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Intel's Newsletter for
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Carnegie Mellon Leads in Real-Time Robots

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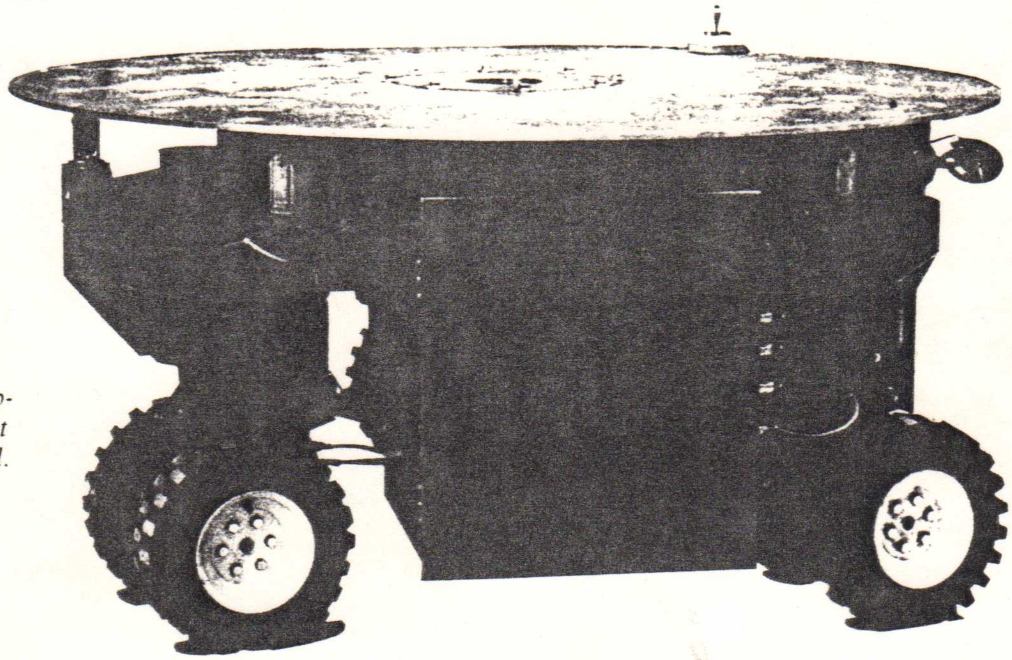

It may not be as handsome as C3PO, *but CMU's Locomotion Emulator is a robot that really knows its way around.*

The Field Robotics Center (FRC) at Carnegie Mellon University develops mobile, perceptive, forceful robots for duty in unpredictable environments such as unstructured work sites and natural terrain. Completed works include three teleoperated robots for nuclear damage recovery, four systems for autonomous navigation, and a robotic excavator. A robot to explore planetary surfaces is in development.

Ongoing research at the FRC includes the development of capable and intelligent control computing architectures that can port to many different robots. The current architecture is partitioned into four functional modules:

Communications. Handles all communication transactions between the controller and command sources. High-level computers interact with this module through a robust command protocol transmitted over serial lines and local area networks. Human operator interfaces include input devices, such as joysticks, keyboards and screen displays.

Control. Executes action commands. The control module

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interrupt-driven environment, a logic analyzer becomes the tool of choice for monitoring real-time activity. Even for a target system which uses the 8096 in the single-chip mode, the development board makes the 8096's address and data bus signals available to the logic analyzer. Alternatively, an in-circuit emulator supports the same activities with more finesse.

Either environment will provide students with the tools and experience to meet the accelerating number of design jobs involving microcontrollers.

Carnegie Mellon Robots, (Cont.)

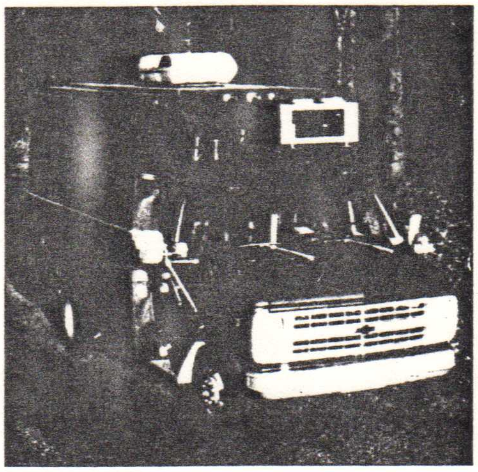
integrates and coordinates navigation sensors, control algorithms, and the individual actuator mechanisms to perform the desired robot motion.

Health monitoring. Provides safeguards to ensure the health of the robot. Preventive protection schemes anticipate and avert potential hazards while reflexive measures are invoked in response to unexpected or harmful events.

Sensor management. Acquires sensor data. The manager converts raw data into meaningful representation and shares this information with controller modules.

The structure of the architecture is highly dependent on a multitasking scheme. The design was based on the principles and characteristics of real-time, multitasking operating systems such as Intel's iRMX® 86. The core of the current hardware configuration consists of two Intel 286/12 single-board computers (for communication and control modules) and Intel serial and parallel I/O boards. Both processors run the iRMX 86 operating system, and all application code is written in the PL/M-86 programming language.

We have implemented controllers on four robotic testbeds for research in navigation and excavation. The Terregator (TERREstrial NaviGATOR), the earliest of our locomotors, is a driverless testbed



CMU's NavLab

designed for all-weather, rough terrain operation. The Terregator communicates with remote hosts through wireless telemetry for offboard computation. Using sensors such as cameras, a sonar sensor array, and a laser scanner, the Terregator has successfully navigated sidewalks and off-road areas and has mapped a portion of a mine.

The NavLab (NAVigation LABoratory), a modified road-worthy truck, is a mobile laboratory for navigation research. All computing, sensing and power generation are housed onboard. The NavLab supports a choice of sensory equipment, including video cameras that provide images for scene interpretation and a scanning laser rangefinder that gives 3D information about the environment.

The Locomotion Emulator (LE), our most recent navigation testbed, which mimics the motions of different vehicles. The LE can emulate the four most common steering modes: unicycle, Ackerman, skid steer, and articulated. A computer or human host issues commands specific to any of these configurations, and the LE generates appropriate motions of the steer, drive, and payload platform to replicate the motions of the target vehicle.

REX, (Robotic EXcavator) an excavation testbed, integrates sensing, modeling, planning, simulation, and action to unearth buried utility pipes. REX interprets sonar data to build an accurate surface model of an excavation site and then consults this model to plan digging operations.

The next phase in our development of computing architectures will be a multi-processor, hybrid environment system residing on a single MULTIBUS® II backplane. An iRMX-based environment will provide control computing while other environments will support higher level computing such as image processing, modeling, and planning. This consolidation of computing abilities will bring the Field Robotics Center closer to its vision of capable, productive robots to work in the world.