A Method for Estimating Order of System Dynamics Delays.

Rahul Roy

Indian Institute of Management Calcutta, P.O. Box 16757, Alipore P.O. Calcutta 700027, India, Email: rahul@iimcal.ac.in

P. K. J. Mohapatra

Indian Institute of Technology Kharagpur

Delays are common elements in industrial and social systems. They occur in physical flows as well as in information flows. Delays in system dynamics are characterised by the specification of the average delay time constant and the order. The average delay time constant is the average length is the average time required for realisation of half of the change. Order is an integer value, greater than or equal to one that gives a measure of the span of its effect. Low-order delays have an immediate response that is felt over a long period of time, whereas a high-order delay has a deferred response that is felt over a shorter period.

In system dynamics delays are assumed to be exponential in nature. A k-th order delay in system dynamics modelled as a series combination of k level-rate pairs, where the flow out of each level is proportional to the level itself and the proportionality constant is equal to k times the inverse of average delay.

Delays considerably influence the systems behaviour. Modelling of delays therefore has to be done with extreme caution in order that the dynamics of the studied system is modelled truthfully. Given a time path of a dynamic system with a delay, the modeller estimates the length and order of the delay.

Because of its importance the, estimation of length and order of system dynamics delays has been a subject of considerable interest among system dynamics researchers. Substantial effort has already been made by practising system dynamicists to develop procedures that estimate length and order of exponential delays.

In this paper we propose a technique for estimating the order exponential delays that is based on the equivalence of exponential delays with a class of transient Markov processes. In the beginning the equivalence of k-th order delay with a k-the order transient process is established. For the k-th order delay, the equivalence helps in developing a generalised polynomial lagged equation. In this context, previous attempts in this direction made by Holmes (1970) and Hamilton (1980) are also discussed. It is shown that the method proposed by Holmes (1970) can be derived as a special case. An algorithm for estimating the length and the order of the delay is proposed. The method is elucidated with an example taken from Roberts et al. (1983). It is claimed that firstly, a technique to estimate length and order based on available data helps in making the model accurate, and secondly, the proposed method provides a better alternative to the available ones in terms of wider applicability and ease of use.