2-D Mapping with Sonar

Leon Fay
Miranda Ha
Vinith Misra
Not Chris
Basic Sonar

- Ultrasound cannot be heard by people
- Small wavelength => good for short distances
- Time of flight can be used to estimate distance
Basic Mapping

- Rotate receiver/transmitter to measure distance at every angle
- Slow update rates because of many distance measurements
Phase Array

- Use multiple receivers, measure different angles using phase relationships
- No moving parts => more reliable
- Faster update rate
Applications

- Draw a top view map of environment
- Security system that detects changes in surroundings
Simplified Block Diagram

- Transmitter
- DAC
- Receivers
- ADC
- Signal Creation Module
- Data-gathering Module
- Processor Module
- Post-Processing Module
- Display
- Data RAM
- RS232 Module
- User Interface
- 24’ RGB
- to lab kit serial port

Transmit/Receive
Data-gathering
Control/Process
Display/Interface
Transmit/Receive

- Transmit a single 40-kHz sine wave pulse (generated from stored values played through DAC)
- Multiple receivers
- Enable signals from Control Module for transmitting and receiving
Data-gathering

Transmit/Receive

Control/Process

Display/Interface

Transmitter
- DAC

Receivers
- ADC

Signal Creation Module

Data-gathering Module

Control Module

Processing Module

Post-Processing Module

Data RAM

Display

RS232 Module

24’ RGB

User Interface

to lab kit serial port
Data-gathering

- Samples data from receivers at intervals dictated by Control Module
- Data stored in one of two RAMs
- Simultaneous storage and processing of data—“double buffering”
Control/Process

Transmit
Receive

Data-gathering

Display/Interface

Transmitter

DAC

Signal Creation Module

Control Module

Data-gathering Module

Processing Module

Post-Processing Module

Data RAM

RS232 Module

24’ RGB

User Interface

to lab kit serial port

Display

Control Module
Control/Process

- Control Module gives Processing Module an angle; Processing Module gives back distance at that angle.
- Post-Processor gets angle/distance pairs ready for display and tells Control Module if more data is needed.
Display/Interface

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Transmit/Receive
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Control/Process
Display/Interface

- Display Module gives VGA controller appropriate RGB signals
- Main purpose is to draw a 2-D, color-coded map of the environment
- RS232 Module is for debugging
- User can choose what is displayed
Sines, Chirps, and Pulses

- What kind of signal to transmit?
  - Steady Sine Wave
  - Chirp (linearly changing frequency)
  - Short pulsed sine wave
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Send a pulse, receive attenuated & shifted signal
Game Plan

- For each reflection, different receivers have similar attenuation, but slight phase shifts.
- Can expand as 2 delays:
  - Object to receiver 1 - DISTANCE
  - Receiver 1 to Receiver N - DIRECTION
The Process

1. Find where a certain phase relation is most likely to have occurred (similar to matched filtering)

2. Record the delay to this region of the signal

3. Distance = (half delay to max) \times \text{(speed of sound)}
The Process

After post-processing, matches almost perfectly in simulation.