Abstracts and Short Presentations

State Space Models for Time Series Forecasting

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The last two decades have witnessed a significant advancement in Markovian or state space models. These models are frequently constructed and applied by modern stochastic controllers in engineering disciplines, but not commonly used by the time series analysts and forecasters, though the behaviour of many systems can be conveniently and effectively described by the dynamics of these models. This is perhaps due to lack of familiarity among statisticians, either of the models themselves, or of the nature of their construction. The paper briefly reviews a common state space model for time series analysis and forecasting and then describes a simple procedure to construct it.

In recent years, numerous state space models have been introduced by stochastic controllers and statisticians to analyse time dependent systems. These models, dynamic in nature, consist of two equations, such as:

$$Y_t = f\theta_t + v_t \quad \text{and} \quad \theta_t = G\theta_{t-1} + w_t$$

called observation and state equations respectively, where, for $t = 1,2,...,n$, f is a $(1\times n)$ vector of some known functions of independent variables or constants; θ_t is a $(n\times 1)$ vector of unknown stochastic parameters, called a state vector; G is a $(n\times n)$ known system or transition matrix with eigenvalues $\{\mu_i\}$ for $i = 1,2,...,n$; and v_t and w_t are Gaussian white noise processes with mean zero and variances V and W respectively.

For the construction of these models, various methods have been proposed by Aoki (1987), Harvey (1981), Harrison and Akram (1983) and others, but, generally, these are difficult to follow. Here, a simple and straightforward procedure is described which may be easily employed by modellers and academics to construct state space models for both practical and teaching purposes.

Suppose a time series $\{Y_t\}$ at time t is modelled as:

$$Y_t = f_t\theta + \delta_t$$

where $\delta_t \sim N[0,\sigma^2]$ and $f_t = f\,G^t$ for $t \geq 0$.

The vector f and the matrix G jointly describe the discrete time system. The characteristic equation of G, defined by $g(\mu) = |G - \mu I| = 0$, where I is an identity matrix, is closely related to the auxiliary equation of the corresponding difference equation model of the system, the roots of which determine the form of G. For canonical form of models the vector f and the matrix G are defined as: $f = (1,0,...,0)$ and $G = \{g_{ij}\}$ for $i,j, = 1,...,n$ where

$$g_{ij} = \begin{cases} \mu_i & \text{for } i = j \\ 1 & \text{for } j = i+1 \\ 0 & \text{otherwise} \end{cases} \quad \text{and} \quad f = (1,0,...,0).$$

For example, a simple linear regression model

$$Y_t = a + bt + \delta_t$$

where at time t, a is the level of the process, b is growth, and δ_t is as defined earlier, can be converted into a second order state space model by defining D as a difference operator and writing the second order difference equation of the noise free term of the above model as:

$$D^2 Y_t = Y_{t+2} - 2Y_{t+1} + Y_t \doteq 0.$$

Solving this equation we get the roots $\mu_1 = \mu_2 = 1$. Considering these roots as the eigenvalues of the matrix G as

$$G = \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}$$

and writing $f = (1 \quad 0)$ and $\theta = (a \quad b)'$ we see that a system that satisfies this difference equation is

$$Y_t = f\theta_t \quad \text{and} \quad \theta_t = G\theta_{t-1}.$$

Considering the noise δ_t as a linear combination of the noises v_t and w_t, and adding into the system equations, we obtain

$$Y_t = f\theta_t + v_t \quad \text{and} \quad \theta_t = G\theta_{t-1} + w_t.$$

If, instead of the canonical form, a diagonal form is desired, this may be achieved by applying the transformation technique of Akram (1988).

References

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Teaching Industrial Statistics in an Australian University

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Australian industry is becoming more aware of the benefits that statistical methods can have in improving quality and enhancing competitiveness. Correspondingly, there is a growing demand for statistics graduates in industry. Traditionally, quality control has usually been a small part of undergraduate statistics curricula in Australia, and the emphasis has been on detection of failures rather than prevention and design. Good curricula exist (such as that of Vardeman and David (1984)), but these have not been designed with the Australian education system in mind, and require fine-tuning. As well, the graduates will not be useful unless they are good at communicating statistical ideas to non-statisticians, can work as part of a team, and are able to extend their knowledge where necessary. As with other courses in applied statistics, these requirements mean that an industrial statistics course must use quite different teaching methods.

This talk described some of the methods used at the University of Western Australia, outlined the technical content in our course, and discussed computing in this context. Some of the points which emerged are more widely applicable.

Reference

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Development of an Introductory Statistics Unit for a Multi-Disciplinary Class of Students

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Prior to 1990, the University College of Southern Queensland offered three introductory units in statistics in degree courses. These units had many topics in common although there were some specialist topics in each and problems and discussions of statistics were discipline-oriented.

In 1989, to increase the efficiency of the offerings of courses within an environment of reduced levels of funding, a statistics unit, to be taken by all students whose course of study required an understanding of the fundamentals of statistics, was developed. At the same time, the effectiveness of the teaching programme had to be maintained.

In this paper I outline the development of the so-called corporate statistics unit.

Development of the unit: The unit was designed for students from Science, Engineering, and Business Studies courses. Although these students have varied mathematical backgrounds, it was necessarily assumed that they would have minimal