Beneath the canopy

by Sophie Yeo

How a team of scientists is using artificial intelligence to change the way information is gathered from the world's largest rainforest

Movement sensors activate technology that identifies passing animals

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The Amazon is well served by satellite imagery, but on-the-ground coverage is less substantial

Monkey specimens in the Mamirauá Institute

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His dream was a system that could monitor the Amazon in real time

The Amazon rainforest is often dubbed the 'lungs of the planet'. A doctor examining the health of this vital organ might first demand its satellite records. Is its canopy intact? Can it take the deep breaths that keep the planet cool and clean? Next, they might test its bodily fluids, its rivers and tributaries. Are they pure and flowing? Then come the camera traps, the x-rays into the heart of the jungle that reveal the secret lives of its animals.

These are some of the methods ecologists use to monitor the health of the world's largest tropical rainforest. Together, they help diagnose the Amazon and provide an insight into how climate change, deforestation, damming, mining and hunting, impact this enormous ecosystem.

But in a place as vast, complex and mysterious as the Amazon, these methods can provide little more than snapshots. Camera traps provide little information beyond the frame of the lens, while satellite images are blind to life beneath the canopy. Meanwhile, monitoring the data can prove time-consuming and expensive, requiring biologists to invest hours flicking through repetitive, monochrome images.

A team of four scientists, hailing from Brazil, Australia and Spain, have a plan to revolutionise this process. They want to install a thousand nodes – boxes consisting of a camera and sound recorder – across the Amazon basin, monitoring the rainforest in real-time and streaming recordings on the internet where anyone can access them. The kits will use artificial intelligence to automatically detect the animals that live within the rainforest. They call it Project Providence.

The system will still rely on camera traps, but, to counteract the limited scope of a photograph, it will also harness the latest in bioacoustics technology, continuously recording the cacophony of the rainforest. The software will then use 'deep learning' (in which computers teach themselves to be more efficient at a task through examination of large data sets) to automatically identify the creatures it records – an innovation that could save biologists hours of monotonous work.

Emiliano Esterci Ramalho, the project's coordinator, is a jaguar expert who works at the Mamirauá Institute. This research group is based in Tefé, a small town that sits alongside the Solimões River in the state of Amazonas. Its slick headquarters, featuring a glass shrine to its founder, José Márcio Corrêa Ayres, feels incongruous amid the crumbling buildings of this Amazonian town. Yet there's no escaping the presence of the jungle. Outside, an assistant excitedly points to a hairy tarantula perched on a pillar near the toilet block. Ramalho's office itself is a collection of maps, skulls, and labelled specimens in boxes. His desk backs onto a pile of dead monkeys, their eyes stuffed with cotton wool. It was here, in January 2016, that he came up with the idea of Project Providence.

The work, he says, was borne out of frustration with the inefficiency of traditional biodiversity monitoring techniques as well as the lack of coordination among different research groups. 'We have camera traps but they're working on different time scales, to different protocols. Data is stored on researchers' hard drives at different institutions, and no one has access to it. And the method's not adequate for most species,' he says. 'The way that we monitor the forest today is through satellite imagery, but we have no access to the animals that are beneath the canopy of the forest.'

His dream was to create a system that could monitor the Amazon in real time. He envisioned a stream of data instantly available to researchers, allowing them to react to threats as soon as they materialise.

But daily recordings from hundreds of nodes across the Amazon is too much for biologists to handle. Instead, the artificial intelligence software, installed in the nodes alongside the visual and acoustic sensors, will automatically classify the animals recorded onsite. This information will be transmitted to the project's servers, transforming an avalanche of data into

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Providence's sound technology records the noises of the rainforest


Researchers hope that real-time monitoring will help identify illegal activity

something from which biologists can draw meaningful insights. If a drought causes a species to migrate, they will know. If loggers illegally build a road, they can alert the authorities.

SYSTEM SURVIVAL

From self-driving cars to applications in medicine and robotics, artificial intelligence is becoming a feature of daily life. Conservationists and interested companies are increasingly getting in on the game. Microsoft is investing heavily in AI-based conservation programmes and the University of Southern California has established a Centre for Artificial Intelligence in Society. Their goal is to use machine learning to predict where poachers and illegal fishermen will strike next and to suggest routes for rangers to patrol.

Also in California is Conservation Metrics, a company that focuses on using AI to improve bioacoustic monitoring of seabirds. 'We're just in the infancy,' says Matthew McKown, the startup's CEO. 'The availability of these techniques, the fact that a lot of biologists are getting professional training in Python and R – two script-based computer languages – and the proliferation of packages making it easy to use these techniques, that combination is really cool. The proliferation of sensors, that is also a huge thing. It's here to stay.'

But developers working out of offices in Silicon Valley have to be careful. A system that can work in the Amazon rainforest is an entirely different beast. José Reginaldo Hughes Carvalho, a computer scientist at the Federal University of Amazonas who was charged with developing the software for the visual component of the Project Providence nodes, quickly discovered that writing the code was the easy part of the job.

Twenty years of experience in robotics and engineering had failed to teach him that insects can eat wires or that monkeys will urinate on electrical equipment, or how to deal with mosquitoes and humidity when attempting to install a system. 'The device has to survive in the forest. It's a totally living environment,' he says.

The absence of any artificial intelligence projects in the Amazon is testament to the challenging environment. AI for Earth, the Microsoft initiative designed to spur the development of high-tech solutions to conservation problems, has provided $50m in grants to projects across the world, but only one of these is in South America. The majority are in Europe and the USA.

'One of the things that you quickly realise when you talk about instrumenting the wild is that people focus on the creation of the hardware that needs to go out there, and the software that the hardware runs, and you feel really excited,' says Lucas Joppa, chief environmental scientist at Microsoft, who helps lead its AI for Earth programme. 'Then you face the really hard challenge: How am I actually going to get those things out there? How am I going to keep them maintained? Thinking about how to saturate an environment with an Internet of Things solution, that's still very difficult and an outstanding challenge that our programme has been thinking a lot about.'

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Field assistants install a Providence antenna on the top of a tree

SQUAWKS, SPLASHES AND RUSTLES

The Project Providence team also encountered technical difficulties when it came to training their device. Before conducting the final field test in March they had to retrain the vision model from scratch. The photographs they had fed into the machine were in colour; the camera trap images were black-and-white. For the software to work, the team had to classify thousands of these new images by hand.

The bioacoustics, led by Michel André, a professor at the Technical University of Catalonia, also posed challenges. André had been using his technology for many years to monitor human disturbances in the ocean. A choppy, saline environment, the ocean offers its own challenges, but it does have one major advantage over the Amazon: it is largely quiet. The rainforest, on the other hand, emits a constant symphony of squawks, rustles, gusts, and splashes. For an acoustician, it's a headache.

'It's rare that an animal will approach the microphone and emit the perfect sound,' says André. Identifying a species means being able to extract its sound from a mishmash of overlapping noise. To deal with this he assigned various 'features' to each animal. As long as the machine picks up a few of these features, it has some hope of identifying the animal at hand. 'Even though a sound is embedded in other sounds, the machine will be able to extract it,' André says.

Creating this detailed directory of animal features wasn't simple. You might be able to recognise the bark of your own dog, but can you identify a bird from its chirp, or a monkey from its cry? Can you pick out the presence of a jaguar by the sudden silencing of its prey? Probably not – and neither could the scientists. Luckily, the forest is filled with indigenous people who can.

'We had to work together very closely with local communities, because they know exactly what species make these sounds,' says André. Whenever the team was faced with an unfamiliar squawk, they'd take the sample to the communities that live along the river within the Mamirauá Reserve, who would immediately identify the provenance of the noise. So far, the machine has learnt to identify around 40 species.

As well as being a vital source of knowledge, the involvement of indigenous and local people helps to ensure that these long-term, high-tech projects are built on sustainable foundations, says Zoe Jewell, co-founder of WildTrack, another organisation that is starting to use artificial intelligence to monitor biodiversity. Instead of camera traps and recorders, their analysis relies on counting and classifying footprints left by wildlife and they too have relied on the insights of indigenous trackers to train their models.

'They have a tonne of other important information in their heads that we wouldn't otherwise have access to. From a technical point of view, that's why we engage with them,' says Jewell. 'But I think there's also an ethical component. These people are often marginalised and not included in the process of conservation, and I think that's a huge loss. As outsiders, we go into an area, we get the data we want, we write a report, and that's as far as it goes. The conservation on the ground doesn't continue. Engaging local trackers brings continuity.'

> They plan to provide the data to local communities, empowering them to protect and preserve the ecosystem

ACCESS FOR ALL

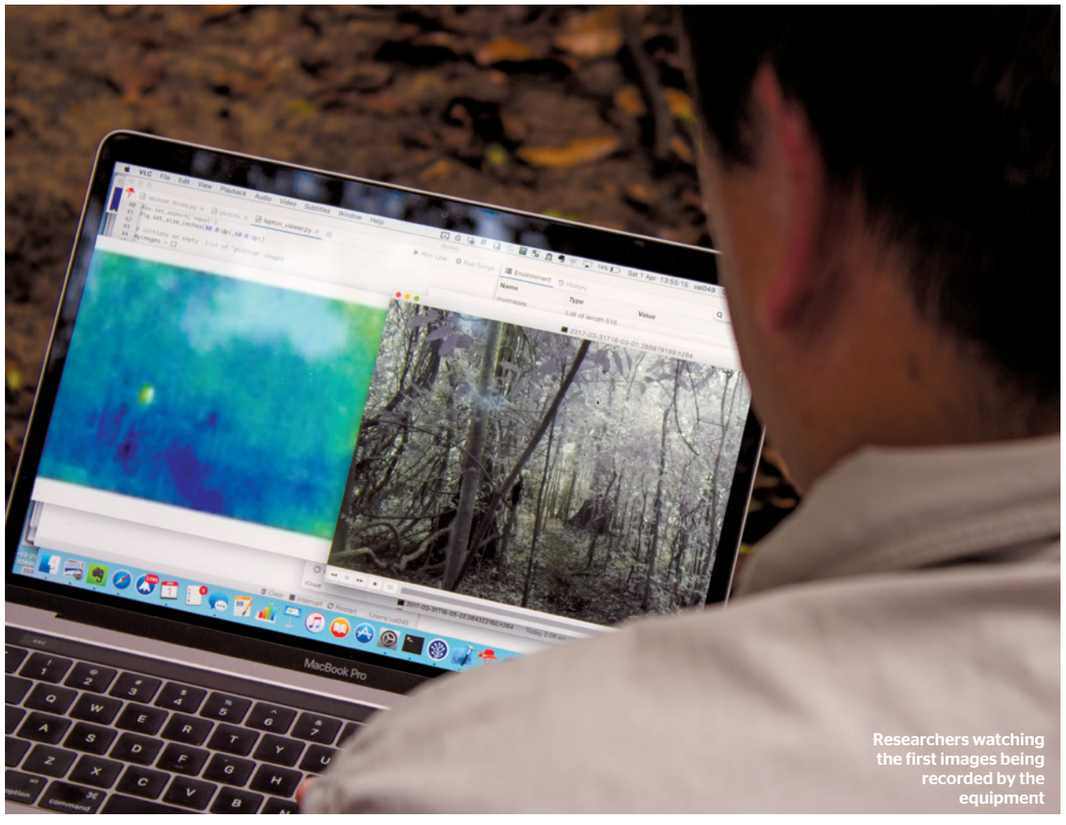
No matter how cleverly or ethically it is collected, data remains useless until it is put to work. For the team behind Project Providence, the priority is to make the data accessible. The nodes will be connected to the project's website, and Ramalho has visions of installing screens in railways and schools, livestreaming the daily life of the Amazon in places where the public will be able to see and learn from it.

'If this is not used, then we're not successful,' he says. 'It's not a question of just being cool. It has to be very cool so that people can use it.' This could mean tracking poachers and loggers, but also observing the movements of species and drawing conclusions about environmental changes, including drought or fire. They plan to provide the data to local communities, empowering them to protect and preserve the ecosystem that is their home.'They are the guardians of the Amazon,' says André. 'The same way they are teaching us to identify different sounds, they will be the ones to alert us to changes we might not detect, because we don't live there and we don't know it.'

This dream remains some years away. Last March, the team completed the last field test of their prototypes. In September, they started installing one hundred nodes across the Mamirauá Reserve. Eventually, this three-million-acre area will become the world's first reserve where biodiversity is monitored in real time. In 2020, they want to install a thousand nodes, covering the entire Amazon basin.

Yet, in some ways, Project Providence is not unique. Artificial intelligence is increasingly becoming a part of the conservationist's toolbox. Image and sound recognition is fast improving. 'If you ask if we can publish an academic paper on what we've done, my answer is no. The camera is not unique. The wireless part is off the shelf,' says Carvalho. The innovation and the beauty of Project Providence is the combination of these parts, he says, integrating the varied capabilities of artificial intelligence into a box that can live in the forest.

Microsoft's Joppa agrees. 'There are lots of people working in this space,' he says. 'That said, any time someone makes a concerted effort to put it all together out in the wild, everyone's watching. If they pull it off there are so many lessons to be learned that just the attempt itself is valuable.' ●



Researchers watching the first images being recorded by the equipment

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