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Helper

Sensor Report

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Introduction

My robot, Helper, clears an area of different colored golf balls while sorting them by color in the process. In order to accomplish this, Helper needs to perform several tasks. First, Helper performs obstacle avoidance and collision detection while maneuvering around the area. Additionally, Helper detects the border lines of the room so that it does not wander outside of the predefined area. Lastly, and most importantly, Helper needs to be able to locate the objects in the area, determine their color, and locate the appropriate location to take the object. The following paper discusses the sensors used to accomplish these tasks.

Bump Switches

The bump switches used on Helper are simple push button switches. They are placed periodically around Helper and are used for collision detection. By placing two switches in the front, two on each side, and two in the rear of the robot, a collision with an object can be detected. The robot will be able to determine which of the buttons was pressed. Therefore it will be able to know from which direction the collision has occurred and will then maneuver accordingly to avoid damaging the motors or motor driver by attempting to move in a direction it can not.

IR Sensors

The IR Range Finders being used on Helper are the Sharp GP2D12 IR sensors. Three IR sensors are placed on the front of the robot, one pointing straight ahead that is located in the middle and two pointed approximately 45 degrees outward from center that are located on the left and right sides.

The IR sensors are used for detecting objects in front of the robots path in order to avoid collisions. The IR sensors output a single analog signal that corresponds to the reflected light intensity, the higher the intensity the higher the value. This signal will be connected to one of the onboard A/D converters of the Maveric II board so that it can be used to allow Helper to detect nearby objects and move accordingly to avoid them. Table 1 below shows the digital IR signal value of the middle sensor with the robot is positioned different distances from an object (a wall in this experiment). The values fluctuate, so approximate ranges of the values are listed in the table.

Distance	Digital Value
2’	90-97
1’ 6”	123-127
1’	184-189
10”	218-223
8”	270-277
6”	365-370
5”	419-423
4”	497-502
3”	525-529

Table 1: IR Sensor Digital Values

At distances of less than approximately three inches, the digital values begin to decline, making them unable to be interpreted appropriately. Therefore, Helper attempts to ensure correct actions are taken within about six inches of an object so that it does not get too close for the sensor values to be incorrect.

Photoreflectors

Two Hamamatsu Photoreflectors will be used to detect the black boundary line of the environment. They will be placed under the robot toward the front, one on each side. The photoreflectors are implemented in the circuit below in Figure 1. This circuit was obtained from the acroname website where the photoreflectors were purchased.

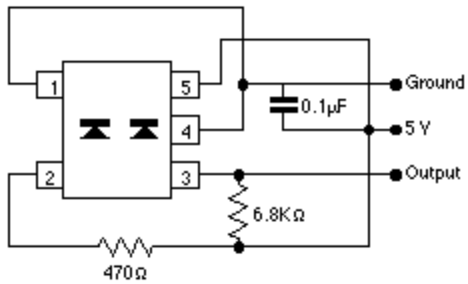

Figure 1: Typical circuit for photoreflectors

When used in the above circuit, the output of the photoreflectors is a logic "1" when the device is placed over a white surface and is a logic "0" when placed over a black surface. This allows Helper to sense when it has reached the black boundary line around the environment. Additionally, using two photoreflectors will allow Helper to detect its orientation relative to the border line so that it can maneuver away form the border accordingly.

CMUCam

A CMUCam is used by Helper for object detection and color recognition. Interfacing the CMUCam with the computer using the provided software is the first step necessary to understand the camera and its command set. Frames can be viewed on the computer using the software.

Using the PC software to capture frames, the pictures in the Figures below were taken of the four different color golf balls are shown under different conditions. The picture in Figure 2 was taken with no LED lighting and the camera's auto white balance off. The picture in Figure 3 was taken with no LED lighting and the camera's auto white balance turned off. The picture in Figure 4 was taken with LED lighting assistance and the auto white balance off. Finally, the picture in Figure 5 was taken with both LED lighting and the camera's auto white balance turned on. The LEDs refers to two circuit boards consisting of four bright white LEDs located placed on each side of the CMUCam. The auto white balance is a register setting that can be turned on/off in software.

Figure 2: No LEDs and no auto balance

Figure 3: No LEDS and auto balance on

Figure 4: LEDs on and no auto balance

Figure 5: LEDs on and auto balance on

This experiment was done in order to determine the best condition in which to locate the golf balls. From the picture it can be seen that the golf balls are the brightest most distinguished in Figure 5 when both the LEDs and the camera's auto white balance were turned on.

Instructions that are used by Helper to locate objects and determine their color include the Get Mean function and the Track Color function. The Get Mean function returns the red, green, and blue mean color values in the current window. Table 2 shows the values returned by the Get Mean command for the four different colored golf balls Helper locates. In this test, the golf balls are placed approximately 3 inches from the camera. The LEDs and the camera's auto white balance were turned on. The values in the table are approximate averages of using the GM command three times.

Color	Red Mean	Green Mean	Blue Mean
Red	142	63	43
Green	94	111	53
Blue	92	64	128
Yellow	133	93	33

Table 2: CMUCam Get Mean Return Values

The Track Color command returns the bounding coordinates of an object that falls within a specified minimum and maximum red, green, and blue mean values. The values from the previous experiment (Table 2) can then be used with the track color command to determine if an object of that color resides in the current window. Information regarding the objects location in the window is returned such as the x and y coordinates of the middle of the object. With this information, the microcontroller can then position Helper to pick-up the object. The track color command will return the number of pixels that make up the object. This allows Helper to distinguish between a golf ball and the much larger drop-off containers of the same color. Finally, the track color command return a confidence level that helps from accidentally mistaking objects in the surrounding areas as the golf ball that it is looking for.

The CMUCam was easy to use and very useful with its built in command set. I would recommend the use of this sensor by anyone in the future in need of a camera to track a color or differentiate between different colors.

Conclusion

Using the sensors described in this report, Helper is able to accomplish the tasks of locating a colored golf ball and taking it to a location corresponding to its color while staying within a predefined border and performing obstacle avoidance.

All of the sensors described in this report have worked satisfactory and consistently so far in my work. My one remaining concern is the ability of the CMUCam to accurately detect the color and presence of an object from location to location (IMDL lab room, NEB rotunda, etc.) as lighting conditions will change. However, this is of no fault to the CMUCam. To control this problem, bright white LEDs are placed on the front of the robot in an attempt to make the lighting conditions more consistent.