Kalman Filter

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Forecasts are rarely perfect; instead they show what is likely to happen "on average". So it is a good practice to complement forecasts with measures of the forecast uncertainty. The most common measure of uncertainty is the variance.

Such measures are particularly useful for decision making. For example, when determining the amount of stock to keep in a warehouse, it is necessary to be able to meet above normal levels of demand, not just the average demand. The amount stock in the warehouse should be based on a measure of uncertainty such as the forecast variance.

The Kalman Filter is an iterative computational algorithm designed to calculate forecasts and forecast variances for time series models. It can be applied to any time series model which can be written in "state space" form. Almost all of the standard time series models in common use can be written in this form.

The Kalman filter is applied recursively through time to construct forecasts and forecast variances. Each step of the process allows the next observation to be forecast based on the previous observation and the forecast of the previous observation. That is, each consecutive forecast is found by updating the previous forecast. The update rules for each forecast are weighted averages of the previous observation and the previous forecast error. These update rules resemble those of an allied approach to forecasting called exponential smoothing. The intriguing feature of the Kalman filter is that the weights in the update rules are chosen to ensure that the forecast variances are minimised. These weights, referred to collectively as the Kalman gain, play a similar role to the so-called smoothing constants in exponential smoothing.

The Kalman filter is important because it may be applied in real time. That is, as each value of the time series is observed, the forecast for the next observation can be computed.

It has been widely used in engineering and the natural sciences, and to a lesser extent in economics and finance.

References:

Harvey, A C, *Forecasting, structural time series models and the Kalman filter*, Cambridge: Cambridge University Press, 1991.