6.270 Servos, Sensors, and Shaft Encoding Workshop

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1 Servos

1.1 Mounting

Screw the 24-tooth LEGO gear onto the servo. Three LEGO plates, and two layers of foam tape seem to work to preserve the magic LEGO ratio. The servo can be commanded to rotate any number of degrees up to about 180, and can be used to turn wheels 90 degrees (useful in turning with a tricycle design), lift heavy components, power doors/gates on your robot, and many other things...servos are very powerful and very useful!

2 Sensors

2.1 Digital Sensors

You have several types of digital sensors, including your keyboard switches, and your various lever switches. These return values of 1 or 0, depending on whether or not the sensor is depressed, and can be used as bump sensors - think about the cases in which it would be useful to know if your robot has bumped up against a wall. Be careful with the keyboard switches - they break easily, and they often will not change value if hit from an angle. Lever switches are particularly useful because the lever can be bent, or LEGO can be attached to the lever, such that the switch can be depressed when pressure is applied from a variety of angles.

2.2 Reflectance Sensors

- CDS cell alone: Not reliable. This sensor is useful for detecting the starting light, but should be calibrated for each different lighting environment that the robot is used in. ***The CDS cell is very sensitive to light, and should be shielded carefully (try using the black heatshrink tubing) to make sure that you are measuring the area you want, and not the ambient light. Phototransistors are available for purchase from the "old sensor store," and do not need to be shielded as carefully.
- CDS/LED pair: Use for detecting differences in color, such as the lines on the table, or the different colors of balls. Needs calibration to be reliable. Once again, shield the CDS cell carefully.
- Blinking CDS/LED pair: Use for detecting differences in color, such as the lines on the table, or the different colors of balls. More reliable, needs less precise calibration (you can differentiate between the LED and ambient light because the LED is blinking). Once again, shield the CDS cell carefully.

- IR LED/Phototransistor: Useful for both breakbeam and reflectance sensing - probably better for breakbeam purposes (remember that IR is susceptible to red light/color). When shielding the sensor, remember that the black heatshrink tubing is transparent to IR - it is better to shield these phototransistors with cardboard.

2.3 IR Beacon/Detector

IR detection can tell your robot which direction the other robot is in, but not how far away it is. Try powering your beacon and another team's beacon, and waving them around near eachother - you will notice that a red LED on your beacon will light up, corresponding to the sensor(s) that detect the other beacon's IR. Remember that you can attach your sensors to the beacon with wire, enabling you to adjust their orientation.

3 Shaft Encoding

3.1 Mounting

The breakbeam sensor should be mounted around a wheel, pulley, or gear that is on an axle close to your wheel. The sensor will keep a tally of the number of times the IR beam is broken - try hooking up the sensor, dumping the break tally to the LCD, and moving a piece of paper such that it breaks the beam.

3.2 Driving Straight

The idea is to have a breakbeam sensor for each separately powered set of wheels. If you have separate drive trains powering the left and right sides of your robot, you should use a breakbeam sensor for each drive train. When setting the motors to both drive forward at the same speed, count the number recorded by each breakbeam sensor. If the number recorded by one sensor is higher than the number recorded by the other sensor, one side is moving faster than the other and your robot is not driving in a straight line. To make a course correction, adjust the power to one of your drive trains until the values are equal again. There can usually be a slight difference in the two values without an appreciable error in the robot's path - experiment with different "buffer" values that represent an acceptable difference before a course correction must be attempted.

3.3 Calibrated Turns

One easy way to make 90-degree turns without line following involves using the breakbeam sensors. If your sensors are already placed as described in secion 3.2, you can calibrate the amount that each wheel should travel, and the associated number registered by the breakbeam sensor, for the desired turn. This number should remain fairly constant, assuming that there is no wheel slippage - just remember that you are only getting feedback regarding the amount that each wheel has turned, not the actual distance that the wheel has traveled on the table.