Mechatronics Laboratory Ultrasonic Sensors

The objective of this lab is to provide you with the experience of using an ultrasonic sensor. Ultrasonic sensors, or sonar sensors, are used in a wide range of applications involving range finding and object detection/avoidance. For example, Polaroid Corporation used sonar sensors in their auto-focusing cameras to detect the distances of objects for focusing. Sonar sensors are excellent sensors to use for robot applications. If a robot needs to navigate through a room filled with obstacles, then it can do it successfully by employing sonar sensors.

How it Works

Sonar sensors work by bouncing sound waves off objects while recording the time of flight between the emission and echo of the sound wave. Figure 1 below shows a simple representation of their operation. A 40kHz ultrasonic burst of sound is emitted from the transducer and an external timing circuit records the time of flight. The reason for a 40kHz frequency sound wave is to reduce the chances of false echoes. For example, it is unlikely that a 40kHz sound wave will come from any other source other than the actual ultrasonic sensor itself. The return echo will be slightly smaller in amplitude, but the return frequency should not change. The external timing circuit looks for a 40kHz return signal to identify it as an echo. External timing circuits can range from custom integrated circuit systems to microcontrollers. Since we have available the MIT Handy Board microcontroller, this lab will focus on the use of sonar sensors and the Handy Board.

Limitations of Sonar Sensors

Sonar sensors are not ideal devices. They are limited to resolution, range, and the size of object they can detect. To optimize their performance, you will determine their resolution, range, and minimum object size that they can detect. Figure 2 shows the cone angle detection range for the ultrasonic system that you will be using in lab. As the sound wave propagates from the transducer, the wave covers more area further away from the transducer. It is up to you to determine the angle of detection, θ .

The external timing circuits of some sonar sensor systems are subject to false echoes. Even the Handy Board has problems. Values returned by the sensor may not match the actual distance of the object. One solution is take an average of your readings, for example ping three times and take an average. This method seems to reduce the effects of false triggers.



Figure 1. Basic Operation of Ultrasonic Senors.



Figure 2. Cone Angle Detection Range for Ultrasonic Sensor.

Laboratory Exercise

Equipment Needed: Handy Board microcontroller, and ultrasonic sensor

Polaroid Sonar Sensor



Figure 3. Polaroid Sonar Sensor System Interfaced to SPI Port on H.B.

- Interface the sonar sensor to the Handy Board as presented by your TA. Turn the Handy Board on and connect it to the computer. Start Interactive C (IC) and download the program "son_lab.c" into the Handy Board from the C:\HANDY directory. Start the sonar program on the Handy Board. Determine the maximum distance the sonar is capable of detecting. Use an object with a large surface area such as a book. Determine the minimum distance the sensor is capable of measuring.
- 2. Using a small object, such as an empty soda can or floppy disk, determine the cone angle as shown in Figure 2. Collect data so that you can make a plot representing the cone angle for your report.
- 3. Experiment more with the sonar sensor and determine some problems it may have. Can it determine the direction of an object? What about size? How could you use the sensor to determine the size of an object? Can the sensor respond to quick moving objects?
- 4. Write a short program using the sonar sensor to turn on a DC motor when an object is greater than 11 inches from the sensor and turn off the motor when the object is less than 15 inches from the sensor. Download your code to the Handy Board and demonstrate to your TA that it works. Use the program son_lab.c as a sample. Do not save over son_lab.c! Make a copy of it before you begin any modifications!

Post-Lab Report

Answer all laboratory exercise questions. Include a copy of your code with appropriate discussion. Present a plot of the cone detection angle from Part 2. How does this limit the ability to detect an object in front of an autonomous robot and how can you overcome this limitation?