NXT Module: Final Design Report

ENGR 102 – Winter 2012
Engineering Design Lab II

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Section Faculty: Spatari, Sabrina

Section Fellows: Marcellus, Kimberlle

Fakharlangeroud, Ghasideh

Group Members: Junho An, Hyungjin Koo, Jongchan Lee

Abstract

This experiment was to design and build the robot with the Lego kit provided, The robot should be built with few functions, such as detecting a waste using various sensors and grasping the object with a gripper . In the provided Lego kit, there contained the block that receives the code from a computer, and controls all the motors attached to the block. By simply implementing the block in the robot, it enabled transmitting the data from a computer to the robot. In order to code, the NXT program was used. There were three motors that supply motive power to robot. Also, the block contained four ports for different sensors which help to work the robot more effectively. With the proper design, the precise code, and the appropriate sensors, the robot was ultimately able to carry the wastes to the certain area. It determined the difference between the waste and the obstacle and got over obstacles if there were any. While the robot detected two different wastes, one of the wastes, nuclear waste, had to be given up because there was no any special set up that the robot could detect and carry the waste to the zone.

Introduction

This lab was designed to give freshmen engineering students in-depth, guided structural engineering experience such as building and programming a robot to do things that cannot be done by human's hands. For such job as cleaning up a large amount of trash and nuclear waste, the future engineers from Drexel University practiced designing the NXT robot and programming the code for the robot with each type sensors work cooperatively. The robot's body was designed considering the functions of each sensors. Touch sensor was used to detect the objects or the obstacles in front of the robot by touching them. Ultrasonic sensor was used for the same purpose as the touch sensor, while Ultrasonic sensor detects the objects in its sight. Light sensor was used to detect the light and made the robot moves toward the light. The shroud was used to cover the light sensor to block the disturbing light and help light sensor find the light from the lamp more accurately. Sound Sensor was used to detect the sound from the nuclear waste and differentiate it from the regular waste. Each week, an experiment was conducted with small scale prototype lego and mindstorm(NXT programming) to learn about each type of sensors. In section 5, the required task was to design and build the group's own NXT robot body and the gripper to move toward the object and grab it. The next task was to program the robot to detect and differentiate the regular waste and the nuclear waste and bring them to the assigned zone.

Materials and Methods

Design Constraints

A small scale area was created to simulate the real spill. The construction and programming of a small scale robot using the Lego NXT software is to simulate and test the performance in the real spill site. Nuclear waste containers have a yellow band around them and emit a high pitch sound when moved. They must be deposited in the nuclear waste disposal. Trash containers are blue and must be deposited in the landfill, marked with a light source that is 8" tall. There were 9 trash containers and 3 nuclear waste containers that are all 2.5" in diameter and 2" tall. The waste depot found in one corner has dimensions of a 24" semicircle radius similar to the nuclear waste disposal on the opposing side. The prototype must collect and deposit as much trash as possible in an 8'x8' arena within a 5 minute time interval while avoiding the 4" high surrounding fence and other robots. These restrictions are depicted the picture of the battle arena below[1]:

Figure 1. The Waste Disposal Challenge arena without the light source at the landfill [1].

For every container properly disposed, the robot performs to earn the points to assess the performance of the robot as two compete in two 5-min rounds. The robot could be constructed with motors and sensors. Beyond this, additional building materials like cardboard, paper, foam core, tape, rubber bands, string, copper wire, hot glue, ping pong balls, drinking straws, and other Lego pieces are allowed. With any of these attached, the robot must fit in a 1x1x1.5 foot box.

Design Proposal

The basic model was designed by following the directions on building the existing NXT robot named Tribot, The base model was the same as the Tribot, but there were few adjustments made to fulfill the requirements due to the design constraints. The first major adjustment made to the original Tribot were the two big wheels on the motors of each side for the robot to move, and a small wheel at the back of the robot to avoid from collapsing. The figures 2 and 3 below show these changes.

Figure 2: the small wheel

The small wheel installed in the back of the robot.

Figure 3: Big wheels on motor

One of the major wheels installed on the side.

Another major adjustment was the attachment of a gripper that is shown in figure 4. The gripper was attached with the two gears that are put perpendicular to each other, which are also attached in the motor. So when the motor operates, the gripper closes. Figure 5 below shows the gears and how they are attached to the motor.

Figure 4: gripper

Long gripper installed in the front of the robot.

Figure 5: The gears

Two gears installed and interlocked for the gripper to function.

The robot design was finalized by adding sensors to detect waste containers while it tries to find its way where the light is located (corner of the arena). The sensors used were touch, ultrasonic, sound and light sensors. The touch sensors were located at the bottom of the robot so that it could sense the nuclear waste and when it hits the waste the gripper closes. The ultrasonic sensor avoids the robot from hitting the obstacle such as walls, fences, etc. The sound sensor detects the sound of the nuclear waste and head the robot towards it. And finally the light sensor detects light that is located where the nuclear waste depot is, so that when it follows the light after capturing a nuclear waste, the robot would end up in the right place.

In the figure 6, the algorithmic programming disregarded the nuclear waste. There was a way to carry the nuclear waste to the nuclear waste zone by following the fences, however, it only worked when only one robot presented in the field. Thus, it would be better to just disregard the nuclear waste.

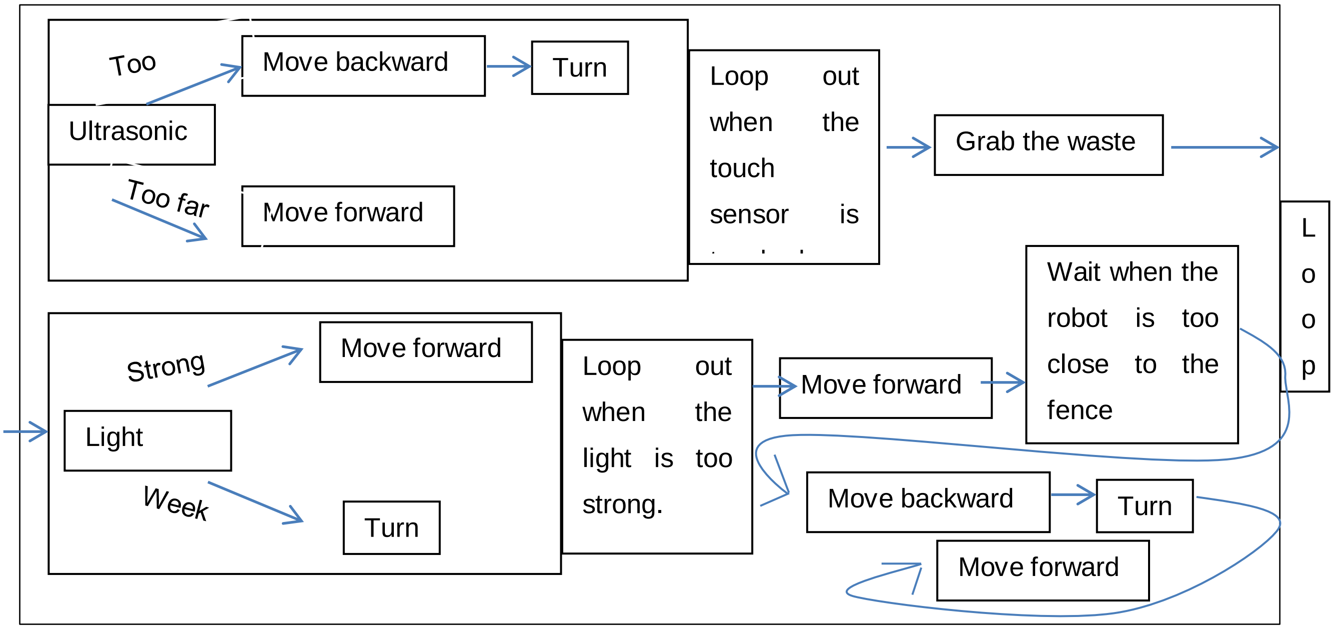


Figure 6. Algorithmic programming of the robot in an organized flow chart.

Characterization of Sensors and Motors

Motors → The Robot was run with the program for different time, and the distance, the robot moved, was measured with a ruler. Under 75 percent power and going straight, the robot moved about 8 cm per second.

<u>The Distance and Time</u>

Table 1:The distance traveled in centimeters is measured each second from 0 to 5 seconds.

	Trial 1 (cm)	Trial 2 (cm)	Displacement of Trial 1 (cm)	Displacement of Trial 2 (cm)
0 second	0 cm	0 cm		
1 second	7 cm	7 cm	7 cm	7 cm
2 seconds	17 cm	17cm	9 cm	9 cm
3 seconds	23 cm	23 cm	7 cm	7 cm
4 seconds	32 cm	32 cm	8 cm	8 cm
5 seconds	41 cm	41 cm	9 cm	9 cm
Average			8 cm	8 cm

. ***Ultrasonic Sensor →*** The ultrasonic sensor measures the distance of objects from the sensor. It could be useful to avoid obstacles. The measured distance was differed from the actual distance.

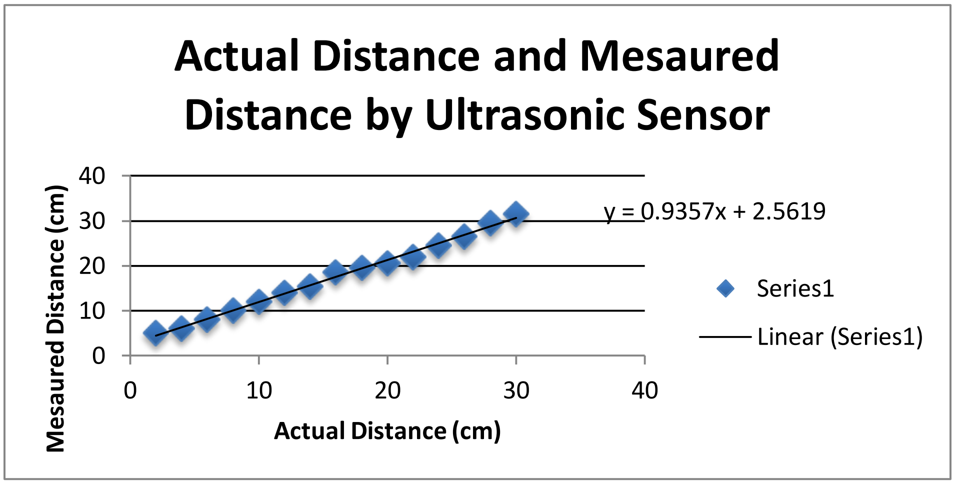
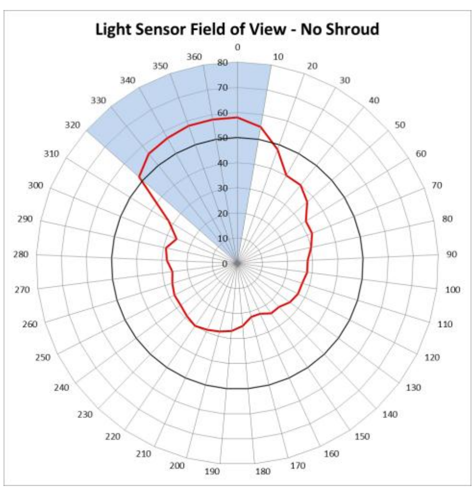


*Figure 7: Distance measured by ultrasonic data. Blue line = Best fit line of the points Blue dots= the actual distance by the measured distance by ultrasonic sensor. Measured Distance = 0.9357*Actual Distance + 2.5619*

Light Sensor → The light sensor measures light intensity and is useful if the robot needs to move toward a source of light. Shrouds can be created to narrow the radius in which the robot reads the amount of light from a stationary light source as depicted below:



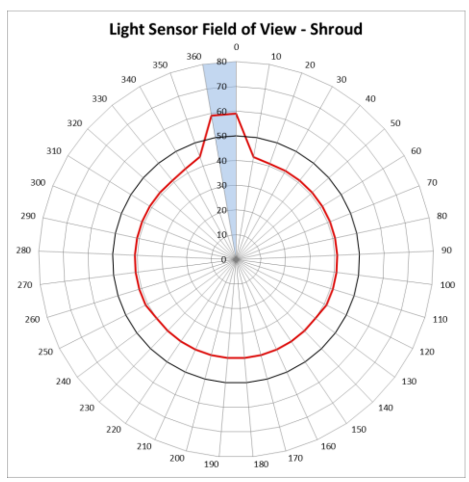


Figure 8 a: Polar plot of light intensity vs. angular orientation.

Red = the measured amount of light distribution

Blue = the range of light based on the measured light.

Figure 8 b: Polar plot of light intensity vs. angular Orientation (with shrouding).

Red = the measured amount of light distribution

Blue = the range of light based on the measured light.

Before measuring the light intensity, the light sensor was calibrated in front of the light for the maximum value and far away from the light for the minimum value. As the polar plot is shown in the two figures(8 a, and 8 b), there is a definite difference of the estimated light range in between. The polar plot in 6 b is a lot narrower than the polar plot in 8 a which indicates that the polar plot in 8 b is more accurate. Thus, the shrouded was installed on the light sensor.

Sound Sensor → The sound sensor is used to detect a sound. It could be useful to find an object which emits high or low pitched sounds. The sound intensity measured may vary with the distance away from the object. The sound sensor was calibrated when the object which emitted a high sound was grabbed as the maximum and when there was no sound around as the minimum. When there was no object around, the measured value was less than 10, however when there was an object which emitted a sound was grabbed, the measured value was around 90.

Final Design

The body portion of the robot remained unchanged. Two motors were used for the wheels and the third motor was used to control the gripper. However, several trials and multiple errors, have led to changes to the design of the gripper and placement of sensors. In the beginning, gripper arms were built that look like 'claws'. The claws were consequently too weak to grab and sustain trash. The gripper design was modified so that it acted more as a barrier around the containers. Instead of opening and closing along the x-axis, the new design opened up and captured trash along the y-axis. With this change, once the touch sensor senses trash, the gripper will come down and create a barrier around the trash and furthermore push the container to the appropriate location.

The positions for some sensors had some modification as well. The ultrasonic sensor is placed in front of the robot with inclination so that it will not detect the wastes but the walls to avoid. When the ultrasonic sensor was paralleled at the front of the robot, it would sometimes detect the wastes and altered the reading. This caused the robot to move unexpectedly. The sound sensor was attached at the front of the robot to differentiate between a normal trash and a nuclear trash. Once the gripper grabs trash, it will move slightly to check if the trash is nuclear waste or regular trash. This is where the sound sensor will detect the high pitched noise made by nuclear waste barrels. The robot will then take the trash to the nuclear disposal area by detecting the area of the least amount of light. If the container is not beeping and is normal trash, the robot will transport the container to the area of the highest light intensity, the trash depot. The touch sensor and the light sensor remained in the same place. A shroud was placed around the light sensor so that only a specific amount of light will be detected in a smaller radius. All these changes greatly reduced the number of errors since the sensors worked more effectively.

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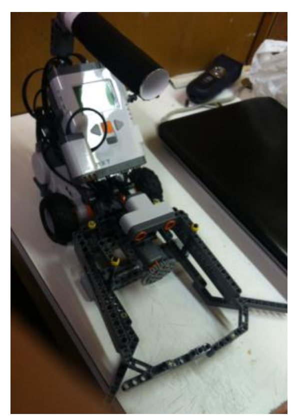

Figure 9: Final Design

Final Design of robot.

Results

Trial Number	Score(points)
1	10.00(two blue waste)
2	15.00(three blue waste)
3	35.00(seven blue waste)

On the section competition day, the robot was not fully prepared to compete against other robots. It could not differentiate nuclear waste from the normal waste, and the light sensor was needed to be recalibrated. During the first competition, the robot could not detect the light from the near nuclear waste disposal area. The robot's gripper part was getting stuck into the gap in between the fences'. The Robot would sometimes get stuck with the other robot during the competition. Some modifications were added to the robot during the break time in between each round. The value for the light sensor got lowered to detect a light by the nuclear disposal zone. Furthermore, the robot's body was added with the wheels on the gripper part and the middle of its body so that it would give less chance to get stuck into the fences. Finally, the robot had got better performance during the matches and won the competition.

Conclusions

The task for this project was to design and build a small prototype of robot that could collect and carry the waste to the certain area. For instance, if there happened to be some containers filled with nuclear wastes and they were exposed to the living area by falling out from a train, then it could possibly harm so many people. It would be very dangerous for humans to clean those containers. Even worse, there might be some chance to get exposed to radiation which could be a serious damage. In order to avoid those potential dangers, many companies had attempted to build a robot which could clean the waste through deliberate process for human beings. One company had successfully built the prototype of a robot. The robot had the program installed in the memory with three different sensors: sound sensor; ultrasonic sensor and touch sensor, so it would work by itself until the area got thoroughly cleaned and no remote functions would be required. The robot had a long gripper in the front to grab the waste easily. In addition it contained three wheels in the sides and in the back for the flow motion.

In order to improve the performance of the robot, there might be some work done in the solution algorithm. As now, the robot carried the regular waste and nuclear waste to the same area with the light. However, if the robot could find the highest intensity of the light by doing arc turn, the robot might be able to differentiate nuclear waste from regular waste and it would ultimately carry the two different wastes to two different areas. The opposite way of the direction which had the highest intensity of the light would always be the nuclear waste area.

The possible issue was that the robot would carry the two different wastes to the same area. However, it would be better to place all of them in one area instead of failing to deliver the wastes to two different areas.

References

[1] ENGR 102, *NXT Hazardous Waste Disposal Challenge.* Philadelphia, PA: ENGR 102 Introduction to Engineering II, Winter 2012. ENGR Web Site: http://www.core.coe.drexel.edu/engr102

[2] ENGR 102, *Introduction to NXT Robots and Programming.* Philadelphia, PA: ENGR 102 Week 1, Winter 2012. ENGR Web Site: https://core.coe.drexel.edu/engr102/downloads/NXT_lab1.pdf

[3] Active Robots. (2012). Electronic references [Online]. Available: Active Robots Quality Robotics & Electronics Web site: http://www.active-robots.com/nxt-building-instructions