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The future of space robots

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ABSTRACT

Space robots have been a significant medium for scientists to further advance their knowledge of space. These robots have enabled remarkable progress in the field of space exploration and have continuously helped in fulfilling the growing curiosity of humans. The Hubble Space Telescope, a legendary scientific instrument has taken pictures of our vast universe, bringing back to us the early moments of the creation of the universe and widening the horizons of our knowledge about the cosmos. The Giotto Spacecraft has enabled scientists to venture into interplanetary space and learn more about the comets and their true nature. Many such wonders of technology have done miracles in space and the bright future of these robots seems to be waiting for us to test our capability and hence design more advanced robots capable of withstanding harsh conditions experienced in space, being more resourceful than humans, having a brain of its own using the emerging technology of artificial intelligence which will make these robots capable of comprehending and analyzing data and sending it to us the most formulated form. This concise data can be used to derive inferences and conclusions which will lead to our better understanding of the extent of the universe and our place in it. This paper provides an overview of space robotics mentioning in detail its evolution and its future scope as well as covering its advantages.

Keywords: *Robots, unmanned missions, space exploration, artificial intelligence, technology.*

1. INTRODUCTION

From the beginning of time, the universe has been a mystery to mankind. The exploration of space by mankind is an expression of one of our finest aspects - curiosity. Space has piqued our curiosity from time to time and slowly over a span of centuries, and we have finally begun remotely understanding it. The exploration of space is deemed necessary to figure out some of the most fundamental questions of science related to the origin of the universe and its constant evolution. This large-scale exploration has only been possible due to the upcoming technology of space robotics. What is a space robot? It is a system having mobility and the ability to manipulate objects plus the flexibility to perform any combination of required tasks autonomously or by remote control, however, in layman's language in the space community, any unmanned spacecraft can be called a robotic spacecraft. The objective of space robots is basically to act as a medium for humans to perform various tasks in space such as position an instrument to take a measurement, collect a sample for examination, assemble a structure, or even move around an astronaut.

These robots have proved their ability to survive in the space environment with the bare minimum of resources, collecting samples with much more accuracy, assembling and constructing with ease, and handling the servicing tasks efficiently. These space robots aid the astronauts and act as their counterparts managing half their work and thus extending their capabilities. The robots can store a lot of information and can process it easily which in turn reduces the cognitive burden of humans which allows them to work on more complex issues which require native intelligence. Space robots are even working on the International Space Station right now. Space exploration has been more progressive ever since these robots have stepped out in the universe unveiling their true abilities to the world.

2. OVERVIEW OF THE RESEARCH PROBLEM

The desire to widen the horizons of our knowledge of space is more than ever. New nations are trying to join the increasing body of knowledge and contribute their bit by developing new technologies and testing them. Essentially there is no actual choice between robotic or human exploration of space, however, both are collaborative and co-dependent. Robotic exploration is imperative to enable human exploration by setting the context, providing critical information and raw data, and reducing the risk that can be caused to humans. Without its robotic precursors— Lunar Orbiter to map the moon's geographical surface, Ranger to get close-up views of areas that helped NASA perfect their navigation skills, and Surveyor to explore the surface, determine its composition and building blocks and practice soft landings, The Apollo program would have not been able to function. Without the immense aid of these robotic precursors, it would've been impossible to know where to go on the moon, how to design the landing hardware, or to have any clue of what experiments to carry out once we reached there.

Now we come across the main problem that can be observed as these points can be countered by researches which state that these results from those missions are fundamentally unintelligible without the archetype provided by the results from the manned Apollo program. The geologically trained astronauts during the Apollo Missions were able to select the most representative samples of a given locality and to discover and recognize interesting rocks and act on their findings. In contrast, the Luna samples were collected by the robotic probes indiscriminately without the understanding of the significance of a particular type of rock or sample. Therefore, we now have a better understanding of the geologic composition and structure of each Apollo site in much greater detail than those of the Luna sites. For a present-day example, consider the Mars Pathfinder mission, which was globally considered a major achievement. Though Pathfinder discovered an unusual, silica-rich type of rock, because of the probe's limitations we do not know whether this sample represents an igneous rock, a sedimentary rock, or an impact breccia. Different origins would have shed light on very different implications about the history of Mars and therefore the discovery has negligible scientific value. A trained geologist could have made a certain identification of the rock, in turn giving context to the succeeding chemical analyses and hence making this scientific discovery more meaningful.

In conclusion, although the unmanned orbiters can provide general information about the atmosphere, surface features, and magnetic fields of a planet and rovers can traverse the planet's surface, testing the physical and chemical properties of the soil and collecting samples for return to Earth, the field study is complex, analytical, and usually protracted. The process of solving the scientific conundrum is often not evident immediately but must be mapped out, analysed, applied carefully, and modified during the course of the study. The most important factor is that fieldwork mostly involves encountering the unexpected. An unexpected finding may lead scientists to opt for different exploration methods or to make new specific observations. But a space robot on a faraway planet cannot be redesigned and constructed to observe and record unexpected phenomena. Therefore, though robots can gather important raw data in abundance, analysing samples and conducting scientific experiments in space requires scientists.

Though sending astronauts seems like a better option now, the criticism of human spaceflight also comes from many quarters. Some people point to the high cost of manned missions. They believe that NASA has a number of tasks to accomplish and that human spaceflight is draining funds from other more important missions. Most scientists agree that STS, the Space Transport System, and the International Space Station are expensive and unproductive means to do space science. Shuttle launches are very expensive. Presently, it has been estimated that just the shuttle program's average cost per flight has been about $1.3 billion over a lifetime and about $750 million per launch over its most recent five years of operations. This total cost includes development costs and numerous safety alterations. Hence, logically it can be inferred that each shuttle launch could pay for 2 to 3 unmanned missions.

Therefore, also considering the limited range of human exploration presently, robotic exploration is necessary to enable manned missions. For the exploration of the solar system, robotic and automation is our only feasible option. This paper intends to give the reader a brief outlook on this diverse and emerging technology and it even proposes a solution in the end which can have a positive impact on space exploration.

3. HISTORY AND EVOLUTION

The history of space exploration takes us back to the 1950s when the major focus of all the space agencies had shifted to sending astronauts to orbit the earth or exploring the moon. This was expensive progress and consequently, robotic proxies came into consideration. These robots were not only cheaper supporting them to survive in space but also had no difficulties in locomotion. While astronauts have to take a lot of precautions before stepping out of the spacecraft into the harsh environment of space, robots are usually built in the form of rovers or arms as an extension of the spacecraft for extended mobility or simply drillers which can easily tolerate the dynamic environment.

In parallel to the failures in the past experienced by scientists while trying to launch certain spacecraft, these robotic proxies provided the constant motivation to further expand the research into outer space. Robonaut 2 or R2 was flown to the space station as part of the STS-133 mission and was the first humanoid robot in space. A small robot named CIMON (short for "Crew Interactive Mobile Companion") is the first robot with artificial intelligence ever to fly to space. Therefore, since those times scientists have put in a lot of effort and invented such space robots which can efficiently perform a lot of multi-tasks and unravel a lot of mysteries of space by just providing us the required information. Over the years space robots have evolved in many significant ways and have hence become an important medium for humans to expand their reach in the cosmos.

4. SOME BASIC FUNCTIONS OF SPACE ROBOTS

The rigidity and conventionality of the aerospace sector are well-known. The implementation of robotic automation has achieved astounding results. Although it is still in its nascent stage, it is past time for us to embrace the possibility of synthesizing an environment in which robotics, in combination with AI and machine learning, can solve complicated, calibrated, and repetitive difficulties. Furthermore, given the wide range of tasks performed, from manufacturing to maintenance, robots may do the majority of the job. There are nearly a thousand holes in a conventional fuselage. These must be done accurately, consistently, and quickly while drilling (pilot hole and final), filling, and reaming procedures are all completed in one pass. Scaffolding is usually required for painting, coating, and sealing, however, because of the broad work envelope of robotic arms and rails, this can be done more faster and with less risk of coming into touch with dangerous paints and fumes. ABB robots, for example. The model M-710iC from FANUC (Fuji Automation Numerical Control) Robotics can remove coatings from aircraft equipment.

Traditional conventional machining techniques such as turning, milling, grinding, and pressing can also be performed by robots. Previously, it was done by various machines such as a lathe, milling machine, press punch, and so on. FANUC, for example. Yaskawa Motoman can weld in a variety of ways, including spot welding (ES Series), plasma welding, and laser welding (EA Series) Six-axis robots from KUKA (Keller und Knappich Augsburg) Robotics ensure precision in cleanrooms, explosive zones, uniform surface treatment, and complicated assembly operations. The KUKA KR150 can assist in the assembly of pieces.

Automated fibre installation of composite fuselages and wing coverings can also be done with robots. Reinforced carbon fibres or plastic fibres are layered next to one other and then impregnated with resin in a predetermined thickness and orientation.

We now have automated machines capable of changing tools quickly. This automatic tool changeover saves a lot of time and eliminates the need to attach heavy parts each time. Non-Destructive Testing (NDT) is used to inspect airplane parts for cracks and fatigue, as well as delamination of composites.

Probes can also be used to measure bore depth, hole diameter, and surface properties. Furthermore, OC Robotics' innovation of snake-arm robots has made it possible to check dangerous or prohibited areas. Spatial snake-arm robots and planar snake-arm robots are the two most common types. Complex jigs are no longer required thanks to robots led by vision technology and CNC codes. Backlash errors are reduced when secondary and tertiary encoders are used. Fabric optimization, spreading, and cutting are all made easier because there is no space for error. The Aquarese technology can penetrate both titanium and foam layers with comparable precision. Higher production rates result in cost savings. Packaging, palletizing, and material handling are among the jobs it may perform. They also assist in payload handling, such as Staubli. ROV (Remotely Operated Vehicle) and RMS (Remote Manipulator System) have both been utilized in space exploration as unmanned deep-space probes and manned space probes. Robotics also aids in the design and simulation of models using 3D software.

5. ARTIFICIAL INTELLIGENCE

Robots are machines with artificial intelligence built-in. They're used in a variety of situations, particularly where they can help with difficult tasks or missions that are too dangerous for humans to execute. Artificial intelligence (AI) refers to all techniques that allow computers to simulate intelligence, such as data analysis computers or systems incorporated in autonomous vehicles. Artificially intelligent systems are typically taught by humans, a process that necessitates the creation of a large amount of complex computer code.

However, machine learning (ML), which trains machines to learn for themselves, can also be used to achieve artificial intelligence. A relatively simple algorithm can be 'trained' to become more complicated via machine learning. The system is fed massive volumes of data, which it adapts and improves over time. In machine learning, machines use artificial neural networks to interpret data in the same way that people do. Since the internet's inception, this sort of artificial intelligence has advanced dramatically.

Furthermore, ML systems are increasingly being used to analyse the massive amounts of data generated by each space mission. AI is being used to convey data from some Mars rovers, and these rovers have even been taught to navigate on their own. In addition, AI currently lacks the dependability and adaptability needed in new software; these attributes will need to be enhanced before AI can take over the space sector.

Currently, spacecraft must interact with Earth in order to function, but developing autonomous spacecraft that employ artificial intelligence to take care of themselves would be extremely beneficial for exploring new areas of the Solar System while also lowering mission expenses. Space technology and applications generate large amounts of data, including telemetry and product data – scientific data collected by a spacecraft, such as information about the Earth from an observation satellite. Machine learning can also be used to analyse all of this data.

6. ADVANTAGES OF SPACE ROBOTS OVER ASTRONAUTS

Space robots have been known to explore the universe more efficiently, reducing the number of resources that astronauts need to stay alive in space. Space agencies are working to make them more autonomous, and new robots will be AI-based in the future. As a stepping stone to deeper research, countries from all over the world seek to create a gateway station around the Moon. There will be communications delays due to the distance (the Moon is a thousand times farther away from Earth than the ISS), and the lunar gateway will be without staff for significant periods at first. As a result, our future generation of space robots will have to work without the assistance of humans, relying instead on artificial intelligence. The basic routine involves tasks that are of greater magnitude in terms of volume, simplicity, and repetition due to their high uptime. Looking through the glass, however, reveals robots in the aerospace industry making high-value, extremely large parts with accuracy, flexibility, and superior performance.

To begin with, unlike humans, robots do not require mandatory requirements such as nutrition, hydration, proper respiration, or regular excretion, making them superior to humans. They'll be able to survive in space for a long time without needing to be brought back to Earth. Second, we can send robots into space with little concern for their safety. Though the robots must last long enough to complete the mission for which they were launched into space, no human lives will be lost if the mission fails. Furthermore, robots can perform a wide range of tasks that humans cannot. Some robots can endure severe temperatures or high quantities of radiation. Humans, while providing operational flexibility, are extremely susceptible and have a low tolerance for the space environment. While preparing for a manned space mission, every aspect of human survival in everyday life must be examined in minute detail. Even health issues such as bone loss and muscle atrophy, which astronauts commonly experience after months in space, are not experienced by robots.

Finally, robots can perform tasks that astronauts would find too dangerous or impossible. Some astronauts are unable to explore the sun and other stars, which are tremendously hot blazing gaseous balls, or the cold wide expanses of our outer solar system, due to their suits' inability to protect them from the severe temperatures. Venus and Mercury are unbearably hot for crewed spacecraft, while the asteroid belt and Jupiter are impossibly cold. Humans can be a mixed blessing once they arrive at an exploration target. The new places being explored by human explorers, who are shedding pollutants and terrestrial contamination with each stride and breath, will become polluted.

Some experts argue that humans are more versatile in space in terms of operational flexibility, but that this comes at a cost. Humans are hefty, frail, and vulnerable creatures who are particular about their surroundings and have a low tolerance for space (i.e., high energy radiation, extreme heat, and cold, etc.). The fragility of humans, our aversion to endangering human life, and our need for consumables (food, water, and oxygen) necessitate significant sums of money to pay for the additional engineering and many redundant systems required to avoid risk to astronauts, as well as the significantly bigger support teams required to look after every aspect of everyday living during a manned space mission. All of this equipment must be monitored, limiting an astronaut's time to conduct experiments.

The capabilities of unmanned spacecraft have advanced dramatically in recent years. The Discovery program at NASA has pushed for the development of small, low-cost probes that can take exact measurements and send high-resolution photos. For roughly $265 million, the Mars Pathfinder mission delivered a treasure mine of data and images. Microsatellites and inertial compasses are among the advanced technologies being tested by NASA's New Millennium program.

The scientific benefit of sending people into space has also been questioned by critics. They contend that human spaceflight is a costly "stunt," and that robotic spacecraft can achieve scientific aims more easily and satisfactorily.

We deploy the robots as our scouts and pathfinders, and they open the frontiers so we can select where and when to send the humans. As a result, through the years of space robot evolution, it has become clear that the benefits of sending these human proxies to space are numerous, and as computers become more capable and efficient, more sophisticated robots will be constructed to tackle even the most difficult tasks.

7. ADVANTAGES OF ASTRONAUTS OVER SPACE ROBOTS

While no scientist can deny the importance of robotic space exploration, many people believe that manned programs are also necessary. Robotic probes, most believe, produce dramatic results for basic survey missions. Scientist-crewed flights could perform better in field research. Part of the issue is that each robotic mission has limited capabilities and scope. Robotic probes are simplified to their bare basics to save money and reduce failure rates. Although these probes collect valuable information, most of it is confusing due to the probe's inability to perform follow-up testing. Robots nowadays are unable to initiate new lines of study. Although raw data is useful, it frequently generates more questions. Worse, the data is frequently unexpected, leaving experts stumped as to how to interpret the findings. They'll need more missions to do different tests and, most importantly, to verify their findings by testing the same location repeatedly over time, which is the cornerstone of all solid science. With unmanned mission failure rates, this recurrent testing of results becomes problematic. Take, for example, the Soviet Union, Russia, the United States, and Japan's Mars exploration programs: all but 10 of the 31 missions launched since 1960 have failed, with only 5 achieving their initial objectives. Compare this to the near-ninety percent success rate of astronaut-crewed missions. Crewed missions are more expensive, but they are also more efficient. Human-calibrated experiments set up on the moon by Apollo missions worked flawlessly for eight years before being shut off in 1977 due to funding constraints. While robotic missions may carry identical devices, placing and calibrating them is extremely difficult. Ruggedness takes precedence above precision, resulting in less sensitive equipment and provide fewer details in the data they collect.

In comparison to robots, humans have various benefits. Rather than waiting for time-delayed instructions from Earth, they can make immediate judgments in reaction to changing conditions or discoveries. Humans can drill deep into for samples and deploy large-scale geologic sensors, which no other rover has been able to do. The accomplishments of astronauts and cosmonauts over the last 47 years have demonstrated the value of humanity as space explorers. Installation and maintenance of complex scientific instruments, as well as field expedition, require human capabilities in space. Human flexibility, experience, and judgment are used in these jobs. They require abilities that are unlikely to be mechanized in the near future. A purely robotic exploration program will fall short of addressing the important scientific questions that make the planets worthy of further investigation.

To perform effectively, many of the scientific instruments transported into space need to be carefully positioned and aligned. Astronauts have successfully deployed instruments in Earth orbit, such as the Hubble Space Telescope, as well as on the moon's surface. In the instance of the space telescope, space shuttle personnel on servicing trips were able to successfully repair the initially defective instrument and maintain it. The Apollo astronauts meticulously set up and oriented a number of experiments on the lunar surface from 1969 to 1972, providing scientists with a thorough picture of the moon's interior through seismic activity and heat flow measurements. These studies ran smoothly for eight years before being stopped off in 1977 due to financial rather than technological issues. In order to deploy sensors on planets or moons from afar, complex robotic approaches have been proposed. Surface rovers, for example, might potentially set up a network of seismic detectors. However, these methods have yet to be tested in real-world space operations. The harsh handling of robotic deployment is not suitable for very sensitive devices. As a result, auto-deployed versions of such networks are likely to be less sensitive and capable than human-deployed equivalents. To address these constraints, advanced and innovative technologies, as well as extremely complex systems, are required.

When intricate equipment fails, the value of humans in space becomes even more apparent. Astronauts have been able to fix hardware in space on multiple occasions, saving missions and the valuable scientific data they produce. Skylab's thermal heat shield was torn off and one of its solar panels was lost when it was launched in 1973. Some failures, such as the damage caused by the explosion of an oxygen tank on the Apollo 13 spacecraft in 1970, are too severe to be repaired in space. When spaceship equipment fails, however, astronauts can usually evaluate the problem, make quick decisions, and come up with creative remedies. Machines can self-repair to a certain extent, usually by switching to redundant systems that can do the same activities as the damaged equipment, but they lack the flexibility that people do. Machines can be programmed to solve predictable problems, but only humans have demonstrated the ability to deal with unforeseen challenges thus far.

Robots must rely on redundancy to deal with problems, whereas astronauts can come up with inventive solutions to practically any issue. Teams from the Space Shuttle repaired the Hubble Space Telescope, making it one of the most successful missions ever. The most important proponents of manned missions are geologists. While data from probes are valuable, they believe that a single trip led by a live geologist may answer all of their questions in a matter of weeks, whereas unending robotic probes may never be able to present a clear image of Mars. A geologist may use all of his or her skills to rapidly determine what should be studied and what should be ignored. Robotic probes are prone to missing vital clues and wasting time on ineffective avenues of investigation and research. Even the best video cameras can't compare to a human's vision, and, more crucially, the human brain, the solar system's best supercomputer, can interpret data on the go.

Space robots must also meet a number of unique characteristics, including the ability to endure launch, operate in harsh environments, often in distant regions, weigh as little as possible because any mass is costly to launch, use little power and have a long operational life, work autonomously, and be exceedingly reliable. Many constraints that robots designed for use on Earth do not confront are imposed by the restrictions of space. Because of the low pressure in orbit, metal parts cold-weld together, atomic oxygen reacts with nearly any material, and convection cooling benefits for electronics are nullified. Heavy particles cause digital equipment to malfunction or even burn, which is different from the radiation found on Earth and in space. External temperatures can range from zero to a hundred degrees Celsius to plus or minus a hundred degrees Celsius. Another feature of space missions is the requirement for robots to operate distant from their home base. As a result, space robots must be self-contained and capable of resolving any issues that arise while doing their duties.

When discussing the advantages of humans over robots, latency is a crucial consideration. A key stumbling point is a time it takes for a signal from a robot to reach mission control on Earth. It takes between 5 and 15 minutes to send a command to a Mars rover. The time it takes for light to travel to reach the moon is around 2.6 seconds. The Earth-moon delay takes 10 minutes to make a knot, but if we can reduce it to approximately 100 milliseconds, the robots will be highly capable. Teleoperated robots on another planet's surface would be stronger, more durable, and more precise than human explorers. In the past, teleoperation was considered for space exploration. The technology was not extensively developed during the Apollo era, but it has taken off in the last decade.

8. POSSIBLE SOLUTION FOR FUTURE DEVELOPMENT

Field research necessitates a high level of skill and intelligence. Is it, however, necessary for people to be physically present? Telepresence, or the remote projection of human abilities into a machine, could allow field research on distant worlds without the risk of logistical issues that come with human spaceflight. In telepresence, the movements of a human operator on Earth are electronically communicated to a robot on another planet's surface that can replicate the movements. The human operator has the sense of being present on the planet's surface, “inside” the robot, thanks to visual and tactile input from the robot's sensors. In addition, the robot surrogate's strength, endurance, and sensory capacities can be improved.

Why do we need humans in space if telepresence is such a terrific idea? For one thing, technology isn't ready yet. The most essential sense used in the field study is vision, and no real-time imaging technology produced to date can match the human vision, which has a resolution of 20 times that of a television screen. However, the most significant barrier to telepresent systems is psychological rather than technological. The method that scientists employ to perform field exploration is little known, and you can't simulate what you don't know.

Finally, there is the issue of time delay, which is crucial. Telepresence, in theory, should have minimal latency between the operator's command to the robot, the command's execution, and the viewing of the effect. The instantaneous response is impossible due to the vastness of space. The round-trip time for a signal between Earth and its moon would be 2.6 seconds. True telepresence is difficult since the round-trip time between Earth and Mars can be as lengthy as 40 minutes.

Robotic Mars probes must have a complex interface that forces the operator to focus on physical manipulation rather than exploration.

NASA is currently concentrating its efforts on constructing the International Space Station. Astronauts stationed on the moon could operate observatories and investigate the local geology for clues to the solar system's history. They might also employ telepresence to investigate the moon's hostile environment and learn how to combine human and robotic operations to achieve their scientific objectives.

In the past, teleoperation was considered for space exploration. The technology was not extensively developed during the Apollo era, but it has taken off in the last decade. In the coming future we will be able to witness astronauts set up camp on Mars' moons Phobos and Deimos and command remote-controlled robots to drive vast distances across the planet's surface, install geologic sensors, and gather samples for research.

9. UPCOMING SPACE ROBOTS

Space robots come in all shapes and sizes. The rover is the most common robot used in space missions. This vehicle can transfer scientific instruments around the surface of another planet. Both the vehicle and the instruments are usually operated independently. The Mars rovers, such as Perseverance and Curiosity, are among NASA's most well-known rovers, but they are just a few of the many fascinating ones. Engineers at NASA are constantly developing new robots. A-PUFFER, which stands for Autonomous Pop-Up Flat Folding Explorer Robot, is the name given to one of the most recent robots. The origami designs inspired this lightweight, two-wheeled adventurer. To inspect confined spaces, the robot can flatten itself out and duck down. BRUIE, the Buoyant Rover for Under-Ice Exploration, is also another fascinating creation. While taking images and gathering data, this robot can float in the water and roll its wheels down the underside of an icy surface. Scientists want to utilize a robot like this in the future to look for indications of life on frozen bodies around the solar system. The subsurface oceans of Jupiter's moon Europa or Saturn's moon Enceladus, for example.

ROVs (remotely operated vehicles) are also well-known. The majority of people have undoubtedly seen these robots traversing tough desert environments in war zones on the news. Remote controls and long-range radio waves are used to control these robots by humans. What makes them so beneficial? These space robots can resist harsh temperatures and significant quantities of radiation. Another sort of robot for space exploration is the remote manipulator system (RMS), like Kibo, a component of the International Space Station. RMS has served as a positioning and anchoring device, as well as a remote assembly device and a grappler, on NASA space missions.

Nasa's robots do not all take the form of rovers; one of the greatest examples is the Hedgehog robot. NASA is collaborating with Stanford University and MIT to develop this spiky cube robot. Hedgehog was created to investigate tiny things like asteroids and comets. There is relatively little gravity in these, and the landscape is exceedingly harsh. Hedgehog leaps and tumbles instead of rolling. It has the ability to operate on any of its sides. It could even extricate itself out of a deep crater by launching itself into the air in a tornado-like move.

NASA also has robots that look like humans. Humanoid robots are what they're called. For some tasks, a robot that moves more like a human might be the ideal option. For example, a humanoid robot could assist in the planning of a future human community on Mars. R5, or Valkyrie, is a robot created by NASA's Johnson Space Center with such objectives in mind. Cameras, sensors, a slew of motors, and two computers power this electric robot. R5 can use these tools to navigate its environment and move like a human.

The near-zero gravity in space is the most advantageous opportunity. Everything weighs far less than it does on Earth, and even the heaviest object can be moved and elevated with little effort, allowing even a small robot to move massive objects. The exceedingly small micro-rover Nanokhod was created by ESA in partnership with European industry. It can transport and position 1 kg of instruments inside a short radius of a small lander while being the size of a huge book and weighing only 2 kg. To collect soil samples from distant planets, a larger robot has been constructed. The robotic drill on the 12 kg MIRO-2 mini-rover can collect up to 10 samples from a depth of 2 m. It then returns to the lander, where the samples can be studied using the onboard scientific instruments.

Robotic space exploration has proven to be a boon in this field. The Mars Pathfinder and Mar Exploration Rovers have exceeded their creators' expectations and continue to provide critical data to earthbound scientists. When the Deep Impact mission slammed with comet Temple 1 in July 2005, it created a cloud of debris that could help scientists better understand comet creation and its building blocks. Future robotic missions are expected to give even more critical data in a variety of fields. The Jack Web Space Telescope, Hubble's successor, is currently being built by TRW (formally the Next Generation Space Telescope). It will be launched in 2010 and positioned in L2 orbit, giving it a considerably greater view of the stars. Because of its proximity to the earth, L2, or Lagrange Point 2, requires only one basic shield rather than the sophisticated cooling system required by Hubble. It will also be beyond the reach of the space shuttle if something goes wrong, as it happened on the Hubble mission.

Robots play an important role in space exploration, whether they are walking, tumbling, flying, or rolling.

10. PROGRESS IN SPACE STATIONS OVER THE GLOBE

Space stations all over the world are putting in immense efforts, day in and day out to organize a successful automated unmanned mission. For many years, the German Aerospace Center (DLR) has been researching AI approaches for space and Earth applications, and in 2021, an Institute of Artificial Intelligence Security will be established. DLR launched an AI assistant in 2018 to assist its astronauts on board the International Space Station (ISS) with their everyday activities. CIMON (Crew Interactive Mobile Companion) is a fully voice-controlled companion that can see, speak, hear, understand, and even fly! After 14 months, CIMON returned, but CIMON-2 arrived in December 2019 to take its place. CIMON-2 is scheduled to spend three years on the International Space Station. NASA has established an Artificial Intelligence Group to do basic research in support of scientific analysis, spacecraft operations, mission analysis, deep space network operations, and space transportation systems, among some other areas. The cognitive radio, which searches out 'white noise' areas in communication bands and uses them to transmit data, was examined by the Agency as a way to make communication networks more efficient and dependable. This maximizes the use of the limited telecommunication bands available and minimizes delay times. NASA has also looked into developing more autonomous spacecraft and landers for deep-space exploration, so that decisions may be made on-site, eliminating the delay caused by communication relay times. NASA and Google have also collaborated to teach Google's AI systems to successfully sift through data from the Kepler mission in search of signals from an exoplanet passing in front of its parent star. This fruitful partnership resulted in the identification of two new exoplanets that had previously escaped the notice of human scientists. Following its first success, the project is now sifting through data from other missions to continue looking for undiscovered planets. The Japanese Space Agency (JAXA) also created an intelligent system for photographing experiments on the ISS's Japanese module, KIBO. The Int-Ball from JAXA was self-contained and capable of taking images and films. It was created to promote extra- and intra-vehicular experiment autonomy while also acquiring the robotics technologies required for future exploration missions. An organization has announced a collaboration with nine American aerospace companies to launch miniature robots to the Moon.

11. FINDINGS OF THE STUDY

Robotics has provided new capabilities for humans to extend their reach in the universe. Previous robotic missions have enabled scientists to increase their knowledge not only in the branch of aerospace but also in other numerous disciplines of science. Future robotics missions will hence continue to change how space is explored in many fundamental forms like permitting more frequent explorations, at a reduced cost, and to even more challenging and dangerous environments. Upcoming Robots in collaboration with artificial intelligence and machine learning will have a knack for multitasking and will be able to single-handedly deal with complex operations efficiently prevalent in this field.

Although space exploration spending has declined since the '60s, space agencies are investing in space robots that could provide scientists with new insights into the Solar System and beyond. Looking into the future a few decades from now, it's hard to imagine what the space robots will be able to accomplish or what will they even look like.

Mankind’s motives behind space exploration are both emotional and logical. The desire to probe new territory is a natural human impulse. Exploration boosts the prospects of our long-term existence by widening the imagination and talents of humans. Robots and unmanned spacecraft can be used wisely to reduce risk and enhance the efficiency of space exploration. Some scientists believe that the application of artificial intelligence may enhance the capabilities of unmanned probes, but so far those capabilities fall far short of what is required for even the most elementary forms of field study. Although space robotics is still in its nascent stage and has yielded some uncertain outcomes, it still provides us the opportunity of carrying out safe and unmanned space explorations. Thus, these space robotics missions will play a major role in furthering human exploration in space and beyond.

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