Can machine learning reveal geology humans can't see?

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During summer of 2019, Leila Donn and her field crew peer over the side of a very large sinkhole in the tropical forest of Belize. The feature was identified from a machine learning program, and verified with a long hike to the site. Donn says the sinkhole was unrecognizable until you were near the edge. Credit: Leila Donn

Identifying geological features in a densely vegetated, steep, and rough terrain can be almost impossible. Imagery like LiDAR can help researchers see through the tree cover, but subtle landforms can often be missed by the human eye.

Now, a team of scientists has tapped into the power of machine learning to identify hidden geologic features. Specifically, the scientists are identifying previously unidentified cave entrances that are difficult to see in imagery, and hard to access on the ground.

Leila Donn, a doctoral student at the University of Texas at Austin and lead author of the new research, is presenting the results of her research on Sunday at The Geological Society of America's Annual Meeting in Phoenix.

The research was inspired in part by the lush, hard-to-access areas of tropical forests. "We saw the need to get LiDAR coverage for our deep tropical forest areas," says Timothy Beach, co-author of the research. "LiDAR imagery has been showing a lot of archaeology, but we also knew they could show a lot of new geology and a lot of new human-environmental interactions."

The project was also inspired by Donn's own field experiences. While helping a colleague look for cave entrances in Guatemala, they would find a spot that looked promising on the LiDAR imagery, then spend all day hiking to the location. "It was really fun, but really, really labor intensive," says Donn. And sometimes their day-long hike led to a spot that wasn't a cave at all—a frustrating situation. "While we were out doing this, I thought, 'What if we could do this with machine learning?'" She explains that instead of the researchers picking out possible locations by eye, the computer would do the identification, revealing the most promising locations.

To test if machine learning could help them narrow in on interesting geology sites, Donn and Beach focused on an area in northwestern Belize that was heavily vegetated and difficult to access. They concentrated on finding cave entrances deep in the forest that had yet to be been uncovered.

Mike Mallner, a technical caver who accompanied Leila Donn on her field work, rappels down into the large sinkhole. The previously unidentified feature is 60 meters by 30 meters and 35 meters deep. Credit: Leila Donn

Using the LiDAR imagery collected from a similar site with mapped

caves, Donn plotted the location of known cave entrances, along with points that were not caves. She then collected information on the landscape, including slope, roughness of terrain, and distance to streams. This information was compiled into a spreadsheet and fed into the machine learning as a way to "teach the computer how to predict what is a cave and what isn't," says Donn.

Over the summer, Donn hacked through the jungle to ground-truth the areas where caves had been identified with machine learning. She confirmed that a number of previously unmapped cave entrances did indeed exist in the landscape, including a very large surprise.

"The coolest thing that we found was a sinkhole that was a collapsed cave complex," says Donn. She said that the find came after an incredibly hard hike through dense vegetation. Despite being 60 meters long, 30 meters wide, and 35 meters deep, "You couldn't see it until you were on top of it," she says.

When she was back in the lab, Donn said she went back to the LiDAR with fresh eyes to see if the cave entrance would now pop out of the imagery. "When I went back to the location and looked at the LiDAR, it was visible," she says, but she notes that without knowing it was there, she probably wouldn't have recognized it as a cave entrance. "The program found it for me."

Her machine learning also can pick up much smaller caves, says Donn. "One of them was a small cave with an entrance that was maybe a meter and a half long and just 30 feet deep." And on the LiDAR, she says that smaller cave was invisible to the naked eye.

Donn says her program can be used for geology studies, like finding and studying undiscovered caves. But she also sees applications for other disciplines like archaeology, forest management, urban development,

and land management. "I see this having a future outside of academia," she says.

"What Leila is doing is an exciting connection between the history and the future of geosciences," says Beach. A project like this, he says, "comes from this ability to get into very difficult places that most of us can't get into, but also then this creative angle of making the machine learn how to do it too."

More information: gsa.confex.com/gsa/2019AM/meet … app.cgi/Paper/339861

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