The URANUS Mobile Robot

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Uranus is a sophisticated vehicle for autonomous mobile robot research. As an omni-directional mobile base, it makes possible experiments in perception, real-world modeling, navigation, planning and high-level control. It is self-propelled and can support a wide variety of sensor and manipulator packages. True autonomy is possible as electrical and computing power are carried on-board.

The most unique feature of *Uranus* is its four wheels. Developed by a Swedish company, MECANUM, for omni-directional movement of factory floor pallets and wheel chairs, we have adapted them for use in mobile robots. With respect to the wheels' Swedish origin, we pronounce *Uranus*: Oo-ron'-oos.

Wheels

Each wheel has twelve free-spinning rubber rollers around its circumference. The axle of each roller is at a 45° angle to a line parallel to the wheel's axle. When viewed from the side, the end of each roller overlaps the beginning of the next, and due to the barrel shape of each roller, the wheel presents a circular silhouette. As a wheel rolls, its contact with the ground changes from one roller to the next smoothly.

There are right-handed and left-handed wheels which can be thought of as working in pairs, with each pair on a common axis. When both wheels are rotated in the same direction, the sideways components generated by the rollers cancels and the wheels move forward or back. However, when the wheels are rotated in opposite directions, the sideways components add and the wheels move sideways.

Structure

Uranus describes a rectangular envelope which is 30" (76cm) long by 24" (61cm) wide by 12"(30cm) high, with additional height of 0.5"-2.5" (1.3-6.3cm) due to ground clearance. The primary frame components are 3"x6" (7.6x15.2cm) rectangular aluminum tubing. The suspension components are all stainless steel.

The vehicle has three layers. The first six inches (15cm) includes the wheels, drivetrain, motors, batteries and power control. As this is the majority of the weight, the center of gravity is very low.

The second six inches (15cm) includes computers and control electronics along with their associated power supplies. The four corners of this level are for springs and dampers of the suspension.

The third level consists of the top plate or deck. It is 23" (58cm) by 27" (69cm); slightly smaller than the vehicle envelope. This allows the wheels to contact a vertical obstacle first. The deck provides structural support for up to 250 pounds (113kg) of additional equipment. It is full of 1/4"-20 holes on a grid of one inch (2.5cm) centers.

Motors

Each of the four wheels is driven by a samarium-cobalt brushless D.C. motor. An on-board computer controls motor position, speed and rotation by monitoring shaft position with an optical encoder. The motors are mounted in the side frame pieces of the first layer between the wheels. The shaft end of the motor protrudes into the frame and connects with the drivetrain. The power electronics for switching a motor's coils is housed in a heat sink mounted directly to the outboard side of the motor housing. This is to minimize EMI and allow convection cooling.

Suspension

Each wheel is mounted on what can most easily be described as a trailing-arm. Vertical movement of two inches (5cm) maximum is possible. Initially, the vehicle is suspended on stiff coil springs which allow just enough compliance to ensure that all four wheels have adequate contact with the ground. Space is available for the option of an active suspension. By computer control of pneumatic or hydraulic actuators, the vehicle can be leveled, raised and lowered to facilitate certain environments.

Power

Power is supplied by an on-board sealed lead-acid battery. The motors operate directly from the 24VDC battery power, whereas the computers and other equipment convert and condition power through dedicated switching power supplies.

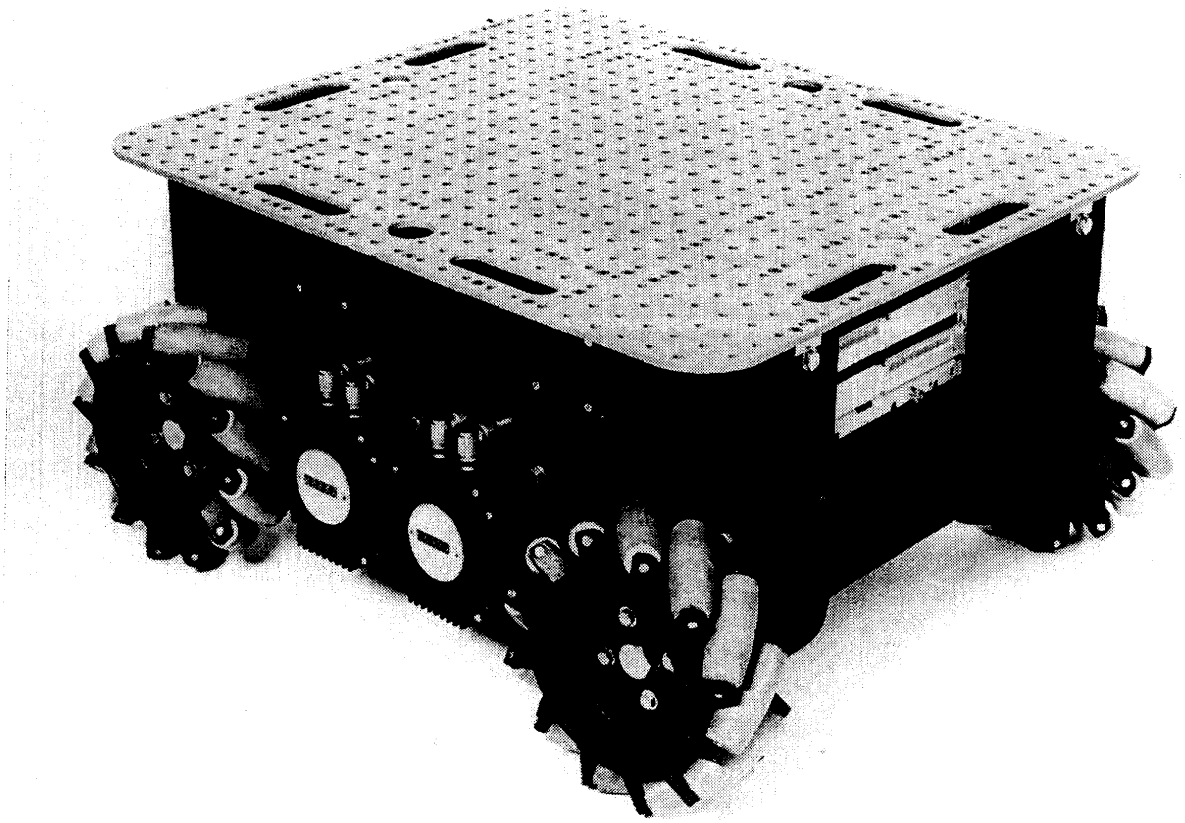
An umbillical provides 24VDC from an off-board supply. This supply is capable of powering the entire vehicle and simultaneously charging the batteries. In this way, experimentation which does not require full wireless operation and indefinite operating times are facilitated.

Performance

Four motors, developing peak torque of 3.5 ft.lbs. (4.7nm) drive the wheels through a 4:1 reduction. With a 9" (23cm) wheel diameter, about 150 lbs. (660nt) of thrust is developed. This is the theoretical maximum; about half this number is a practical value.

With these motors the maximum speed is about three feet (1m) per second or 2MPH (3.2KPH) which is adequately fast for a cluttered environment. This can be increased if need be.

With on-board batteries, about four hours of wireless operation is possible. This estimate must be reduced if the vehicle requires more power for rough terrain or interaction with objects in the environment. Similarly, more time is available for a single experiment if the movements are more sedate.



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