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Study of AI and ML Based Technologies used in International Space Station

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There are billions of galaxies, stars, solar systems, planets, and other undiscovered mysterious objects in expanding space. Humans took a giant step forward in exploring such a three-dimensional dark box when the International Space Station was deployed into Earth's lower orbit for study and to better understand the environment of space. Previous publications have discussed how artificial intelligence is being utilized to explore space and identify habitable worlds. This paper describes some of the AI-based technologies that are employed in the International Space Station, which is a key component of future space exploration. The study also looks at AI technologies that might be deployed on the International Space Station to increase its efficiency and provide security to the crew. The study includes a full explanation of the requirement, operation, and construction of NASA's "Robonauts" designed for the International Space Station. The paper also mentions ATLAS, an asteroid detecting system. The methods for providing medical aid to the crew, debris and its influence, analyzing data and extracting insight from space research data using machine learning are also highlighted. This study investigates how technology used in space exploration could be used to the ISS to improve its performance and provides an overview of some of the existing AI-based technologies utilized in the International Space Station (ISS).

Keywords: Artificial intelligence, Asteroids, ATLAS, Debris, International Space Station, Machine learning, Robonauts

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Introduction

The Space is a limitless vacuum that is home to billions of galaxies, each galaxy is home to billions of stars with their solar systems and this network keeps drilling until we appear on Earth. In this gigantic universe, exploring space and planets seems impossible without the use of technologies based on Artificial Intelligence but how about living in space? The International Space Station is one of the wonders created by human beings. Its mere existence in earth's orbit is enough to prove the capability and potential of the human mind. Every day researchers are making new technological advancements in the field of artificial intelligence which are being implemented in various fields like the military, hospitals, Space research, etc. This paper would cover the artificially intelligent technology used to enhance the working of the ISS and the potential technologies that can be used as well.

ISS, International Space Station is a habitable artificial satellite in the earth's lower orbit [5]. Astronauts and scientists live in the ISS to understand the working environment of space better and perform local exploration tasks. Such delicate work needs efficient technologies that ensure the safety of the crew in the space. Artificial Intelligence is one of the most important keys to achieving such challenging and risky tasks. For a long, the humans wished to go beyond the blue sky and know what is out there in the infinite dark world. Unfortunately, in the past, we lacked both the technology and a skilled astronaut as they also need high-level rigorous training with one of the most expensive training and equipment in this world like Zero gravity room, Spacesuits like model A7L [1], which is made up of more than 20 layers of materials like Aluminum, Dacron, Mylar, Teflon, and helmets with gold plated visors to reflect sun's rays. They are designed with such high precision to ensure astronaut survival in a vacuum full of radiation where the temperature goes from shivering cold of -270 °C [6] to burning hot in some planets like 475 °C on Venus [7], and other harsh conditions in space. In such conditions, how is anyone supposed to do any work? How could we possibly explore the space or even go to space and come back alive? This is just the tip of the iceberg for the challenges to exploring space and planets.

To ensure our own race's safety, we used animals in earlier space programs to know if it is possible for a human to survive there or not. Fruit flies were the first living organisms to be transported into space. On February 20, 1947, they were transported aboard a V2 rocket. The rocket flew 67 miles before parachuting back to Earth. The height of 100 kilometers is currently recognized by NASA as the official start of space. As a result, fruit flies are regarded as the first animals to reach space. Several kinds of animals, including monkeys, mice, and dogs, were flown into space by the Soviet Union and the United States after the fruit flies for suborbital flights. On 3 November 1957, aboard the Soviet spacecraft Sputnik 2, the dog Laika became the first animal to make an orbital journey around the Earth [2]. As soon as humans got the confidence to board one of the rockets to venture the space, many tragic accidents occurred. In the "Space Shuttle Columbia disaster" of 1 February 2003, the space shuttle disintegrated as it entered the atmosphere, killing all the seven crew members on board. The paper covered the above space exploration facts, issues, and accidents to explain to the audience how the need for AI technologies arose and why do humans need AI to guarantee the safety of our astronauts. This paper gives an overview of current technologies being used in the International space station and discusses the technologies that are used for space exploration and how they could be used in ISS to enhance its working. The objective here is to understand the working and need of AI-based technologies used in the International Space Station, How they affect the environment of ISS, and help in research task. To discuss the potential AI-based technologies that can be used to enhance working in ISS.

Purposed Technologies

Artificial Intelligence is bringing a technological revolution in all domains including Space research and exploration. This module will cover the various AI-based technologies used in the ISS.

Robots to assist – Robonauts

Robonauts are "Robot-Astronauts", that are Artificially Intelligent robots used in the International Space Station. They are humanoid Robots series, based on the concept of a humanoid automaton working alongside astronauts.

Robonaut could assist in a variety of tasks, from operating on the International Space Station to exploring other worlds. For astronauts, outer space is a perilous area, especially when they need to go on a spacewalk, which is normally to perform maintenance and repairs on their spacecraft or other satellite. Robot assistants can make space safer for astronauts while also taking over some of the tedious or challenging tasks that humans must perform. NASA developed two Robonauts, called Robonaut1 and Robonaut2. Robonaut1 was created for experiment purposes to understand if such a machine could be an asset or hazard in ISS. NASA created Robonaut2 to work alongside humans in orbit. It's been on the International Space Station since 2011 when it arrived on the final flight of the 'Discovery' space shuttle. They are being used in ISS to perform cleaning, this saves time for astronauts so that they can focus on the main research work. They also assist the astronauts by providing them required tools for research.

In the current scenario, they are being used for the basic task but in near future, they will be used for exploring planets to check their habitability for humans, perform tasks outside the ISS and handle repairing on the satellite in space. It is a Dexterous robot [3] that can move its hands and fingers like a human and it can do anything that a person can do and even better. It performs various other tasks like measuring airflow in ISS almost perfectly because it can stand still for hours since it does not breathe, flipping the switches is another task it does.

Figure 1: Structure of Robonaut

Let's understand the structure of Robonaut (Figure 1). The height of a Robonaut is around 3 feet excluding the head and it weighs 150 kgs. Robonaut's head is equipped with four cameras, two of which give "stereo vision," which allows it to sense the depth of objects in

Its environment. Robonaut uses infrared radiation to determine how far away other things are, which is located in its mouth. To look around itself, the robot can rotate its head left and right, up and down. Thanks to "force sensors" that give it a feeling of touch, Robonaut can work securely beside people. When you touch the robot's arm, it will come to a halt. Each of Robonaut's arms has a 9-kilogram lifting capacity. NASA launched a set of legs to the International Space Station in September 2014 so Robonaut could move around the station more readily. The torso's support post was removed, and the legs were attached instead. Each of its long legs is almost 9 feet long [4].

Machine Learning for Data Analysis

ISS orbits the earth at the speed of 28,000 per hour [5], captures a ton of data every day of different types from space data, earth data to ISS data. The data is in huge amount and is expanding which makes it a big data getting stored in data warehouses. Such data gets filtered and the information is extracted out, this process is data mining. Almost all the space data is gold to the researchers to understand the space better and how the environment is there. To Extract information and meaning out of such huge data, Machine learning algorithms are used which helps to make the information extract faster and more efficiently. The extracted information is then used to develop future technologies that will be suited for the space better than the current machines and work far better ensuring safety to us humans.

The collected data would be Labeled and Unlabeled data. The majority of the data would be unlabeled therefore unsupervised learning algorithms would be needed to perform clustering of the data. For the labeled data, supervised learning algorithms would be used.

$H_\theta(x) = \theta_0 x_0 + \theta_1 x_1 + \ldots + \theta_n x_n$

In above equation, the input x would be computed to result an output y which would predict the regression, input x is the features and Theta are the parameters that would generate the ideal hypothesis.

AI technology to detect debris and clean it

Debris is a major threat that cannot be ignored. Debris is the waste material, wreck of spaceship and garbage spread in space which orbits the earth
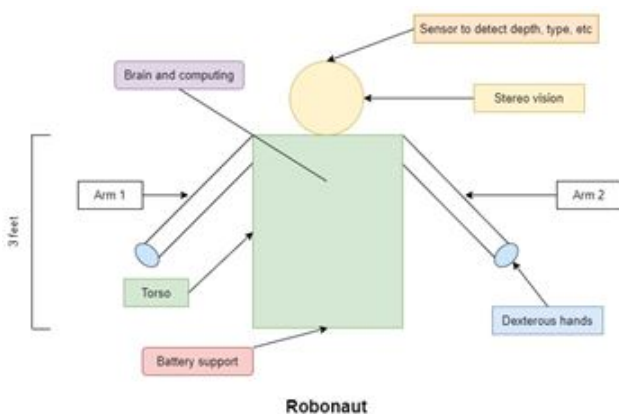
At speed of around 25000 km per hour. With such mass and velocity, if it hits something or someone, it would create a massacre. Artificial intelligence could be used in such cases to detect such fast-moving hazards and clean them. Machine learning has a lot of detection algorithms that could be used to detect the debris and send the cleaner or absorber to its predicted location to collect it.

European Space Agency, along with swiss 'Clear Space' has planned to launch a project to clear the debris in space, it would be implemented in 2025 [8]. With the help of AI-enabled cameras incorporated in the system, the ClearSpace-1 chaser aircraft will locate debris autonomously. After being identified, its four robotic arms will gather the trash, and the pair will enter the Earth's atmosphere and burn up.

Debris is a direct threat to ISS and to the crew inside. If some external force changes the course of debris and directs it to the ISS, it could be tragic so debris must be cleaned and prevented to spread or being created. More advanced technologies which share this aim can be developed with the help of machine learning algorithms.

Medical Aid to Astronauts: Astronauts are far from any facilities like us, imagine getting sick from some virus in space and no doctor or hospitals nearby? Such cases could be dangerous and medical assistance could be provided to the crew in the ISS. Although they are trained to manage such situations, Astronauts are not medical specialists. Fortunately, Robonaut is being developed by NASA in such a way that it could provide medical support to the crew in ISS. In Houston, a version of Robonaut 2 is already being trained to perform medical activities including syringing and performing an ultrasound imaging exam [3].

The important thing to note here is that sometimes humans are stressed while dealing with such situations but machines do not feel stressed and they can perform the task with greater accuracy at any time or condition. More such medical AI-based technologies could be implemented in the ISS.

Asteroid Detection and course changing: Just like debris, Asteroids are a major threat to everyone in this universe. Not to mention, they were the reason for the mass extinction of all dinosaur species 65 million years ago which destroyed almost 80% of living beings on earth and brought the

Ice Age later. Asteroids vary in size from the size of a tennis ball to the size of a planet itself. Scientists have already developed an AI system that detects the asteroid coming to the planet or passing nearby it. Such asteroids are a threat to ISS and Asteroid detection is monitored by the laboratories on earth. Detecting machines detects any asteroids that are on course to collide with ISS using AI-based technology and change its course but this could be implemented to ISS itself so it does not need any monitoring from the earth and can act on its own intelligently. ATLAS, Asteroid Terrestrial Impact Last Alert System, is a NASA-funded system that detects asteroids and predicts their course. The detection system is set up on different parts of the earth which have huge powerful telescopes and AI systems to detect the asteroids [9]

Conclusion

The Space is enormous. To explore it, Humans took a huge step 24 years ago [5] and sent a lab to space to understand space better. To enhance the productivity of that satellite, Artificial Intelligence came to its aid. Artificial Intelligence with its subsets Machine learning and deep learning, is bringing a revolution in every domain making them more advanced, better, and more productive than ever before.

This paper covered the current AI technologies used in ISS and suggested some AI technologies that can be implemented. The space is hostile to all living beings and the temperature there can even freeze lava or burn iron. Exploring such a place is not easy so we need artificial intelligence to perform the task that humans cannot. AI is primarily used to ensure the safety of astronauts in that hostile vacuum.

Robonaut, a Humanoid robot was sent to ISS to help astronauts with daily work and research. Robonaut2 helped to measure airflow in the ISS, flip switches and perform many other tasks to help the astronauts save time so that they can use time efficiently and focus on the main research work. One of its versions is being tested to provide the astronauts in ISS with medical aid. Debris and Asteroids are major threats to everyone in space, they must be cleaned and detected to change course respectively. Debris is a space shuttle wreck and is commonly spread by humans whereas Asteroids are space objects.

Both of them could be detected if are a threat to ISS and be dealt with using AI-based technology. As discussed, ISS's objective is to do space research so it is obvious that a huge amount of data would be generated and must be stored to extract meaningful information out. Machine learning algorithms are used to analyze the data and extract insights. Such information is later used to develop better AI machines that would be suited for space. Artificial intelligence is the key by which humans can explore space and planets. Habitable planets can be found using AI, where humans can migrate to in the future. Building and maintaining the International Space Station is the first step and now humans have a huge ladder to climb with the support of Artificial Intelligence.

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