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NASA TECH BRIEF

Computer Programs Perform Spectral Analyses of up to Seven Time Series

The problem:

To devise computer programs that will describe the interrelationships between two or more time series in situations where simultaneous measurements of the time-varying quantities are recorded in an experiment.

The solution:

Two computer programs that will perform statistical spectral analysis of up to seven time series. One of these programs is specifically for cross-spectral analysis of two stationary time series, and the other for performing a multidimensional spectral analysis of up to seven time series from stationary or nonstationary processes. These programs are available in both Fortran II and Fortran IV versions.

How it's done:

The cross-spectral analysis program takes as input two stationary time series from simultaneously measured sample records. Multiple cases are treated sequentially, and the time series as well as all the other input data may differ in any respect from one analysis to another. For data input purposes, the X (input time series of the linear model) and Y (observed output) time series sample records are handled in an independent manner. Initially, the two sample records need not consist of the same number of points, nor to have been sampled at the same rate. When this is the case, the program will reduce the effective sampling rate of the data prior to the cross-spectral analysis as indicated by one of the control variables. After any desired sampling rate reduction has been accomplished, for either time series, the resulting sample records are calibrated by the application of multiplicative calibration factors and trends are derived from the resultant sample records. The program then computes estimates of the autocovariance and the cross-covariance functions and then obtains smoothed estimates of the power spectral densities, cospectral density, and quadrature spectral density. From these, estimates of the coherence and frequency response functions are derived.

In addition to trend removal and arbitrary prescaling of the time series, the program provides other auxiliary features such as tests of significance of convex power peaks, corrections for frequency response characteristics of the measurement system, and corrections for filters employed in the generation of the time series input. A variety of modes of data input and output are available on a user option basis, including CRT plots of the various functions estimated.

The multidimensional spectral analysis program performs the same types of calculations as those described above when dealing with stationary time series, but, in addition to computing the coherence and frequency response pertaining to each pair of time series, it also computes multiple coherence functions relating any one of the time series to the remaining ones. In addition, if two or more of the time series are chosen as inputs and the remaining series as outputs in a linear time-invariant system model, the program provides estimates of the matrix frequency response function of the system and computes related quantities.

For nonstationary time series, this program computes time-varying estimates of the types described

(continued overleaf)

by automatically partitioning the total sample record into equal-length overlapping subrecords. A complete multiple spectral analysis is then carried out for each subrecord and each time-varying estimate obtained may then be analyzed to obtain estimates of quantities such as spectra of power fluctuations or spectra of coherence.

A high degree of flexibility is also available in this program because of the modular design and the many user-controlled input and output options.

Notes:

1. These programs should have applicability to a variety of engineering systems in the fields of geophysics, physiology, acoustics, and structural analysis. One possible application would be in testing the dynamic response of structures under wind loading.
2. Inquiries concerning this innovation may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B66-10539

Patent status:

No patent action is contemplated by NASA.

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