Clementine: Colorado School of Mines

Undergraduate Interdisciplinary Robotics Team
Robin R. Murphy, Associate Director and Advisor
Center for Robotics and Intelligent Systems
Colorado School of Mines
Golden, CO 80401-1887
phone: (303) 273-3874 fax: (303) 273-3975
rmurphy@mines.edu

The 1996 Entry

The Colorado School of Mines (CSM) is fielding a team comprised of undergraduates in Computer Science or Engineering who are enrolled in the Robotics and AI Minor. The intent is to provide a forum for the students to a) transfer what they have learned in the classroom to a more realistic setting, b) meet with top researchers in the field, c) have an undergraduate research experience, and d) have fun. The students work with the team advisor and graduate students at CSM to integrate and modify code developed for NSF, ARPA, and NASA funded research projects. This will be the fourth year CSM has participated in the competition.

The team's platform is *Clementine*, a Denning-Branch MRV-4 research robot. She has a ring of 24 ultrasonics, a laser navigation system, and supports two cameras. All processing is done onboard by a 75MHz Pentium processor. A SoundBlaster board and speakers provides feedback on the robot's activities. *Clementine* is used for research in indoor task domains such as the surveillance and maintenance of stockpiles of hazardous materials, site assessment of dangerous environments such as a burning building or a collapsed mine, or security. A custom robot, *C2*, is used for outdoor environments.

Objectives

This year's team is concentrating on Event 1. There are two primary pedagogical objectives. *1. Gain familiarity with hybrid deliberative/reactive architectures by applying it to a well defined problem.* This objective is being met by having the students use a subset of the CSM hybrid architecture. The deliberative layer handles all activities which require knowledge about the robot's task. The *task manager* receives the the topological map, starting node, and goal node for the event via a human interface. It then activates the *cartographer* which produces a list of nodes, called the path plan, representing the best path between the start and goal. The task manager selects the behavior(s) for traveling between the current node and the next node on the path plan. The *reactive*, or behavioral, layer is responsible for executing the constituent behaviors encapsulated by the abstract navigation behavior.

2. Gain practical experience in using multiple sensing modalities. As mobile robots are developed for more demanding applications, it will become necessary to use multiple sensing modalities (e.g., vision, sonar, range finders, inclinometers, GPS, etc.). Accordingly, the students are required to use ultrasonics (sonar) for obstacle avoidance and basic navigation, and computer vision for identification of rooms.

Research Innovations

The students are incorporating two novel concepts from ongoing research at CSM: *scripts* for the coordination and control of concurrent and sequential activities in the reactive layer, and the partitioning of behaviors into *strategic* and *tactical* categories. Scripts, originally developed as a representation for Natural Language Processing, serve as a template for coordinating and controlling a collection of behaviors needed to perform a highly stereotyped task over time. The navigational activities needed for Event 1 have been collected into two abstract behaviors: **NavigateHall** and **NavigateDoor**.

Another novel aspect of the CSM hybrid architecture is its organization of behaviors in the reactive layer into strategic and tactical activities. Strategic behaviors, such as **NavigateHall**, generate strategic directions or navigational goals for the robot based on large scale concerns. Tactical behaviors such as **avoid-obstacle** and **fuzzy speed-control**, interpret the robot's strategic intent (e.g., go straight) in terms of the immediate situation (e.g., there's an obstacle directly ahead) and actually produce the action for the robot to take.

Acknowledgments

The Undergraduate Interdisciplinary Robotics Team entry is supported in part by Denning-Branch International Robotics, Pittsburgh, PA.