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Applications of Robotics and AI in the Space Industry

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Abstract

Developments in robotics and AI are helping out many different industries, one of which is the space industry. From remote operations of machines to exploring extra-terrestrial rocks, astronauts and engineers heavily rely on robotics and AI to assist them.

1 Introduction

Robotics and artificial intelligence (AI) go hand in hand. One could say that AI are the 'brains' and robotics are the 'brawns'. However, they do not need to be applied together to work, as robots can be controlled by human operators while AI can be used to automate other specific tasks.

Within the space industry, there are many areas where the applications of robotics and AI can be beneficial. This includes the automation of dangerous or meticulous operations, all the way to explorations of extraterrestrial bodies and deep space.

2 Automation

The space industry automates many of their operations to cut down the time and increase productivity. Automation is heavily reliant on the use of AI to complete tasks that are too tedious or dangerous to humans.

2.1 Manufacturing

The machines and equipment used in the space industry can be intricate and complex, ranging from small robots up to large spacecrafts. AI can be used to assist in the manufacturing of these machineries where there may be complications. For example, AI can improve the manufacturing process of satellites by helping with the meticulous engineering that goes into the assembly of multiple pieces of components (Elite & Finucan 2019).

2.2 Satellites

Satellites are expensive pieces of technology and just like any other complicated machinery, they need to be maintained. This maintenance, called satellite servicing, can be performed by robots. Service spacecrafts with robotic arms can rendezvous with a particular satellite, pull it close then repair or exchange faulty parts (Choudhary 2019). Servicing can also include cleaning and taking measurements of the health status of core components within satellites to keep engineers updated (Elite & Finucan 2019).

As well as for repair, robots can also be used as garbage disposal units to push dead satellites into the atmosphere so they disintegrate (Grush 2020). Dead satellites count towards space junk and are dangerous as they cannot be controlled so the less of it, the better.

Another way that the space industry can reduce satellite failure is to utilize AI. For example, the space agency, SpaceX, have used AI to monitor and control satellites through shared ephemeris data so they won't collide with one another (Elite & Finucan 2019). AI can also be implemented into satellites to execute debris avoidance maneuvers autonomously.

3 Space Exploration

The space industry's main focus is to expand our horizons beyond Earth. Space exploration is a major area where the applications of robotics and AI are needed, especially since the environment outside of Earth's atmosphere isn't exactly friendly.

3.1 Teleoperations

Teleoperations is the operation of a system or machine from a distance. Many space agencies utilize teleoperations to explore extraterrestrial

bodies such as the moon, asteroids and other planets. For example, According to Schreckenghost et al. (2010, p. 20-25), NASA uses interactive robots for space explorations which can include scientific discoveries, site surveys and mission reconnaissance of other planets or bodies of mass.

This reconnaissance, called robotic reconnaissance involves the use of remote-controlled planetary rovers to collect measurements. The primary objective of a planetary rover is to navigate through hostile and unknown terrain and be able to deploy scientific instruments to collect data (Ellery 2004, p. 303). All this is done with a lack of data about the robot's surroundings. The planetary rover would also have to self-localize, which is the process of determining where the rover is within the environment (Huang & Dissanayake 2016). This process can be difficult due to the lack of information of its surroundings.

Robotic reconnaissance can be used to scout out particular parts of the environment not achievable from orbit such as on another planet. These robots can help collect surface measurements with scientific instruments to provide data for determining the best location for field work and improve the productivity of astronauts. For example, Yamamoto (2016, pp.103-115) describes the use of fish-based robots that can be used to conduct a geological survey of the moon and other planets. It can be used to detect rocks and minerals underground by producing waves that vibrate off the minerals and received by receivers on the surface.

Currently, the control of robotics for exploration mostly uses teleoperation. Operators on Earth will remotely supervise these robots while they are working and will perform manual operations that assists the robot's tasks. The flexibility to allocate tasks between humans and robots that are working together is called adjustable-autonomy (Schreckenghost et al. 2010, p. 20-25, cited in Sheridan 1998, pp.20-25). Adjustable-autonomy is used to bring manual operations into a robot's autonomous operations in a flexibly planned way that improves performance overall. However, an alternative to teleoperations will have to be considered for future deep space missions.

3.2 Deep Space Missions

The use of teleoperations in future deep space missions will be difficult if the operator is remotely controlling a machine from Earth. The time delay for signals to travel between Earth and anywhere in deep space will render the use of teleoperations in robotics close to useless. Teleoperations can still be used if human operators are relatively close to the machine being controlled such as staying in orbit and remotely controlling a rover deployed on the planet below. This however would require human astronauts to go along on these deep space missions.

Effective deep space missions will require future human astronauts to be adapted and enhanced physiologically. Szocik and Tachibana (2019, pp. 208-219) argues that artificial adaptation is risky and may cause unpredictable adverse effects.

An alternative to this could be robotic missions instead of human space missions. In comparison to human missions, robotic missions are less expensive and do not place anyone in danger. Engineers and mission planners would only need to focus on designing the research tasks of these robots as the development of life support is not needed. Both autonomous systems and teleoperations can be used during robotic missions. Currently, teleoperations are used when controlling the robot in real time by an Earth-based operator is applicable. In future deep space missions however, the robots would need to be equipped with advanced autonomous AI due to the communication delay if teleoperations were used. Robotic missions will require advanced AI to make space robots as intelligent as possible, however a problem that comes with this includes the possibility of the creation of artificial general intelligence (AGI), which can pose a threat to humanity (Szocik and Tachibana 2019, pp. 208-219).

4 Future of Robotics and AI

While these applications assist in solving current problems within the space industry, they can also introduce new problems that engineers still need to overcome.

The future space industry will become heavily reliant on robotics and AI. By applying their uses, space agencies will be able to extend the reaches of human missions beyond Earth's orbit.

References

Choudhary, M 2019, What is on-orbit satellite servicing?, Geospatial World, viewed 19 March 2020, <https://www.geospatialworld.net/blogs/on-orbit-satellite-servicing-process-benefits-and-challenges/>.

Elite, R & Finucan, L 2019, Trends and Applications of AI in Space, Satellite Today, viewed 19 March 2020, <http://interactive.satellitetoday.com/via/october-2019/trends-and-applications-of-ai-in-space/>.

Ellery, A 2004, 'Space Robotics: Part 3: Robotic Rovers for Planetary Exploration', International Journal of Advanced Robotic Systems, vol. 1, no. 4, pp. 300-307.

Grush, L 2020, Here's how robots could repair or dispose of broken satellites in orbit, The Verge, viewed 19 March 2020, <https://www.theverge.com/2020/1/28/21092089/satellite-servicing-repair-orbit-destroy-robot-collision-space>.

Huang, S, Dissanayake, G 2016, 'Robot Localization: An Introduction', In Wiley Encyclopedia of Electrical and Electronics Engineering.

Schreckenghost, D, Milam, T & Fong, T, 2010, 'Measuring performance in real time during remote human-robot operations with adjustable autonomy', IEEE Intelligent Systems, vol. 25, no. 5, pp.36–45.

Sheridan, T.B. 1998, 'Allocating Functions Rationally between Humans and Machines', Ergonomics in Design, vol. 6, no. 3, pp. 20-25.

Szocik, K. & Tachibana, K., 2019. Research Viewpoint: Human Enhancement and Artificial Intelligence for Space Missions. Astropolitics, 17(3), pp.208–219.

Yamamoto, I 2016, Practical Robotics and Mechatronics: Marine, space and medical applications, The Institution of Engineering and Technology, pp. 103-115.