TECHNICAL REPORT
ON
SPACE ROBOTICS

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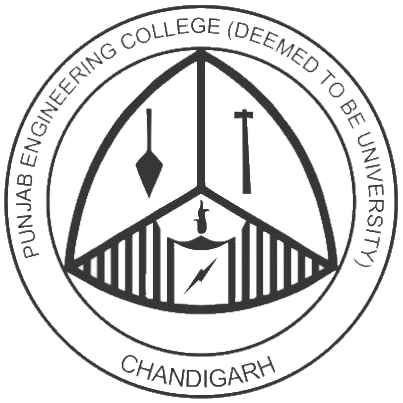

PUNJAB ENGINEERING COLLEGE

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Contents

1 Introduction

The space exploration has always been a suicidal mission for astronauts.The first Satellite was launched on October 4,1957 making Russian Lt. Yuri Gagarin the first human to orbit Earth.The advancements in the space research has led the robotic missions to reach space faster and gather more information than humans.The space technology is extensively developing with every passing year.Now astronauts can spend as long as 1 year in space. NASA is trying to reduce the human effort in space by deploying space robots who can extensively assist astronauts in various tasks.
'Space robotics is the development of general purpose machines that are capable of surviving (for a time, at least) the rigors of the space environment, and performing exploration, assembly, construction, maintenance, servicing or other tasks in space.'[2]
Robots can perform tasks less expensively and with improved performance over humans doing the same task.They can survive in extreme environmental conditions of space and can be sent to places which are otherwise inaccessible by humans.Robots don't get bored or distracted thus making them more effective and useful than humans.Moreover in many space missions,the cost of returning back to space is very huge.So,by using these robots that cost can also be reduced.Robots require less infrastructure and less safety requirements thus making them more useful in space exploration industry.

2 How Robots work in Space?

Robots work in space according to the SPA Algorithm.SPA stands for Sense,Plan and Action.
SENSE: A robot must be able to sense its surroundings about important things like the presence of obstacles and navigation aids.This is done through several sensors attached to the robot body like thermal, light, sound, chemical, object proximity, resistance etc.
PLAN:The robots needs to examine the sensed data and respond appropriately to it based on pre-planned strategy and knowledge.
ACT: Finally, the robot must actually act to carry out the actions that the plan calls for.e.g. move arms and legs, speech text, operate etc.

3 Technological Issues

There are four key issues in Space Robotics:

- Mobility:-The robot must be able to move quickly and accurately between two points without collisions and without putting other robots, astronauts, or any part of the work-site at risk.
- Manipulation:-The robots must use arms and hands to contact work-site elements safely, quickly, and accurately without accidentally contacting unintended objects or imparting excessive forces beyond those needed for the task.
- Time Delay:-allowing a distant human to effectively command the robot to do useful work
- Extreme Environments:-The robots must be designed to operate despite intense heat or cold, ionizing radiation, hard vacuum, corrosive atmospheres, very fine dust, etc.

4 Types of Space Robots

Th space robots are broadly categorized into two types-

- Remotely operated vehicles (ROV):
  A typical ROV can be a rover moving over the terrain upon landing. They are generally operated from a stationary point remotely by humans from earth so they have non-negligible speed-of-light delays.Besides being used by space researchers for terrain exploration in space, ROVs are used by bomb squads to detect potentially hazardous materials, in nuclear facilities and in sub sea.
- Remote manipulator system (RMS) RMS is the most common robotic device used in industry and manufacturing. It is more like a robotic arm that recreates various movements of the human arm including up-and-down, side-to-side and 360 degree circular motion. It can be either computer-operated or manually controlled.They are generally controlled from a "local" control console with zero speed-of-light delay.

5 Recent Missions

5.1 The MARS Exploration Rover

The MARS Exploration Rover is an ongoing mission initiated by NASA in 2003.This mission has two rovers namely SPIRIT and OPPORTUNITY

which were launched in July,2003 to explore the Martian Surface and search for the answers about the history of waters on mars.
Both of them landed on separate locations on Mars in January,2004 outlived their planned missions of 90 Martian solar days.Spirit was active till 2010 and Opportunity is still active 2018 and holds the record for the longest distance driven by any off-Earth wheeled vehicle.
The rovers had huge airbags over which they bounced when they were landing.They bounced several times before finally resting statically onto the surface. The rover was encapsulated inside the airbags which then deflated and the rover started its operation.
These rovers are controlled by NASA scientists from Earth remotely. Due to the far controllers some speed of light delays occur in transmissions.The rovers collects information about the environment and have sent over 80000 pictures to the control room.
"Opportunity is operating from over a decade now and broke the record of longest extraterrestrial travel by rolling greater than a distance of 26-mile marathon."[1]

5.2 Dextre

Dextre is the most sophisticated space robot ever built.It is a space handyman with a mission: keep the International Space Station (ISS) in shape. Dextre is a kind of robot arm which operates on Canadarm2 to move from work-site to work-site in space.The main task of Dextre is to undergo maintenance work of the International Space Station by stepping into space like changing batteries,tighten bolts,replacing cameras.Dextre chores are extremely helpful to astronauts since it exempts them from risky spacewalks for such repairs which are characterized as routine chores in ISS.Thus gives the astronauts more time for science which is the main aim of ISS.Dextre's special skills and awesome location also offer a unique testing ground for new robotics concepts like servicing satellites in space.
Dextre was initially designed to be operated by the astronauts inside the ISS but the latest operation is done from ground by a Canadian Space Agency.

5.3 Robonaut

The most advanced space robot created by NASA till today is Robonaut series.It is designed to be a humanoid,i.e. it works like humans. Robonaut could help with anything from working on the International Space Station to exploring other worlds.NASA began working on the Robonaut project in 1996 and produced the first version of the robot in 2000.Robonaut 2 or

R2 is the newest model.Robonaut has a head,torso, arms and hands like a person and cameras in the head to provide vision.Robonaut is called a dexterous robot because its hands and fingers move like that of person's.
Robonaut2 was first tested on Earth laboratories but now it is being sent to ISS to note its operation in Space and if everything goes well, it will be deployed in Destiny Laboratory of ISS.
NASA is still deciding what the future holds for Robonaut. If the test inside the space station goes well, Robonaut could someday be tested outside the space station. This testing would determine how well Robonaut could work with, or instead of, spacewalking astronauts. Robonaut's designers even have ideas for sending a robot like Robonaut to another world someday!

6 Disadvantages of using robots

- Robots are not able to perform autonomously without guidance of humans.They always need a human control either remotely or locally.This is the major aspect of future scope of space robotics i.e. to make robots work by their own.
- They require considerable human interaction to perform most scientific tasks. The creation of robots with human like cognitive and analytic abilities have not been achieved so far and it will continue to elude the scientific community for a long time.
- The abilities of robots are limited to assist only other cognitive tasks as well to perform simpler tasks.Although, robots are expandable relative to humans but their cost can be very huge.

7 Future Scope

Future trends in Space Robotics are expected to lead to planetary rovers that can operate many days without commands, and can approach and analyze science targets from a substantial distance with only a single command. Robots that can assemble/construct, maintain, and service space hardware using very precise force control, dexterous hands, despite multi-second time delay. Technology such as drones and augmented reality is rapidly becoming more commonplace on Earth, and so does there potential for use in space.

- SPACE DRONES:-NASA's researchers are looking at a helicopter drone that will be able to fly on Mars and direct future rovers that touchdown on the planet. "The helicopter would fly ahead of the rover almost every day, checking out various possible points of interest and helping engineers back on Earth plan the best driving route," [3]

- SELF-REPLICATING ROBOTS:-One space-exploring robot or drone may one day be able to create an army of similar exploring robots while it is in space. The idea is based upon the theory of mathematician John Von Neumann, who wondered if it was possible to develop a non-biological system that could replicate itself in a certain environment.
- HOLOGRAMS:-We're still a far away from putting humans on Mars to explore for ourselves, but hologram and augmented reality technology will put us as close to the surface as never.

8 Conclusion

The space program have contributed to many applications on Earth to make our lives more comfortable. Satellites are very complex robots. Robots in space are now a fundamental part of Satellite TV, weather forecast, and many other tools. And of course the GPS system is what makes you find your way when you travel is all a part of space robotics research and development.
There is the ISS robotic arm Canadarm that helps a lot in safety, speed and cost of maintenance operations in the space station. This robot pushes a lot further the capacities of industrial arm robots, and may lead to great improvement in industrial robotics.
Due to the advent of Space Robotics from the past few decades, the space missions that were earlier called "suicide missions" are now carried out effectively by robots with no constraint of returning back to earth either.
Furthermore, the cost of sending space robots is really cheaper than sending astronauts. The burdens of a manned flight are numerous, and represent a totally different level of challenge. We have to add the weight of living supplies (oxygen, food and other necessities) and of the return module.
The safety issues are also a big problem: you have to make sure the cabin is isolated, that radiations are minimal, and that the rocket doesn't accelerate more than what a man can bear at take-off. All of this adds up to make space robots a very cheap and efficient alternative for space exploration.
The SPACE Robotics Challenge by NASA is a budding competition which tasks teams to develop and display abilities for R5 Robonaut and offering 1 million dollars prize thus attracting people towards space research.

References

[1] Spirit and opportunity.

[2] Vijay Kumar Brian Wilcox, Robert Ambrose. Space robotics.

[3] Matt Burgess. Future scope, 2015.