CPE 470/670 Report #02
Lab 04: Tunnel Navigation

Team-1: Bandith Phommounivong, Terence Henriod

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Hardware and Software Design

Hardware

For this challenge, a very slim design was used. The main chassis of the robot consisted of the brick, 2 motors with wheels to form a centered axel, two simple forward raked arms and a trailing, swiveling castor wheel, all minimally connected.

Each arm held two sensors. On each arm was a sonar sensor, on the right arm was a color sensor, and on the left arm was an RF sensor.

The color sensor was attached in such a way that it was aimed straight down and raised approximately an inch and a half above the ground in order to provide optimal color readings.

The RF sensor was placed facing downward also, but with approximately one quarter of an inch of clearance in order to be capable of reading the RF nodes scattered on the playing field.

The two sonar sensors were arranged in a forward facing manner, but so that they spanned the width of the robot. This provided good forward obstacle detection and mediocre side obstacle detection. In order to ensure that the sensors provided a symmetric range of “vision,” one sensor was attached upside down using normal means and Lego pieces, while the other had to be attached right side up using more creative means - i.e. some tape.

Software

The software design of the robot featured a publish/subscribe architecture, and a driver program composed of two main algorithms.

The publish/subscribe architecture was built by creating threads for each type of sensor. These threads used global variables (booleans) as switches to begin and end data collection. The sensor tasks then continually collected readings and performed any pertinent computations. The results were then stored in global variables to be read by the main program. In retrospect, only raw values should have been published, and computations should have been performed elsewhere.

The driver program utilized two main algorithms: a gathering mode, and a home finding mode.

In the gathering mode, the robot was designed to wander aimlessly, detecting “food” as it was encountered. This was achieved by either randomly swaying to the left or right or by proceeding forward for short periods of time. The swaying motions were weighted to occur more often than the straight forward motion. The resulting motion was reminiscent of the wandering of an insect. In the case that the robot encountered a wall, it was programmed to back up and make either a sharp turn or a U-turn to get far away from the wall.

In the home finding mode, the robot was designed to find a wall, and if the wall was in front of it or to the left, the robot would make small right turns in order to follow the wall to the corner where “home” was located.

Problems Encountered During Implementation and Their Solutions

Sensor Placement
It was difficult to attach the sensors appropriately. The color and RF sensors required particular distances from the ground to function effectively, and the sonar sensors needed to be placed as wide as the robot itself as well as low enough to detect the low walls of the arena.

This problem was solved using some creative Lego piece use and some tape to attach a sonar sensor so that it could be positioned low enough.

Color Sensing
The color sensor presented some peculiar difficulties. In addition to the sensor being difficult to position appropriately as mentioned previously, the color sensor regularly returned reading that were in error. The color sensor would regularly indicate that the white gathering field color was color number 4, or green. While it might seem like the robot could be programmed to ignore green along with white, this was not feasible given the fact that green "foods" were available for gathering.

To remedy this, it was helpful to access the RGB values read by the color sensor, and not solely the single number 0-17 the color sensor maps colors to. As it turns out, the "green" of the white field read by the color sensor had a red component that differed significantly from that of the green food. It was possible to detect a false green by checking to see if the red component of any green/4 reading was greater than 6, solving the problem of false readings.

Unsolved Problems

Missed Food Collections
The robot performed poorly in terms of food gathering. It seemed that by slowing the robot's forward movement and covering more lateral area via the swaying motion described in the design section would result in a higher food detection rate. Whether by chance or because of imperfect design or implementation, the robot seemed to sway just around the foods it passed over and missing the chance to detect them. In testing, the gathering method used performed acceptably, although maybe not as well as other robots. It was thought that the random nature of the contest would equalize this.

After observing some of the other robots perform much better at food gathering, it appears that simply moving in straight lines to cover more of the field's area is a better design strategy. It is likely that the robot's gathering performance could be improved by switching to this strategy, or developing a better swaying strategy (perhaps one where the swaying was more sustained rather than alternating randomly).

Overturning Resulted in a Missed Homing Attempt
In testing, the robot occasionally overturned, or detected a wall and turned away from it while trying to find home. This was problematic, as it caused the robot to become set on a trajectory

that would miss the “home corner.” This behavior was uncommon, however, so it was thought that this imperfect behavior would not manifest in the competition. Unfortunately, it did.

This could have been remedied with a slightly more sophisticated home finding strategy. Perhaps a strategy that would determine which side of the robot the wall was on based on the direction of the last turn made, and then periodically sway back towards the wall. This would guarantee better wall hugging behavior, resulting in the robot entering the home corner more consistently. Unfortunately, this though about design did not present itself until after the in-class challenge.