Passive Radar

Mentor: Erik Johnson
By Koushik Roy
What is RADAR?

- RAdio Detection And Ranging
- A radio transmitter emits an electromagnetic pulse and waits for the echo.
- An object $t$ seconds away produces an echo reflection of the transmitted signal, delayed by $t$ seconds.
- Each reflection scales the amplitude of the wave down by a factor.
- Echoes from objects in the environment consist of scaled and shifted (or delayed) versions of the originally transmitted pulse.
A Modern Radar Detection System
Passive or Active Radar?

• Active radar systems transmit a known signal.
  – Most systems are active.
  – Such systems can be detected and jammed.
• Passive radar systems rely on *ambient* signals, and their reflections.
  – Signal processing
    • Reference signal and reflection signals
  – Hard to detect or jam.
  – Efficient power usage
Challenges involved in Passive Radar

- Extra signal processing must occur to select and detect the reference signal
- Receiver and transmitter are in different locations
- Reference signal must be filtered out of the input received by the receiver
Goals and Assumptions

• Segment space into regions, and to classify valid signals in each space.
• Select a good reference signal.
  – Fits energy and modulation criterion
• Receiver remains stationary
• Use signals from the FM band
• Simulations will provide much of the environment for refining theories.
Progress

- Radar signal processing theory
  - How can we use reflections to detect objects
  - What constitutes a typical radar system
  - What separates active from passive radar.
- Electromagnetic Wave propagation theory
  - Time delays in reflections
  - Amplitude scaling in reflections
  - Beamforming and wavefronts
- A coherent model of a passive radar system.
- MATLAB code.
  - A radar simulator
  - A beamforming weights generator
  - A beamformer
The Current Model

• Beamformer
  – Allows us to sweep the environment spatially
  – Segment space into different regions

• Classifier
  – Determines the properties of ambient signals.
  – Statistically chooses a reference signal.

• Detector
  – Filters out the reference signal
  – Determines the reflections of the reference signal

• Conventional Radar Techniques
Beamformers

• Typically implemented with a phased array of omnidirectional antennas.
• All electromagnetic plane waves have wavefronts.
• These wavefronts hit different receivers in the phased array at different times, based on the incident angle of the waves.
• By applying digital weights to each antenna, we can digitally steer the array of antennas.
Beamforming System
Simulator Output
3 Transmitters, 3 Point Reflectors, 6 Receivers

Inputs
Simulator Output
3 Transmitters, 3 Point Reflectors, 6 Receivers

Outputs
Work to be Done

• Segmentation of the environment spatially
• Statistically classify ambient signals
• Analysis of the energy and frequency modulation properties of signals.
• Make a correct choice for a passive radar reference signal.