HSB
Hochschule Bremen
City University of Applied Sciences

Underwater Acoustics and Sonar Signal Processing

Questionnaire

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Chapter 1: Fundamentals of Ocean Acoustics

1) How does the sound velocity depend on the different physical parameters?
2) Please specify typical vertical sound velocity profiles?
3) Sketch qualitatively sound ray diagrams for typical sound velocity profiles.
4) Which different phenomena determine the transmission loss of sound?
5) Please report on the different absorption models considered.
6) Describe the reflection and transmission of sound waves at interfaces?
7) Explain the modeling of sound scattering at the surface and bottom as well as within the water volume?
8) Specify qualitatively the spectral distribution of the underwater ambient noise and indicate the different contributing components.
9) What is the goal of sonar performance prediction?
10) How is the Sonar Equation defined?
11) Please specify the typical parameters required for evaluating the sonar equation.

Chapter 2: Sound Propagation Modelling

1) Describe qualitatively how the wave equation can be derived.
2) Which different techniques have been considered to solve the wave equation?
3) When are the different techniques considered applicable?
4) How can sound rays be constructed if the image source or ray tracing approach is used?
5) Please explain qualitatively how the normal mode solution can be derived.

Chapter 3: Sonar Antenna Design

1) Describe the calculation of pressure fields generated by continuous or discrete apertures.
2) What tells us the beampattern of an antenna and how can it be derived?
3) Report on the characteristic features and differences of beampattems for circular, rectangular and line apertures.
4) How changes the beampattern of a line array if the element spacing and/or the number of elements is varied?
5) Explain how amplitude shading affects the beampattern of a line array.
6) Describe how phase shading can be used either for electronic steering or for a broadening of the main beam.
7) Specify the performance measures introduced for transmitter and receiver arrays.

Chapter 4: Sonar Signal Processing

1) Specify the transmitter and receiver processing chain of a sonar system?
2) What is the purpose of a matched filter and how can it be derived?
3) Explain the notion analytical signal and complex envelope.
4) How can the complex envelope be obtained?
5) Why is the quadrature demodulation useful?
6) How can the quadrature demodulation be implemented?
7) Does the quadrature demodulation have an impact on the SNR?

8) Specify the matched filter required after quadrature demodulation.
9) Report on the various definitions of range resolution.
10) Why has the Doppler effect be treated differently for electromagnetic and sound waves?
11) Specify the impact of the Doppler effect on the received signal.
12) For modeling the impact of the Doppler effect on the received signal, which simplifying assumptions are usually exploited?
13) How can the contradiction between a high energy and high range resolving signals be circumvented?
14) Explain the principle of pulse compression.
15) What is the relationship between pulse compression and matched filtering?
16) How is the ambiguity function defined and what does the ambiguity function tell us?
17) Explain the impact of different waveforms on the ambiguity function.
18) Describe qualitatively the different steps of a hypothesis test procedure for signal detection and explain the meaning of the so-called receiver operating characteristic ROC.

Chapter 5: Array Processing

1) What is a wave field and how is it spatially sampled by an array of sensors?
2) How is the so-called array manifold vector defined?
3) Explain the meaning of the so-called frequency-wave number response function and indicate its relationship to the beampattern of an array.
4) How are the array gain and the directivity index of an array of sensors defined?
5) Report on conventional beamforming procedures for signals of narrow/medium bandwidth.
6) What is fast convolution and what are the benefits?
7) When does fast convolution require the application of the overlap save or the overlap add principle?
8) Describe the main processing steps of frequency domain beamforming.
9) Is frequency domain beamforming suited for broadband signals?
10) Report on the narrowband snapshot model.
11) Describe the classical beamformer and show its relationship to the estimation of the frequency wave number spectrum?
12) How can the MVDR/Capon beamformer be derived?
13) Which property of the covariance matrix of the array output motivates the MUSIC algorithm?
14) Report on Maximum Likelihood DOA and Signal Parameter Estimation.
15) What is the appealing idea that makes the EM algorithm applicable for Maximum Likelihood DOA and Signal Parameter Estimation?