A Study of Time Series-Networks

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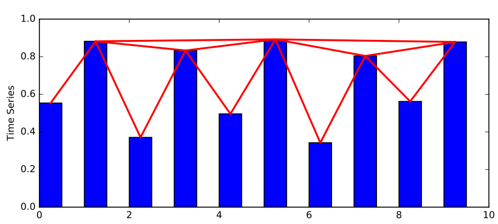
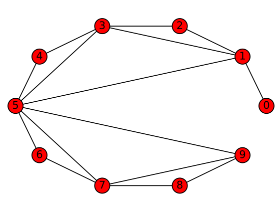
A time series (TS) is an ordered collection of data points of a variable describing a given dynamical system. Traditionally, an analysis of the dynamical system can be carried out by studying the TS through techniques of Fourier transform, Lyapunov exponent etc. This work aims to use a nontraditional technique to study a dynamical system's TS.

We first convert a TS into a TS-network using the visibility algorithm [1]. A network or graph is an object composed of nodes, pairs of which are linked through edges. An illustration of TS to network conversion is shown in Figures 1a and 1b for the logistic map TS at parameter value $\mu = 3.56995$.

We hope to understand a given system from the connectivity structure of its TS-networks. Standard network characterizers, like average path lengths, clustering coefficients, degree distributions etc. can be calculated to study the TS-networks. Here, we subject our TS-networks to Q-analysis [2]-[4], under which we study the network's connectivity patterns by looking at the simplicial structure of the network, which is considered to be made up of simplices or cliques. In this manner we hope to make an analogy between the dynamical regimes of the dynamical system (e.g. regular or chaotic) and the corresponding TS-network.



(a)



(b)

Figure 1: (a) Logistic map TS with μ=3.56995 (onset of chaos at the end of period doubling cascade), and (b) corresponding TS-network.

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To gain an understanding of these characterizers, we study them on TS-networks for TS extracted at different parameter values of the logistic map. The parameter values considered are: $\mu = 3.45$ (period 4), 3.82843 (onset of period 3), 3.836 (period 3 window), 3.56995 (onset of chaos at the end of period doubling cascade), 3.801 (chaos before period 3 window), 3.857 (intermittency), 3.86 (after intermittency), 3.88 (chaos after period 3 window), 4 (full chaos). These parameter values can be seen in Figure 2 on the logistic map bifurcation diagram.

Using this technique, we have been able to differentiate between the logistic map TS obtained at the different parameter values. This means that we have been able to differentiate between the different dynamical regimes observed in the logistic map. Since this analysis can be used to draw insight about the regimes of a dynamical system, it can be used to study systems where the underlying dynamics is unknown.

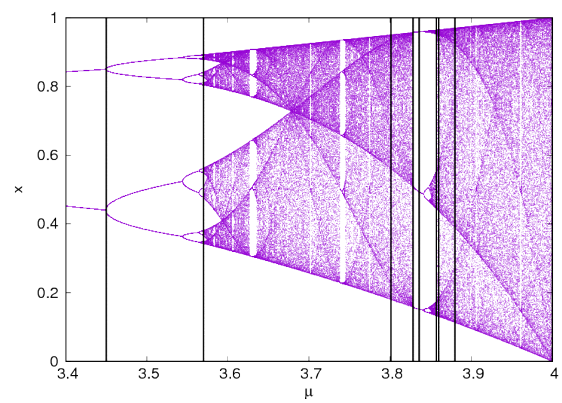

Figure 2: Logistic map bifurcation diagram with parameter values marked at $\mu = 3.45$, 3.82843, 3.836, 3.56995, 3.801, 3.857, 3.86, 3.88, 4.

References

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