Robots: our helpers in space

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A big advantage of space robots is that they need neither food nor drink and can support very inhospitable conditions. More important still, although expensive to design and produce, their loss is always preferable to that of an astronaut. At this month's ASTRA 2004 workshop robots designed in ESA's space research and technical centre in the Netherlands attracted much attention.

"On Earth, robots regularly take over when it comes to repetitive tasks or when human health may be at risk. They are used to assemble cars, deactivate bombs, weld pipes at the bottom of the sea and work in nuclear power plants," says Gianfranco Visentin, Head of ESA's Automation and Robotics Section at ESA's ESTEC, the Netherlands. "In space, it is even more attractive to use robots," he emphasises. "They can support or replace people to carry out tasks that are too dangerous, too difficult, repetitive, time consuming or even impossible for astronauts, they can also be faster and more precise than people."

Jokingly he adds, "plus they can operate around the clock and do not need to break for lunch or sleep".

What is a space robot?

In the space community, any unmanned spacecraft can be called a robotic spacecraft, but Visentin prefers a more specific description: "a system having mobility and the ability to manipulate objects plus the flexibility to perform any combination of these tasks autonomously or by remote control".

"The objective of space robots is basically to perform an action 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."
In some ways space robots are no different than their siblings on Earth – they basically replace a human performing an action.

However, those for space do have some special requirements as they have to:

withstand a launch
operate under difficult environmental conditions often in remote locations
weigh as little as possible as any mass is expensive to launch
use little power and have a long operational life
operate autonomously
be extremely reliable

To respond to these constraints, advanced and innovative technologies are needed, as well as very complex systems. Says Visentin, "this sounds like a lot of trouble, but space also provides great opportunities for creating robots that could not be made for use on Earth."

"The most advantageous opportunity is the almost zero gravity in outer space. This means that everything weighs much less than on Earth and even the heaviest object can be moved and raised with little effort, so a small robot can move huge objects."

Types of robots

The most conventional robot used in space missions is the rover. This vehicle can move around the surface of another planet transporting scientific instruments. Usually both the vehicle and the instruments are

operated autonomously.

ESA, in collaboration with European industry, has developed the incredibly small micro-rover Nanokhod. Although only the size of a large book and weighing just 2 kg it can transport and position 1 kg of instruments within a short radius of a small lander.

A larger robot has been developed to collect soil samples from other planets. The 12 kg MIRO-2 mini-rover carries a robotic drill that can collect up to 10 samples from a maximum depth of 2 m. It then returns to the lander where the samples can be analysed by the scientific instruments on board.

A third mini-rover being developed by ESA is the fully solar powered 15 kg Solero mini-rover that uses miniature batteries to store electricity on board. This also has an innovative chassis. Its six wheels arranged on the vertices of a hexagon enable it to operate in very rough terrain.

Learning from nature

Robot designers often use nature for inspiration. One good example is the impressive Aramies/Scorpion robot under development by ESA. With its eight legs and motion inspired by the animal world it can operate in very rugged terrain and on dunes.

Another example is the EUROBOT. This robot, which is as large as a human, is designed to carry out astronaut's tasks on the International Space Station. EUROBOT will be able to climb the outside of a space station, attach itself to the handrails just like an astronaut and be tele-operated by the crew inside.

Nature also inspired the hopping robot. Even if less than 40 cm high it can leap over obstacles up to a couple of metres high, a feat that is

impossible on Earth with its force of gravity but fairly easy to accomplish on the Moon or Mars.

Visentin emphasises that ESA's research focuses on space-specific issues that are not interesting or profitable for terrestrial use and does not duplicate what is already available.

"Whenever possible we re-use robotics technology used for applications on Earth, but some of the operations needed for space exploration are of no use on Earth. For instance, nobody would want to make a robotic field biologist to explore the Earth, as even with the most advanced technology the result would always be far inferior to a real biologist, at least today. On Mars, however, a robot is the only option at present."

Space poses many constraints not faced by robots for use on Earth. The very low-pressure in orbit causes metal parts to cold-weld together, atomic oxygen to react with almost any material and nullifies the cooling benefits of convection for electronics.

Radiation also differs from that encountered on Earth and in space, heavy particles make digital electronics misbehave or even burn. Thermal conditions are also extreme, with external temperatures ranging from plus or minus more than a hundred degrees centigrade.

Another characteristic of space missions is that robots have to operate far away from their home base. Radio signals to control and monitor them have to travel for a long time and this introduces communications delays prohibiting real-time or near-real-time tele-operation. Therefore space robots must be able to operate on their own and handle any problems that occur while carrying out their tasks.

All these are problems that ESA's space engineers have learnt to cope with. Qualified design techniques, materials, hardware and electronics

components are specifically designed to work reliably despite these effects.

“We are continuing to do research into new types of robots which can cope with the special conditions in space, go where humans cannot and help astronauts manage the huge amount of work on the International Space Station,” says Visentin.

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