COMMUNICATION SCIENCES

AND

ENGINEERING

XI. DETECTION AND ESTIMATION THEORY

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A. ADAPTIVE ARRAY PROCESSING FOR PASSIVE SIGNALS

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Joint Services Electronics Program (Contract DAAB07-74-C-0630)

Arthur B. Baggeroer

1. Narrow-Band Passive Systems Theory with Applications to Positioning and Navigation

This research has been completed by José M. F. Moura, and the results have been submitted as a thesis to the Department of Electrical Engineering and Computer Science, M. I. T., on April 7, 1975, in partial fulfillment of the requirements for the degree of Doctor of Science. This study is being prepared for publication as Technical Report 490 in the Research Laboratory of Electronics series. A summary of the thesis follows.

The passive tracking problem with narrow-band and linear constraints on geometry and motion is considered.

In Part I a model is developed which exhibits explicitly the nonhomogeneous received wave field structure induced by the spatial baseline (observer's array) and/or temporal diversity (source motion). This model encompasses the basic phenomena of many practical situations, and is sufficiently simple to be useful in analytical studies. The fundamental question of global parameter identifiability is pursued, with emphasis on passive ranging. The structure and global and local performance of the optimal and suboptimal receivers is examined and, by considering two limiting geometries (distant and close observer), analytical intuitively pleasing expressions are derived which bound the mean-square performance. The issues of spatial/temporal factorability and coupling are investigated, with the focus on the implications of processing complexity and identifiability nonsingularity.

In Part II a practical hybrid solution to the passive tracking problem is developed, and a compromise is achieved between global parameter identifiability and receiver complexity. The behavior of the hybrid algorithm and its sensitivity to the underlying model assumptions of linear path perturbations are analyzed. The theory of passive tracking is applied to positioning in such situations as air traffic control, underwater JSEP

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acoustics, and navigation (orbiting and geostationary satellites). Tradeoffs among attainable accuracy, geometry, and statistical parameters are discussed. Finally, we present Monte Carlo simulations showing the existence of regions of convergence for the theoretical and simulated results.

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