1. Ocean Sonar

1.1. Sonar Oceanography

1.2. Ocean Acoustics

1.3. Sonar Signal Processing

1.4. Statistical Detection Theory

1.4.1. Probability Metrics

The vector of received acoustic data is modelled as $\vec{x}$. The two possibilities to be discerned upon receiving acoustic data are:

- Noise only
- Signal present in the noise

The hypothesis that the acoustic data contains only noise is labelled H_0, and the hypothesis that the acoustic data contains a signal with the noise is labelled H_1.

The distributions of the acoustic data under the noise-only hypothesis $X_0 = T\left(\vec{N}\right)$ and the signal-present hypothesis $X_1 = T\left(\vec{S} + \vec{N}\right)$ depend on your noise $\vec{N}$ and signal $\vec{S}$ distributions and the choice of data processor T for enhancing the signal-to-noise ratio.

The probability of false alarm P_f is the metric for an incorrect decision that a signal is present when the true scenario is that the signal is absent. It is thus defined as

$$P_f = \Pr\left\{\vec{X}_0 \geq h \mid H_0\right\} \tag{1}$$

Similarly, the probability of detection P_d is the metric for a correct decision that a signal is present. It is defined as

$$P_f = \Pr\left\{\vec{X}_1 \geq h \mid H_1\right\} \tag{2}$$

The threshold value h is termed the *detector threshold*, to be distinguished from the detection threshold.

The values of both probabilities need to be under consideration when making a decision as to the presence of a signal.

1.4.1.1. Gaussian Noise with Gaussian Signal

The following assumptions are made:

- Noise is white, bandpass, wide-sense-stationary, ergodic, Gaussian.
- Noise spectral density is $\vec{N} \sim \mathcal{CN}\left(\vec{0}, \lambda_0 \vec{I}\right)$