Robo Golf

Team 1
Final Project

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Robo Golf

Problem Description:
In this lab, we had to build a robot that would be able to orient itself, then collect as many golf balls from the arena (Fig. 1) as possible within 2.5 minutes, and deposit them in the center of the arena. Our robot would compete against the other teams' robots in a double-elimination tournament in which the robot to collect the most golf balls in each round continued to the next. We were able to use two reflective optosensors, two Lego light sensors, and two touch sensors to guide our robot, and used both the handy board and the Lego RCX to control our robot in this competition.

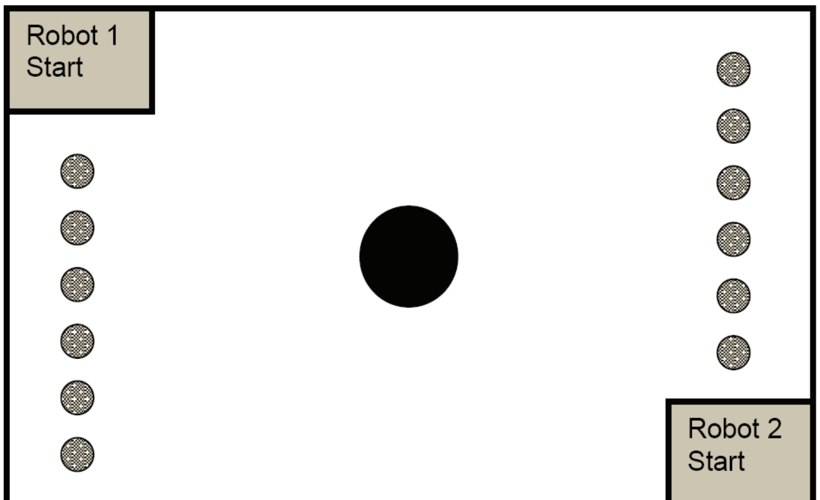

Figure 1: The Robo Golf arena.

Solutions:

Hardware:
In the initial design stage we discussed various possible hardware solutions, including multi gate solutions, designs with slip differentials, claws, etc, but ended up with a simple box with a forward gate. The goal was to create a robot that would store as many balls as possible, and in the initial design the robot could easily hold 10 balls, although as it evolved the capacity decreased to an 8 ball maximum, which was partially due to the inclusion of interior side skids, to stop balls from getting stuck on the interior protrusions in the robot. The initial structure was built with sturdiness in mind, and had 2 sensors facing the sides, one facing inward, and one facing down. We ended up moving the inward facing sensor to a downward facing position to better see the black dot in the center of the arena, while the 2 outward facing sensors faced away at 90 degree angles so that we could use them to figure out our initial orientation. The gate was simply attached directly to the 3rd motor. The robot was also equipped with two touch sensors facing forward to detect walls or other robots, and was also equipped with two side rollers that allowed us to wall follow to an extent. This, along with the wide opening for the front gate, allowed the robot to collect the initial 6 golf balls by simply going forward against the wall, which allowed us to consistently gather the initial 6 balls.

Software:

RCX:
Again we used the Lego RCX board to allow us to use the full potential of the Lego light sensors. In this lab we simply used a program that would check the light values, and would output on the motor outputs whenever the light value dropped below some critical value, in this case 28, which we would then detect on the handy board.

Handyboard:
The handy board used a program that was broken down into a couple distinct behaviors. When the program started, a self orientation function activated that would look at the light values detected on the side sensors, and would use these values to determine which orientation it was currently in. (For example, if the light sensor that pointed forwards registered lower light values, and the light sensor that pointed to the right registered a higher light value, the robot would be pointing opposite the direction it needed to go.) Once the robot had determined which direction it was facing to begin with, it would then turn slightly longer than it needed to in order to face the correct direction. This made the side roller hit the wall, and aligned the robot perfectly with the initial 6 golf balls regardless of small fluctuations in battery power.

Once the robot finished facing the correct direction, it would start a function designed specifically to collect the 1st 6 golf balls. It would go forwards with the gate open until the front-facing light sensor registered the presence of a wall. At this point, the robot would close its gate, turn towards the center, and go into the wandering function.

In the wandering function, the robot will go forwards until a bump sensor is hit, or until the light sensor is registers the light values associated with a wall. If a the left bump sensor is hit, the robot will close its gate, back up, and turn to the right, and will close its gate, back up, and turn to the left if the right sensor is hit. When the robot saw the wall, it would close its gate, back up, and turn in a random direction. If no sensors were triggered for a period of 4 seconds, the robot would initiate a random turn. Whenever one of the downwards-pointing sensors saw the black dot, the robot would turn until both sensors were on the dot. It would then stop for 1.75 seconds to let the balls settle, then open its gate and back up, leaving the balls in the center of the table. It would then resume the wandering behavior.

Once the 2.5 minutes alloted for each round of the competition was finished, the robot would stop, leave any balls it had collected, and wait for the start button to be pressed again.

Problems and Solutions:

One of the challenges we faced in this lab was sensor placement and design. We started out with one two light sensors pointing to the side at a 90 degree angle, in order to allow the robot to position itself in the beginning, one sensor pointing across the opening of the gate, so that the robot would know then it had captured a golf ball, and one sensor pointing directly at the ground so that the robot could tell when it was over the black dot in the center of the table. We discovered, however, that we needed two sensors pointing at the ground so that we could be sure that the robot would center itself over the dot before depositing golf balls. Designing robust touch sensors that did not obstruct the robot's gate was also challenging. We went through several designs before settling on the one that we used in the final competition (pictured in the photos section of the website.)

Another problem that we had was settling on an appropriate gear ratio for our robot. We originally attempted to make a one-to-one gear ratio work, but it did not give enough torque to allow our robot to go at full speed, and also had a prohibitive effect on battery life. We ended up gearing the robot down to a two-to-one gear ratio, which gave the robot enough torque to run at full speed without stalling out the motors, and did not drain the battery nearly as much.

The structure of our gate also presented a challenge. Originally, it would over rotate, so that in its closed position, the balls could still escape. We fixed this by adding a catch that would prevent the gate from closing past a certain point. However, this presented an additional challenge, in that the gate closed with enough force to rip itself off of the rest of the robot. We were required to reinforce the join between the gate and the main frame of the robot with vertical struts.

Another problem we were forced to solve was that of making our robot deposit the balls smoothly in the center. Originally, even though we had a high storage capacity, there were interior protrusions that would catch on the balls as the robot backed up, and prevent them from remaining in the circle as the robot left it. We were able to solve this problem by running long Lego pieces from the back of the robot to the front, just past all of the protrusions, so that the balls had a smooth track to run against. Although this reduced our storage capacity, we were still able to hold up to 8 golf balls.

We also experienced some difficulty in making the RCX communicate with the handy board, but this ended up being due to low battery power in the RCX, and a bad job of attaching the sensor wires on our part.

Our final problem was a result of attempting to be more energy-efficient and ease the strain on the gate motor. We had programmed the motor to only run at 10% power when opening the gate, but this ended up not being fast enough if we started facing forwards with the gate down. We did not discover this problem until the final competition, but were able to get around it by always starting the robot with the gate open initially. If we had been able to re-program the robot during the competition, we could have completely fixed the problem by increasing the motor output at the beginning.

Conclusion:

We feel that our solution to this lab was very well-designed and well-implemented overall. If we were to do it again with the knowledge we have now, we would probably make some changes, such as adding scoops to the front of the robot to allow it to scrape balls off the side while it is wall-following, making the robot slightly wider and shorter to improve both its turn radius and its chances of grabbing loose balls, redesigning the gate to be sturdier and to not grind the gears constantly when it is closed, and to base the duration of the turns on the battery voltage, in order to get more consistent angles when we turn. However, our robot was able to gather the initial 6 balls almost every time we tested it, and the majority of the time in the competition, and it had the fastest localization time out of all the robots, as it used light sensors rather than bump sensors. So, although there were some improvements we could have made to our robot's design, we feel that our final design was very appropriate to face the challenges presented by the competition.