OPTIMAL SYSTEMS FOR ECHO-LOCATION

BY

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ABSTRACT

This thesis is concerned with the factors affecting the performance of pulse echo systems for target localization. Such systems locate a target by estimation of its range and bearing. The thesis is chiefly concerned with situations where Doppler effects are negligible because the relative velocities of receiver, target and scatterers with respect to the transmitter are all small.

In this context, three performance indicators are derived which together can be used to analyze the performance of such a system. By this means, the performance is related to the transmission path characteristics and the energy spectrum of the signal transmitted. Optimal spectra are derived with respect to several performance criteria and their theoretical performances are compared. The theoretical analyses are backed up by computer simulation results.

When the transmission path characteristics are variable or uncertain due to estimation error, a robust system may be required. It is shown that the jointly optimal signal and receiver with respect to a minimax robustness criterion are optimal for a least-favourable transmission path within the class for which the optimization is being performed.

The performance of gated maximum likelihood ranging systems are analyzed to determine the effect of gate width on performance under various conditions. In particular, adaptive systems in which the gate width is coupled to estimated tracking error are analyzed to determine the optimal ratio of gate width to tracking error. A new conditional M.A.P. estimator is then derived which uses the same information but in an optimal way. In particular, the prior information, in the form of a range prediction and a prediction error estimate, is used in a way that minimizes the additional spurious information used. This is done by constructing the conditional prior probability density
function according to a maximum entropy criterion. It is shown that such a system is highly practical, particularly for digital implementation. The performances of various systems are compared by simulation under various conditions and the conditional M.A.P. estimator is shown to consistently yield best performance.

Finally, a case study is undertaken in which robust system optimization and conditional M.A.P. estimation are used. Details of the design of a real time digital system using a linear array of modern signal processing microcomputers are presented. This system was designed for use in robotics experiments for research into automated sheep shearing.
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