Washington University in St. Louis

# ULTRASONIC SOURCE LOCALIZATION


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## Abstract


When multiple robots must operate in the same area it is especially important for each robot to be cognizant of the location of the other robots. On one robot we mounted an ultrasonic transmitter and on another robot we mounted two ultrasonic sensors with narrow beams onto a rotating servo motor. We placed the two ultrasonic receivers close to each other so that they are present at the same phase center and fixed them at a thirty degree angle. The signals from these two receivers are in phase but differ in amplitude. By rotating the array until the amplitudes of these two signals are the same we determine the direction of a signal arriving from another robot in real-time.


## Overview

### Goal

Develop an algorithm that enables a robot to detect the location of other nearby robots using ultrasonic transducers.

### Approach

• Use two ultrasonic receivers mounted with beam patterns separated by a fixed angle.

• Determine which sensor has the highest amplitude signal and rotate sensor array until the amplitudes match.

### Applications

Autonomous robotics, defense, aircraft refueling.

### Background

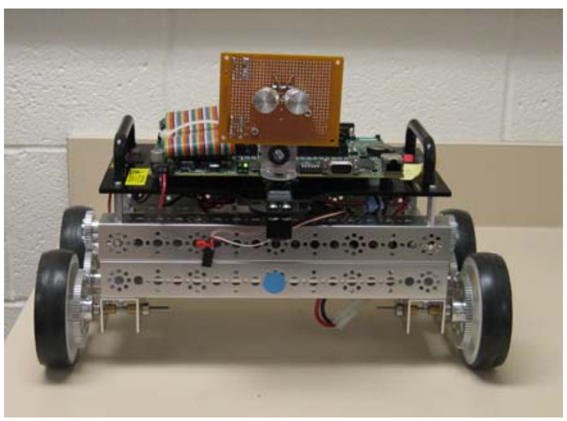
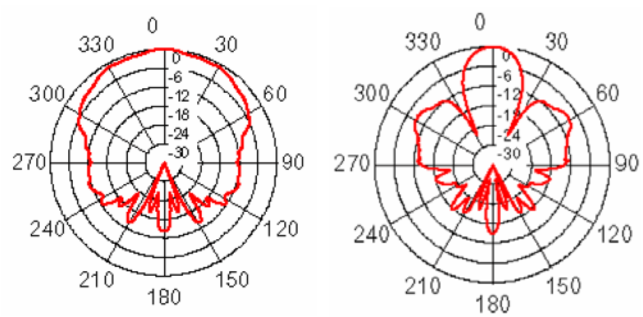


Figure: Photograph of the robot platform used to develop the algorithm. Ultrasonic sensors are visibly attached to a rotating servo motor to allow rotational freedom of motion. The angle of the ultrasonic source relative to the robot is determined by rotating the array until the signals from the two sensors have the same amplitude.

## Amplitude-comparison monopulse algorithm

### Transmitter & Receiver Beam Patterns

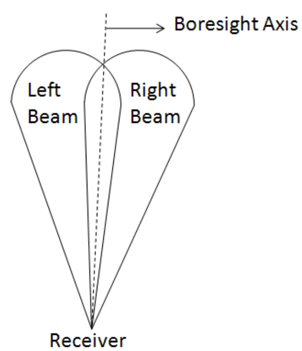



Beam pattern of the ultrasonic transmitter (left) and the receiver (right).

•The transmitter is omnidirectional and sends out 40kHz sinusoid waveforms.

• The receivers have a -6dB bandwidth of 1.5kHz and a -6dB beamwidth of 30°.

### Algorithm




•The transmitter and receivers operate at 40kHz. Hence, the Nyquist sampling rate is 80kHz.

•Within each processing interval, the robot collects 0.5 s of data at a sample rate of 125kHz from each of the receivers.

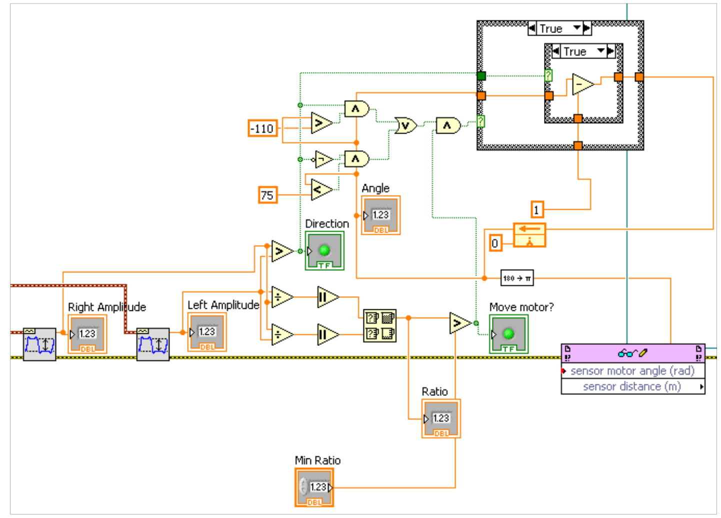
•The RMS voltages of the waveforms from both the channels are computed.

•These RMS voltages are compared by computing the monopulse ratio.

•The receiving sensor array is rotated by one degree in the direction of the sensor with the higher RMS voltage if the monopulse ratio is higher than 1.4. This is done by rotating the servo motor.

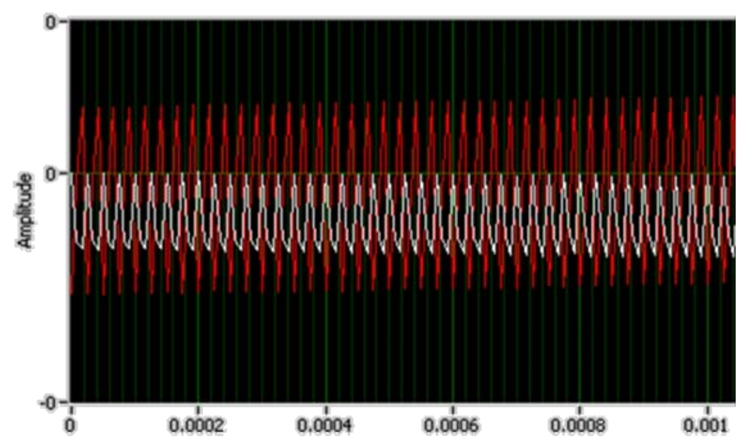
•This process is repeated until the monopulse ratio is less than 1.4. This means the transmitter is aligned with the boresight axis.

## Software Implementation




Screenshot of our experimental software implementation in LabView.

## Sample data




40KHz sinusoid signals received by the two-sensor array. The sensor on the right is represented by the red waveform. Since the amplitude is higher for the right sensor than the left sensor, the target is located toward the right.