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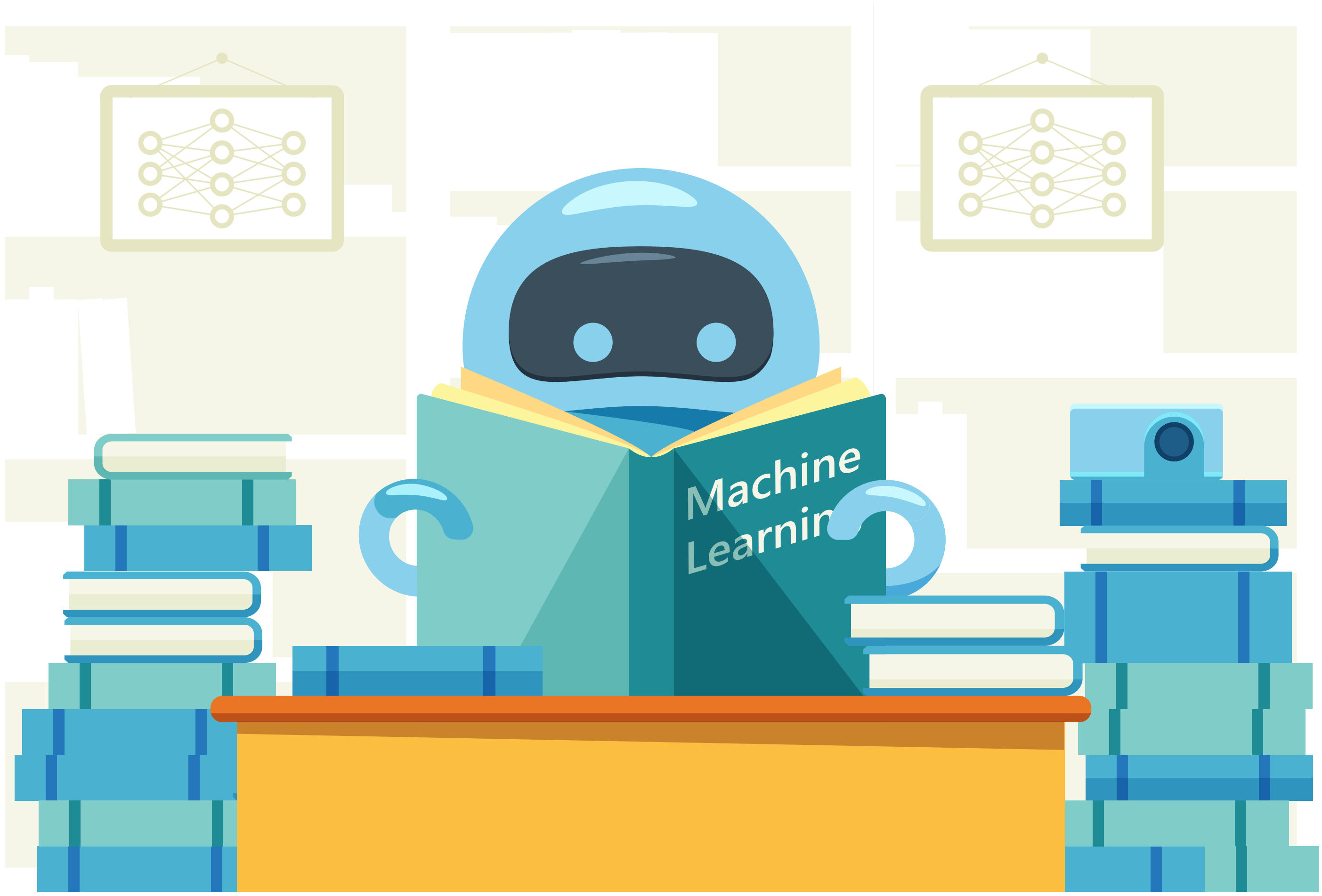

Eight ways machine learning is assisting medicine

There has been a lot of hype around the applications of machine learning in medicine. But how is machine learning actually helping bench-to-bedside scientists and clinicians do their jobs?

Mike May

The idea of improving medicine with computation is almost as old as digital computers. In the early 1960s, scientists used a computer in diagnosing blood diseases, and that was just one pioneering example in this field. In the branch of artificial intelligence (AI) called 'machine learning', computer software learns from experience. The results teach medical researchers and clinicians new ways of studying diseases, making medicines and treating patients.

In the lab

Computation in general enhances several key areas of clinical research, and AI-based methods promise even more applications for researchers. Despite not being in wide use so far, machine-learning systems already influence several areas of clinical research, such as appreciating the value of big data.

1. Reconstructing diseases

Combining machine learning with multi-modal datasets and almost unlimited computing power allows clinical researchers to "reconstruct the underlying mechanisms of disease," says Colin Hill, CEO and cofounder of GNS Healthcare. For example, GNS Healthcare's AI-driven simulation platform Gemini provides a computer model of the progression of multiple myeloma and drug responses. This model "harnesses the power of causal machine learning and simulation and in-depth clinical and molecular patient data to allow pharma companies to simulate drug response at the individual patient level," Hill explains.

2. Hypothesis testing

In any medical research, predicting the outcome for a particular scenario proves very difficult. "With partial or imperfect biological knowledge, statistical models are the best way to reveal structure and predict outcomes," says David Watson, doctoral candidate at the Oxford Internet Institute of the University of Oxford and founding member of the Digital Ethics Lab. "It is not always obvious how to do this with clinical data alone, and although clinicians are often confident that genomic information can solve the problem, this data is so noisy that it may make the task harder rather than simpler." By combining information from clinicians and data-science tools, including machine learning, scientists can develop a hypothesis, model it, adjust it, and replicate the process in an iterative manner. "This requires close collaboration between clinicians and data scientists, who tend to conceptualize problems rather differently, but getting people with different realms of expertise to work together on challenging problems is what good research is all about," Watson says.

3. Recruiting patients

Clinical trials provide a key element of medical research, and one complicated challenge is recruiting patients. As pharmacologist Mira Desai of the Nootan Medical College & Research Centre in India wrote, "Surprisingly, participant enrollment issues are the major reasons for trial terminations." Machine learning could help medical researchers solve that problem. At the Commonwealth Scientific and Industrial Research Organisation in Australia, a group of scientists developed a machine-learning technique that explores patient medical records to find people who would fit specific trials. This example is one of many in which machine learning is just getting started in improving clinical trials.

4. Big data

"In the past, a large dataset for clinical researchers would often mean hundreds of patients only," says Pearse Keane, consultant ophthalmologist at the UK-based Moorfields Eye Hospital NHS Foundation Trust. "As a byproduct of the infrastructure required for machine learning, we are starting to be able to aggregate much, much larger datasets." Keane studies age-related macular degeneration, which is the most common cause of blindness in Europe, the UK and the USA, as well as in many other countries. "In the next decade," Keane says, "I anticipate we will be doing clinical studies using images from every patient diagnosed with [age-related macular degeneration], perhaps running into the hundreds of thousands of patients per year."

In the clinic

In the clinic, machine learning offers great promise, but much work lies ahead. As Keane says, "There is a huge gap between showing a proof of concept in a research paper and actually deploying a machine learning system in the real world — something that Eric Topol of Scripps Research and I have described as 'the AI chasm.'" He adds, "There is undoubtedly huge potential for machine learning to transform healthcare, but going 'from code to clinic' is the hard part."

5. Developing diagnostics

From military applications to medicine, computation can be used to analyze images. Imaging and clinical experts Dineo Mpanya and Nqoba Tsabedze of the Charlotte Maxeke Johannesburg Academic Hospital in Johannesburg, South Africa, teamed up to describe the impact of machine learning on the interpretation of medical images, such as chest X-rays. Subtypes of machine learning, such as convolutional neural networks, "can identify subtle changes in chest X-ray films, and in some instances, the accuracy levels for diagnosing conditions, such as pneumonia, are equivalent or superior to that of clinicians," the scientists note. "Unlike traditional statistical methods, where inferences are made based on the population studied, machine-learning algorithms mimic human cognitive processes when making decisions."

In April 2018, the US Food and Drug Administration approved the first AI-based diagnostic, IDx-DR, which detects diabetic retinopathy in people with diabetes by analyzing retinal images. Machine learning will soon be applied to many other medical conditions, from cardiology to neurodegenerative diseases and beyond.

6. Improving prognostics

In addition to using it to diagnose conditions, clinicians can use machine learning to predict a patient's prognosis. The first application that comes to mind here is usually cancer. For example, one international team of scientists developed a machine learning–based tool that analyzes the prognosis of patients with stage III colon cancer, and the group reported that the results "could provide crucial information to aid treatment planning" for people with this disease. Plus, John Halamka, president of the Mayo Clinic Platform, and his colleagues suggested that machine learning might improve a clinician's ability to determine the likely outcome of a patient with COVID-19. As with the use of machine language in clinical diagnosis, work in prognosis promises many improvements ahead.

7. Patient monitoring

Traditionally, physicians come in contact with patients after symptoms appear — sometimes not even until an illness creates a health crisis. "This is slowly changing with the development and increasing use of predictive analytics linked to machine learning and artificial intelligence models," says Ali Rezai, the John D. Rockefeller IV Chair in neuroscience at West Virginia University. One day, machine learning and wearable technology could continuously monitor a person's health. "Two of the most commercially available AI systems are incorporated in devices like the Apple Watch or the Kardia Alivecor devices, which can detect arrhythmias and send alerts to patients through their smartphone apps," Rezai says. "While this is not fully integrated into the current clinical flow, AI will likely have a big impact in cardiology, cancer, and neurosciences by helping stratify and profile patients, enabling more proactive management and care."

8. Requiring collaborations

Perhaps more than anything else in medicine, machine learning promises to drive collaboration — in fact, getting the most from machine learning–based applications depends on it. That is exactly what Maria Littmann, a doctoral candidate in bioinformatics at Technical University Munich, and her colleagues found when they analyzed 250 articles that described applications on machine learning in biology or medicine. These scientists discovered that 73% of the machine-learning applications in these articles arose from interdisciplinary collaborations of computational scientists, biologists and medical experts.

Experts from different fields bring varying perspectives and different modes of data, such as genomic and patient information, as well as different ways to analyze the data. Such collaborations will build bigger datasets. "As the volume of multi-modal data grows, the potential for machine learning's impact on clinical research grows with it," Hill says. "So far, we have just scratched the surface, and the impact is clear: Machine learning fueled by the right data has the power to transform the development of breakthrough, new medicines and optimize their use in patient care." ❐

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