quality and efficiency of care. The lack of interoperability between IT systems also still inhibits their ability to do more with this data.

AR: What can be done to increase effectiveness and get better insights from healthcare data?

Dr. Pien: In its most theoretical definition, an artificially intelligent program can be trained to accept information about a problem, generate a list of actions it could take, and maximize its chances of achieving goals by using logic and probability to choose the path with the highest likelihood of success. The challenge in broadly applying this approach in clinical situations is that errors can potentially bring harm to a patient. However, if we shift our thinking and focus on solving a particular clinical problem, we can readily see how clinical AI can make a dramatic difference in patient care right now.

At Philips, we've combined clinical AI techniques with a deep, contextual understanding of what's relevant to produce Adaptive Intelligence. Combining AI and other methods with knowledge of the clinical, operational, or personal context in which they are used enables technology to do a better job of satisfying all those constraints more quickly and with fewer iterations. Incorporating the clinician's understanding of what is relevant, or what is likely to change because it's intrinsic to the physiology or the biology of the disease--this is the contextual understanding that Adaptive Intelligence really implies. Without it, one risks catastrophic failures, and we just cannot tolerate errors like that in health care.

AR: What are some clinical areas where Adaptive Intelligence can have the most impact?

Dr. Pien: Radiation treatment planning is one clinical problem that Adaptive Intelligence can help solve. When radiation treatment is indicated, the first step is to plan a radiation therapy session. This is not an easy task; the entire care team, from the physicist to the radiation oncologist, must often re-plan and restart the process until they are in agreement on the plan. It typically takes about 12 days from imaging to the first radiation dose. Adaptive Intelligence can enable us to reduce that time to 1-2 days by eliminating the manual planning iterations while accounting for all of the variables that go into radiation therapy planning. If you create a system that can configure the most optimal plan the first time, every single time, then you have a radical improvement in patient care.

Without Adaptive Intelligence, the difference between correlation and causation is extremely significant in a scenario involving AI. To identify something that's indicative of disease, we don't want to make a conclusion based on just one feature in an image, because the next set of images may not

have the same feature. To the degree possible, we want to understand whether it's causing that disease; whether it's part of the pathophysiological process, and we work very hard to elucidate that chain of events so that when we're designing a neural network, we're selecting those factors that are important to the patient's physiology. From an efficiency perspective, Adaptive Intelligence is reducing the workload on radiologists, and more importantly, creating greater capacity for radiologists to work as part of an integrated care team to provide better care for patients.

AR: How is Philips bridging the data gap to share the early successes of Adaptive Intelligence?

Dr. Pien: Philips strongly believes across the board that AI augments the role of radiologists and is not meant to replace them. AI and deep-learning networks are currently, and will continue to be, very narrowly defined, so if we train a program with 500 examples of lung disease, for instance, that's all it will do. But when a patient with lung disease experiences heart failure, and his enlarged heart is visible in the chest image, will it confound the neural network? Human beings are trained to identify and understand confounding factors, but it's difficult for an AI algorithm, and even more difficult to train that data properly.

Because cancer patients receiving treatment often develop other serious conditions, each patient's experience is different. If you are using similar patient data to develop a clinical algorithm, as we define disease in ever more precise terms, the number of patients in any one institution becomes smaller and smaller to satisfy all the permutations. You get to the problem of not getting a large enough sample size to train the network.

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We're excited to introduce a new project that will help alleviate this problem and facilitate data sharing among our customers to promote better patient outcomes. For example, for some cancer patients, therapies can cost as much as $400,000. If the patient is not going to respond to that therapy, it's not only incredibly expensive, but there's also an opportunity cost. Not being on the drug that's most effective the first time is bad for the patient, bad for the hospital, and bad for everyone all around if you don't pick the right therapy the first time. So that's what we're building.

We announced earlier this year that we're working with Dana-Farber Cancer Institute, one of the leading cancer treatment facilities in the country, to establish best practices in cancer care. The Dana-Farber Clinical Pathways will be deployed through Philips' IntelliSpace Precision Medicine, providing clinical decision support to physicians via a patient-centric solution. The implementation will help oncologists quickly obtain the most appropriate

treatments, based on the unified view of the patient across diagnostic modalities and the embedded knowledge of Clinical Pathways, and can be delivered through existing electronic health record platforms. What we've been able to encapsulate is how they treat patients in terms of the clinical pathways they select. For example, if I am treating a Stage 3 lung cancer patient with a particular mutation, I can see how Dana-Farber's clinicians would treat a similar patient. This decision tree is completely embedded within our IntelliSpace Precision Medicine. This doesn't necessarily mean that Dana-Farber's approach is the correct way for other clinicians to treat their own patients, but it does offer a standard of care from an institution that is generally thought of as one of the top cancer centers in the U.S.

Ideally, we would have one treatment pathway that is better than another or leads to a lower cost than another. We're not there yet, but mapping the Dana-Farber clinical pathway is a very significant and exciting first step.

AR: What are some other areas where AI can help radiology?

Dr. Pien: In the very near term, we are developing solutions around repetitive workflow tasks, and operational tasks like scheduling patients, or better understanding why patients don't show up for their imaging exams to help predict which ones have the highest likelihood of not showing up. New tools can help radiologists and staff take action proactively so that these patients come to their exams.

Another example is examining patient follow up. At the end of every single radiology report is a set of follow-up actions to be taken. In a substantial portion of the reports that we've examined, the follow-up actions were never taken. Those are the things that create a lot of fatigue. When a clinician works hard to take care of a patient, we know what the next thing to do should be and the patient doesn't follow up. This is the sort of thing that causes frustration, and high costs to the healthcare system. When that patient finally does come back, they're in a much direr situation then if they had followed the clinician's instructions.

These are some of the things that cause patient dissatisfaction, that cause staff fatigue, and stress the healthcare system. Radiologist burnout is reaching an epidemic stage across the U.S. healthcare system. Changing the patient experience and improving staff experiences are highly compelling topics for AI to tackle. There are clinical things that we're working on, but a lot of our effort is also going into trying to make the radiologist more efficient, and to trying to make their jobs more fulfilling. With a greater impact, they can better integrate to other service lines, because radiology doesn't stand on its own, it's part of a broader context of diagnostics.

AR: How does health care move into the future using AI?

Dr. Pien: The true power of AI can only be realized by working hand-in-glove with healthcare professionals. The successful application of AI requires deep contextual knowledge of the clinical and operational context in which it's used and should involve seamless integration with other technologies. With all the data being collected in hospitals by new medical devices and equipment, and rising expectations for improved patient health outcomes, the case for AI adoption is compelling and every opportunity to make clinical and operational improvements should be explored.