RSS Course Challenge

Spring 2005

April 14, 2005

1 Challenge Objective and Background

The Grand Challenge of the course is to "Build a Shelter on Mars." During the term, each group will to build a robot that can explore, search, gather and build a structure in a dynamic partially-known environment. The robot will be given a partially specified map of this space. However, the environment will have dynamic obstacles whose location and behavior will not be known to the robot. The robot's starting location will be known. The robot will also be given a known location for the construction of the structure.

Within this space the robot will have to search for prefabricated components of multiple types that can be used to create a structure at the construction site. Some of the components will be damaged and the robot will have to detect these and not fetch them to the construction site. Some specified parts of the robot's environment will be known to contain these parts. However, useful parts are also scattered throughout the environment so that your robots will have to use their sensors to look for them. The components will be blocks of two different sizes. The blocks will be colored. Some of the blocks will emit light. Some of the blocks will be damaged by the elements. These blocks will have special marks (for instance colored red) which can be detected. Your robot should not bring damaged objects to the construction.

Your robots will be built out of parts form a robot kit and will be autonomous: they will be controlled by an on-board computer.

Your robot's task will be to collect as many useful components as it can and use the objects to assemble a wall at the construction location.

2 The Robot Tasks

Your robot will need the skills for the following tasks:

1. navigate in the environment
2. locate good construction objects
3. identify the location of the construction site
4. retrieve, carry the objects to and place the components at the construction site

5. create a simple structure (a wall) at the construction site

Depending on your approach to solving the challenge task you may wish to add to this basic skill list.

Your robot will have a gradation of skills within each task. You will be evaluated on the skill level of your robot. We strongly advise you to do build the control system of your robot according to the skill hierarchy. Start with the simplest skills, make sure they work, and then move on to the next level of difficulty. You get rewarded for every level of competence reached by your robot. Your robot is required to have the most basic level of each type of skill. You challenge to reach this skill level necessary to accomplish the task in its most basic form and then build as much additional smarts as possible in your robot within the time you have for the course.

- Navigation: basic navigation from the initial location to the construction site; motion planning within a given map, starting and goal location, motion planning with dynamic obstacles given a map, a starting location and a goal location, the starting location is unknown: using features from the environment the robot identifies its starting location on the map.
- Finding Objects: detecting objects at known locations, identifying object type (good vs. bad), detecting objects at unknown locations
- Identifying construction site: identify when reaching the construction site; given the construction site on the map, move to that location in the physical space; choosing the location of the construction site given structure specs and moving to that location
- Moving Objects: picking up components, transporting them, and depositing them at the construction site
- Construction: placing the components in a pile, placing the components next to each other as a one row wall; stacking objects on top of each other as a multi-row wall.

3 The Final Challenge

On the last day of classes, each group robot will be given 15 minutes to build a shelter on Mars. A trial run will take place two weeks before this date. A map with the location of the blocks in known locations will be available. We will set up the robot environment with walls and obstacles in advance and give you this map. The robot will start in a special position called "home". For extra credit the judges will place the robot anywhere they want in the environment. The robot will have to pick a construction site (home, or at a given place, or by reasoning), identify as many objects as possible, bring them to construction site and build as much of a wall structure as possible at the site.

The objective of the challenge is to complete as much of the task as possible. Your solutions should be reliable and robust. You will be expected to have basic solutions for each of the challenge sub-tasks.

After the start of the round, no modifications are allowed to your programs. No parts or substances may be deliberately dumped, deposited, or otherwise left in the robot's space.

4 The Robots

Each group will receive a kit of parts including:

- Single-board computer running Linux
- ORC Robot controller board
- aluminum frame materials
- motors and various wheels
- camera
- bump sensors
- ultrasonic rangers
- light sensors

Your robot will have to be built out of the parts in this kits. The parts in the kit may not be modified except to facilitate the mounting of a sensor or actuator.

Any robot that appears a safety hazard will be disqualified.

Your robots will reside in the lab space allocated to the course. You may take the robots to the challenge site but you may not take them home. If you take the robot our of the course space and the robot becomes damaged or stolen you will be responsible to replacing it. If the robot parts fail during routine testing and operation please contact us asap so we can help you fix the problem and/or replace the broken part.

5 The Programs

The robots will be programmed in Java. The Sun workstations in our lab have the complete development environment installed on them. Instructions for installing the development environment are available on the course web site.

6 The $ 50 Rule

To encourage creativity, teams may spend up to $50 to purchase additional components used in their designs. We will assign a value to found parts you may wish to incorporate in your design. You must document these components with receipts and you will get reimbursed. No single part may cost more that $10.

7 Requirements

Each group is required to participate in a 20 minute review meeting during the Tuesday lab session. This meeting will be conducted in parallel with the other lab activities on that day. Each group is required to keep a web journal with weekly entries and a lab report for each assigned lab. A project report is required at the end of the course. The report should document clearly all your design and coding decisions. At the end of the term each group member is required to write a short essay entitled "Building Brains and Bodies" that addresses the lessons learned in this course.

8 Rules

8.1 Robots

1. The robots must be constructed with parts form the kit.
2. You have a budget of $50 to buy extra parts.
3. Any robot that appears to be a safety hazard will be disqualified (fire, liquids and explosives are prohibited).
4. Your will not be allowed to modify your robot hardware after April 19 2005. You will be allowed to do small repairs. In the unlikely case of catastrophic failure contact your instructors.

8.2 Prefabricated Components

1. There are 2 shapes of blocks: $5cm \times 5cm \times 5cm$ and $5cm \times 10cm \times 5cm$. The weight of each object is no more than 100 grams.
2. Objects are colored red, white, and blue.
3. There are three types of components: mapped, unmapped, and damaged. There will be 6 mapped components and 6 unmapped components. Of these 12 components, 4 will be damaged.
4. Damaged components will be red.
5. Non-mapped components will emit visible light which can be detected by photo cells. The light will be visible for at least 1 meter. The light will radiate in a fairly tight beam from the center of 3 faces of the object (not the top and bottom faces). The battery in each lighted object will be new at the start of each round—the intensity of the light may decrease during the round as the battery discharges.

8.3 Time

Each robot will have a total 15 minutes to find and retrieve as many components as possible and to create a structure as large as possible at the construction site.

8.4 Finding and Fetching Components

Robots will signal that an object is "found" by beeping. A single beep can be used to indicate that any type of object has been found. 3 beeps will indicate that an unmapped object has been found. The 3 beeps must be generated when the robot is within 1 foot of the object. Random beeping will be penalized. The judges will determine whether beeps are meaningful.

A component is considered "returned" if it resides in the construction area when time expires.

8.5 Construction

The construction site can either be provided as input on the map or computed by your robot given constraints on the size and the orientation of the desired structure.

Your robot will have to signal the identification of the construction site by stopping and beeping 5 times. The robot will have to bring the good objects to the construction site. You should aim from randomly placing the objects at the site to carefully placing them in a pile or a wall.

8.6 Nudging the robot

If your robot gets off course, you can manually put him on course. You can do this at most 2 times during the competition.