[HED] AI: To the Moon and Beyond
[DEK] The age of discovery on earth filled in blank spots on maps. Now AI is filling in maps of the moon.

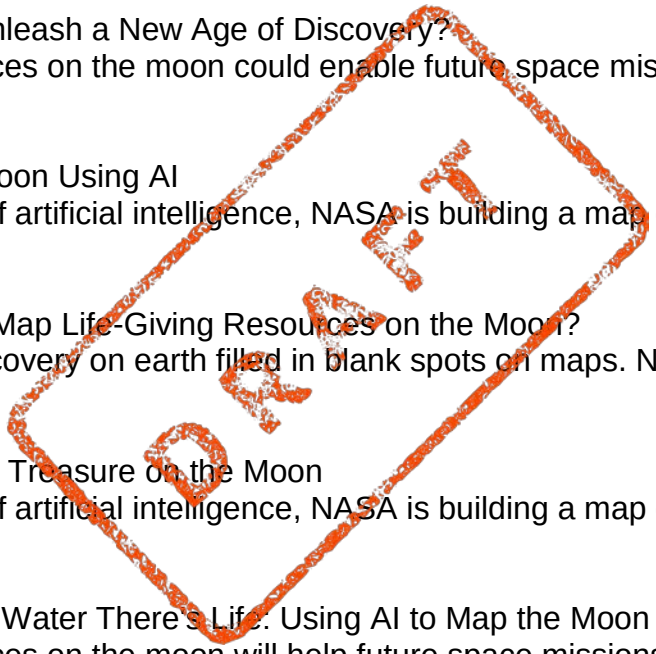
[HED] Can AI Help Unleash a New Age of Discovery?
[DEK] Finding resources on the moon could enable future space missions be self-sufficient.

[HED] Mapping the Moon Using AI
[DEK] With the help of artificial intelligence, NASA is building a map of the moon's craters.

[HED] Could AI Help Map Life-Giving Resources on the Moon?
[DEK] The age of discovery on earth filled in blank spots on maps. Now AI is filling in maps of the moon.

[HED] Finding Hidden Treasure on the Moon
[DEK] With the help of artificial intelligence, NASA is building a map of the moon's craters.

[HED] Where There's Water There's Life: Using AI to Map the Moon
[DEK] Finding resources on the moon will help future space missions be self-sufficient.



By Elissa Gilbert

Maps can uncover mysteries and reveal new worlds. They can lead to buried treasure or warn of dangers lurking around dark corners. And now even the moon, and all its intricacies, is being mapped with the help of artificial intelligence.

This is particularly important because longer exploratory missions to outer space can't carry all the resources they need from Earth. Finding water, hydrogen, carbon dioxide, and other valuable elements may help NASA as it plans future missions to the moon or even to Mars.

They'll need to know where to source these resources and how to get to them safely. For instance, the polar regions of the moon are a likely place for finding ice, but because they're always in shadow and NASA's photographs contain artifacts, identifying treacherous craters in images isn't always straightforward.

"We have 50 years' worth of NASA imagery both of the light and the dark sides of the moon, and we also have these new sensors that have been placed in the last 10 years that give us depth data and hyper spectral imagery, and no one has thought to put them

on top of each other and make one big, awesome map," Shanshi Jain, Innovation Manager at Intel, said.

Using deep learning, a kind of AI that programs artificial neural networks modeled after the way human brains function, NASA worked with Intel to build a map of craters on the moon. Its these craters that hold both assets (water and other chemicals needed to support exploratory missions) and danger (steep slopes that a rover can't drive out of).

Making Maps from Millions of Images

"There's thousands of these craters in every strip of imagery you get from a satellite. If you don't line them up perfectly, then you're going to have a poor quality map, so we built a tool that lines them all up, and allows you to lay them perfectly on top of each other to make an amazing map," Jain said.

"Today, planetary scientists are the ones who are identifying spots or identifying craters, or identifying features on the moon. They're doing it manually," he said.

That manual effort takes a lot of time, so NASA worked on a solution with Intel through a partnership called Frontier Development Lab (FDL). Intel's FDL team built a training set for its learning application from 30,000 data points, which meant looking at images and identifying whether the image had a crater. Doing it for 30,000 images took Jain six hours…which doesn't sound that bad until you realize that mapping the moon means looking at *hundreds of millions* of images.

The team used Intel Nervana deep learning technology to address this challenge, developing adaptive convolutional learning algorithms that identify craters more quickly than humans and more reliably than existing machine learning applications.

Using two datasets from the NASA Lunar Reconnaissance Orbiter (LRO) mission, one with optical images and the other with altimeter data, the team developed a computer vision program that could identify craters at the lunar poles and the equatorial regions.

Looking at an image, the application can simply decide yes there's a crater or no there isn't. After learning to classify photos from the 30,000 images in the training set, the program's decisions matched human evaluation of the pictures more than 98% of the time, which is better than previous algorithms, and at 1,000 images per second, a great deal faster than people, too.

Intel expects to continue enhancing and improving the algorithm. Besides its use for space application, the code is publicly available in GitHub and, Jain said, will serve as the "Hello, World" application for Nervana.

Partners in Space Research

NASA's FDL partnership allows the organization to work with interdisciplinary, international teams. NASA selects participants with planetary science or information technology backgrounds and NASA scientists provide mentorship and review work.

"NASA Frontier Development Lab is an applied Artificial Intelligence Accelerator. NASA FDL uses a public-private partnership approach that pairs NASA data and expertise with the private sector's tools and expertise to apply AI on difficult challenges that either would have difficulty solving on its own." Sara Jennings, a Producer at FDL, said.

It's an effective process, said Jennings: "The accelerator approach also allows for expedited results due to the sprint methodologies and rapid iteration involved in the process."

Intel supplied its Nervana AI technology as well as mentors to the Lunar Water and Volatiles team during the FDL's eight-week program hosted at the SETI Institute in Mountain View, California. Intel's space resources group was just one of 5 teams that took part in challenges; the others worked on planetary defense and space weather challenges, like long period comets (comets that take more than 200 years to complete an orbit) and solar storm prediction.

The space agency chooses the topics for the teams to investigate. Jennings said, "NASA drives the challenge category selection based on research areas that they feel are best suited for the FDL program, as well as areas they are interested in."

One aspect that makes challenges a good fit for the FDL program is accessible data. For instance, the lunar water team had extensive lunar imagery available from NASA's missions to the moon.

Some of the work from other FDL teams has already been used in NASA projects. Jennings points to the Long Period Comets team's work at FDL using AI to automate the data reduction pipeline for Cameras for All Sky Meteor Surveillance (CAMS), a project that observes meteor showers.

Jain described Intel's work with NASA FDL this year as "the summer of exploration with artificial intelligence right here on earth."

With better maps of the moon and other solutions from FDL, soon NASA will have summers, winters, and years of exploration with AI on the moon and beyond.