XVIII. DETECTION AND ESTIMATION THEORY*

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RESEARCH OBJECTIVES AND SUMMARY OF RESEARCH

The research in this group is focused upon the theory of detection and estimation and its application to the development of effective signal-processing methods. Specific areas of interest include nonlinear estimation theory, array-processing techniques, and signal processing for oceanographic research.

1. Optimum Array Processing and Nonlinear Theory

Several useful results concerning optimum array processing have been obtained. For the multiple discrete interference problem we have obtained a processing algorithm that reduces the required computation significantly. This procedure suggested a new adaptive algorithm which we are now investigating. Many arrays with high array gains are quite sensitive to the assumed signal and noise environment. We have developed a procedure for designing optimally insensitive arrays to help eliminate this problem. A third result of interest is an array which adaptively tracks a changing noise environment. We have formulated an approximately optimum receiver and are now investigating its behavior.

H. L. Van Trees

2. Application of Detection and Estimation Theory Methods to Problems in Oceanographic Research

With today's signal-processing methods in oceanographic research, scientists are quite limited in their ability to measure extensively the resolution and area of the ocean bottom and the seismic structure beneath it. As significant portions of the oceans have only been surveyed roughly, one of the charges for the International Decade of Oceanography is to alleviate this situation, and it is quite apparent that signal processing is going to play a major role in this.

We have considered two topics in this area during the past year. In the first, we have examined the random characteristics of the ocean channel to determine the resolution that it will support. Current echo sounders have a 2°-3° quoted accuracy. From our work based upon published measured data and optimum signal-processing procedures, the channel should support a 0.1°-.01° resolution. The next aspect of this analysis is to extend it to the synthetic-aperture methods for echo sounding that are now being advanced in oceanographic research.

While the first topic is primarily concerned with the ocean bottom, the second focuses on the underlying seismic structure. Local areas in shallow water can be surveyed by using the techniques of oil exploration companies; this is quite expensive, however, and is confined to small geographical areas. We have developed a procedure based upon random-process estimation methods which we hope can be applied to large-scale surveillance.

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This work is being done with the assistance of the staff at Woods Hole Oceanographic Institute. Professor Baggeroer spent the summer there as a Visiting Investigator, and the cooperative effort is continuing into the academic year.

A. B. Baggeroer

3. Theoretical Work in Detection Theory

In an Sc. D. thesis, entitled "Chernoff Bounds on Error Probability for the Detection of Non-Gaussian Signals in White Gaussian Noise," J. E. Evans developed the theoretical and computational results that are necessary to apply Chernoff bounding techniques to the detection probabilities of non-Gaussian stochastic signals. The methods are particularly effective when the stationary process long observation time (SPLOT) situation exists.

In order to disseminate the fundamental theoretical concepts that have evolved from our research, two books were written.[1, 2] The first book gives a comprehensive treatment of nonlinear modulation theory. The second book deals with Gaussian signals in noise and the radar/sonar problem.

4. Proposed Research

During the coming year, we shall continue our study of array processing techniques and nonlinear estimation theory. The joint effort between Professor Baggeroer and Woods Hole Oceanographic Institute will also continue.

H. L. Van Trees

References

1. H. L. Van Trees, Detection, Estimation, and Modulation Theory: Part 2. Nonlinear Modulation Theory (John Wiley and Sons, Inc., New York, 1971).

2. H. L. Van Trees, Detection, Estimation, and Modulation Theory: Part 3. Radar-Sonar Signal Processing and Gaussian Signals in Noise (John Wiley and Sons, Inc., New York, 1971).