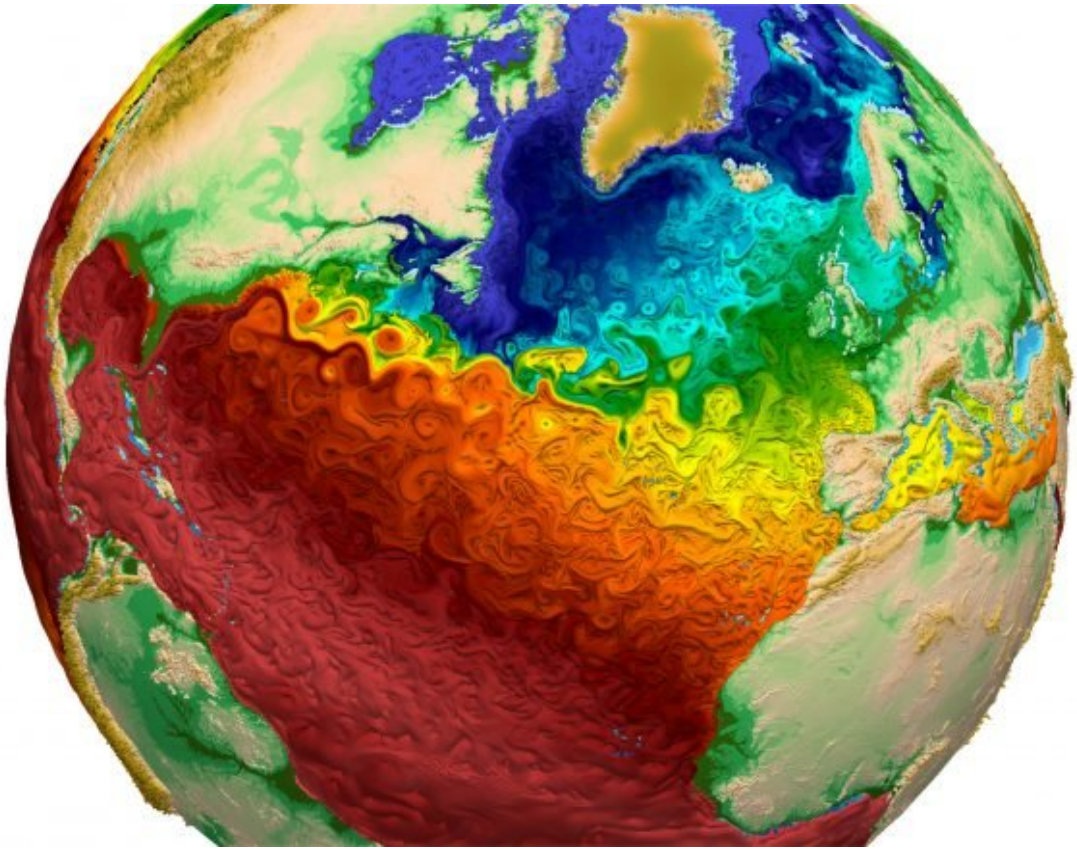
Artificial intelligence—a game changer for climate change and the environment

June 6 2018, by Renee Cho



AI is continually improving climate models. Credit: Los Alamos National Lab

As the planet continues to warm, climate change impacts are worsening. In 2016, there were 772 weather and disaster events, triple the number that occurred in 1980. Twenty percent of species currently face

extinction, and that number could rise to 50 percent by 2100. And even if all countries keep their Paris climate pledges, by 2100, it's likely that average global temperatures will be 3˚C higher than in pre-industrial times.

But we have a new tool to help us better manage the impacts of climate change and protect the planet: artificial intelligence (AI). AI refers to computer systems that "can sense their environment, think, learn, and act in response to what they sense and their programmed objectives," according to a World Economic Forum report, Harnessing Artificial Intelligence for the Earth, authored by PwC UK.

In India, AI has helped farmers get 30 percent higher groundnut yields per hectare by providing information on preparing the land, applying fertilizer and choosing sowing dates. In Norway, AI helped create a flexible and autonomous electric grid, integrating more renewable energy.

And AI has helped researchers achieve 89 to 99 percent accuracy in identifying tropical cyclones, weather fronts and atmospheric rivers, the latter of which can cause heavy precipitation and are often hard for humans to identify on their own. By improving weather forecasts, these types of programs can help keep people safe.

What are artificial intelligence, machine learning and deep learning?

Artificial intelligence has been around since the late 1950s, but today, AI's capacities are rapidly improving thanks to several factors: the vast amounts of data being collected by sensors (in appliances, vehicles, clothing, etc.), satellites and the Internet; the development of more powerful and faster computers; the availability of open source software and data; and the increase in abundant, cheap storage. AI can now quickly discern patterns that humans cannot, make predictions more

efficiently and recommend better policies.

The holy grail of artificial intelligence research is artificial general intelligence, when computers will be able to reason, abstract, understand and communicate like humans. But we are still far from that—it takes 83,000 processors 40 minutes to compute what one percent of the human brain can calculate in one second. What exists today is narrow AI, which is task-oriented and capable of doing some things, sometimes better than humans can do, such as recognizing speech or images and forecasting weather. Playing chess and classifying images, as in the tagging of people on Facebook, are examples of narrow AI.

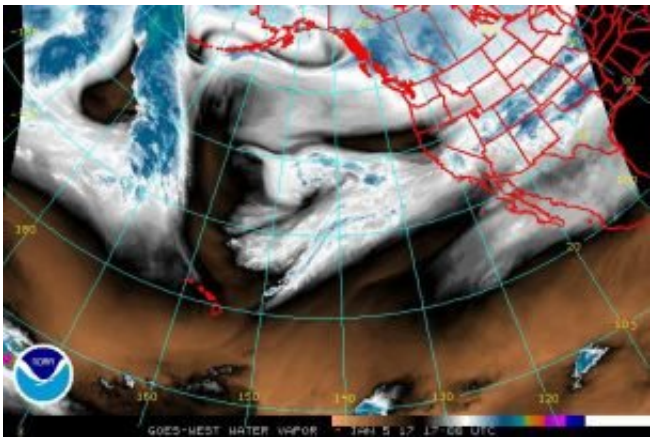
When Netflix and Amazon recommend shows and products based on our purchasing history, they're using machine learning. Machine learning, which developed out of earlier AI, involves the use of algorithms (sets of rules to follow to solve a problem) that can learn from data. The more data the system analyzes, the more accurate it becomes as the system develops its own rules and the software evolves to achieve its goal.

Deep learning, a subset of machine learning, involves neural networks made up of multiple layers of connections or neurons, much like the human brain. Each layer has a separate task and as information passes through, the neurons give it a weight based on its accuracy vis a vis the assigned task. The final result is determined by the total of the weights.

Deep learning enabled a computer system to figure out how to identify a cat—without any human input about cat features— after "seeing" 10 million random images from YouTube. Because deep learning essentially takes place in a "black box" through self-learning and evolving algorithms, however, scientists often don't know how a system arrives at its results.

Artificial intelligence is a game changer

Microsoft believes that artificial intelligence, often encompassing machine learning and deep learning, is a "game changer" for climate change and environmental issues. The company's AI for Earth program has committed $50 million over five years to create and test new applications for AI. Eventually it will help scale up and commercialize the most promising projects.



An atmospheric river over California. Credit: NOAA

Columbia University's Maria Uriarte, a professor of Ecology, Evolution and Environmental Biology, and Tian Zheng, a statistics professor at the Data Science Institute, received a Microsoft grant to study the effects of Hurricane Maria on the El Yunque National Forest in Puerto Rico. Uriarte and her colleagues want to know how tropical storms, which may worsen with climate change, affect the distribution of tree species in Puerto Rico.

Hurricane Maria's winds damaged thousands of acres of rainforest, however the only way to determine which tree species were destroyed and which withstood the hurricane at such a large scale is through the use of images. In 2017, a NASA flyover of Puerto Rico yielded very high-

resolution photographs of the tree canopies. But how is it possible to tell one species from another by looking at a green mass from above over such a large area? The human eye could theoretically do it, but it would take forever to process the thousands of images.

The team is using artificial intelligence to analyze the high-resolution photographs and match them with Uriarte's data—she has mapped and identified every single tree in given plots. Using the ground information from these specific plots, AI can figure out what the various species of trees look like from above in the flyover images. "Then we can use that information to extrapolate to a larger area," explained Uriarte. "We use the plot data both to learn [i.e. to train the algorithm] and to validate [how well the algorithm is performing]."

Understanding how the distribution and composition of forests change in response to hurricanes is important because when forests are damaged, vegetation decomposes and emits more CO2 into the atmosphere. As trees grow back, since they are smaller, they store less carbon. If climate change results in more extreme storms, some forests will not recover, less carbon will be stored, and more carbon will remain in the atmosphere, exacerbating global warming.

Uriarte says her work could not be done without artificial intelligence. "AI is going to revolutionize this field," she said. "It's becoming more and more important for everything that we do. It allows us to ask questions at a scale that we could not ask from below. There's only so much that one can do [on the ground] … and then there are areas that are simply not accessible. The flyovers and the AI tools are going to allow us to study hurricanes in a whole different way. It's super exciting."

Another project, named Protection Assistant for Wildlife Security (PAWS) from the University of Southern California, is using machine learning to predict where poaching may occur in the future. Currently

the algorithm analyzes past ranger patrols and poachers' behavior from crime data; a Microsoft grant will help train it to incorporate real-time data to enable rangers to improve their patrols.

In Washington State, Long Live the Kings is trying to restore declining steelhead and salmon populations. With a grant from Microsoft, the organization will improve an ecosystem model that gathers data about salmon and steelhead growth, tracks fish and marine mammal movements, and monitors marine conditions. The model will help improve hatchery, harvest, and ecosystem management, and support habitat protection and restoration efforts.

How AI is used for energy

AI is increasingly used to manage the intermittency of renewable energy so that more can be incorporated into the grid; it can handle power fluctuations and improve energy storage as well.

The Department of Energy's SLAC National Accelerator Laboratory operated by Stanford University will use machine learning and artificial intelligence to identify vulnerabilities in the grid, strengthen them in advance of failures, and restore power more quickly when failures occur. The system will first study part of the grid in California, analyzing data from renewable power sources, battery storage, and satellite imagery that can show where trees growing over power lines might cause problems in a storm. The goal is to develop a grid that can automatically manage renewable energy without interruption and recover from system failures with little human involvement.

Wind companies are using AI to get each turbine's propeller to produce more electricity per rotation by incorporating real time weather and operational data. On large wind farms, the front row's propellers create a wake that decreases the efficiency of those behind them. AI will enable

each individual propeller to determine the wind speed and direction coming from other propellers, and adjust accordingly.

Researchers at the Department of Energy and National Oceanic and Atmospheric Administration (NOAA) are using AI to better understand atmospheric conditions in order to more accurately project the energy output of wind farms.

Art created by deep learning. Credit: Gene Kogan

Artificial intelligence can enhance energy efficiency, too. Google used machine learning to help predict when its data centers' energy was most in demand. The system analyzed and predicted when users were most likely to watch data-sucking Youtube videos, for example, and could then optimize the cooling needed. As a result, Google reduced its energy

use by 40 percent.

Making cities more livable and sustainable

AI can also improve energy efficiency on the city scale by incorporating data from smart meters and the Internet of Things (the internet of computing devices that are embedded in everyday objects, enabling them to send and receive data) to forecast energy demand. In addition, artificial intelligence systems can simulate potential zoning laws, building ordinances, and flood plains to help with urban planning and disaster preparedness. One vision for a sustainable city is to create an "urban dashboard" consisting of real-time data on energy and water use and availability, traffic and weather to make cities more energy efficient and livable.

In China, IBM's Green Horizon project is using an AI system that can forecast air pollution, track pollution sources and produce potential strategies to deal with it. It can determine if, for example, it would be more effective to restrict the number of drivers or close certain power plants in order to reduce pollution in a particular area.

Another IBM system in development could help cities plan for future heat waves. AI would simulate the climate at the urban scale and explore different strategies to test how well they ease heat waves. For example, if a city wanted to plant new trees, machine learning models could determine the best places to plant them to get optimal tree cover and reduce heat from pavement.

Smart agriculture

Hotter temperatures will have significant impacts on agriculture as well.

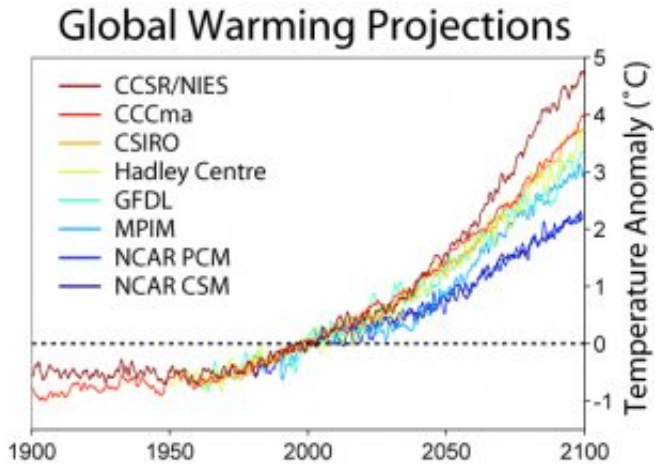
Data from sensors in the field that monitor crop moisture, soil composition and temperature help AI improve production and know when crops need watering. Incorporating this information with that from drones, which are also used to monitor conditions, can help increasingly automatic AI systems know the best times to plant, spray and harvest crops, and when to head off diseases and other problems. This will result in increased efficiency, enhanced yields, and lower use of water, fertilizer and pesticides.

Protecting the oceans

The Ocean Data Alliance is working with machine learning to provide data from satellites and ocean exploration so that decision-makers can monitor shipping, ocean mining, fishing, coral bleaching or the outbreak of a marine disease. With almost real time data, decision-makers and authorities will be able to respond to problems more quickly. Artificial intelligence can also help predict the spread of invasive species, follow marine litter, monitor ocean currents, keep track of dead zones and measure pollution levels.

The Nature Conservancy is partnering with Microsoft on using AI to map ocean wealth. Evaluating the economic value of ocean ecosystem services—such as seafood harvesting, carbon storage, tourism and more—will make better conservation and planning decisions possible. The data will be used to build models that consider food security, job creation and fishing yields to show the value of ecosystem services under differing conditions. This can help decision-makers determine the most important areas for fish productivity and conservation efforts, as well as the tradeoffs of potential decisions. The project already has maps and models for Micronesia, the Caribbean, Florida, and is expanding to Australia, Haiti, and Jamaica.

More sustainable transport on land



As vehicles become able to communicate with each other and with the infrastructure, artificial intelligence will help drivers avoid hazards and traffic jams. In Pittsburgh, an artificial intelligence system incorporating sensors and cameras that monitors traffic flow adjusts traffic lights when needed. The systems are functioning at 50 intersections with plans for 150 more, and have already reduced travel time by 25 percent and idling by more than 40 percent. Less idling, of course, means fewer greenhouse gas emissions.

Eventually, autonomous AI-driven shared transportation systems may replace personal vehicles.

Better climate predictions

As the climate changes, accurate projections are increasingly important. However, climate models often produce very different predictions,

largely because of how data is broken down into discrete parts, how processes and systems are paired, and because of the large variety of spatial and temporal scales. The Intergovernmental Panel on Climate Change (IPCC) reports are based on many climate models and show the range of predictions, which are then averaged out.

Averaging them out, however, means that each climate model is given equal weight. AI is helping to determine which models are more reliable by giving added weight to those whose predictions eventually prove to be more accurate, and less weight to those performing poorly. This will help improve the accuracy of climate change projections.

AI and deep learning are also improving weather forecasting and the prediction of extreme events. That's because they can incorporate much more of the real-world complexity of the climate system, such as atmospheric and ocean dynamics and ocean and atmospheric chemistry, into their calculations. This sharpens the precision of weather and climate modeling, making simulations more useful for decision-makers.

AI has many other uses

AI can help to monitor ecosystems and wildlife and their interactions. Its fast processing speeds can offer almost real-time satellite data to track illegal logging in forests. AI can monitor drinking water quality, manage residential water use, detect underground leaks in drinking water supply systems, and predict when water plants need maintenance. It can also simulate weather events and natural disasters to find vulnerabilities in disaster planning, determine which strategies for disaster response are most effective, and provide real-time disaster response coordination.

What are the risks of artificial intelligence?

While AI enables us to better manage the impacts of climate change and protect the environment in addition to transforming the fields of business, finance, health care, medicine, law, education and more, it is not without risks. Some prominent individuals such as the late physicist Stephen Hawking and Tesla CEO Elon Musk have warned of the existential dangers of uncontrolled artificial intelligence.

The World Economic Forum report identified six categories of AI risk:

- Performance. The black box conclusions of AI may not be understandable to humans and thus it may be impossible to determine if they are accurate or desirable. Deep learning could be risky for applications such as early warning systems for natural disasters where more certainty is needed.
- Security. AI could potentially be hacked, enabling bad actors to interfere with energy, transportation, early warning or other crucial systems.
- Control risks. Since AI systems interact autonomously, they can produce unpredictable outcomes. For example, two systems came up with a language of their own that humans couldn't understand.
- Economic risks. Companies that are slower to adopt AI may suffer economic consequences as their AI-based competition advances. We are already seeing how brick and mortar stores are closing as the economy becomes increasingly digitized.
- Social risk. AI is resulting in more automation, which will eliminate jobs in almost every field. Autonomous weapon systems could also hasten and exacerbate global conflicts.
- Ethical risks. Since AI uses inferred assumptions about groups and communities in making decisions, it could lead to increased bias. The collection of data also raises privacy issues.

To deal with these risks, the World Economic Forum states that

government and industry "must ensure the safety, explainability, transparency and validity of AI application." More interaction among public and private entities, technologists, policy-makers and even philosophers, and more investments in research are needed to avert the potential risks of artificial intelligence—and to realize its potential benefits to the environment and humanity.

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