Robotic at HMC

In the summer of 2007, for example, a team of three Harvey Mudd students set out to prepare an entry for the Tapia 2007 robotics competition. The overarching vision guiding this work included:

- How to best use off-the-shelf computational such as a laptop computer with the low-cost Create platform. We use a shelf designed and prototyped this summer.
- Investigating cost-effective sensors and interfaces to those sensors. We have integrated two interface boards: the Acronyme Brainstem and the Arduino controller.
- Designing algorithms for reliable wandering and color-based recognition.
- Ultimately, we hope to contribute to the accessibility of the Create platform for other uses through our hardware, software, and design.

The hardware

We modified an out-of-the-box iRobot Create, shown unarmed to the left, in order to construct our competition platform. The sensors added include an iSight camera and two sonars for range sensing -- both mounted on panning servo motors. An Acronyme Brainstem interfaces with the motors, while an Arduino controller interprets the raw signals from the sonar.

[Image of iRobot Create and sensors]

An unusual feature of our robot, Insomnia, is that its computation comes from an ordinary Mac laptop held by a custom-designed platform. The advantage of using off-the-shelf computation is that networking, the development environment, and interface with ordinary peripherals requires no additional setup. For example, the Create itself is simply a serial peripheral of the Mac it is carrying.

Visual processing

The robot combines several partial behaviors, e.g., for wall-following, marker detection and approach, and recovery from unexpected obstacle bumps. A finite state machine arbitrates among these behaviors based on the current sensory input and current goals. Feedback is available to observers through the laptop's voice synthesizer and/or network access from a second machine.

[Diagram of robot's point of view with highlights showing recognized colors. (Right) Wandering among markers.]

The overall coordination of the robot's behaviors is expressed in this finite state machine:

Software Architecture

Because of the markers' format, color dominates the visual processing in our system. The vision software allows for quick recalibration of the color definitions that distinguish one object from another. Once defined, the colors provide distinct patches from which connected components are extracted. Vertically aligned components form markers.

[Diagram of robot's sensors and actuators]

The range sensors available on the simulated robot were lasers with 1 degree of angular resolution. With that much data, it is possible to recognize locations, for example, through the range signatures of each of the four corners of the room. The physical robot uses sonar to detect obstacles, but its resolution does not suffice to recognize regions.

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Range sensing

The team wrote Lu and Millios's scan-matching algorithm in Python in order to recognize places via laser ranges.

Snapshots of both the simulated and real robots finding their markers.

Qualifying and preparation

The qualification round of the competition involved creating a program that would successfully locate all six markers regardless of starting position of the markers or the robot. By using the task of following walls while looking out for markers, as sketched below to the left, the robot navigated the perimeter of the environment. In order to localize itself at the start of the task, it roamed around the walls counterclockwise until its laser range finder recognized that it had reached the southwest corner. Obstacle-avoidance routines could escape even the small gap between the C and S.

The Approach - Wall Finding

Roomba follow-the leader at AAI 2007 (right) and a landmark-mapping algorithm running atop an iRobot Roomba vacuum cleaner (left) and

Tapia 2007 and beyond

We appreciate the opportunity to participate in the Tapia 2007 robot competition. Beyond this experience itself, we hope that the iRobot Create platform will mature into a powerful resource for roboticists and educators of all stripes. The Association for the Advancement of Artificial Intelligence offers an additional forum at which we can interact with other educational roboticists. Below, at left, is another Create-based project implementing follow-the leader, in which a Create tracks down a Roomba based on color cues. Mapping algorithms are also accessible, as there is so much computation there on board.