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Nature’s mystery, unlocked with AI

The next invasive species or disease outbreak could be spotted by software

Bob Holmes

ECOLOGISTS have it hard. The ecosystems they study often contain dozens if not hundreds of interacting species, each one affected by myriad variables such as weather, soils, predators and local history. In such a jungle, it can be hard to find a path to understanding. But now ecologists have a new guide: artificial intelligence.

Already in use in disciplines such as stock market analysis, software that can recognise hidden patterns and trends in messy data offers a powerful tool for ecology.

“The real strength of machine learning is you can take these really complex databases that contain tonnes of species interacting in ways we can’t even imagine, and let the data speak for themselves,” says Barbara Han, an ecologist at the University of Georgia, Athens, who co-organised a symposium on machine learning in ecology at last week’s meeting of the Ecological Society of America in Austin, Texas.

For example, ecologists have struggled for decades to predict which introduced plant species are likely to spread and become serious pests, but so far they haven’t managed to find a method that works. So John Paul Schmidt, also at the University of Georgia, turned to AI.

First, Schmidt gathered data on the size, habitat and other biological attributes of nearly 7900 horticultural plants introduced into Hawaii, as well as their pest status. Then he ran the data through an AI process known as boosted regression tree analysis, which makes repeated guesses about which factors might predict pest status, gradually refining its choices to end up with the strongest predictors.

The results surprised him. “When I started out, I thought things like growth form – shrub versus herbaceous versus vine – were going to be good explanatory variables,” he says. But instead, he found that one of the best predictors of a potential pest is a large number of chromosomes, especially compared with related species (PLoS One, DOI: 10.1371/journal.pone.0017391). Plant species with more chromosomes have probably experienced a doubling of chromosome numbers more recently in their evolutionary history, which may give them more genetic raw material for adapting to their new environments, Schmidt says.

Besides their ability to find subtle patterns, AI techniques have two big advantages over conventional statistical analyses, says Schmidt. First, they do not assume, as most conventional analyses do, that measurements such as seed size or chromosome number follow a bell-shaped distribution – an assumption that is often violated in the real world. Second, the AI techniques cope easily with missing data, such as species for which seed size or chromosome number are unknown, whereas conventional analyses often omit such species from the analysis.

AI techniques do have their problems, though, not least that they require lots of data. If too little data is available, they can “overfit” – that is, they make far more precise predictions than are warranted, much as someone looking at just two weeks’ weather data might conclude that Fridays are the warmest days simply because those two Fridays were.

This was shown by Reuben Keller, an ecologist at the University of Chicago in Illinois, who found that AI techniques performed no better than conventional statistical methods at predicting invasive species of birds, fish, molluscs or pine trees when data sets contained just 18 to 87 species (Diversity and Distributions, DOI: 20.1002/...
There are now many examples of AI’s use in ecology. Han is just beginning a project that will use AI to predict where emerging diseases will pop up, and which animal species will transmit them (see “Spotting the next SARS”, below). John Drake of the University of Georgia is using AI to identify the most important interactions among species within an ecosystem. And Bill Langford of the Royal Melbourne Institute of Technology in Australia is using it to help set conservation priorities more effectively.

AI can also help us make sense of the behaviour of individual animals. It is already being used to identify individual penguins in video images. Now Robin Freeman, a computational ecologist at Microsoft Research in Cambridge, UK, and his colleagues are using it to identify particular behaviours in migratory seabirds.

Freeman’s team has tagged individual Manx shearwaters (Puffinus puffinus) with geolocators that allow them to track the bird’s location each day. They also collect a continuous record of whether the leg bearing the tag is immersed in water, which indicates that the bird is either sitting on the surface or diving to feed.

The team used a machine-learning method to tease from the immersion record three discrete behavioural patterns – one with little immersion that corresponded to migratory flight and two corresponding to feeding on winter and summer ranges. When they matched these sorted records to the location data, they found that the birds made mid-ocean feeding stops during their migration from the UK to South America – something no one had been able to prove before (Proceedings of the Royal Society B, DOI: 10.1098/rspb.2008.1577).

“There is the potential for using machines to spot things about individual animal behaviour that we couldn’t spot before,” Freeman says. “It’s exciting to think what we’ll be able to do 10 years from now.”

Creepy robot reads music and sings

Try to stop your skin crawling: this robot head could one day be greeting you in a restaurant. Developed at the National Taiwan University of Science and Technology in Taipei, the freaky-looking robot can read a simplified music score to sing in a synthesised voice. It takes a photo of the music using cameras in its eyes, then an algorithm extracts pitch, rhythm and lyrics and sends the information to its voice synthesiser. The synthesiser matches the sounds in Mandarin with the Roman spellings of the lyrics. So be on your guard: the plan is for the uncanny heads to act as robotic receptionists at large restaurants in China.

Concrete balls give wind a boost

Wind energy is often accused of being unreliable. When it is blowing a gale, all is well – but how do you keep the lights on in calm weather? Researchers at the Massachusetts Institute of Technology are working on a project called Ocean Renewable Energy Storage (ORES), in which hollow concrete spheres sit on the sea floor, tethered to floating wind turbines. During times of blustery plenty, a motor attached to the sphere uses excess wind power to pump water out of the spheres. When the doldrums set in, or demand is simply too high, water flows back into the spheres, turning the motor into a generator of electricity.

Date-rape drug alarm

So-called “date-rape” drugs affect memories of assaults, among other effects, and metabolise in the body quickly, leaving few traces. Researchers at Tel Aviv University in Israel have developed a sensor that, when dipped into a drink, will instantly detect the presence of GHB or ketamine, two of the most commonly used drugs, which are colourless and tasteless in drinks. They do, however, change the optical properties of the liquid. When a ray of light comes into contact with a drugged drink, it is slightly altered. The sensor can pick up that subtle change and sound an alarm.

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