Chapter 2

RoboRats

Night falls on Vassar Street. You awake from your nest under the train tracks, stretch out your long body, yawn (displaying your four long teeth), and groom yourself for the coming night. Scraping your forepaws' nails through your fur you groom your left rear leg, right rear leg, back (twisting all the way around), right fore arm, left fore arm, behind the ears, over your face. Standing up on your hind legs, your whiskers twitch as you get your bearings and survey the environment. That's right, you're a rat.

You notice that there's some food scattered around your nest. There's a mound of garbage in a straight shot to a neighboring family's nest. There's food near to their nest too, but perhaps you can beat your neighbors to the food near their nest, then gather the ones around your nest later. But rats aren't that stupid, and you quickly realize that your neighbor could do the same. However, the mound of garbage catches your eye. If it were less stable to travel on, the neighbors couldn't get to your food so easily. You ponder this for a moment and then realize:

Rats eat *garbage!*

The contest for the 1997 6.270 contest is **RoboRats**. The scenario is this: you are a rat. You want food. You want lots of food. In fact, you want to have more food than any other rat. Of course, the goal is simple, but there are a few details you need to examine to fully appreciate the simplicity and complexity of the contest.

2.1 The Table

The layout of the contest table is shown in Figure 2.1. The table, overall, is 4 feet by 10 feet 8 inches, and the base color of the table is white. As you can see, the table

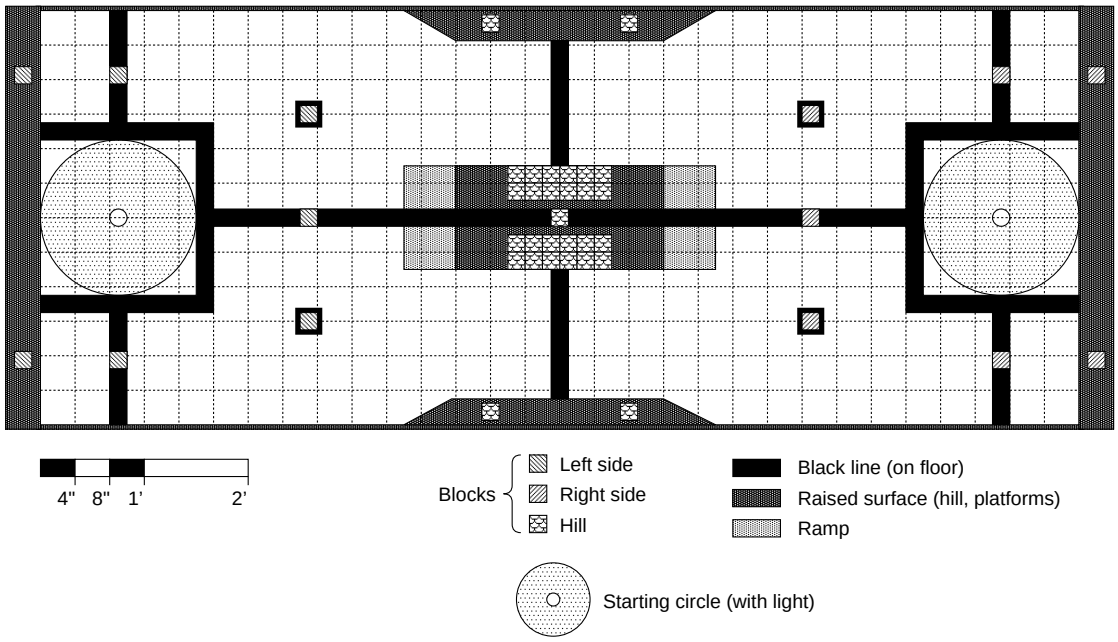

Figure 2.1: The contest table for RoboRats

is symmetric as viewed from each side's starting circle, thus we shall concentrate the description on only one half of the table.

The starting circle is positioned in the center of the table, 9 inches from the back edge of the board. It is 18 inches in diameter with the circle just tangent to the center of the back edge of the table. There is a starting light array, which is about 3 inches in diameter, at the center of the circle.

Forming a box (with the back edge), in which the starting circle is inscribed, are three black lines, each 2 inches wide. A black line down the center of the table connects this box with the matching box on the other end. A food cube will be placed along this line, halfway to the hill (see below). An additional food cube will be placed between this one and each side wall, centered on a 3 inch by 3 inch black square. In addition, a line extends from each of the two other sides to the corresponding edge of the table. Again, food cubes will be placed at the middle of these lines.

Along the back edge of the table, is a raised scoring platform 4 inches deep and 3 inches tall. Two food cubes will initially be placed on the platform.

In the center of the table there is a hill, which is 2 inches tall, 12 inches wide (towards the sides of the table), and 24 inches long. At each end there is a 6 inch long ramp down to the table surface. A food cube will be placed on the center of the hill. A 12 inch by 4 inch section of each side of the hill will be filled with a 6 by 2 group of food cubes.

Along the edges of the table nearest the hill will be additional raised platforms,

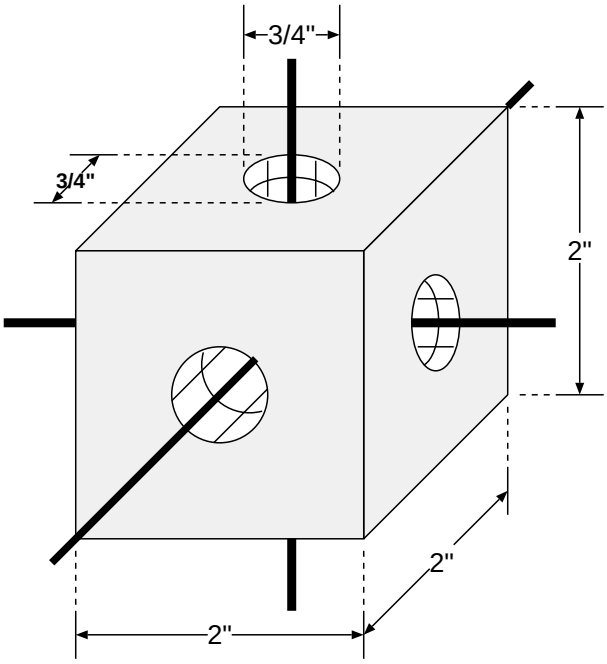

Figure 2.2: A food cube (holes not to scale)

here 3 inches deep (except at the ends, where they slope to join the edge of the table) and half an inch tall. Each of these platforms will be 36 inches long, including 6 inches at each end where they are sloping to the table edge. Two food cubes will be placed on each platform, one towards each end.

Each side has seven food cubes that are considered to be "owned" by the side that they begin on (and they will be colored as such). The cubes in the center area of the board are considered "unowned" and will have a third color.

The food cubes (see Figure 2.2) are made of a foam rubber block 2 inches in each dimension. The cubes also have a three-quarter inch diameter hole drilled through them along each major axis in the center of the appropriate cube faces.

2.2 Scoring

The score of each individual rat is determined by the end state of contest board. Each rat receives points for collecting and storing food cubes. The scoring is summarized in Table 2.1.

A food cube is considered to be in the possession of your robot if, if your robot were moved in the plane of the table, the cube would move with the robot. A food cube is considered to be on the scoring platform if it is *directly* in contact with the platform and can stay on the platform without support. A cube which is in the

Cube Type	In Your Robot	On Your Platform
Yours	2	4
Center	3	6
Opponent's	4	8

Table 2.1: Scoring summary

possession of your robot as well as being on a platform scores points for being on the platform but not for being in your possession.

Each food cube from the center area which is in your possession at the end of the round is worth three points. Each cube from your side of the table in your possession is worth two points, and each cube from the other side of the table in your possession is worth four points. Cubes on your platform at the end of the round are worth twice as much as if they were in your possession.

Note that the initial table configuration scores 4 points for each side, so ending up with this configuration (without scoring other points) is not sufficient to pass the qualifying round.

2.3 Period of Play

- The contestants will have 30 seconds to place their machines on the field from the time they are called to the playing field.

- The contestants will place the machines on the playing field within the designated starting circles. The starting orientation for the round will be randomly selected by the judges from 4 discrete directions. Both machines will have the same orientation.

- Each machine must have a clearly marked "forward" direction which must point in the direction indicated by the judges at the start of the round.

- Each machine must have a clearly marked "center" point which must be above the starting light at the start of each round.

- The contestants must stand a given distance away from the playing field. Any contestant who touches his or her machine or otherwise affects its performance during the round of play will automatically disqualify his or her robot from the round. All robots must be solely controlled by their onboard computers.

- The beginning of a round is signalled by the judges turning on the starting lights. The lights are located underneath the table in the center of the robots' starting circles and will remain on for the duration of the round.

- The machines must have their own internal clock (software will be provided to do this) that cuts off power to the motors at the end of 60 seconds. Any machine that continues to supply actuator power after 60 seconds will be disqualified.

- The round ends when all machines and other objects on the table come to rest.

2.4 The Competition

- The contest will be an double elimination competition held over two days (three sets of rounds). Machines must qualify for the final night of competition, as follows:

  - *Round 1.* All machines will play in a qualifying round. If a machine demonstrates the ability to score points, it will proceed to the next rounds of the contest, regardless of a win or loss. If a machine fails to do this, modifications may be made, and it will have two chances to run against an inert placebo. If it cannot win against the inert placebo after two tries, it will not qualify for the rest of the contest. Losses from round 1 *do* count and carry through the rest of the contest.
  - *Round 2.* Only qualifying robots will play in the second round. Robots which lost in round 1 will be eliminated from competition should they lose in this round as well. Round 2 may be skipped this year if few enough robots make it past round 1.
  - *Final Contest.* The main competition. Machines will play until they accumulate two losses. Losses against opponents from rounds 1 and 2 still count. Robots with interesting behavior which have not qualified or have been eliminated in rounds 1 and 2 may have an opportunity to perform between actual contest rounds.

    The final round of competition may be conducted in round-robin format, ignoring previous losses, at the discretion of the organizers.

- All rounds will have two robot players. If necessary, a placebo will be used for one player in some rounds.

- In rounds involving a placebo, the contestant's robot must win by at least one point in order to be declared the winner of that round.

- If there is a tie score at the end of a round, the judges may award either a double win or a double loss.

2.5 Infrared Beacon and Light Sources

All robots are required to carry an infrared transmitter. This transmitter acts as a beacon so that robots can locate each other on the playing field. The following rules describe the functionality of the infrared beacon.

- All entries must carry an infrared beacon that is capable of broadcasting infrared (IR) light modulated at either 100 Hertz or 125 Hertz with a 40,000 Hertz carrier (hardware and software is provided to do this).

- Machines failing to meet the infrared transmission specification, or in any way modifying or jamming their transmission frequency during the round of play will be disqualified.

- Judges will assign frequencies for IR emitters to the machines in the beginning of each round. Contestants should set this using the robot's DIP switch 1. If the switch is one, the robot should broadcast 100 Hertz infrared light. If the switch is zero, the robot should broadcast 125 Hertz infrared light. Software will be provided to do this.

- The IR broadcasting beacon must be located at between 17 and 18 inches above the surface of the playing field when mounted on the robot.

- The beacon must be located so that its center is never more than four inches (measured horizontally) from the geometric center of the microprocessor board.

- The beacon may not be deliberately obstructed, or be designed in such a way that "accidental" obstructions are probable. Because of this, robots may not extend farther than 16.5 inches vertically (and should avoid lifting objects above 16.5 inches off above table).

- A polarized light lamp will be placed behind each end of the table. The lamp near the robot transmitting 100 Hertz IR will have a +45 degree (with respect to the vertical) polarization, while the lamp near the robot transmitting 125 Hertz IR will have a -45 degree polarization.

2.6 Structure

- All kits contain exactly the same components, with the exception of some LEGO parts that may be colored differently in different kits.
- Only LEGO parts and connectors may be used as robot structure.
- LEGO pieces may not be joined by adhesive.
- LEGO pieces may not be altered in any way, with the following exceptions:
  1. The grey or green LEGO baseplate may be altered freely.
  2. LEGO pieces may be modified to facilitate the mounting of sensors and actuators.
  3. LEGO pieces may be modified to perform a function directly related to the operation of a sensor. For example, holes may be drilled into a LEGO wheel to help make an optical shaft encoder.
- String may not be used for structural purposes.
- The wooden dowel may be used only as a tower to mount the infrared transmitters and any receivers.
- Any non-LEGO part may be attached to at most five LEGO parts.
- A reasonable amount of cardboard, other paper products, and tape may be used for the purpose of creating optical shields for light sensors. The shield may not obstruct IR transmission. Please ask TAs or organizers if you would like ruling on your particular shield.
- Wire may only be used for electrical, and not structural, purposes.
- Rubber bands may be glued to LEGO wheels or gears to increase the coefficient of friction.
- Only the thin rubber bands may be used to provide stored energy.
- Contestants may not alter the structure of their entry once the contest has begun, but may repair broken components between rounds if time permits.
- Contestants may not alter the program being used by their entry once the contest has begun, except by setting DIP switch 1 as described above.

- At the start of each round, each robot must fit within a one foot cube. The broadcast and detection beacon may extend above one foot. Wires may be compressed, if necessary in order to fit. Entries may, however, expand once the round has begun.
- Entries may not drag wires between two or more structurally separate parts of their robot.
- No lubricants may be used.
- Cable ties may not be used for structural purposes.
- Some parts in the 6.270 kit are considered tools and may not be used on the robot. If there is any question about whether an object is a "kit part" or a "tool part," ask the organizers.
- No parts or substances may be deliberately dumped, deposited, or otherwise left to remain on the playing surface. A machine that appears to have been designed to perform such a function will be disqualified.
- Any machine that appears to be a safety hazard will be disqualified from the competition.
- Machines are not allowed to destroy, or attempt to destroy, their opponent's microprocessor board or infrared beacon.

2.6.1 The $10 Electronics Rule

To encourage creativity, contestants may spend up to $10 of their own funds for the purchase of additional electronic components used in their design. Other than this rule, robots must be designed completely from standard kit parts. The following conditions apply to all non-kit-standard electronic additions:

- The following components, categories of components, or varieties of circuitry are *disallowed:*
  - Batteries of any variety.
  - Motor driver circuitry, including relays, power transistors, or any other replacements or modifications to the standard motor driver circuitry.
  - Microprocessors of any kind.
- Resistors rated less than 1 watt and capacitors valued less than 100 μF may be used freely, without accounting toward the $10 total.

- Contestants who add *any* non-kit parts to their project must turn in a design report that includes: description of the modification, schematic of all added circuitry, and store receipts for parts purchases. This design report must be turned in to the organizers with the robot at impounding time. *Any machines found with added circuitry that has not been documented in this fashion will be disqualified.*

- If a contestant wishes to use an electronic part which has been obtained through other means than retail purchase, an equivalent cost value to the part will be assigned by the organizers. Contestants must obtain this cost estimate *in writing* from the organizers and include it in the design report mentioned above.

  The main reason for this rule is to allow contestants to explore new ways for sensing, and create new sensors.

2.7 Organizers

Contestants may approach the organizers in privacy to consult about possible designs that may be questionable under the rules listed above. These designs will not be divulged to any of the other contestants. You can send e-mail to `6.270-organizers` for any rule clarifications.