

Human Detection by Tartan Swarm

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Abstract

Tartan Swarm was an autonomous, multi-robot entry in the 2002 Mobile Robot Urban Search and Rescue Competition. The robots were designed to be low-cost, adaptable, and *disposable*. Emphasis was given to human detection techniques. The design did not feature localization or mapping capability. In the competition, the robots may have detected bodies, but were unable to report location or success.

Introduction

The Carnegie Mellon Robotics Club is a growing undergraduate organization. All projects are conceived of and implemented entirely by undergraduates of varying experience and background. The AAI Urban Search and Rescue (USAR) project was designed as an introductory program for the purpose of exposing and gaining real robotics experience. 75% of the team of 12 were first-year students.

Doing voluntary work in the cyclic demands of semesters presents distinct motivation challenges. The approach taken was to find a design that can be implemented quickly, separates into discrete parts, and permits numerous upgrade paths. Within days of considering the project, a mechanical platform was prototyped. Sensor testing development was therefore decoupled from the mechanical design. The sensor system was a compound of several sensor technologies, each enhancing the overall system. Students could be quickly motivated to work, and could make tangible progress quickly and often.

The Vision

There will be no single solution to the challenges posed by urban search and rescue. Recognizing this, Tartan Swarm was built to consider a particular niche, *disposable* robotics.

To be disposable, a robot would have a low cost of failure. In addition to being cheap, this means that the importance of any task being accomplished should be greater than the resource requirements. Dedicating an operator during a rescue operation is undesirable.

The Tartan Swarm was a prototype of this vision. They could be completely assembled by untrained personnel in less than 30 minutes; with even minimal design effort, this

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could be reduced to less than 5 minutes. Each platform (*logic, sensing, mechanical*) of each was modular and interchangeable.

We envision a scenario where a rescue team arrives, selects a number of mechanical bases, an assortment of sensors appropriate for the scene, perhaps enters some initial navigation commands and search type, snap together and drop the robots at the scene, and continue their rescue efforts as trained. As the effort continues, the robots are either useful or transparent. At the end of the situation, the surviving robots may be collected.

The Swarm

At the competition, the Tartan Swarm consisted of three homogeneous differential drive robots. The robot team successfully demonstrated autonomous human detection by observing and recognizing the crowd as a heat source. The robots navigated the crowd, pausing to transmit about individuals encountered.

Mechanical

The frame of each robot consisted of DC gear-head motors sandwiched in an aluminum frame. In addition to this common frame, we associated the base to include the low-level sensing and communication of the robot. These included two "whiskers", a range finder (Sharp QP2D12), and a radio transmitter (Lynx TXM-433-LC-R). Later we upgraded the base to include some rough encoder measurements, though they were not fully implemented.

Logic

Each robot was controlled by a Cerebellum microcontroller. The Cerebellum is an integrated package featuring the 16F877 PIC Microcontroller. This controller was used to implement a state-based robot behavior where each state represented a distinct function of input to output motion.

Sensors

The primary method of body detection was with a pyroelectric sensor (Eltec 442-3). Pyroelectric sensors are sensitive to infrared radiation from 8-14 micrometers, which includes the range of human bodies. Pyroelectric sensors contain a

pair of polarized crystals; change in incidental thermal energy changes the electrical polarization level. As a pair, the crystals can be used to detect differences in heat. Stationary heat sources were detected by mounting a sensor on a servo and panning its orientation.

Competition

The competition emphasized several underdeveloped aspects of the Swarm. Our vision focused on getting robots to people, but less on what would happen when the people were found. Consequently, search behavior was robust, but multi-robot transmission, and basic dead-reckoning, were primitive. Prior to the start of the conference, the robots had no sense of location.

The competition was not oriented toward autonomous designs. A variant in the rules was granted; we hope that the rules are revised to accommodate autonomous entries. Overall, the competition appropriately replicated some of the challenges an urban search and rescue robot would encounter. The rules target a somewhat different solution set than we fielded. In several of these differences the competition was right.

Conclusions

The case for mapping technologies was made in several ways at the competition. If a new Tartan Swarm is fielded, this will no longer be a secondary objective.

An incident during one of our trials emphasized the importance of data collection capacity when deploying new technologies. When the competition video system failed to track our robots for several minutes, we were unable to recover information from that part of the run. Had we considered data collection a priority, we might have devised or refined technologies for the purpose – on-board, or made the wireless transmission work earlier in the development cycle.

If a new Tartan Swarm is fielded, greater emphasis will also be focused on exploiting the modular design. The hardware platform was not robust; for any practical discussion of urban search, a platform capable of entering the Yellow and Red zones is required. The sensor platform and main control loop was designed to accommodate several different sensing technologies. Future Tartan Swarm sensor packages should be more robust by including additional detection methods beside heat; sound, motion, and vision are obvious additions.

The Tartan Swarm successfully demonstrated a simple, inexpensive approach to human detection. We believe autonomous, disposable robots are a feasible and viable approach to the challenges of urban search and rescue.

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