

EL7021 Robotics & Autonomous Systems

Assignment 2: Sensors (Cont'd)

2010, Semester 2

The speed of radio waves can be assumed to be 3×10^8 m/s.

1. A vehicle is able to move in a 2D plane, and is carrying a millimetre wave RADAR unit, which is able to scan a focussed radio wave through 360° within that plane. The vehicle is initially located at the origin and a single target is located at coordinates (6.0, 8.0), all units being in metres. The RADAR emits radiation at 77 GHz, has an antennae power gain of 40dB, a transmitted power of 1W and an efficiency of 50%. The RADAR bin is analysed, and a returned power of $10\mu\text{W}$ is detected for the target.
 - (a) Calculate the RADAR cross section of the target.
 - (b) If the vehicle now moves to coordinates (4.0, 1.0), what will be the power received from the same target. What assumptions have you made in this calculation?
2. An FMCW RADAR is designed to have a chirp signal transmission time of 2ms and a chirp band width of 1 GHz. It is required to have a range capability of 100m.
 - (a) Calculate the minimum cut-off frequency necessary for any filter which processes the beat-frequency signal.
 - (b) What would be the range to a target, if the recorded beat frequency were 100 kHz?
 - (c) It is proposed to filter the beat frequency signal in such a way that the filter output produces an estimate of the received power which is independent of the range to the target. What kind of filter would you suggest to achieve this?
3. A SONAR is operated at a frequency of 200 kHz in air, where the speed of sound is 300 m/s. What kind of reflection would you expect from a target which is:
 - (a) extremely smooth?
 - (b) extremely rough and jagged (roughness $> 5\text{mm}$)?
4. Prove that when an ultrasonic transducer points near to a smooth 90° corner, as in figure 1, that the estimated distance after specular reflection at the two surfaces A and B is always the same as the perpendicular distance l from the transducer to the actual corner itself.

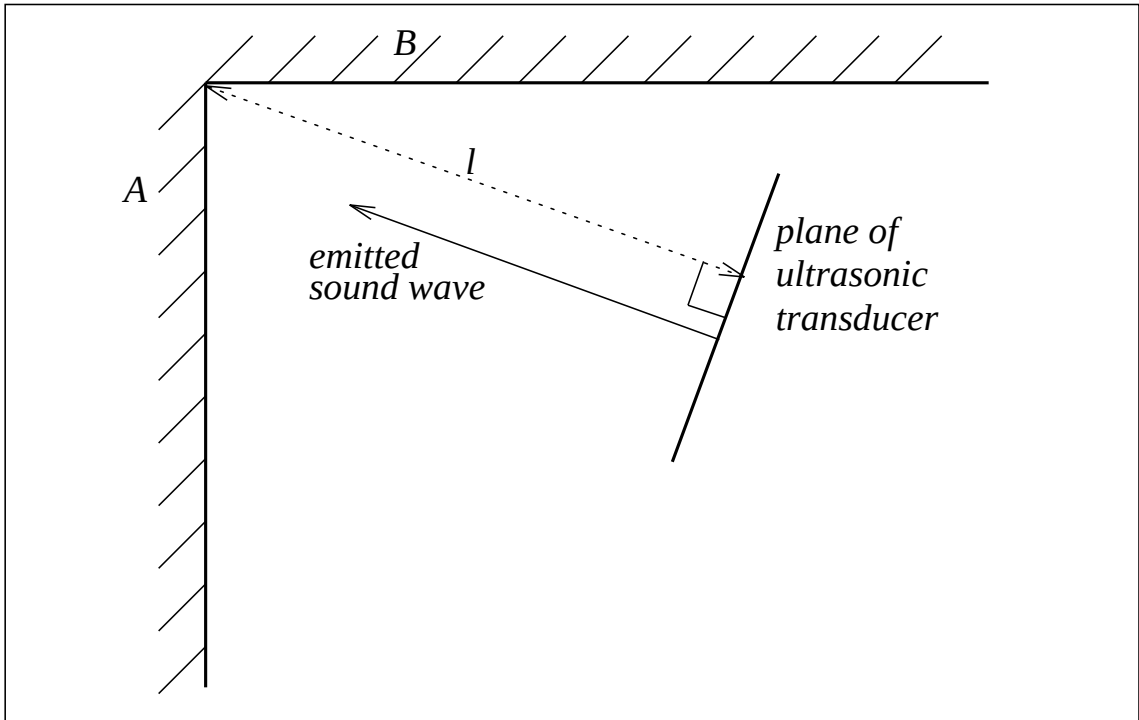


Figure 1: