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A Study On Artificial Intelligence In Space Exploration

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Abstract

Space contains numerous mystifications and awful aspects. Scientists explore space for the possibility of extraterrestrial life and also for space exploration. Scientists say only 4% of the universe has been observed by us; the remaining have yet to be discovered. Space exploration and discoveries always require analyzing vast quantities of data. AI and Machine Learning are the smart ways to handle and reuse data in this case. AI refers to letting machines think rationally. Machine learning is one of the branches in the AI field. It trains machines to improve their intelligence by learning and makes them efficient to do complex tasks by using their intelligence. The primary goal of this study is to present an overview of the Artificial Intelligence Technologies used in Space Exploration.

Keywords

Artificial Intelligence, Space Exploration, Machine Learning

Introduction

Artificial Intelligence is revolutionizing the space industry for making previously arduous and even impossible tasks instantaneous and highly efficient. Everyday satellites are capturing millions of images. Before AI, humans were responsible for scanning large quantities of images which are captured by satellite for analysis. It took countless hours. But After, Scientists use Artificial Intelligence for analyzing data/images speedily to take decisions for which direction to go and which direction will be less dangerous, etc. They use AI to automate operations on spacecraft.

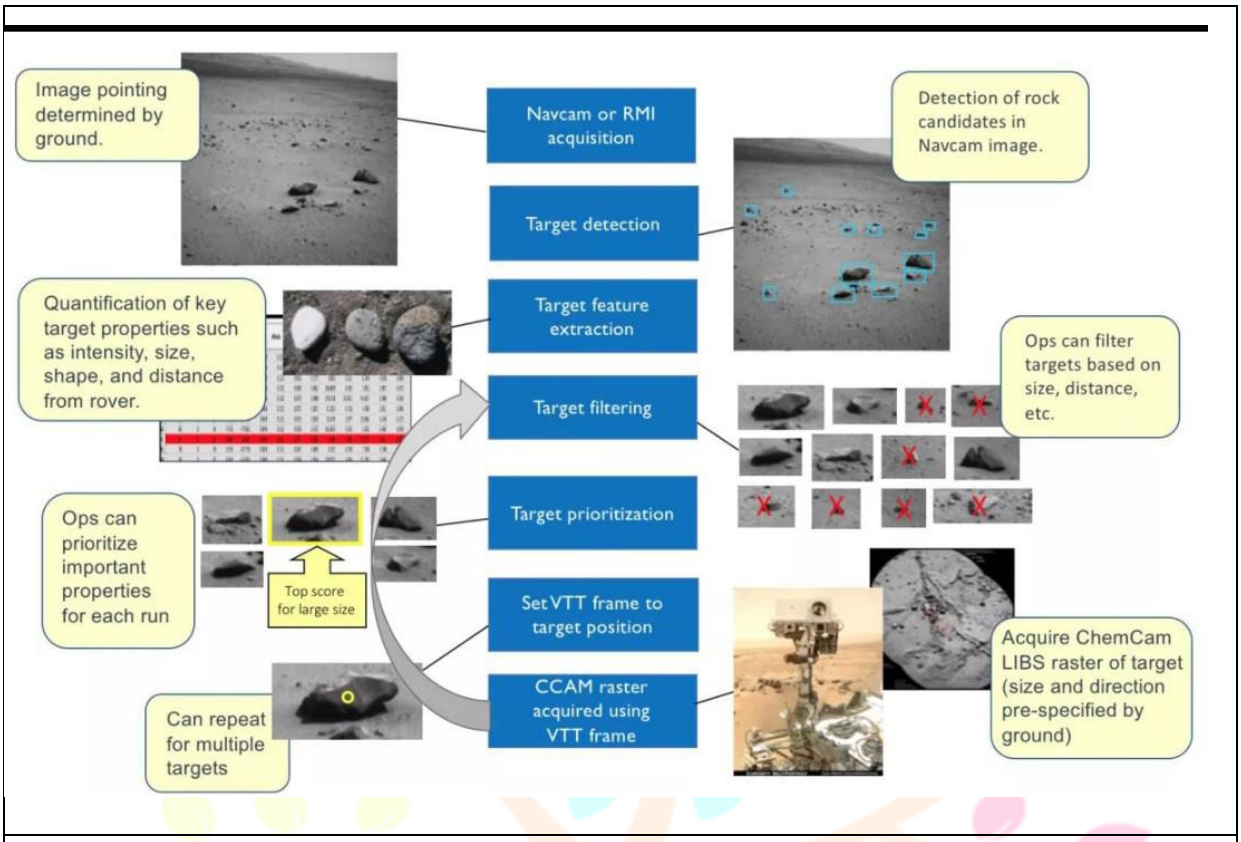
The time of an astronaut is very precious. It is very expensive to send an astronaut to space and Astronauts should have to take threats of their life too. Therefore, Artificial Intelligence and Machine Learning helps to relieve astronauts from small tasks. Then, they can really concentrate, on what they really deserve them. Thus, instead of sending astronauts to space, Scientists use Robots and AI Enabled Rovers to probe and explore space.

Rocks, Craters, Environmental Hazards, and other features can be detected by the rover's detectors and the data can be analyzed by AI algorithms to determine the easy and shortest path forward. Therefore, the rover can safely pass without any threat of collision.

This paper briefly explains about Mars 2020 Rover, Curiosity Rover, AEGIS, AI-enabled robots and assistive free-flyers, Morpheus machine learning model and AI technology used in Chandrayaan 3

AEGIS

AEGIS is an Autonomous Exploration for Gathering Increased Science Systems (AEGIS). AEGIS is a computer vision-based detection system. It is one of the greatest inventions because it finds the path to completely autonomous space exploration rovers. The Mars Exploration Rover and Curiosity Rover are autonomously performing and navigating on the face of Mars for more than ten years.



source: www.planetary.org

James Web Telescope and Black hole

Morpheus, the well-known machine learning model was created by researchers and taught to go through images, identify faded blob-shaped objects from the deep hole of space, and assess whether they are galaxies or not, and if so, what kind of galaxies they are. With the aid of this Morpheus, machine learning software, the James Webb Space Telescope lets us to understand the universe in a new way that we have never seen before.

Space contains thousands of galaxies and billions of stars and they are captured by James Webb Telescope. Therefore, humans alone cannot document its findings. Therefore, in this context, Morpheus, the AI system tasked with analyzing the images. Morpheus was trained on a supercomputer named UC Santa Cruz's Lux. The UC Santa Cruz's Lux has 28 GPU nodes. Each node has two Nvidia V100 Tensor Core GPUs.

The famous first image of a black hole at the center of the M87 galaxy was identified when using an AI system by a research team.

The Mars 2020 Perseverance Rover

The AI-enabled Mars 2020 Rover was launched from Earth on an Atlas V Launch Vehicle on July 2020. The Mars 2020 Rover landed in the Martian Crater Jezero on Feb 2021.

Source: https://mars.nasa.gov/mars2020/

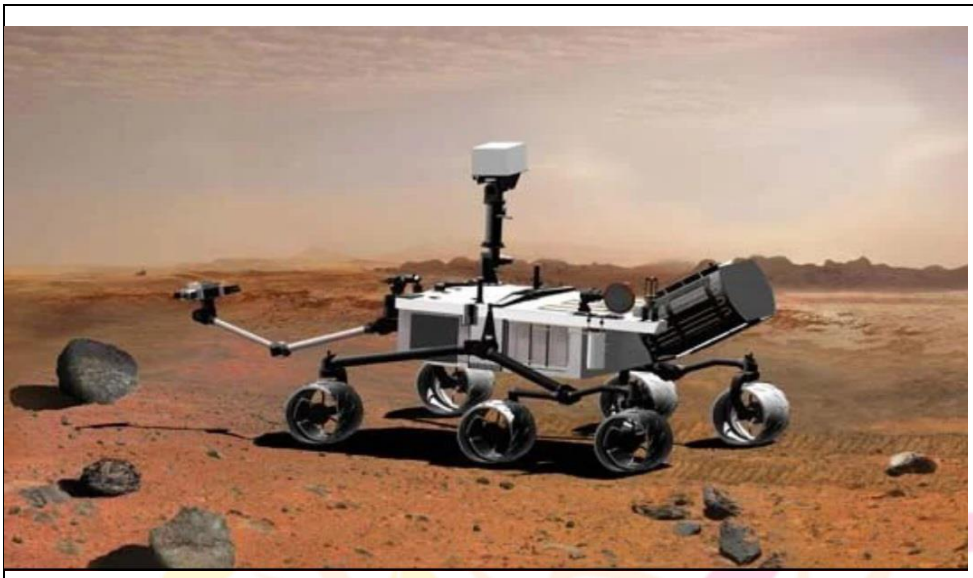
The Rover called Perseverance has AI-powered tools. The Tools include a set of machine learning algorithms. The algorithm helps the Rover to find rocks and check whether there was ancient microbial live.

The Given AI, AEGIS (Autonomous Exploration for Gathering Increased Science (AEGIS), is used by NASA's Perseverance Rover. It was developed for handling independent target of cameras and choose what to probe on Mars.

Source: https://mars.nasa.gov/mars2020/

Curiosity Rover

Curiosity was launched on Nov 2011 and landed on Mars on Aug 2012. AI is being used in NASA's Curiosity Mars Rover also. It allows the Rover to find and choose targets autonomously in its surroundings. It uses a 'chemcam' instrument to get geochemical gamuts.



Source: https://mars.nasa.gov/mars2020

Satellite Operations / Navigating System

Before AI, satellites were actively managed by scientists to prevent collisions. Now AI algorithms can manage satellites and automatically make corrections to prevent collisions.

The algorithms use a combination of data from the satellite's detectors, including its position and velocity, to identify dangerous steps and take fugitive action. The process of satellites can be optimized by AI into their correct path ways. Using AI, scientists reduces the energy needed and the period demanded to achieve the asked orbital position.

AI ROBOTS

The space life is very difficult to an astronaut. To live in space, some additional requirements are needed which are not required in Earth. The liquids in the body move upward to the head in microgravity. This may put pressure on the eyes and cause vision problems. In addition, if they stay long period in space, it will give them physical and mental problems. AI enabled Robots may replace Astronauts. AI Robots save money as well as human live.

The German Aerospace Centre along with Airbus and IBM have developed Simon, an AI based Assistant for astronauts that has been sent to the ISS fly around. Many other AI-enabled Robots have also been sent to ISS.

AI drones are already helping with the Terraform earth by scouting optimal locations for trees

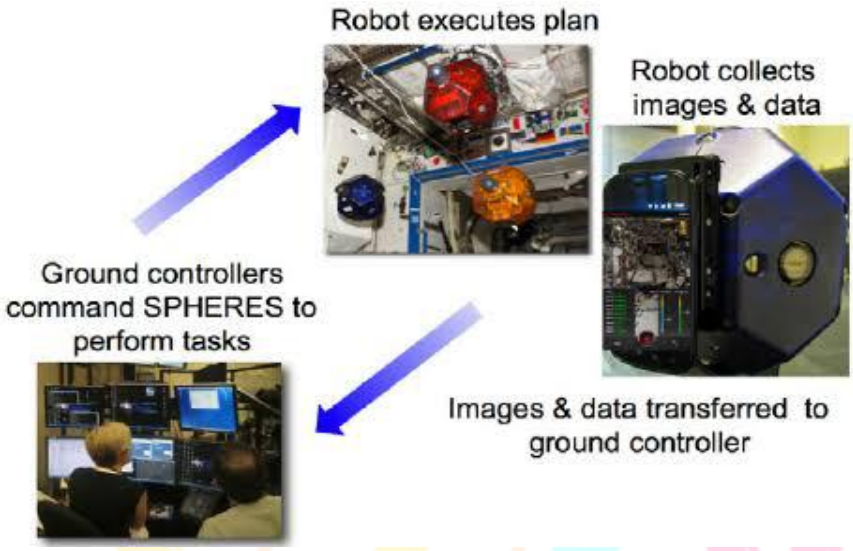
AI makes Robots that they're capable of making decisions on their own. While exploring space, the landing phase have been almost completely automated using AI Technologies.

Assistive free-flyers

Instead of Astronauts, Assistive free-flyers are used for some operations in the ISS.

Assistive free-flyers are AI Robots and they're capable of free floating in absence of gravity. For Example, inside the International Space Station, there will be more than 63 free-flyers on tasks. Free flyers can also be used beyond the international new applications within international space station. For example in the context of helping

astronauts with extravehicular activities, servicing and repairing spacecraft. The entire field is called orbit servicing by robotic systems.



Recognize patterns of Galaxy

Deep learning or neural network algorithms in AI, use many interconnected nodes and they are able to learn to recognize patterns. They are very appropriate solutions for finding out the patterns of galaxies. Astronomers started to use neural networks to classify galaxies in the early 2010s. Now the algorithms are very efficient and they can classify galaxies with an accuracy of 98%.

Chandrayan 3

Chandrayaan-3's cutting-edge design incorporates solar-powered technology, enabling direct communication with Earth. The six-wheeled robotic vehicle relies on solar energy, ensuring sustained functionality even during the challenging lunar nights, thanks to an advanced thermal control system. This groundbreaking approach showcases the mission's commitment to overcoming environmental challenges on the lunar surface.

Chandrayaan-3 employs a sophisticated navigation system, integrating high-resolution cameras and laser altimeters to meticulously select a secure landing site. Real-time processing of data from these sensors involves advanced algorithms, assessing crucial factors such as slope, roughness, and lighting conditions. This intricate approach ensures precise identification of optimal landing sites, showcasing the mission's dedication to safe and effective lunar exploration. A combination of sensors and AI algorithms have been used to ensure a safe landing on the Moon by lunar lander. Some of them are as follows:-

- LIDAR (Light Detection and Ranging): Lidar sensors emit laser beams and measure the time it takes for the light to bounce back, creating a 3D map of the lunar surface.
- RADAR (Radio Detection and Ranging): Radar can penetrate the lunar surface and provide information about the composition and depth of the terrain.
- Visual Odometry: This algorithm uses images captured by onboard cameras to estimate the lander's position and motion relative to the lunar surface. Stereo vision and structure-from-motion techniques are often employed.
- Inertial Navigation: Accelerometers and gyroscopes can be used to measure the lander's acceleration and rotation, allowing for estimation of its position and orientation.

- Simultaneous Localization and Mapping (SLAM): SLAM algorithms combine sensor data with motion models to simultaneously map the terrain and localize the lander within that map.
- Terrain Classification: Machine learning algorithms can be used to classify different types of terrain (e.g., rocks, craters, flat areas) based on sensor data, helping the lander choose a safe landing site.
- Hazard Detection and Avoidance: Algorithms are used to identify hazards such as boulders or steep slopes and make real-time decisions to steer the lander away from them.
- Trajectory Planning: These algorithms calculate the optimal descent path and landing site, taking into account factors like fuel consumption and safety margins.
- Autonomous Landing: Autonomous algorithms take control of the lander's descent and landing sequence, making adjustments in real time to ensure a safe touchdown.

These algorithms work in concert to enable a lunar lander to map and navigate the lunar terrain accurately, avoid obstacles, and safely land on the Moon's surface.

Literature Review

The applications of AI are in various aspects of space exploration, including satellite operations, rover missions, telescope observations, and robotic assistance for astronauts. The impact of AI in enhancing efficiency, automating tasks, and enabling autonomous decision-making in space exploration endeavors. The AEGIS system, the James Webb Space Telescope, Mars rovers (2020 Rover and Curiosity Rover), and AI-enabled robots are some examples for AI implementation in space. AI are needed for handling large volumes of data and images captured by satellites.

AI algorithms are employed to manage satellites, optimize their orbital positions, and prevent collisions. The use of data from satellite detectors to identify potential threats and take corrective actions.

The application of deep learning algorithms and neural networks in recognizing patterns of galaxies. AI has improved the efficiency and accuracy of classifying galaxies, aiding astronomers in their research.

AI were used specifically in the Mars 2020 Rover and Curiosity Rover. The AI-powered tools and machine learning algorithms are used by these rovers to autonomously navigate, identify targets of interest, and analyze rocks for signs of ancient microbial life.

The Morpheus machine learning model is used to analyze images and identify galaxies. The use of AI enables a deeper understanding of the universe by processing vast amounts of data.

AI-enabled robots and assistive free-flyers are used in space missions. The development of AI-based assistants for astronauts, such as Simon, and their deployment on the International Space Station (ISS) is very useful. The benefits of AI robots in replacing astronauts for certain tasks are cost savings and reduced risks to human life.

Conclusion

As AI has been improved by day to day, it has become an essential tool for astronomers. As telescopes get better, as data gets larger, it is likely that this technology will play a central role in future discoveries about the universe.

It becomes evident that Artificial Intelligence has significantly revolutionized the space industry, enabling scientists and engineers to explore space more efficiently, make informed decisions, and expand our understanding of the universe. The applications of AI in satellite operations, rover missions, telescope observations, and robotic assistance have collectively contributed to making space exploration safer, more cost-effective, and scientifically fruitful. With ongoing advancements in AI technology, the future of space exploration holds even more exciting possibilities.

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