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Introduction to the special issue on statistical signal extraction and filtering

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Abstract

The papers of the *Special Issue on Statistical Signal Extraction and Filtering* are introduced briefly and the invitation to contribute to the next issue to be devoted to this topic is reiterated. There follows an account of the history and the current developments in the areas of Wiener–Kolmogorov and Kalman filtering, which is a leading topic of the present issue. Other topics will be treated in like manner in subsequent introductions.

Keywords: Statistical signal extraction; Kalman filtering; Wiener–Kolmogorov filtering

The decision to devote an issue of *Computational Statistics and Data Analysis* to the topic of Statistical Signal Extraction gave rise to a call for papers which included the following statement:

> The need to extract signals and other components from time series is a requirement in many empirical sciences, including Medicine, Engineering, Economics and Climatology, to name but a few. Nowadays, a wide variety of methods are available, including Wiener–Kolmogorov Filtering, Kalman Filtering, Principal Components Analysis, and Wavelet Analysis. Given the variety of the available methods of Statistical Signal Extraction and Filtering, and given the diversity of the subject areas in which they are applied, there are plentiful opportunities for cross fertilisation and technology transfer.

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The call for papers has resulted in numerous submissions that, in the majority of cases, have fallen squarely into one or other of the areas mentioned above, with only a handful that defy such neat categorisations.

The largest group of papers deals with the theory and practice of Wiener–Kolmogorov filtering and Kalman filtering. There are seven papers in this category. The paper of Broto and Ruiz applies the methodology of structural times series modelling to data that are affected by GARCH-type heteroskedasticity. (GARCH is also the topic of another paper by Ruiz, Pascual and Romo.) The paper of Maravall is a classic study in the analysis of unobserved components via the method of canonical decompositions, and that of Mazzochi is an application of Kalman filter methodology. The remaining papers by McElroy and Sutcliffe, by Godolphin and Triantafyllopoulos, by Strickland, Forbes and Martin and by Pollock all propose methodological innovations and extensions of the basic methods of Wiener–Kolmogorov and Kalman filtering.

The paper by Fried, Bernholt and Gather concerns a class of non-linear filtering methods that aim to preserve abrupt shifts of level and monotonic trends while rejecting the sporadic and impulsive noise that may obscure the signal. It serves to remind us that the topic of time series filtering extends far beyond the range of the linear methods.

The next group of papers concerns principal components analysis. These papers are by Ombao and Ho, by Coakley, Fuertes and Smith and by AminGhafari, Cheze and Poggi. Although links can be forged between unobserved components and principal components, none of the papers here have done so; and this remains a topic for future issues.

The paper by AminGhafari, Cheze and Poggi forges links between principal component analysis and the third major topic which is that of wavelets analysis. This is also represented by the papers by Whitcher, by Amato, Antoniadis and De Feis and by Stoev, Taqqu, Park, Michailidis and Marron. The latter uses wavelets to analyse local dependence structures in the data in pursuit of a test of long range dependence and self similarity.

The remaining papers in this collection fall outside the main clusters but well within the ambit of the special issue on statistical signal extraction. The first to mention is the paper by Zeng and Garcia-Frias concerning the use of hidden Markov models in the analysis of gene expression. The paper of Strickland Forbes and Martin also uses Markov chain modelling. It applies the Kalman filter and the fixed-interval smoothing algorithms to a linear Gaussian approximation of a non-Gaussian state–space model; and thus it closes the circle. The final paper, which lies outside the boundary of the tight circle, is that of Lehtinen on signal extraction for simulated games. This is a fascinating application, which is doubtless a surprising one to many. The paper demonstrates the wide scope of the subject of this issue in a way that is most welcome.

More than enough material has arisen from the call for papers to suggest that this is a worthwhile enterprise; and we envisage a regular succession of special issues of the journal devoted to the topic of statistical signal extraction. An invitation to submit papers to the second issue has already been broadcast, and it is appropriate to reiterate it here.

The text that accompanied the original call for papers, which is reproduced above, serves equally for the second call; and we see no merit in limiting the scope. In successive issues, we shall attempt, via a policy of active solicitations, to shift the emphasis from one major area to the next; but this should not be a concern to any potential contributor who is attracted by the broad terms of the invitation.