Robotic Dog Design Project

MEG 100
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<u>Team #1</u>

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Table of Contents

Table of Figures

Introduction

We were given the assignment of creating a robotic dog that would locate a stick within an enclosed field, pick it up, and then bring the stick back to a home base. The robotic dog would have to be completely autonomous, meaning that it would have to retrieve the stick without any human interference. The field's area is 87 inches by 71 inches. The stick will be placed inside a 4 foot by 3 foot rectangle within the field. The dog will have a two minute time limit to retrieve the stick. To locate the stick, our dog will follow a grid-like pattern around the field until it comes in contact with the stick.

Our design alternatives were limited by the number of sensors and motors that we were able to use. We were allowed the use of 3 motors, one for the jaw and two to act as drive motors. We were given the option of using 3 separate sensors; our particular design requires two light sensors and one touch sensor. The touch sensor is located on the front of the dog, where it will become depressed whenever it comes in contact with a wall or other solid object. Once this touch sensor is pressed, the dog will back up several inches, then make a 90 degree right turn. As for the two light sensors, one is placed on the rear of the dog, while the other is located within the dog's jaw. The forward light sensor serves to notify the RCX when it has located the bone, and to find the home base. Once the light sensor passes over the bone, it will recognize the difference in lighting between the black field and the white bone, prompting the jaw to close down and pick up the stick. This recognition is accomplished by having the light sensor on the rear of the dog taking ambient light readings, and them comparing it with the readout of the forward light sensor. Once there is a significant difference in light readings, the jaw will close down.

With this program, the robot will be able to operate under any ambient light conditions.

Design Selection

The first thing that my partner and I had to consider was what kind of chassis we would use. The chassis had to be durable, not too heavy, would have to hold the RCX, and would have to be able to support the jaw of the dog. We simply constructed the rover bot from the Lego building instruction book, but modified it for our specific purposes. We had to add support bars to make sure that the dogs head would be secure and would not weigh down the chassis. We have supports running from the top of the dogs head all the way to the rear of the dog, to the bottom of the chassis. This required the addition of two additional support wheels right under the dog's head. These two wheels were not connected to the drive motors in any way; they were there to prevent the front of the dog from falling forward and dragging its head along the ground.

One of our primary concerns during the design process was in choosing the mechanism that would grasp the stick securely. We tried out many different alternatives. Our first alternative involved the use of a pulley system with the rubber bands included in the Lego Mindstorms kits. This proved to be inefficient because the bands would slip, or would not always be perfectly aligned. The next alternative we tested out consisted of a series of gears. With our jaw design, it was not possibly to align two gears perfectly, so it took many gears to get the teeth lined up in such a way that it would move the jaw efficiently. This proved to be too much of a hassle, since there were so many moving parts involved. Finally, we decided to use a gear box with a worm gear inside. This proved to be very efficient, since it could open and close the jaw with ease, while maintaining high torque, so that it would be able to pick up the stick for sure. With this system, the dogs jaw actually lifts the front part of the dog off of the ground, to ensure that the jaw picks up the stick off the ground and holds it securely.

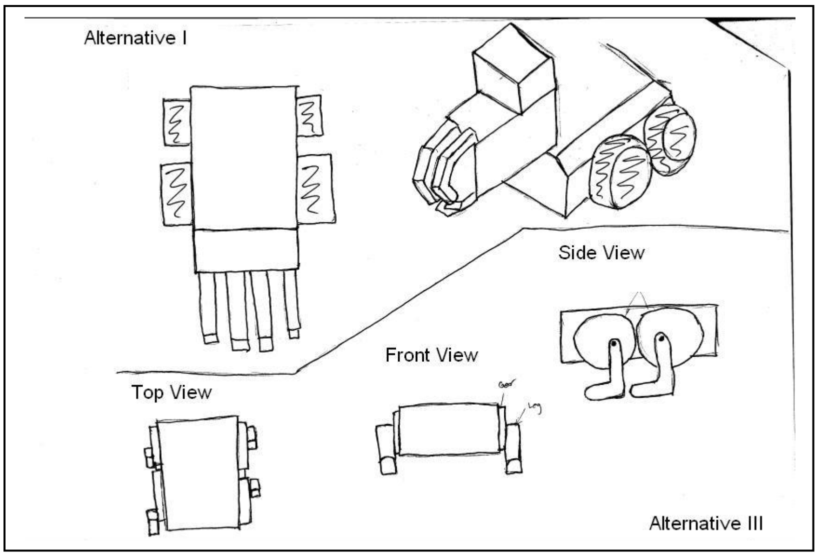

Figure 1

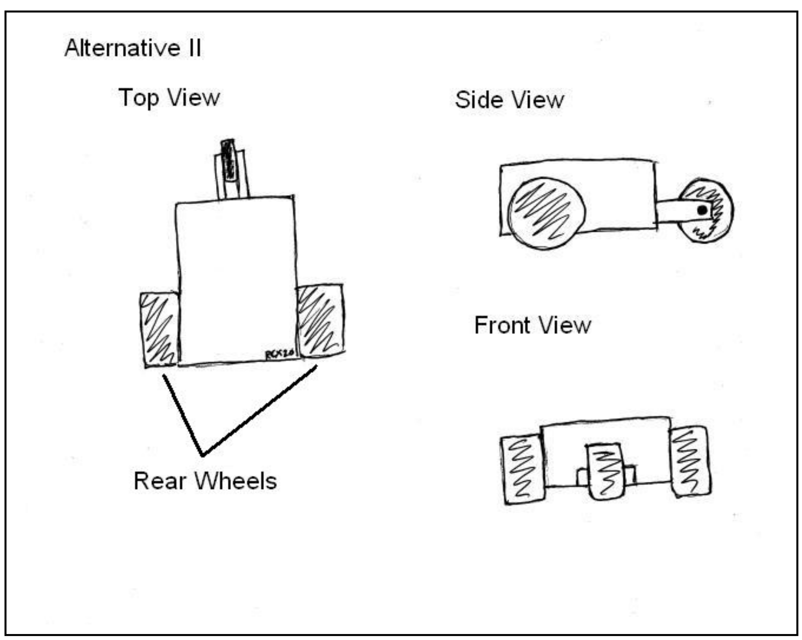

Figure 2

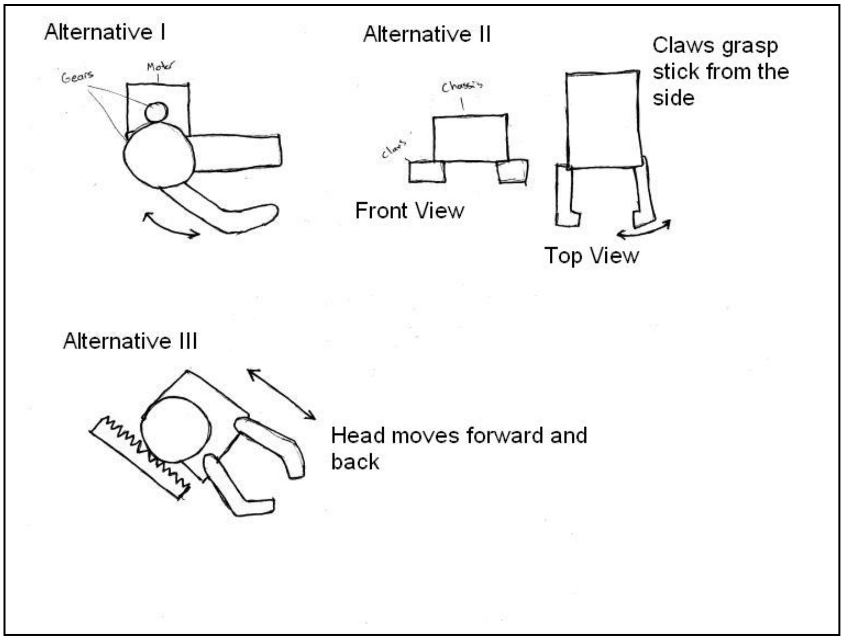

Figure 3

Design Description

Our final design alternative came after much work. We had to build our chassis and modify it. We also had to decide on which design would be our final design for the jaw. Once this was accomplished, we had to find a way to mount the dog's head onto the body. The dog's head consisted of one motor to operate the jaw's opening and closing mechanism. To do this, there is a gear box connected to the motor by a rod, with a worm gear inside the gear box. The worm gear then moves a regular gear to open and close the mouth. Located within the jaw is the forward light sensor used to recognize the stick and to locate the home base, which is designated with aluminum foil.

In addition to the jaw, there is also the front bumper, which consists of a touch sensor and long rods extending from the touch sensor. These rods extend low enough to reach the height of the wall at the edge of the playing field. Since the bumper system extends from the head, it gives the head a tendency to lean forward.

To compensate for the weight of the jaw and bumper system on the head, we modified the rover bot chassis by adding support bars that ran from the top of the dogs head to the rear of the chassis, where the rear light sensor is located.

With all of the above accomplished, my partner and I then proceeded to improve our design by fine tuning our gear ratios and adjusting the power of the motors to give the dog an appropriate speed. We also made sure that the chassis was durable and could withstand the weight of the dog's head.

Design Features

Features of our dog:

- Use of worm gear to operate mouth
- Use of two different light sensors to get ambient light readings
- Strong chassis design able to support the dog's head
- Bumper mechanism to navigate walls

Limitations of our dog:

- It travels slowly across the playing field
- It does not travel in a perfectly straight line
- The dog's body is very heavy in the front end
- It may take a while to locate the bone successfully

Prototype

Our prototype model is the result of many designs and trials to see what worked well. As discussed before, the challenge was very arduous. Our final design is one that has taken the best features of all of our designs and tests. We preformed tests on many parts of the design. Theses test included collision/durability, grab strength and speed as well as sensor configuration tests.

Our first test was with collisions. We tested for how our different designs reacted when they hit a wall or other hard object. Some passed and others failed and broke apart on impact. We found that the more compact designs held together better.

Our next test was on the jaw strength. The jaw had to both grab and hold the bone when it was found. We use many designs in out tests. The first was with gearing. This proved to be too complex and did not have enough torque to grab the bone. The second was with pulleys. This too proved to not posses enough torque. Our last design was using a worm gear. This had enough torque to both grab and hold onto the bone.

Our next test was with speed. We changed the gear ratios on the robot to adjust speeds. We had many failures with faster speeds, so we decided to remain with a slightly slower model.

Our last tests were with sensor configurations. We ran tests with different amounts of touch and light sensors. We found it very difficult to use only touch sensors and only light sensors. We decided to mix the two with one touch and two light sensors. This configuration showed the best overall results.

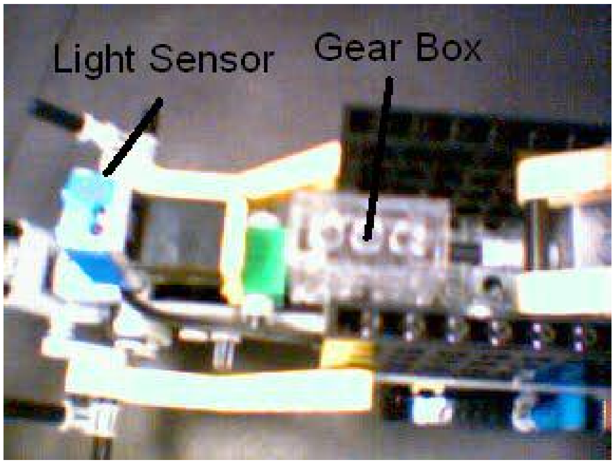

Figure 4

Figure 5

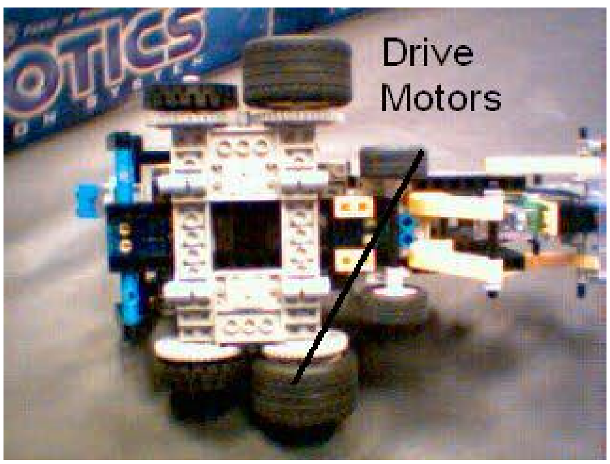

Figure 6

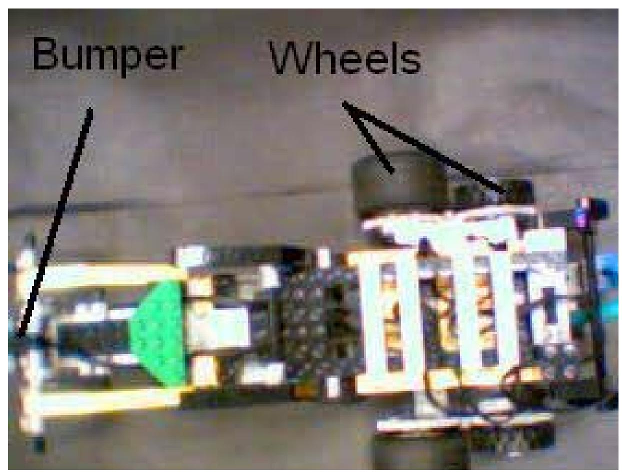

Figure 7

Figure 8

Project Schedule

Project Milestones:

- Final choice of chassis
- Final choice of jaw device
- Final choice of sensors
- Development of bracing supports
- Development of forward bracing wheels
- Program completion
- Program refinement
- Program testing
- Total failure of every part of robot
- Repairs and revisions

Attendance Log:

Every team member has been present for all the lab sessions and the out of school team meetings. There have been three out of school meetings to discuss designs and to do extra programming and construction.

Project Summary

Considering the design project entirely, there have been some things that we have learned. We have learned to think better as a team and less as individuals, to use engineering methods to derive successful results and to figure out that you learn a lot more when you fail than when you succeed. We also learned about the characteristics needed to create a successful robot.

Our unique strengths and weaknesses are not that numerous, due to “industrial espionage” and “borrowing” of designs from other groups. For a little while at least, we were the only group to have extensions on our jaw to grab onto a wider area with the teeth. We also had the first six-wheeled design and the first to add aesthetic elements to our dog. However, we did observe other groups to see what worked for them as well. We are also the only group to have an ambient light element of our program.

We do have some unique weaknesses though. We have the slowest dog, giving us a slight disadvantage with the time factor, but we think we can make that up with our more efficient programming.

We have learned that in the future, it is ok to share ideas and that the only result is that everybody succeeds. Also, we learned that sacrificing integrity for a little more speed would not necessarily be a bad tradeoff.

Lab Log

Week 3: Constructed a vehicle with a working sensor

Week 4: Constructed a motorized gripper that is activated by a sensor

Week 5: Constructed a steerable vehicle with two motors.

Week 6: Constructed a vehicle with two drive motors and one motor to activate a gripper

Week 7: Presented a completed vehicle with working sensors and motors

Week 8: -Remounted head to body and added more support
-Added touch sensor device to detect walls
-Added "dog ears"

Work in progress: Working on programming

Problems: Robot would lose it's balance and then fall forward
Solution: We added two small wheels in the front to balance it

Week 9: -Adjusted the wall sensor
-Refined programming

Work in progress: Program

Problems: Wall sensor not working correctly
Solutions: Making sensor less flexible

Week 10: -Added another light sensor
-Changed bumper design
-Added chassis reinforcement

Work in progress: Programming

Problems: Trying to use a touch sensor to find the bone
Solutions: We are using a light sensor to find the bone

Week 11: -Named our dog BEN
-Worked on programming

Work in Progress: Programming

Problems: Adjusting sensors for different light levels
Solution: Rewriting program for light sensor

Week 12: -Reworked program
-Refined search pattern.

Work in Progress: Testing

Problems: Search pattern.
Solution: Timed turns better.

Literature Search

Robotic pets are one of the current trends of children's toys. There are many of them in stores today and online and on TV. They have many features, including legs, eyes, mouths, and ears. They can walk, talk, see, and grab things with their mouths. They also can follow magnetic bones or certain colors.

All of these features and such are patented ideas. Patents protect the ideas of inventors and allow them to reap the benefits of their work. The patents are held in the United States Patent Office. Here they are recorded and can be used in any time of need.

The newest robot pets are fully autonomous. They have independent power systems and can have a rather large memory. They can be programmed to respond to a single person's voice or a certain signal. They can respond to hand gestures by using camera recognition. Also, some have infrared leashes. These work by having the user hold a device and that device transmits a signal to the collar of the dog or cat. This in turn would make the cat or dog stop or go. It can also make it jump or turn or perform some other action. The same technology is also used to create a pen that the pets cannot leave.

The main use for these pets is for people who either cannot have a real pet or for those who want the companionship without all the mess. These pets do not need to be house-trained, groomed or fed. All they need is a little programming and a battery charge here and there. Of course, there is not substitute for the real thing. The current technology only allows for minor movement and only partial voice and signal recognition. Of course this is likely to change in the near future due to the advances in technology.

Sources: http://www.uspto.gov/patft/index.html

References

US Patent Office Website: http://www.uspto.gov/patft/index.html

Official Lego Website: www.lego.com