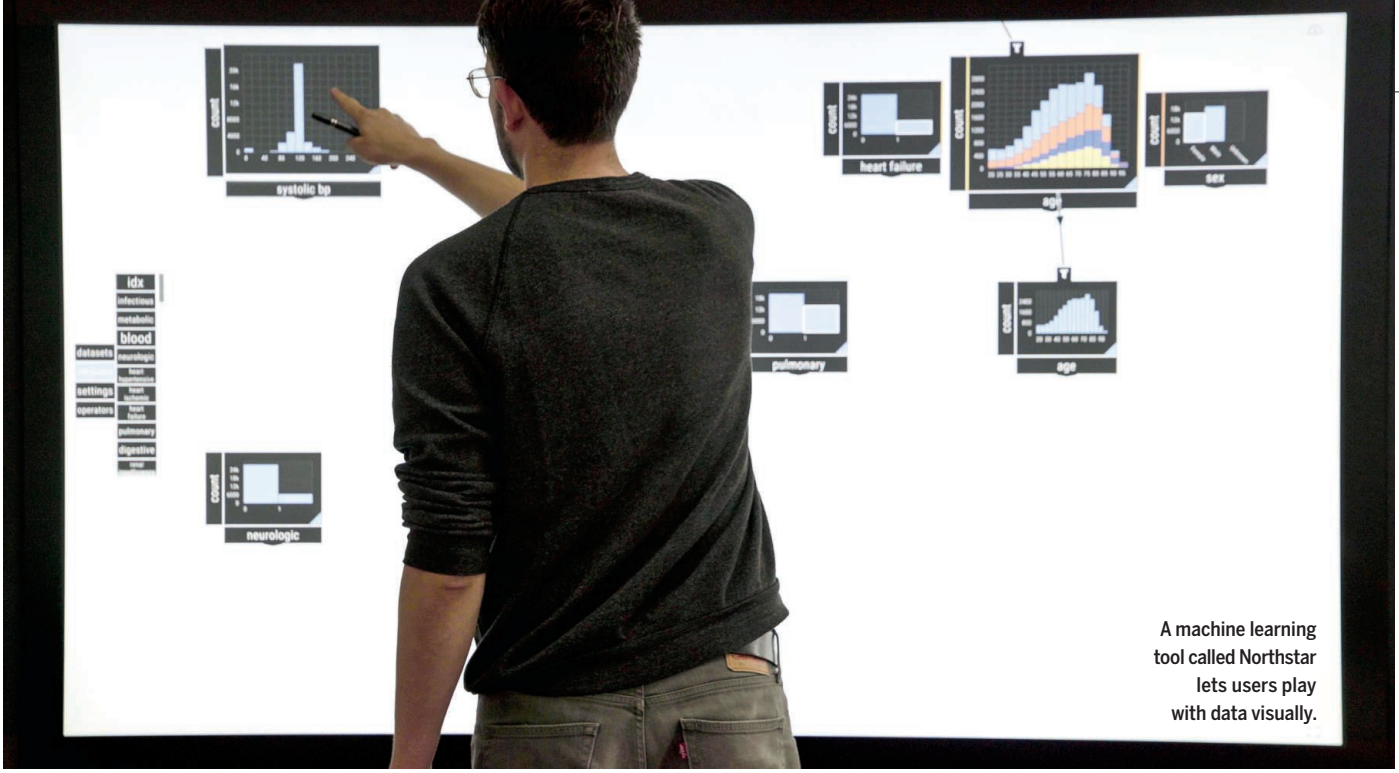

A machine learning tool called Northstar lets users play with data visually.

PHOTO: MELANIE GONICK

ARTIFICIAL INTELLIGENCE

Bringing machine learning to the masses

Scientists without coding skills adopt easy-to-use artificial intelligence software

By **Matthew Hutson**

Yang-Hui He, a mathematical physicist at the University of London, is an expert in string theory, one of the most abstruse areas of physics. But when it comes to artificial intelligence (AI) and machine learning, he was naïve. "What is this thing everyone is talking about?" he recalls thinking. Then his go-to software program, Mathematica, added machine learning tools that were ready to use, no expertise required. He began to play around, and realized AI might help him choose the plausible geometries for the countless multidimensional models of the universe that string theory proposes.

In a 2017 paper, He showed that, with just a few extra lines of code, he could enlist the off-the-shelf AI to greatly speed up his calculations. "I don't have to get down to the nitty gritty," He says. Now, He says he is "on a crusade" to get mathematicians and physicists to use machine learning, and gives about 20 talks a year on the power of these new user-friendly versions.

AI used to be the specialized domain of data scientists and computer programmers. But companies such as Wolfram Research, which makes Mathematica, are trying to democratize the field, so scientists without AI skills can harness the technology for recognizing patterns in big data. In some cases, they don't need to code at all. Insights are just a drag-and-drop away. Computational power is no longer much of a limiting factor in science, says Juliana Freire, a computer scientist at New York University in New York City who is developing a ready-to-use AI tool with funding from the Defense Advanced Research Projects Agency (DARPA). "To a large extent, the bottleneck to scientific discoveries now lies with people."

One of the latest systems is software called Ludwig, first made open-source by Uber in February and updated last week. Uber used Ludwig for projects such as predicting food delivery times before releasing it publicly. Ludwig can train itself when fed two files: a spreadsheet with the training data and a file specifying which columns are the inputs and outputs. Once it learns to recognize associations, the software can process new data to label images, answer questions, or make numerical estimates.

At least a dozen startups are using it, plus big companies such as Apple, IBM, and Nvidia, says Piero Molino, Ludwig's lead developer at Uber AI Labs in San Francisco, California. Scientists are using it to analyze images from telescopes and microscopes. Tobias Boothe, a biologist at the Max Planck Institute of Molecular Cell Biology and Genetics in Dresden, Germany, uses it to visually distinguish the thousands of species of flatworms, a difficult task even for experts. To train Ludwig, he just uploads images and labels. "Just to get something started and get a result was superstraightforward," he says.

The AI tools are more than mere toys for nonprogrammers, says Tim Kraska, a computer scientist at the Massachusetts Institute of Technology in Cambridge who leads Northstar, a machine learning tool supported by the $80 million DARPA program called Data-Driven Discovery of Models. Wade Shen, who leads the DARPA program, says the tools can outperform data scientists at building models, and they're even better with a subject matter expert in the loop.

In a demo for *Science*, Kraska showed how easy it was to use Northstar's drag-and-drop interface for a serious problem. He loaded a freely available database of 60,000 critical care patients that includes details on their demographics, lab tests, and medications. In a couple of clicks, Kraska created several heart failure prediction models, which quickly identified risk factors for the condition. One model fingered ischemia—a poor blood supply to the heart—which doctors know is often codiagnosed with heart failure. That was

"almost like cheating," Kraska said, so he dragged ischemia off the list of inputs and the models immediately began to retrain to look for other predictive factors.

Maciej Baranski, a physicist at the Singapore-MIT Alliance for Research & Technology Centre, says the group plans to use Northstar to explore cell therapies for fighting cancer or replacing damaged cartilage. The system will help biologists combine the optical, genetic, and chemical data they've collected from cells to predict their behavior.

The Wolfram computer language, which powers Mathematica, does require some coding to tap into its machine learning tools, but it makes thousands of complex functions available through simple language-like commands. In a demo for *Science*, Jon McLoone, a strategist at Wolfram in Oxford, U.K., trained his computer's camera to recognize when he was forming a rock, paper, or scissors with his hand—without specifying what type of algorithm to use. In this case, it chose a neural network—an algorithm made of interconnected layers inspired by the brain.

Marco Thiel, an applied mathematician at the University of Aberdeen in the United Kingdom, was so enamored with the program that he used it to train an algorithm to distinguish cats from toddlers, and connected the software to a camera and a garden sprinkler. Now, the sprinkler soaks the neighbor's pet when it intrudes—but isn't triggered by his own daughter. He also works with drug companies that are sifting through patient data in search of early signs of dementia or the triggers of epileptic seizures. To search for telltale patterns, Thiel feeds Mathematica patient data from home cameras, appliances, and wearable devices like Fitbits.

The trend toward off-the-shelf AI has risks. Machine learning algorithms are often called black boxes, their inner workings shrouded in mystery, and the prepackaged versions can be even more opaque. Novices who don't bother to look under the hood might not recognize problems with their data sets or models, leading to overconfidence in biased or inaccurate results.

But Kraska says Northstar has a safeguard against misuse: more AI. It includes a module that anticipates and counteracts typical rookie mistakes, such as assuming any pattern an algorithm finds is statistically significant. "In the end it actually tries to mimic what a data scientist would do," he says. ■

Matthew Hutson is a journalist based in New York City.

PALEONTOLOGY

Fossils show large predator prowled Cambrian sediments

"Millennium Falcon" stirs up ideas about ecosystems at the dawn of animal life, 500 million years ago

By **Joshua Sokol**

In the summer of 2018, paleontologists hammering away at rocks high in the Canadian Rockies turned up hundreds of specimens of an unknown, but evidently hyperabundant creature. With a hand-size carapace that looks like it was sketched out in science fiction concept art, the diggers nicknamed it "the spaceship" (*Science*, 23 November 2018, p. 880). Now, they've given the creature its first scientific description and a name: *Cambroraster falcatus*—after the famed Millennium Falcon starship from *Star Wars*.

"It's just such a bizarre-looking animal" says Joseph Moysiuk, a graduate student at the University of Toronto in Canada and first author of the study published this week in the *Proceedings of the Royal Society B*. "We thought we'd have a little fun."

Cambroraster falcatus **got its name from its spaceshiplike carapace.**

The ship was one of the largest known animals of its day to churn up the sea floor. It sailed in fleets over muddy ocean sediment, plying its unusual claws in the hunt for small prey.

Most fossils of the animal showed only hard parts. But one specimen preserved the entire creature: a carapace with two eyes peeking out from either side, trailed by soft, undulating flaps for swimming. "You so rarely get the whole body," says paleontologist Allison Daley of the University of Lausanne in Switzerland, who did not participate in the research. "I was really excited when I saw this."

The fossils come from the Burgess Shale, a formation that for more than a century has yielded a strange and world-famous menagerie living roughly 507 million years ago, during the first bloom of animal life on Earth. During this period, burrowing organisms and their would-be predators like trilobites began an evolutionary arms race that may have helped spur the explosion of new forms. But most creatures were small, and no digging carnivores of this size had come to light.

Cambroraster had a round mouth lined with toothlike plates, fronted with comblike claws it could hold out like a basket. Its eyes sat in deep notches that give the carapace its signature "spaceship" look. Expedition leader Jean-Bernard Caron of the Royal Ontario Museum (ROM) in Toronto and Moysiuk place it in the radiodontans, a long-enigmatic group of extinct arthropods.

Radiodonts offer a glimpse of how today's arthropods evolved their now-standardized body plan from stranger beginnings. The most famous radiodont is the free-swimming *Anomalocaris*, the Cambrian's iconic meter-long apex predator. Others in the group were filter feeders, and now *Cambroraster* shows that some scrounged the sea floor like modern-day horseshoe crabs. Given that radiodonts filled so many ecological niches, it's "surprising they got outcompeted," says Harvard University paleontologist Joanna Wolfe.

In 2018, the ROM team unearthed dozens of separated carapaces and claws in single layers of shale, suggesting *C. falcatus* individuals had congregated and then molted their exoskeletons, huddling together for safety or to reproduce, like some arthropods do today.

Back at the museum, the team found unrecognized or mislabeled "spaceships" in drawers and realized that *C. falcatus* lived at other Burgess Shale sites, too. Last year, a Chinese team published a fossil carapace with a similar shape from the 518-million-year-old Chengjiang biota. And paleontologist Liu Yu of Yunnan University in Kunming, China, is studying yet another Cambrian creature that he intends to assign to the genus *Cambroraster*. "I think this animal was widespread worldwide," Liu says. ■

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PHOTO: JOHN LEHMANN/ROYAL ONTARIO MUSEUM

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