Estimating Impulse Responses

Consider the descriptions (3-1) and (3-2). To directly estimated the impulse response coefficients, also in the multivariable case, it is suitable to define a high order Finite Impulse Response (FIR) model.

$$y(t) = g(0)u(t) + g(1)u(t-1) + \ldots + g(n)u(t-n) \qquad \textbf{(3-30)}$$

and estimate the *g*-coefficients by the linear least squares method. In fact, to check if there are non-causal effects from input to output, e.g., due to feedback from *y* in the generation of *u* (closed loop data), *g* for negative lags can also be estimated.

$$\begin{aligned} y(t) = {} & g(-m)u(t+m) + \ldots + g(-1)u(t+1) + g(0)u(t) + \\ & g(1)u(t-1) + \ldots + g(n)u(t-n) \end{aligned} \qquad \textbf{(3-31)}$$

If *u* is white noise, the impulse response coefficients will be correctly estimated, even if the true dynamics from *u* to *y* is more complicated than these models. Therefore it is natural to filter both the output and the input through a filter that makes the input sequence as white as possible, before estimating the *g*. This is the essence of *correlation analysis* for estimating impulse responses.