Mechanics/Machinery

Ultra-Compact Transputer-Based Controller for High-Level, Multi-Axis Coordination

Features include reduction in flex wear, streamlining of robotic structures, survivability, and uniformity in handling various types of servos.

Lyndon B. Johnson Space Center, Houston, Texas

The design of machines that rely on arrays of servomotors such as robotic arms, orbital platforms, and combinations of both, imposes a heavy computational burden to coordinate their actions to perform coherent tasks. For example, the robotic equivalent of a person tracing a straight line in space requires enormously complex kinematics calculations, and complexity increases with the number of servo nodes. The conventional method of executing these calculations is with a PC-style set of electronics including a powerful CPU (central processing unit) microprocessor, operating system, power supply, a number of peripherals, connectors to support each servo node, and a web of star-topology wiring across the machine (including flexing joints), generally exceeding 100 conductors. In industry, the most common implementation is one or more dedicated PC cards mounted on an ISA (Industry Standard Architecture), PCI (Peripheral Component Interconnect), or VME bus. These cards provide the I/O connectors and supplement the CPU to execute the massive kinematic calculations in real time.

A new high-level architecture for coordinated servo-machine control enables a practical, distributed transputer alternative to conventional central processor electronics. The solution is inherently scalable, dramatically reduces bulkiness and number of conductor runs throughout the machine, requires only a fraction of the power, and is designed for cooling in a vacuum.

The benefit of this innovation is total elimination of the central controller and reducing the heavy web of star-topology wiring across the machine to four wires along a shared serial bus. This scalable innovation results in decreased power consumption, decreased bulk, and vacuum compatibility.

This controller places a digital signal processor (DSP), instead of a microprocessor, at each motor axis, each with its own power supply, conduction cooling, etc. The DSPs communicate via CANbus over RS-485 hardware, forming the heart of the transputer.

Features of the device include reduction in flex wear in serial-articulating joints, streamlining of robotic structures (with reduced wire-harness bulk), survivability in the case of a single-processor failure, and uniformity in handling various types of servos (brushless, brushed, etc.) and sizes up to 300 W. Brushless compatibility supports elimination of brush-life limits and particulate generation. Power in the 2-wire bus flows directly between regenerative power nodes and motive power nodes, rather than traversing the round-trip star topology.

This work was done by Brian Zenowich, Adam Crowell, and William T. Townsend of Barrett Technology Inc. for Johnson Space Center. Further information is contained in a TSP (see page 1).

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Barrett Technology Inc.
625 Mount Auburn Street
Cambridge, MA 02138-4555 USA
Phone: (617)252-9000
Fax: (617) 252-9021
E-mail: robot@barrett.com

Refer to MSC-24295-1, volume and number of this NASA Tech Briefs *issue, and the page number.*

Regolith Advanced Surface Systems Operations Robot Excavator

This design enables new ways of excavating for resources on planetary bodies.

John F. Kennedy Space Center, Florida

The Regolith Advanced Surface Systems Operations Robot (RASSOR) excavator robot is a teleoperated mobility platform with a space regolith excavation capability. This more compact, lightweight design (<50 kg) has counter-rotating bucket drums, which results in a net-zero reaction horizontal force due to the self-cancelation of the symmetrical, equal but opposing, digging forces.

This robot can operate in extremely low-gravity conditions, such as on the Moon, Mars, an asteroid, or a comet. In addition, the RASSOR system is designed to be easily transported to a space destination on a robotic precursor landing mission. The robot is capable of traversing over steep slopes and difficult regolith terrain, such as an impact crater on the Moon, and has a reversible operation mode so that it can tolerate an over-turning incident with a graceful recovery, allowing regolith excavation operations to continue.

The RASSOR excavator consists of a mobility platform with tread belts on the port and starboard sides that are each driven by electrical motors, but it could also operate with a wheel system to further reduce mass. Two batteries are mounted in a "saddlebag" configuration on either side. Two counter-rotating bucket drum digging implements are held by a rotating cantilever mechanism at the fore and aft ends of the mobility platform. The cantilever arms are raised and lowered to engage the bucket drum into the soil or regolith. A variable cutting depth is possible by controlling the angles of the cantilever arms.

The unit has three modes of operation: load, haul, and dump. During loading, the bucket drums will excavate soil/regolith by using a rotational motion whereby scoops mounted on the drum's exteriors sequentially take multiple cuts of soil/regolith while rotating at approximately 20 revolutions per minute. During hauling, the bucket drums are raised by rotating the arms to provide a clearance with the surface being excavated. The mobility platform can then proceed to move while the soil/regolith remains in the raised bucket drums. Finally, when the excavator reaches the end-user or dump location, the bucket drums are commanded to reverse their direction of rotation to the opposite spin from digging, causing the gathered materials to be expelled out of each successive scoop. It can also stand up in a vertical mode to deliver regolith over the edge of a hopper container.

The RASSOR can operate with either side up in a reversible mode and it can flip itself over. This means the unit can drive directly off of the deck of a lander to deploy in low gravity, eliminating a deployment mechanism, which saves mass and increases reliability due to decreased complexity. The RASSOR system is scaleable and may be mounted on mobility platforms of various sizes, and has control equipment — wireless signal router, computer, joystick, E-stop, and associated software.

This work was done by Robert P. Mueller, Jonathan D. Smith, Tom Ebert, Rachel Cox, Laila Rahmatian, and James Wood of Kennedy Space Center; Jason Schuler of EASI; and Andrew Nick of Sierra Lobo. For more information, contact the Kennedy Space Center Innovative Partnerships Office at 321-867-5033. Refer to KSC-13664.

Magnetically Actuated Seal

Design replaces existing pressure-actuated lift-off seals in turbopumps and eliminates low pressure drains, thereby increasing overall efficiency.

Marshall Space Flight Center, Alabama

This invention is a magnetically actuated seal in which either a single electromagnet, or multiple electromagnets, are used to control the seal's position. This system can either be an open/close type of system or an actively controlled system.

A lift-off seal (LOS) is a type of shaft seal used in a turbopump that does not allow propellants to enter the turbine during pre-start operations, such as when a cryogenic turbopump is being chilled-in or when the pump is being primed prior to start. Typically, lift-off seals are pressure activated and a low constant pressure in the seal's secondary seal cavity is needed to provide the delta-P necessary for the seal to open. This is typically accomplished with an overboard drain cavity. The LOS must remain closed during pre-start operations. This prevents cryogenic liquid from chilling-in the turbine, which would result in excessive thermal shock, and subsequent turbine blade cracking. During the start-transient, the LOS must open to prevent propellant gasification and sometimes to provide coolant to the turbine disk. If it opens too soon, however, the turbine pressure can be higher than the pump pressure, and result in hot gas ingestion into the pump or bearings. If it opens too late, the seal surface speed becomes excessive, and results in excessive wear and premature failure of the seal.

The magnetically actuated LOS is more reliable and requires no low-pressure secondary seal cavity or overboard drain (thereby improving efficiency). An electromagnet is used to open and close the seal at an exact prescribed instant during the transient. Additionally, with the magnetically actuated seal, the particular instant can be different between the start transient and shut-down transient. This allows for more desirable and predictable transient performance of the turbopump as well as more certain wear performance of the seal.

This work was done by Alex Pinera of Florida Turbine Technologies, Inc. for Marshall Space Flight Center. For more information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-32979-1.

Hybrid Electrostatic/Flextensional Mirror for Lightweight, Large-Aperture, and Cryogenic Space Telescopes

A much lighter-weight structure with higher correction range uses polymer-based membrane mirror technology.

Marshall Space Flight Center, Alabama

A lightweight, cryogenically capable, scalable, deformable mirror has been developed for space telescopes. This innovation makes use of polymer-based membrane mirror technology to enable large-aperture mirrors that can be easily launched and deployed. The key component of this innovation is a lightweight, large-stroke, cryogenic actuator array that combines the high degree of mirror figure control needed with a large actuator influence function. The latter aspect of the innovation allows membrane mirror figure correction with a relatively low actuator density,