# NASA: Using Artificial Intelligence To Explore Space And Distant Worlds

NASA will launch its next mission to Mars in 2020. It has landed four Mars rover craft on the surface of the red planet so far, starting with the first successful landing of Sojourner in 1997. The most recent landing was by the rover Curiosity in 2011. As artificial intelligence (AI) technology is far more advanced than at the time the last rover was launched, the as-yet unnamed Mars 2020 rover craft will be the most automated and intelligent yet. Its primary goal will be searching for signs that the red planet may once have been home to life.

Beyond this, NASA's deep space probes – such as the New Horizons mission to Pluto and the Voyager missions to the outer reaches of the solar system – have travelled further than any other man-made object from Earth, and continue to send back data, adding to our understanding of the universe we live in.

## What Problem Is Artificial Intelligence Helping To Solve?

One of the biggest obstacles in space exploration is the limited amount of bandwidth available for sending information back to Earth. Due to the distances involved, even today these data volumes are measured in mere megabits.

Particularly when exploring the far reaches of the solar system, unmanned spacecraft can often be out of contact with humans for long periods of time. Their ability to make autonomous decisions about what information is valuable to their Earth-bound operators is vital.

Another problem is the limited amount of power available to operate the spacecraft. As they are often far from recharging stations, and even further from the sun's source of solar energy, power usage must be carefully predicted and monitored. Running out of energy on the surface of a distant planet or in the far reaches of interplanetary space means a multi-billion dollar spacecraft becomes a non-responsive and inoperative hunk of metal, plastic and circuitry.

Additionally, when it comes to manned space exploration, problems arise because working conditions in space often put stresses on the human body far beyond those that human bodies are used to coping with.

## How Is Artificial Intelligence Used In Practice?

Spacecraft – from deep space probes to planetary landers like the rovers – are equipped with a large number of sensors to capture every possible piece of information about the environments. This isn't because most of that information is useful – in fact, it generally isn't. The vast majority of space is an empty vacuum and the vast majority of planetary surfaces are comprised of lifeless, inert matter, no different from that found on Earth.

Instead, what it is used for is to build an understanding of what is normal, so that interesting, unusual and valuable information stands out. Teaching space-faring machines to recognize this anomalous data is the main purpose of AI work carried out by NASA.

As Kiri Wagstaff, principal data scientist with NASA's Jet Propulsion Laboratory machine learning group, says: “We don't want to miss something just because we didn't know to look for it.

“We want the spacecraft to know what we expect to see and recognize when it observes something different. If you know a lot in advance you can build a model of normality – of what the robots should expect to see. For new environments we want to let the spacecraft build a model of normality based on its own observations, that way it can recognize surprises we haven't anticipated.”

Smart systems also carefully monitor the power usage of spacecraft – particularly the Mars rovers – to determine which systems are using the most energy, and what can be shut down at any given time to ease the burden on the radioisotope thermoelectric and solar generators. Data on energy use can be correlated in real time with the craft's “plans” for what it has to do over a particular time period – travelling or taking readings – to ensure that the 100 watts of power available at any time are used efficiently.

AI-driven robots are also increasingly being used to augment the abilities of human astronauts working in space. Since the 1970s, NASA has been developing humanoid robots that can carry out manual work or provide assistance alongside human crews. NASA currently uses a robotic system known as Robonaut 2 to assist humans carrying out complex technical operations in the hazardous environments of outer space. Robonaut 2 is a modular, humanoid robot equipped with AI-driven image recognition technology.

## What Were The Results?

Previous rover missions, which did not rely on autonomous decision making by onboard systems, were constrained by the fact that it took 24 minutes for information gathered by their sensors to reach Earth, and another 24 minutes for instructions based on that information to be returned to the red planet. For deep space probes, that delay is obviously far longer. Thanks to the implementation of AI systems, information can now be acted on almost instantaneously by the rover, meaning it can make up its own mind about which locations are worth investigating. Given the huge cost of operating interplanetary vehicles and their Earth-bound operation centers, this means more productive missions and a greater human understanding of what lies on the “final frontier”.

The smart data-driven analytics engines on board the Curiosity rover were instrumental in helping NASA establish that Mars once was a habitable environment for life. The next rover – scheduled to launch in 2020 – will be built around this technology from the ground up, and its mission will be to find out whether life actually existed on Mars.

**What Technology, Tools And Data Were Used?**

To sift through the vast amounts of data collected by lander craft and probes, NASA relies on similar tools to those used by today's data-driven online services such as Netflix and Amazon.

Elasticsearch – the open source search and analytics engine – forms the backbone of several AI systems, including those used on the rover but also to capture high-resolution data on soil moisture across wide geographical areas back home on Earth.

It also uses a software system called AEGIS (Autonomous Exploration for Gathering Advanced Science) to determine interesting features such as anomalous rocks that can be vaporized by Curiosity's lasers so that their composition can be determined.

Robonaut 2 was developed in cooperation with General Motors and has almost human levels of manual dexterity. It became the first humanoid robot in space when it was despatched to the International Space Station in 2011. Since then it has received continual upgrades and is currently capable of carrying out many manual, repetitive and dangerous tasks. In the future, it is planned that it could lead the way on missions to other planets such as Mars, with the task of preparing environments suitable for arriving humans. The technology is also available for licensing by other companies, and NASA points to its suitability in a wide range of logistics, manufacturing, industrial and medical roles.

**Key Challenges, Learning Points And Takeaways**

* NASA is pioneering AI to help solve problems in outer space as well as back home on Earth.
* Space exploration generates huge volumes of data, and it is far more efficient to use autonomous machines to work out what is worth sending home and what can be discarded.
* Technology developed for space exploration often has utilities back home on Earth – and licensing them can help fund the high cost of development and deployment in space.

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