Advanced Topics in Detection and Estimation Theory
Reading and assigments for the different course topics
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1. **Introductory lecture**

   The MUSIC algorithm:

   Ralph O. Schmidt: Multiple Emitter Location and Signal Parameter Estimation, IEEE Trans. on Antennas and Propagation, Vol. AP-34, No.3, March 1986.

   General textbooks:

   H. van Trees, Detection, estimation and modulation theory, Wiley. Especially volumes 1 and 4.

   S. Kay, Fundamentals of statistical signal processing, volumes 1-2.

   P. Stoica and R. Moses, Spectral analysis of signals, Prentice-Hall

2. **Asymptotic analysis of estimators and detectors**

   Basic theory:

   L. Ljung, System Identification: *Theory for the user.*

   T. Söderström and P. Stoica, *System Identification.*

   Sections 6.5-6.6 of S. Kay, Fundamentals of Statistical Signal Processing, Part II: Detection Theory.

   Applications:

   E. G. Larsson and D. Danev, "Accuracy comparison of LS and squared-range LS for source localization," IEEE Transactions on Signal Processing, vol. 58, pp. 916–923, Feb. 2010.

   M. Viberg and B. Ottersten: Sensor array processing based on subspace fitting. IEEE Trans Sign Process vol 39, 1110-1121, 1991

   Suggested structure and material to cover in the presentation:
   Present the basic methodology for asymptotic analysis of estimators. Prove that uniform convergence of the cost function onto a limiting cost function implies consistency (Stoica & Söderström textbook, exercise 7.15). Then give at least a heuristic derivation of the asymptotic covariance matrix. Exemplify with the applications source localization, and array processing. Finally, give a brief overview of asymptotic performance of detectors: recap what we know from the basic course (van Trees) and give the basic formulas for asymptotic performance of the GLRT.

3. **Conditional and unconditional maximum likelihood**

   P. Stoica and A. Nehorai: Performance study of conditional and unconditional direction of arrival estimation. IEEE Trans. Acoust., Speech, Signal Process., vol. ASSP-38, 1783-1795, Oct. 1990

4. **MUSIC, Maximum Likelihood and CRB**

   P. Stoica and A. Nehorai, "MUSIC, Maximum Likelihood and Cramer-Rao bound", IEEE Trans. ASSP, vol. 37, May 1989.

5. **Cramer-Rao bounds**

   The purpose of this lecture is to learn some techniques for finding CRBs. Three techniques will be covered:

   1) Constrained CRBs. Reading:

   T. Marzetta: A simple derivation of the constrained multiple parameter Cramer-Rao bound, IEEE Trans. Signal Processing, June 1993.

   2) Projector methods for finding neat proofs of CRBs. Reading:

   P. Stoica and E. G. Larsson, "Comments on Linearization Method for Finding Cramer-Rao Bounds in Signal Processing," IEEE Transactions on Signal Processing, vol. 49, pp. 3168-3169, Dec. 2001.

   3) Concentrated CRBs (we will not discuss all proofs in detail):

   B. Hochwald and A. Nehorai: Concentrated Cramer-Rao bound expressions, IEEE Trans. Information Theory, March 1994.

   Also read this paper, but we will not discuss it in the lecture:

   P. Stoica, E. G. Larsson, and A. B. Gershman, "The stochastic CRB for array processing: a textbook derivation," IEEE Signal Processing Letters, vol. 8, pp. 148–150, May 2001.

6. **Model order selection**

   The recommendation for this presentation is to recapitulate the Laplace approximation of the posterior log-likelihood that we did in the basic detection & estimation course (pages 60-64 here: http://www.commsys.isy.liu.se/DetEst2010/slides2010.pdf) Then from there, more on to more specific techniques.

   Reading:

   P. Stoica and Y. Selen, "Model-order selection: a review of information criterion rules", IEEE

Signal Processing Magazine, July 2004.

M. Wax and T. Kailath, “Detection of signals by information theoretic criteria”, IEEE Trans. ASSP, April 1985.

7. **Covariance matching techniques**

   Focus on this paper:

   B. Ottersten, P. Stoica and R. Roy, “Covariance Matching Estimation Techniques for Array Signal Processing Applications ”, Digital Signal Processing, 1998.

   Further reading:

   M. Wax, J. Sheinwald, and A. J. Weiss, “Detection and localization in colored noise via generalized least squares”, IEEE Transactions on Signal Processing, July 1996.

8. **Basic spectral estimation - 1**

   Introduction: Definitions of PSD, the spectral estimation problem, broad classification of spectral estimation methods

   Nonparametric methods: windowed periodograms and their analysis

   TBD

9. **Basic spectral estimation - 2**

   Introduction to parametric methods. Parametric methods for rational spectra

   TBD

10. **Basic spectral estimation - 3**

    Parametric methods for line spectra?
    Data dependent filters (Capon, ...)?

    TBD