Agnirva Project Report

Project Report Topic: **Ethical Considerations in the Use of Robotics for Space Exploration**

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- **Introduction**

The exploration of space has historically relied on human ingenuity and increasingly on robotic systems to achieve more ambitious goals. With advancements in technology, space robots have become integral in performing complex tasks in hostile environments, enabling humanity to extend its reach into space. This report examines the primary functions of space robots and their contributions to various space missions.

- **Exploration of Hostile Environments**

One of the primary roles of space robots is to explore environments too extreme for humans. Notably, robotic rovers like NASA's *Curiosity* and *Perseverance* have explored Mars to analyse its soil, rocks, and atmosphere for signs of life. Equipped with advanced scientific tools, these rovers can traverse challenging terrains and relay crucial data to Earth, greatly expanding our understanding of the Martian environment. Their autonomous capabilities allow them to make navigation decisions, enabling scientists on Earth to focus on scientific objectives rather than micromanaging each movement.

Key Missions:

- *Curiosity Rover* (Mars Science Laboratory, NASA)
- *Perseverance Rover* (Mars 2020 Mission, NASA)

- **Satellite Servicing and Maintenance**

Space robots play a significant role in extending the life and capabilities of satellites. Robotic arms like the *Canadarm2* on the International Space Station (ISS) are used to perform repairs, upgrades, and capture visiting spacecraft. This servicing ability reduces the need for risky extravehicular activities (EVAs) by

astronauts, ensuring safety and maximising the operational life of valuable assets in space.

Key Missions:

- *Canadarm2* on ISS (NASA/CSA)
- Robotic Refuelling Mission (NASA)

- **Assembly and Construction of Space Infrastructure**

Space robots are crucial in the construction and maintenance of large structures in space, an ability critical for missions involving building habitats on celestial bodies. For example, the ISS was assembled with the help of robotic arms that pieced together its various modules in orbit. This assembly capability is key to future endeavors, such as the construction of space telescopes, lunar bases, and potential habitats on Mars.

Key Examples:

- ISS Assembly (NASA/ESA/Roscosmos/JAXA)
- Upcoming lunar and Martian habitats (conceptual)

- **Scientific Research on Celestial Bodies**

Robots are also deployed as probes, orbiters, and landers for in-depth scientific research. ESA's *Rosetta* mission, featuring the *Philae* lander, succeeded in landing on a comet and conducting unprecedented studies of its composition. These missions provide data that would be impossible for humans to gather due to distance, time, and environmental challenges.

Key Missions:

- *Rosetta* and *Philae* Lander (ESA)
- *Voyager Probes* (NASA)

- **Space Debris Management**

With the proliferation of satellites and space missions, space debris has become a significant concern. Space robots are being developed to address this problem by capturing and removing defunct satellites and other debris, minimising the risk of damaging operational spacecraft. These developments are essential to maintaining the safety and sustainability of space operations.

Key Examples:

- Active Debris Removal Missions (conceptual)
- ESA's *ClearSpace-1* (planned mission for debris removal)

- **Future Prospects**

Future missions will likely involve even more sophisticated robots, with capabilities such as autonomous decision-making, in-situ resource utilization, and enhanced adaptability for building and maintaining human habitats on the Moon and Mars. The evolution of space robotics will expand human capabilities, allowing us to push deeper into space while minimizing risk to human life.

- **Conclusion**

Space robots are indispensable in contemporary space exploration,

facilitating exploration, maintenance, construction, research, and space debris management. These machines enhance mission safety and efficiency, empowering humans to achieve ambitious objectives. With further advancements, space robots will continue to play an essential role in the pursuit of knowledge and the sustainable expansion of human activities in space.

- **References:**
  - NASA Mars Missions: Curiosity and Perseverance Rovers

    https://science.nasa.gov/mission/msl-curiosity/

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    https://www.nasa.gov/international-space-station/space-station-facts-and-figures/

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