Abstract

It is well known that the many of the real-world systems (processes) are complex in nature. Though sometimes individual subsystems are simple in behaviour, the nonlinear interaction between them leads to complex behaviour of the total system. Till recently it was assumed that this kind of behaviour in the real-world systems was unpredictable and therefore to be avoided. The recent developments in understanding the nature of chaos is making it possible to tackle it in real-world systems.

In the present work a framework to model real-world chaotic systems from their short, noisy, observed data, to understand their behavioural changes with respect to time and parametric space, has been developed. The study has been performed in terms of qualitative analysis and quantitative analysis. In the qualitative analysis the underlying dynamics of the system is analysed by constructing the bifurcation diagrams (The BD can be constructed with respect to any accessible control parameter, called bifurcation parameter). In the case of quantitative analysis the underlying dynamics is quantified by calculating a system invariant called maximum Lyapunov exponent, computed with respect to initial conditions.

The developed framework is first verified on observed data from a known mathematical chaotic discrete system called Hénon map, in its known ranges of so called control parameters. The methodology is also verified for different factors like number of patterns used for the training, architecture of the Recurrent Neural Network (RNN), presence of noise in the observed time-series (which is inherent part of the real-world systems and processes), Mean Squared Error (MSE) level of training *etc.* It has been observed that MSE level of the training plays a major role in modelling. Further, the RNN model is found to be able to filter out the most of the noise that is present in the data.

The optimised framework is then used to construct the BDs of a real-world system (Process) with respect to possible control parameters. Based on the model developed, the Lyapunov Exponents of the considered system(process) are also calculated. Further, the BDs and LEs of system (process) are then used for the analysis of the system (process) to find out the different zones of the operations possible in the considered system (process).