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NASA TECH BRIEF

Manned Spacecraft Center

Closed-Loop Control of Stochastic Non-Linear Systems

The Problem:

The classical quadractic synthesis approach to control systems - optimization of a deterministic cost and perturbation estimation, and control about that solution - gives 24% more cost and 97% more mean-squared terminal error than the combined optimization approach to a problem involving control of a first-order system with an unknown time constant. Furthermore, the optimum controller automatically designs the best controller to minimize the effects of the unknown parameter, without artificial augmentation of the cost function as is done in the sensitivity theory approach.

The Solution:

A sophisticated new technique has been developed to resolve problems in complex control systems, such as those used for the guidance and control of space vehicles.

How It's Done:

The solution is obtained by expanding the cost function in a power series around a deterministic trajectory with the assumption of linear perturbation estimation and control about that trajectory. Optimization of the expanded cost function gives the necessary conditions dependent on the covariance matrices and the deterministic portion of the cost. When these necessary conditions are solved, a set of open-loop controls, perturbation controller gains, and perturbation estimator gains are obtained that can be precomputed and implemented into the system.

The main disadvantage of the procedure is that it is only appropriate in situations where the reference-trajectory concept is valid. One situation where this is true is an atmospheric-entry problems where the reference-trajectory concept is well-established and this technique has been applied to that particular problem. Other possible applications might include, for example, optimal guidance and navigation policies for space and terrestrial vehicles and optimum closed-loop process controllers. The extension of the theory to discrete systems represents a straightforward, though not necessarily trivial task.

Note:

Requests for further information may be directed to:

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Patent status:

No patent action is contemplated by NASA.

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