NASA TECH BRIEF

Marshall Space Flight Center

Approximate Properties of the Response of Nonlinear Dynamic Systems to Stochastic Inputs

A recent report presents two approaches for the approximate determination of the statistical response properties of nonlinear dynamic systems to stochastic influences. Both methods consider problems which have not previously been subject to analysis, and are relatively easy to apply.

The Indirect Method, as described in the report, is a more fundamental approach in that it obtains approximate probability densities of certain characteristics. From these densities various statistical properties may then be calculated. A basic advantage of this method is that the effect of nonlinearity on the approximate probability density is brought out for observation, whereas other methods ignore this effect. The only other presently known method giving information about the probability density of the response applies only to white noise inputs, and results have been obtained only for steady state solutions. It was shown by calculation and simulation that neglecting the effect of nonlinearity on the distribution significantly increased the error approximation in some cases.

The Indirect Method depends, in general, on an expansion of the random processes affecting the system, in terms of known time functions. Although a finite expansion of these random processes may be a source of error, it was shown that, even in the case of white noise inputs, good accuracy can be obtained by using such an expansion, especially when the damping is small.

The Direct Method determines the moments of the response directly, and may be easier to apply in some cases than the Indirect Method. The Direct Method avoids the complication of having to expand the input in terms of known functions of time, but presumes a knowledge of the form of the system response probability distribution, leading to an increase in error. An added difficulty is that an appropriate form for the approximate solution of the differential equations involved may not be apparent. It may then be desirable to select a linear model for the nonlinear system.

A significant advantage that both methods possess over previous methods is that no restrictions are placed on the motion of the system with regard to whether or not it is stationary.

It is felt that the methods presented are a significant contribution in that they are a reasonable approach to classes of problems for which present methods may be either inapplicable or unsuitable. In addition, a proposed technique takes into account the effect of a nonlinearity on the probability density of the response for general systems and inputs.

Note:

Requests for further information may be directed to:

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No patent action is contemplated by NASA.

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