CS148
Building Intelligent Robots

Week 6 : Sonar — *Out: 9 Mar 2004*

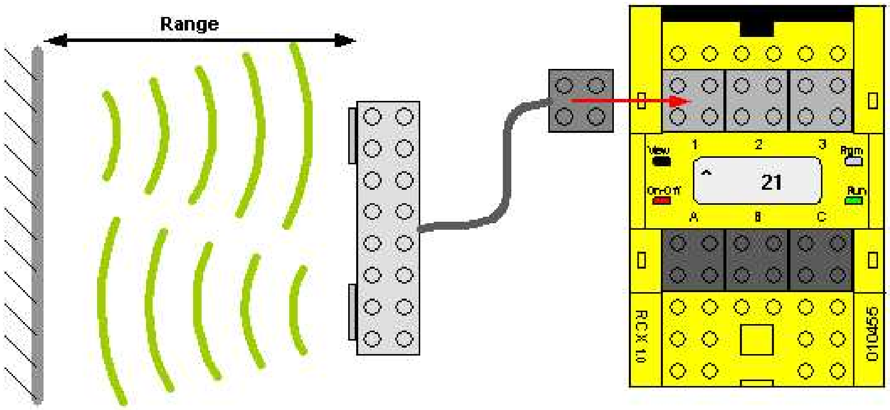
The purpose of this week's lab and project is experiment with and get a feel for simple sonars. You will be conducting tests with the sonars to see how they work and implementing a sonar-based wall following robot.

Since we only have five sonars avaliable, each group will have to sign up for a time slot. All times are Thursday, they are 9–10:30am (normal lab time), 12–1:30pm or 2:30–4pm. Signup sheets will be posted in the Lego Lab. Your lab will be graded during these slots.

Sonar Review

Ultrasonic sensors are often used in robots for obstacle avoidance, navigation and map building. Much of the early work was based on a device developed by Polaroid for camera range finding. From the Hitechnic Ultrasonic Sensor web page we learn that their "ultrasonic range sensor works by emitting a short burst of 40kHz ultrasonic sound from a piezoelectric transducer. A small amount of sound energy is reflected by objects in front of the device and returned to the detector, another piezoelectric transducer. The receiver amplifier sends these reflected signals (echoes) to [a] microcontroller which times them to determine how far away the objects are, by using the speed of sound in air. The calculated range is then converted to a constant current signal and sent to the RCX." The Hitechnic sensor is different from the Polaroid sensor in that it has separate transmitter and receiver components while the Polaroid sensor combines both in a single piezoelectric transceiver; however, the basic operation is the same in both devices.

HiTechnic Ultrasonic Range Sensor



Attach the Ultrasonic Range Sensor as shown. The sensor port should be set to light sensor mode. With the Lego firmware loaded, use the View button to select the port and observe the value displayed. The distance to the target surface is the range as follows;

$$\text{Range} = (\text{Reading} / 2) + 6 \text{ inches}$$

In the example shown the range is 16.5 inches (21/2 + 6). The sensor actually measures in half inch increments beyond the first six inches.

If you have any questions, email us at [illegible] or visit www.hitechnicstuff.com

There are a number of complications involved in interpreting the time-of-flight information returned by an ultrasonic sensor. If the sensor face is parallel to the surface of the nearest object and that surface is flat, reflective and relatively large, e.g., a plaster wall, then the information returned by the sensor can be reasonably interpreted as the distance to the nearest object in front of the sensor. However it the object deviates significantly from this ideal object, the time-of-flight information can be misleading. Here is one of the more benign sorts of interpretation error caused by the fact that the signal (corresponding to a propagating wave of acoustic energy) spreads as it propagates further from the sensor with most of the energy of the leading edge confined to a 30 degree cone. If the surface is angled with respect to the face of the sensor (as it is below) then the time of flight information will record the distance to nearest point within the 30-degree cone.

Lab

In this week's lab you will implement a sonar-based wall following robot. You will also conduct tests to better understand the behavior of a sonar sensor.

Use the sonar the same way you would use a light sensor. **When attaching the connector plate to the input port on the RCX, make sure the plate is oriented so that the cable is on the left**

The sensors we have provided have a range of 6 - 50 inches, with a $\frac{1}{2}$ inch of resolution. You should use the following equation for reference:

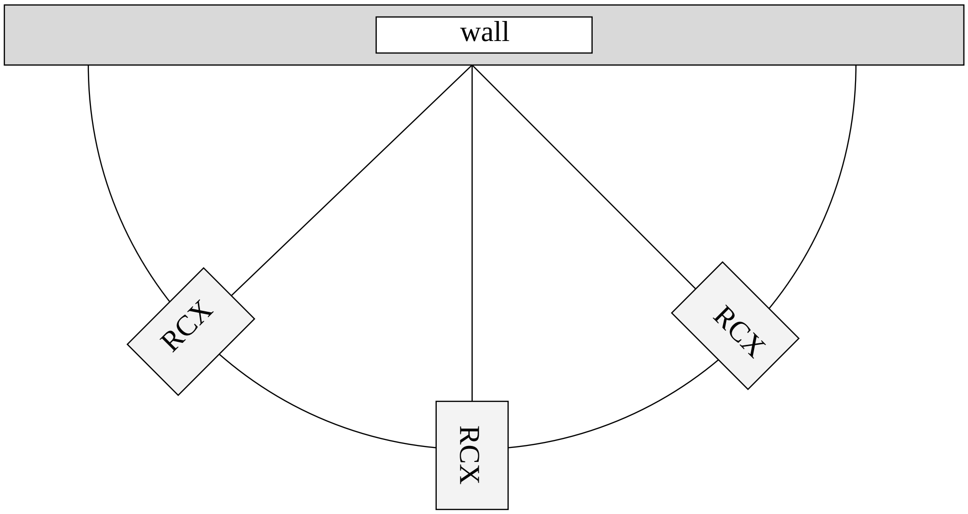
$$\text{Distance to target} = \frac{Reading}{2} + 6\ inches$$

0.1

We first need to understand how the sonar behaves when facing a small surface. Take a small, flat object, and place it approximately 12 inches away from your RCX so that the surface of the object is perpendicular to the sonar. Record the sonar measurements as you rotate the object. Take measurements in 15 degree increments and make a rough plot. If your measurements fluctuate rapidly, then average them out.

0.2

Now see how the sonar behaves when it is facing a large flat surface. Pick a point on the wall and imagine a semicircle around that point. Now place your RCX at various points on that semicircle, always facing the same point on the wall. Record the sonar readings that you get. Make a rough plot.



0.3

Now that you have a feel for how the sonar responds to its environment, you can put it to some use. Your task now is to build a sonar-based wall-following robot. Your robot should be able to travel at least 10 feet while maintaining a set distance (18 inches is good) from the wall.

If you want to impress us, make your robot turn corners.

No project this week! Work on your midterm!