Editorial

The third special issue on Statistical Signal Extraction and Filtering

The third special issue on Statistical Signal Extraction and Filtering has been longer in the making than was expected by its editors at the outset. The previous issues have been edited by Pollock (2006) and by Pollock and Proietti (2007). This series has arisen from the perception that similar techniques for statistical signal extraction are being pursued in academic fields that appear to be unrelated. There is a limited awareness amongst research workers in these diverse disciplines of the commonality of their methods. The purpose of the special issues has been to bring such work together in a way that should clearly demonstrate its commonality.

The question has arisen of why the degree of cross fertilisation amongst these disciplines has been less than one might reasonably expect. One answer to this conundrum, which has gradually dawned on us, concerns a condition of modern academic life that affects the majority of research workers, wherever they happen to be located. This is the current prevalence of the research assessment exercises, which affect all of the disciplines and which militate against interdisciplinary activities.

Such exercises purport to assess the worth of academic research according to the particular criteria of the disciplines. Researchers who are keen to receive due credit for their work are, nowadays, strongly advised to publish it in journals that lie within the mainstream of their own disciplines. These are not readily accessible to outsiders. Moreover, as the academic population has grown, the degree of its specialisation, or – as some might say – its tribalism, has increased, and the effect has often been stultifying.

The special issues on Statistical Signal Extraction and Filtering are in direct opposition to the trends described above. In this respect, they accord well with the philosophy of Computational Statistics and Data Analysis, which continues to be characterised by a vigourous eclecticism. The present issue comprises papers from a variety of disciplines, including Economics, Geophysics and Medicine; and there are a handful of methodological papers that do not declare any direct affiliation.

There are two papers that evidently relate to Economics. The first of these, which is titled “Removing Seasonality Under a Changing Regime: Filtering New Car Sales” is by Thornton (in this issue). It considers the use of filters for the seasonal adjustment of data on new car registrations in the UK. The strong seasonality in the numbers is attributable to the desire of motorists to defer the purchase of a new car until the beginning of the registration year, in order that their vehicle should have the most up-to-date registration plate. The paper describes, in detail, the use of a Butterworth lowpass filter in estimating the underlying trajectory of the numbers of car sales.

The second economics paper, which is by Li (in this issue), is titled “An Unscented Kalman Smoother for Volatility Extraction: Evidence from Stock Prices and Options.” The paper concerns the problem of determining the volatility in stock prices when their trajectories are described by diffusion models. Such models are highly non-linear and, therefore, the standard Kalman filter and the associated smoothing algorithms, which are based on linear models, are unsuited to the task. Instead, the paper uses the unscented transformation approach, recently developed in the field of engineering. It is found that the method cannot capture adequately the volatility dynamics if only stock price data is used. However, when account is taken of the prices of both stocks and options, the precision of volatility estimation is improved dramatically.

There are two papers in Geophysics. The first of these concerns the early prediction of earthquakes. It is by Wang and Bebbington (in this issue) and it is titled “Identifying Anomalous Signals in GPS Data Using HMMs: An Increased Likelihood of Earthquakes?” The authors propose to extract signals from the GPS measurements of ground deformation in order to assess whether these can be used in predicting earthquakes. The authors introduce a non-linear filter to extract the anomalous signals and they fit a hidden Markov model to the filtered GPS measurements in order to classify the deformation data into states. Finally, the information is used to examine whether the extracted states possess significant predictive power.

The paper by Gazeaux et al. (in this issue), titled “Extracting Common Pulse-Like Signals from Multiple Ice Core Time Series” uses the records that are inherent in polar ice cores to identify episodes of major volcanic activity that are likely to have had a short-term effect on the global climate. The presence of abnormal quantities of sulphates and of acidic particles

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are indicative of heightened volcanic activity, but the records are also affected by background noise. The paper employs a multivariate approach comprising ice core data from several locations in an attempt to separate the signal from the noise. A multivariate state-space model is employed in conjunction with the Kalman filter.

There are three papers that relate to biomedical applications. The paper by Prado (in this issue) titled “Sequential Estimation of Mixtures of Structured Autoregressive Models” is concerned with the extraction of electroencephalogram signals recorded in circumstances of cognitive fatigue. The proposed procedure is able to decompose the observed signals into a collection of latent processes that represent brain activity in various frequency bands. The signals are extracted after fitting mixtures of autoregressive processes with structured prior distributions in the quantities of interest, such as the moduli and wavelengths of the reciprocal roots of the autoregressive polynomials. The methodological contribution of this paper is the use of a particle-based algorithm for the sequential posterior estimation of the parameters and of other quantities of interest, which allows on-line estimation.

The paper by Ramirez-Cobo and Vidakovic (in this issue) titled “A 2D Wavelet-based Multiscale Approach with Application to the Analysis of Digital Mammograms” concerns the detection of breast cancer via signal extraction techniques. It proposes to use wavelets in a 2D analysis of the images. By focussing on the whole background of the image instead of concentrating on microcalcifications, they present a new clinical methodology, which can be combined with other diagnostic tools.

The third of the medical papers, which is by Zamba et al. (in this issue), and which is titled “A Three-State Recursive Sequential Bayesian Algorithm for Biosurveillance”, concerns the monitoring of diagnostic data in order to provide a prognosis of an epidemic. Each of the diagnostic variables is classified according to whether it represents a flat state, a rising state or a declining state, and a Bayesian method is applied to the vectors of the variables in order to form the prognosis.

The remaining five papers of the special issue form a heterogeneous collection. Two of these papers are devoted to novel topics in functional analysis. The paper of Poskitt and Sengarapillai (in this issue) titled “Description Length and Dimensionality Reduction in Functional Data Analysis” aims to identify a family of basis functions, appropriate to a given data function, that represent orthonormal eigenfunctions of a covariance kernel. The objective is to find a low-dimensional, finite basis that accounts for a large proportion of the variation of the data. In certain circumstances, where the data represent a signal embedded noise, the signal will be estimated by projecting the data onto the basis. The paper considers how the dimension of the basis should be determined, and it advocates some so-called description length criteria. Two examples, one from mass-spectroscopy and the one from climatology, are used to illustrate the ideas.

The paper of Moghadderi et al. (in this issue), titled “Trend Filtering via Empirical Mode Decompositions” explores the use of a technique of signal extraction that is markedly different from those that depend on predefined sets of basis functions. In this respect, the technique is akin to the method of principal components, which underlies a singular spectral analysis. However, the basis functions are extracted from the data by an heuristic method that makes no reference to an explicit criterion function. It is remarkable that the components that are extracted by the method of empirical mode decompositions, when it is used in trend estimation, are very similar to those that would emerge from a singular spectral analysis. This is a circumstance that awaits a fuller explanation.

There are three remaining papers in this collection. The first of these is the paper of Frei and Kunsch (in this issue) titled “Mixture Ensemble Kalman Filters.” In common with the paper of Junye Li, it deals with a system whose evolution is governed by a stochastic differential equation. The observations on the system are assumed to be afflicted by errors. The methods described in the paper are based on the ensemble Kalman filter. The filter is extended to encompass nonlinearities in the updating equation as well as non-Gaussian error distributions, which are modelled via Gaussian mixtures. The paper is a contribution to the burgeoning literature on particle filters.

The penultimate paper, which is by Navarro-Moreno et al. (in this issue), is titled “Wide Linear Prediction for Transfer Function Models Based on the Infinite Past”. This paper concerns the modelling of complex-valued data series. A widely linear model is linear in both the complex variable and its conjugate. The widely linear (WL) formulation has provided a new perspective for solving several problems concerned with complex-valued time series. The paper concerns the formation of predictions for both WL ARMA models and WL transfer function models.

The final paper of the issue, is by Nandi and Kundu (in this issue), and is titled “Noise Space Decomposition Method for Two Dimensional Sinusoidal Model.” This paper revisits a classical problem in Fourier analysis.

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