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Letter to the editor

Artificial Intelligence in Neurosurgery: A Comment on the Possibilities

Luis Perez-Breva[1], John H. Shin[2]

[1]MIT School of Engineering, Massachusetts Institute of Technology, Cambridge, MA, USA
[2]Department of Neurosurgery, Harvard Medical School, Massachusetts General Hospital, Boston, MA, USA

Corresponding Author
Luis Perez-Breva
https://orcid.org/0000-0002-3653-9476

MIT School of Engineering, Massachusetts Institute of Technology, 25 Ames St., Room 66-548, Cambridge, MA 02139, USA
Tel: +1-617-253-8653
E-mail: lpbreva@mit.edu

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To the editor

What people call artificial intelligence (AI) has begun to permeate our work and home environments. It provides customer service to consumers, suggests travel routes, and figures out when to turn up thermostats in our homes. It promises to empower precision medicine, handling of medical records, and eventually even replace human drivers. Professionals of all sorts turn to AI applications as "partners" in the work they do. How much should you believe? And most importantly, how can it help neurosurgeons?

So-called generalized intelligence remains a distant, elusive aspiration. But there are ample opportunities to avail ourselves to the tools of AI to push the envelope and help discover and answer new questions in myriad fields, including neurosurgery. That requires understanding what the tools can do and how to phrase problems in neurology and neurosurgery to overcome the many limitations of these AI tools and make the most out of them.

When the editors of *Neurospine* suggested we write a commentary, another particularly intriguing opportunity rose to mind: understanding how the neurology and neurosurgery community might benefit from the tools of AI could also help AI itself. The AI community has always hoped to gain inspiration from the way our brains (and entire perceptual and mechanical apparati) might work. Cognitive science has provided some of that, but as computational technology makes AI tools increasingly accessible for neurosurgery research, is there room to imagine collaborations that inform new opportunities in neurosurgery and new insights for AI following from a finer understanding among computer scientists of the phenomenally complex, robust architectures that support what we call "intelligence"?

To get there, we need a shared understanding of what AI tools can and cannot yet do. Think of there being 2 ways to use AI. One is typically associated with analytics, regression, classification models, and statistical learning. These tools make the most sense when you have plenty of data. As long as you reduce a problem to a single factor and you have enough data, these tools can power fairly sophisticated software that interprets medical images, anticipates outcomes, or helps spot correlative trends you had not noticed. In these cases, AI tools are not providing fundamentally "new" insights; this is just modeling that may be extraordinarily complex and beyond most human comprehension. And just about everyone seems to think the magic formula for this is more data.

Using AI tools this way is the most common and simplest. It is also the source of much of the common confusion—and, frankly, panic—about AI, which most people tend to think of as doing what humans already do, but better—such as outperforming humans at, say, statistical tasks. That's the source for the fear over AI simply as automation rather than as advancing human intelligence.

Again, though, there are 2 ways to think about using AI. The other one sees AI as giving us fundamentally new tools to find things, not by scouring data but by using ideas and examples—like how a computer can search and find a picture of you after being told about how you look. At this frontier of AI, it can make seemingly disparate pieces of information comparable; help build narratives that attach and explain meaning to complex data; and make inferences without a model, with less data, or altogether avoiding the kind of intermediary questions that may be useful and even necessary for human understanding but are not needed for computing. That last one, in other words, is AI helping us go where current models cannot.

In that latter sense, AI fulfills a role somewhere between theory and practice that may be particularly suitable for medicine —especially when our models of science are incomplete or simply more conducive to understanding than to action. The tools of AI can afford the means to think about problems—indeed, even *science* itself—in ways that may simply be out of reach for our human brains.

One of the present authors has an example from more than 20 years ago, when he and his colleagues invented a technology to locate cellphones in dense urban environments much faster and more accurately than GPS (Global Positioning System) ever could. The standard approach would be to force tons of data into a model (likely overengineered) in search of some "truth" that would lead to the answer. The group, however, was stuck: quite early on, they recognized that while traditional science helped explain the problem, and that it should be *possible* to locate the cellphone, traditional science could not actually solve it. Put more accurately, it was the limitation in human thinking about science that was failing, not science itself. So, they focused their attention on building an AI that could figure out science they did not even know.

This mattered immensely, because the reason for confronting the problem was that 911 emergency services could not locate a distress call precisely. Today, this invention is how you are found. The same technology also helps mobile carriers spot coverage problems in their networks, optimize traffic, and provide better overall service.

All this can be in the service of tackling real problems we cannot resolve in any other way—including, as already mentioned, with *known* science.

So, what might something similar to the cellphone application, or any of these other applications, look like in the medical world—neurosurgery in particular? For example, one of the most common clinical scenarios neurosurgeons see routinely is cervical disc degeneration causing spinal cord and nerve compression. Though the indication for surgery is familiar to neurosurgeons—unrelenting pain, weakness, loss of function, and coordination—the question of not only how much the symptoms will improve but also which ones will improve and over how much time eludes surgeons. Most neurosurgeons have patients whose symptoms never improve despite decompression. Why is this so? Is it the degree of compression prior to surgery or the duration of such? It is nearly impossible to study duration as magnetic resonance imaging (MRI) of the spine is not routinely performed for any health maintenance measure. As a highly specialized diagnostic test, it is used relatively sparingly by most general primary care physicians so there is a lack of longitudinal data that we would be able to study with traditional means. Patients may also present with severe radiographic findings on MRI yet are asymptomatic. This is one of the most challenging situations. Spinal cord and nerve compression may be clearly visible on MRI but in the absence of symptoms, is there benefit to early intervention? Or is observation sufficient? Is it worth subjecting an asymptomatic patient to the risks and potential complications of surgery?

The opportunities, we believe, abound. Beyond posing questions we may not even be able to think of due to our inherent human limitations and the present limitations of our models, AI could harness latent knowledge in data about surgeries of a specific type that could allow for calculations we can hardly imagine and, by doing so, reveal new and more effective treatment paths. There has already been some work by one of the present authors showing how AI can help doctors build disease map from clinical trial headers—in other words, using less data to get to answers.[1]

The most promising future collaborations between neurosurgery and AI will emerge from outgrowing the definition that has made AI so desirable and frightening at the same time. It is not about replacing human neurosurgeons, but about using AI to learn more from every example of neurosurgery. That is a path to expanding the breadth of capabilities of our own human brains, not by copying human generalized intelligence but rather by being guided by and to *another* intelligence.

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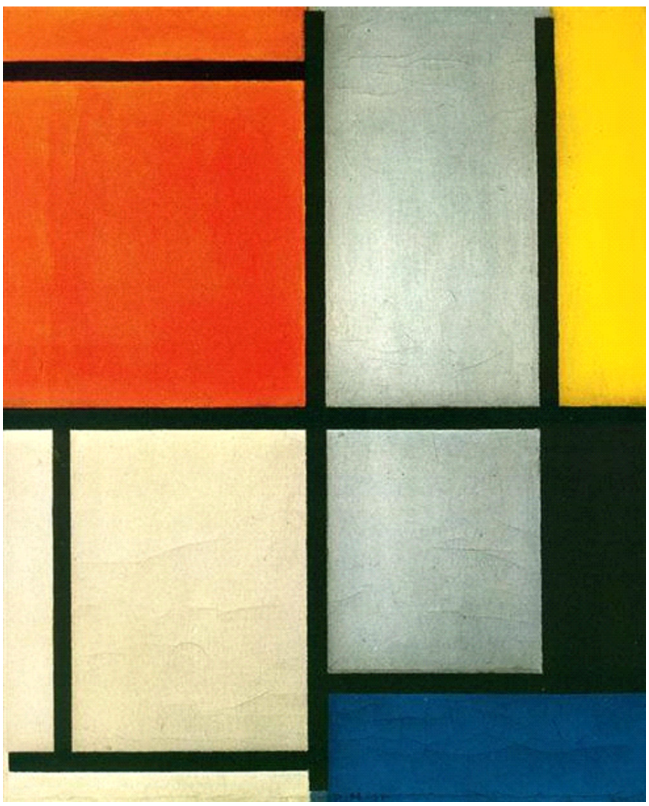
CONFLICT OF INTEREST

The authors have nothing to disclose.



Title: Tableau 3 with Orange -Red, Yellow, Black, Blue and Gray
Artist: Piet Mondrian
Year: 1921

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