The Dartmouth Mobile Robot: SK

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Abstract

The Dartmouth Mobile Robot Serial Killer (see Figures 1 and 2) is a minimalist, architectually-lean autonomous robot that can vacuum your room. The robot is controlled by a Motorola 6811 microcontroller and has 40kb usable memory. The robot has several sensors including sonar, motion detection, contact, and analog IR. The robot's motion is based on a combination of off-line and on-line algorithms that run on-board.

Serial Killer was originally designed as a class project. Its hardware began as the A. K. Peters Rug Warrior kit. We modified the kit to include a larger chassis, supported by bigger wheels. The new chassis supports several boards designed and built in the Dartmtouh Robotics Laboratory, as well as batteries (see Figure 2). The team added two sonar transducers, an ultrasonic motion detector, and a stepper motor for aiming these additional sensors. The team also added two analog IR sensors pointed downwards, attached next to the wheels. The team will be adding a dust buster under the chassis of the robot for actual vacuum cleaning.

The low-level motion control software is built around a worldview comprised of a matrix in SE(2). Odometry adjusts the worldview incrementally, and wheel controller software using feedback and feedforward parameter estimation enables the robot to pursue straight paths and make rolling turns. The sonar sensors make corrections to the worldview as they determine the robot's position in a symbolic map. Serial Killer navigates based on a configuration space constructed off-board and stored on-board.

The robot's motion plan is computed by a hybrid algorithm that uses both off-line (planning) and on-line (reactive) strategies. A map and upper bounds on the sensor uncertainties are used to compute a configuration space off-board. The robot uses configuration-space reasoning on the map to compute a set of critical points, such as the location of tables and corners. This configuration space is translated into a compact representation, where the critical points are marked. This representation is downloaded into the robot's memory. At this point the robot becomes fully autonomous. The robot combines this representation with a random walk to sweep the floor of a room. The robot uses sonar and the contact sensors to detect static obstacles. The robot uses the downward-pointed IR sensors to detect dirt. When a pile of dirt is detected the robot turns the vacuum cleaner on and sweeps the dirt pile. Upon completion, it resumes the hybrid path-following/randow-walk in search of a new pile of dirt.

Other sensors such as the infrared sensors, the motion sensor, and the microphone allow Serial Killer to detect the reflection coefficient of the floor, detect the presence of humans, and accept user input, respectively.

Acknowledgements

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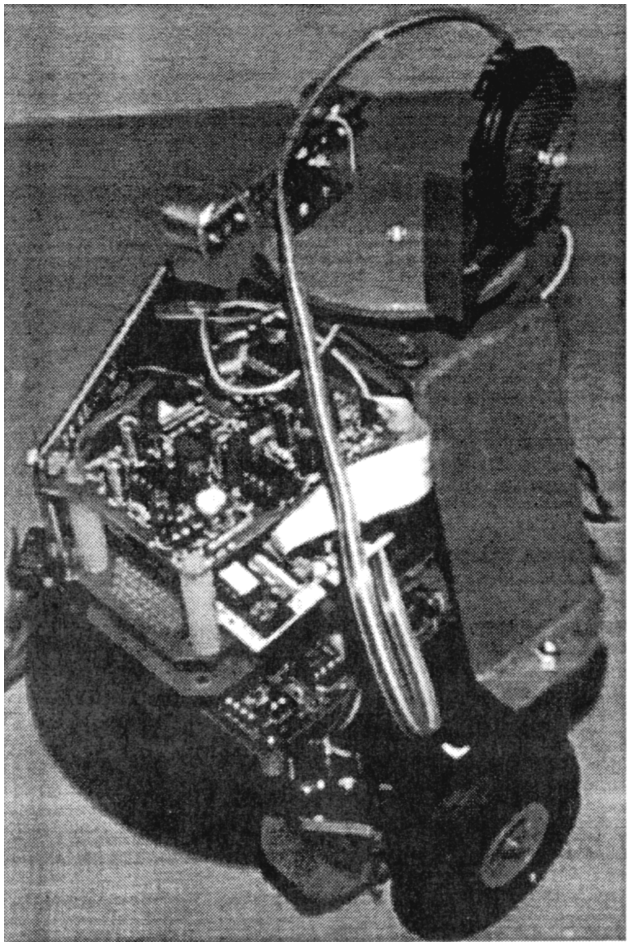

Figure 1: The Serial Killer robot. The robot is based on a Motorola 6811 microcontroller. It includes: differential drive locomotion, shaft encoders which measure wheel rotation (odometry), two photodetectors (light level), front-looking near-infrared detector, with two transmitters (senses near obstacles, 6"), microphone (measures ambient audio level; we don't have enough memory or processor to sample audio), three bump sensors (measures contact with obstacles), serial interface, piezo buzzer, 32-character LCD display sonar (measures distances from 10" up to maybe 10'), stepper motor (aims a rotary tray containing pyro and sonar through 360 degrees), zero-detect infrared encoder (aligns stepper motor), ultrasonic motion detector (detects humans 4-7m away), 9V battery for ultrasonic motion detector, lead-acid battery to provide longer supply and greater current draw for motors. For the vacuum cleaning task we have attached IR sensors pointed downward next to the wheels.

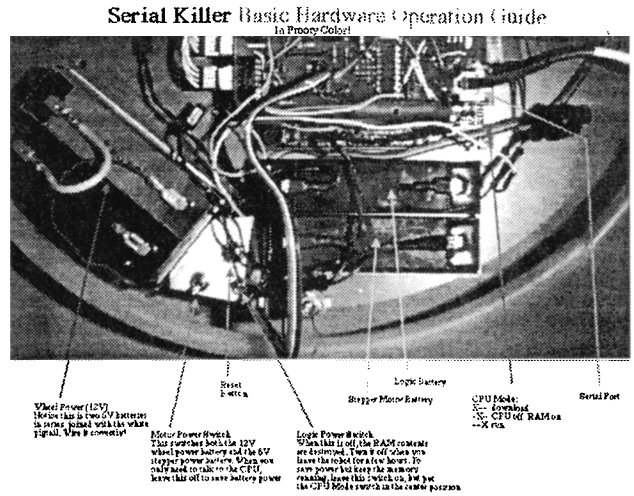

Figure 2: A top view of the robot hardware. The outer tube is the skirt of the robot that senses contact in four discreet regions: front, back, left, and right. From left to right we have 2 6V batteries that power the wheels, the motor switch, the reset button, the logic power switch, a 6V battery that powers the stepper motor, a 6V battery that powers the logic, and the serial port.