The Information Limit in Clutter: CRLB in the Presence of False Measurements and the ML-PDA Estimator

Y. Bar-Shalom
Distinguished IEEE AESS Lecturer
University of Connecticut ECE Dept.
Storrs CT 06269-2157
ybs@ee.uconn.edu

Abstract

The CRLB is known to provide the minimum achievable mean-square error for parameter estimation. An implicit assumption in it is that there is no "origin uncertainty" in the measurements. The work presented here solves the problem of deriving the CRLB in the presence of false measurements (clutter), an unavoidable situation when one deals with "low observable" (LO) targets. This result is illustrated for a passive sonar problem. Another aspect of this work is the utilization of a target feature, namely, the amplitude information (AI). The AI can be used quantitatively in the estimation process itself to enhance the performance in the presence of clutter where the target-originated measurements cannot be identified with certainty, i.e., for LO (low SNR) targets. A *probabilistic data association* combined with a *maximum likelihood* (ML-PDA) parameter estimator for target motion analysis that uses amplitude information is derived. It is shown that the Fisher Information matrix (FIM) in the case of measurement origin uncertainty is given by the FIM from the perfect-certainty measurement-origin case multiplied by a less-than-unity **scalar** *information reduction factor* (IRF) [3, 4]. The ML-PDA estimation technique has been shown to be efficient (it meets the CRLB) in a passive sonar problem with 6dB SNR in a resolution cell [4, 1]. The same methodology can be used for radar acquisition of LO targets, where it is efficient down to 4dB SNR in a cell [5]. Similar results are available for state estimation [6] where a scalar IRF quantifies the effect of clutter on the Bayesian CRLB.

References

[1] Y. Bar-Shalom, P. K. Willett and X. Tian, **Tracking and Data Fusion**, YBS Publishing, 2011.

[2] W. Blanding, P. Willett, Y. Bar-Shalom and R. Lynch, "Offline and Real Time Methods for ML-PDA Track Validation", **IEEE Trans. Signal Processing**, 55(5):1994–2006, May 2007.

[3] T. Kirubarajan and Y. Bar-Shalom, "Low Observable Target Motion Analysis Using Amplitude Information", **IEEE Trans. Aerosp. Electronic Systems**, AES-32(4):1367–1384, Oct. 1996.

[4] T. Kirubarajan, H. Chen and Y. Bar-Shalom, "Parameter Estimation and the CRLB with Uncertain Origin Measurements", **Methodology and Computing in Applied Probability**, 3(4):387–410, Dec. 2001.

[5] S. Sivananthan, T. Kirubarajan and Y. Bar-Shalom, "A Radar Power Multiplier Algorithm for Acquisition of LO Ballistic Missiles Using an ESA Radar", **IEEE Trans. Aerosp. Electronic Systems**, AES-37(2):401–418, April 2001.

[6] X. Zhang, P.K. Willett and Y. Bar-Shalom, "A Dynamic Posterior Cramer-Rao Lower Bound for Target Tracking in Clutter", **IEEE Trans. Aerosp. Electronic Systems**, AES-41(4):1154–1167, Oct. 2005.