Evaluation of the Constrained Bayesian Methodology
for Signal Detection

By

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ABSTRACT

The constrained Bayesian methodology (CBM) is a new approach to the design of structurally constrained statistical inference and decision rules. The methodology is based on constrained minimum mean-squared error estimation of posterior probabilities. The solution for the estimates is specified by a set of linear equations in terms of only the prior probabilities, and moments and conditional moments of prescribed functionals of the observations. The CBM is developed and its applications to signal detection and estimation partially investigated by Gardner in a series of papers. This thesis broadens the development and application of the CBM for signal detection. The general results obtained include the following:

1) The CBM is shown to be equivalent to the constrained maximum generalized signal-to-noise ratio design methodology, which links the CBM to other maximum SNR approaches.

2) The CBM is shown to be a useful tool for parameter estimation, and this is exploited to compare decision rules based on parameter estimates with the rule that chooses the largest estimated posterior probability. The comparisons afford insight into estimation-based decision rules in general, and offer alternatives to degenerate decision rules arising from inadequate posterior estimates.

3) The solution to a general detection problem, that of detecting signals with separable moments in additive white Gaussian noise, is partially characterized, and it is shown that many

of the problems analyzed in this thesis are special cases of this general problem.

These results are given in Chapters II, III, and VI, respectively. In addition to these general results, performance and structural analyses of many detection problems are presented. Specifically, the linear, quadratic, and zero-memory nonlinearity-correlator structures are analyzed in detail with evaluations of probability of error, in Chapters IV, V, and VII, respectively. The analyses show that the CBM is a viable design tool for a wide variety of detection problems, being particularly useful for non-Gaussian noise for which there is no general theory for optimum receiver design. The analyses also provide insight into conventional structures such as matched-filter tapped-delay line receivers for high-speed data transmission, and suggest novel structures such as a modified quadrature correlator receiver for noncoherent reception.