up with concise equations such as $E = mc^2$. To do this, they had to design a new type of neural network, a machine-learning system inspired by the structure of the brain.

Conventional neural networks learn to recognize objects — such as images or sounds — by training on huge data sets. They discover general features — for example, 'four legs' and 'pointy ears' might be used to identify cats. They then encode those features in mathematical 'nodes', the artificial equivalent of neurons. But rather than condensing that information into a few easily interpretable rules, as physicists do, neural networks are something of a black box, spreading their acquired knowledge across thousands or even millions of nodes in ways that are unpredictable and difficult to interpret.

So Renner's team designed a kind of 'lobotomized' neural network: two sub-networks that were connected to each other through only a handful of links. The first sub-network would learn from the data, as in a typical neural network, and the second would use that 'experience' to make and test new predictions. Because few links connected the two sides, the first network was forced to pass information to the other in a condensed format. Renner likens it to how an adviser might pass on their acquired knowledge to a student.

Planet positioning

The team gave the network simulated data about the movements of Mars and the Sun in the sky, as seen from Earth. From this point of view, Mars's orbit of the Sun appears erratic; for example, it periodically goes 'retrograde', reversing its course. For centuries, astronomers thought that Earth was at the centre of the Universe, and explained Mars's motion by suggesting that planets moved in small circles, called epicycles, in the celestial sphere. But in the sixteenth century, Nicolaus Copernicus found that the movements could be predicted with a much simpler system if both Earth and the planets were orbiting the Sun.

The team's neural network came up with Copernicus-style formulae for Mars's trajectory, rediscovering "one of the most important shifts of paradigms in the history of science", says Mario Krenn, a physicist at the University of Toronto in Canada, who works on applying artificial intelligence (AI) to scientific discovery.

Renner stresses that although the algorithm derived the formulae, a human eye is needed to interpret the equations and understand how they relate to the movement of planets around the Sun.

This work is important because it is able to single out the crucial parameters that describe a physical system, says roboticist Hod Lipson at Columbia University in New York City. "I think that these kinds of techniques are our only hope of understanding and keeping pace with increasingly complex phenomena, in physics and beyond," he says.

Renner and his team want to develop AI technologies that could help physicists to solve apparent contradictions in quantum mechanics. The theory seems to produce conflicting predictions about the outcome of an experiment and how it is seen by an observer who is subject to its laws (D. Frauchiger and R. Renner *Nature Commun.* **9**, 3711; 2018).

"It's possible that the current way [quantum mechanics is] formulated is in some way just a historical artefact," says Renner. He adds that a computer could potentially come up with a formulation that is free of such contradictions, but the team's latest techniques are not yet sophisticated enough to do so. To move towards that goal, he and his collaborators are trying to develop a version of their neural network that can not only learn from experimental data, but also propose entirely new experiments to test its hypotheses.

ACADEMICS IN SOUTH KOREA CAUGHT NAMING KIDS AS CO-AUTHORS

The practice was probably used to improve the children's chances of securing a university place.

KIM HONG-JI AUN/REUTERS

Dozens of papers with child authors who did not contribute to the work have been identified.

By Mark Zastrow

The number of South Korean academics accused of naming children as co-authors on research manuscripts — even though the children did not contribute to the research — continues to grow. An education ministry report released last month details 11 university academics who named high-school- or middle-school-aged children on papers that the children allegedly did not contribute to. Nine of these are newly identified, bringing the total number accused to 17, and the total number of papers affected to 24, since the practice was exposed in late 2017.

Five of the nine newly identified academics named their own children on papers, said the report. One named a child of an acquaintance, and the others had no special relationship to the children. It is thought that in some cases, the children were named on papers to boost their chances of winning university places, for which competition in the country is fierce. The papers the ministry has identified as problematic stretch back at least as far as 2007.

The report's release comes amid intense national scrutiny of the way children of South Korea's wealthy, well-connected 'elite' get accepted to university. Unjustified authorship is considered research misconduct in South Korea.

The report follows an announcement by the education ministry in May, in which it said that it had found nine university academics who gave unjustified co-authorship to children. One of those, the ministry has now told *Nature*,

was later absolved after the academic filed an objection. The 8 other academics, along with the 9 identified in the latest report, bring the total accused to 17.

In South Korea, research misconduct can carry harsh penalties. The education ministry says that disciplinary actions under consideration for the cases include reprimands, a one-year limitation on participating in national research activities, and dismissal. At least one academic, at Sungkyunkwan University in Seoul, has reportedly been dismissed, and another academic at the same university has been reprimanded over the allegations, the ministry says. When asked to confirm this, the university pointed *Nature* to the ministry report.

Misconduct uncovered

The practice of adding children to papers came under scrutiny in late 2017, when a case of child co-authorship was uncovered at Seoul National University. After that, the government launched an investigation, and in January 2018 the ministry said that it had identified 82 academic papers with child co-authors. On about half of the papers, the ministry said, students seemed to have participated in the research as part of a school programme, whereas on the other half they had not. At the time, the ministry did not say how many academics were involved, but said that it would refer the cases to university ethics committees to confirm whether the children's involvement was legitimate.

The ministry and universities have now identified a total of 794 publications with child co-authors, of which 549 have been reviewed, the education minister Yoo Eun-hae said in a statement on 17 October. Of those, the ministry found that 24 papers had unjustified authorship. The ministry's report did not say in which journals the problematic papers had been published.

Of the 11 university academics referred to in the latest report, the ministry highlights several cases in which a child got into university after citing an allegedly problematic co-authorship in their application.

So Young Kim, a science and technology political scientist at the Korea Advanced Institute of Science and Technology in Daejeon, thinks the problem is likely to go well beyond those cases uncovered so far. "My impression is that this practice is more widespread than we might think," she says.

Changgu Lee, a materials scientist at Sungkyunkwan University's Suwon campus, says that he doesn't agree with papers being used for university entry. "I don't like colleges emphasizing publications in admission process because high-school students cannot be involved in research seriously, and because publication achievement can be misused for admission," he says.

SPACEX

SpaceX sent 60 communications satellites into orbit on 11 November.

SPACEX LAUNCH HIGHLIGHTS THREAT OF 'MEGACONSTELLATIONS'

Astronomers fear that plans to send tens of thousands of satellites into orbit will disrupt observations.

By Alexandra Witze

Space-flight company SpaceX launched 60 communications satellites into orbit this week as the basis for a web of spacecraft designed to provide global Internet access. But many astronomers worry that such 'megaconstellations' – which are also planned by other companies that could launch tens of thousands of satellites in the coming years – might interfere with crucial observations of the Universe. Researchers fear that the satellites could disrupt frequencies used for astronomical observation, create bright streaks in the sky and increase congestion in orbit, raising the risk of collisions.

SpaceX sent its second set of these satellites – called Starlinks – into orbit from Cape Canaveral, Florida, on 11 November. The first 60 went up in May. But these launches are just the beginning: by the end of 2020, there could be hundreds of Starlinks in orbit, and SpaceX envisions thousands in the years to come. Other companies, such as Amazon, headquartered in Seattle, Washington, and London-based OneWeb, are planning launches that altogether could more than double the number of existing satellites. They are meant to bring reliable Internet to under-served communities worldwide, and have other potential applications, including improving satellite Internet for military planes.

Although it's not clear how many of the planned megaconstellations will actually be built, several researchers have begun to analyse how the satellite networks could affect astronomy. The situation doesn't seem as bad as initially feared, but might still dramatically shift how some astronomers do their jobs.

Sky streaks

Satellites are not a new challenge for astronomy; the US military tracks and releases information on nearly 20,000 objects that are in orbit. Many are small and don't interfere with