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Optimum processors for some sonar detection problems

Allan J. Fenwick

Sonar signals may be detected using a number of receivers, the outputs of which are combined in a way which enhances a signal relative to the background noise. This operation is known as beam-forming, and it is followed by further processing. By representing the background noise as a realisation of a random function, the signal as either a known function of time, or as being noise-like, and the processing operations as linear and non-linear transformations, a mathematical model of the detection process can be constructed. Given suitable measures of efficiency, several workers, including Edelblute, Fisk, and Kinnison [2], and Cox [1], have been able to find optimum processors for certain signal and noise fields.

In this thesis, optimum processors are found which eliminate, partially or completely, a signal with given characteristics, thus extending the results derived in [1] and [2]. Two measures of efficiency are used: array gain, which measures the relative increase of signal power over noise power after processing, and the detection index, a measure of the detectability of a signal after processing. For a known signal, linear processing is assumed. For a random signal, linear beam-forming is followed by squaring and averaging. Various methods are used, including application of the Schwarz inequality and theorems on the maxima of quadratic forms.

A practical application to the detection of two signals arriving from

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almost the same direction is the reason for the derivation of processors optimum subject to a constraint. The problems arising in detecting two signals are similar to those involved in detecting a signal in noise containing a localised source or interference. Formulae for the gains and detection indices of various processors operating in interference are given. For detection of two similar signals, systems consisting of two processors in parallel are considered. An attempt to rank these systems using the detection index of each processor and its response to the alternate signal proves to be inconclusive, and further work, involving numerical calculations, is proposed.

A subsidiary topic, but one important in its own right, is the maximisation of array gain by varying the spatial relationship of the receivers. An optimum configuration for a noise field containing an interference source is found.

References

[1] Henry Cox, "Optimum arrays and the Schwartz inequality", *J. Acoust. Soc. Amer.* 45 (1969), 228-232.

[2] David J. Edelblute, Joanne M. Fisk, and Gerald L. Kinnison, "Criteria for optimum-signal-detection theory for arrays", *J. Acoust. Soc. Amer.* 41 (1967), 199-205.

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