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ANALYSIS OF NONGAUSSIAN, NONLINEAR TIME SERIES WITH LONG -MEMORY

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13. ABSTRACT (*Maximum 200 words*)

The project has been concerned with statistical analysis of certain time series and stochastic signals that are unusual, in that they have long memory and are nonGuassian. Standard statistical procedures, such as the Box-Jenkins procedure which presumes Guassianity and short range dependence, when applied to these series will certainly produce inferior and suboptimal results.
The PI pursued two approaches to address the twin problems of long memory and nonGuassianity. The first approach is rather general and it uses the setup of the Kolmogorov-Wiener prediction theroy of stationary processes. The second approach is more specific and it uses a random coefficient stochastic difference equation, which has a stationary solution with long memory and nonGuassian marginial simulating time series data with aforementioned properties. Such simulated data are used in verifying empirically the more general results obtained via the first approach.

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Final Technical Report

1. Project Director: Mohsen Pourahmadi
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DeKalb, IL 60115

2. Title of the Project: Analysis of NonGaussian, Nonlinear Time Series with Long-Memory

3. Period of Support: 09/30/88 - 03/31/91

4. Progress Report:

The project has been concerned with statistical analysis of certain time series and stochastic signals that are rather unusual, in that they have long memory and are nonGaussian. Standard statistical procedures, such as the Box-Jenkins procedure which presumes Gaussianity and short range dependence, when applied to these series will certainly produce inferior and suboptimal results.

The PI has pursued two approaches to address the twin problems of long-memory and nonGaussianty. The first approach is rather general and it uses the setup of the Kolmogorov-Wiener prediction theory of stationary processes. The second approach is more specific and it uses a random coefficient stochastic difference equation, which has a stationary solution with long memory and nonGaussian marginal distributions. This stochastic difference equation is ideal for simulating time series data with aforementioned properties. Such simulated data are used in verifying empirically the more general results obtained via the first approach.

A data set may look nonGaussian or have some unusual properties because of some external disturbances and intervention, or more generally because of some unsuspected contaminations. To check for such causes, it is natural to delete certain observations and reestimate them using the rest of the data. When formulated in the context of the Kolmogorov-Wiener prediction theory, this leads to the *semi-finite interpolation problem*, that is the problem of finding the optimal estimator of X_0 based on $\{X_t;\ t \leq n,\ t \neq 0\}$, where $n > 0$ is a given integer and $\{X_t\}$ is the underlying signal or stochastic process. The Russian probabilist Yu. Rozanov [Stationary Random Processes, Holden-Day, 1967] refers to it as a difficult problem. The PI has been successful in solving this problem in its full generality in [4] (the number refers to the corresponding article in the Publication List.) This solution has far reaching implications as far as estimating impact of interventions, outliers and other structural disturbances in time series and signal processing are concerned. Indeed, in [3, 6, 7] the PI has shown that this solution viewed property, essentially subsumes all existing methods of detecting outliers that are developed either by ad hoc methods or by the well-known *likelihood principle* in statistics. As a discussant of the paper [Leave-k-out diagnostics for time series, J. of Royal Statist. Soc. Ser. B, (1989) 51, 363-424] read before the Royal Statistical Society, Professor R.M. Loynes expresses the desire for developing diagnostic measures for time series that are analogous to those in the linear regression models. In [3] the PI has developed such diagnostics for time series that are based on and motivated by the solution of the semi-finite interpolation problem. Ideas similar to these are used by R.J. Bhansali [On a relationship between the inverse of a stationary covariance matrix and the linear interpolator, J. of Appl. Probability, 27 (1990), 156-170] for testing time-reversibility and Gaussianity of time series data.

Alternatively, a data set may look nonGaussian and/or nonlinear because the underlying stochastic process does not have finite variance. In [2] the structural similarities and differences between stationary processes with and without infinite variances are studied thoroughly. Since for stationary processes with infinite variance neither the Wold, nor the spectral decomposition exists, appeal is made to the geometric notion of basis for the time-domain of the process. The approach of this paper, lays the foundation for a unified study of the prediction problem, semi-finite interpolation problem and autoregressive representation of predictors for such processes. During the term of the project, also I have been working on a case study in finance where the use of a time series model with random coefficients is inevitable. The work in [5] is concerned with estimating and interpreting the so-called beta or systematic risk of a portfolio. More specifically, a method is proposed to estimate the covariance matrix of securities in a portfolio, and the role of this matrix in diversification of risk of a portfolio is explained.

5. Awards and Honors

(i) The PI was invited to organize and chair an invited session "On probability and prediction theory" for the AMS regional meeting at South Bend, IN, March 1991. He also presented and invited paper at this meeting.

(ii) The PI was invited to give an hour long talk at the Summer Program in "New Directions in Time Series" (July 2-31, 1990), sponsored by the Institute of Mathematics and its Applications (IMA) at the University of Minnesota.

(iii) The PI was invited for consultation and as a colloquium speaker by the Department of Mathematics, Hampton University, Hampton, VA, December, 1989.

(iv) The PI was sponsored to attend for two weeks the IMA workshop on "Robustness, Diagnostics, Computing and Graphics in Statistics", August 1989, and gave a 30-minute talk on "m-innovation and outliers in time series".

(v) The PI was an invited speaker at the Institute of Mathematical Statistics (IMS) meeting at Davis, California, June 26-28, 1989.

6. Participating Professionals:

(i) David Olive (U.S. citizen) was supported for two months in 1989. He is currently working for his Ph.D. in Statistics at the University of Illinois.

(ii) Jeff Thompson (U.S. citizen) was supported for one month in 1989. He has received an M.S. in Applied Probability and Statistics from Northern Illinois University and currently is employed by NALCO Company as a Statistical Consultant.

(iii) R. Mohanty (Indian citizen) was supported for two months in 1990. He is a Ph.D. Candidate in Probability and Statistics at Northern Illinois University.

(iv) Sara Clayton (U.S. citizen) was supported for typing some of the manuscripts.

(v) Professor A.G. Miamee, Department of Mathematics, Hampton University, Hampton, Virginia.

(vi) Professors W.C. Chang and D. Wiess, both of the School of Business, Northern Illinois University.

7. Publication List:

1. Computation of canonical correlation and best predictable aspect of future for time series. J. of Time Series Analysis. To appear.

2. Prediction and basicity of stationary sequences and exponentials. Submitted to Sankhya.

3. m-innovations, leave-k-out residuals and outliers in time series. Submitted to Scandinavian J. of Statistics.

4. Semi-finite interpolation of multivariate stationary stochastic processes. Submitted to Ann. of Probability.

5. Covariance of beta and decomposition of risk. Under revision.

6. An alternative derivation and interpretation of the Box-Tiao intervention analys Manuscript.

7. Von Neumann alternating projections and interpolation of stationary processes. Submitted.

8. Fundamental roles of the idea of regression and Wold decomposition in time series. To appear in the IMA volumes in Mathematics and its applications. Springer-Verlag.