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采用LS-SVM计算时间序列的Lyapunov指数谱

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摘要 为了计算未知系统的Lyapunov指数谱，首先，对一维观测数据序列进行相空间重构，然后，利用最小二乘支持向量机（LS-SVM）逼近重构系统的动力学方程，再通过雅克比矩阵计算Lyapunov指数谱。采用提出的方法计算Henon映射的Lyapunov指数谱，可以得到精确的计算结果且需要的序列步长小于1 000。计算了实测不同状态的交通流时间序列的Lyapunov指数谱。结果表明：在拥挤状态下，有多个Lyapunov指数大于零，说明系统是超混沌的；在同步状态下，有一个或多个Lyapunov指数大于零，说明系统是混沌的或超混沌的；在堵塞状态下，Lyapunov指数全小于零，说明系统不是混沌的。

关键词 混沌时间序列 Lyapunov指数谱 最小二乘支持向量机 交通流 超混沌

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Calculation Lyapunov exponent spectrum of time series based on least-squared support vector machine

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Abstract

In order to calculation Lyapunov exponent spectrum of unknown system，firstly，reconstruct phase space of observed one-dimensional time series，secondly，use Least-Squared Support Vector Machine（LS-SVM） approximate dynamical equation of reconstruction system and calculation Lyapunov exponent spectrum by Jacobian matrix.Lyapunov exponent spectrum of Henon system has been calculated by proposed method，result is precise even length of time series is shorter than 1000.Lyapunov exponent spectrum of real traffic flow time series of different condition has been calculated，the result shows that：in crowded condition，system is hyper chaotic because there are two or more positive Lyapunov exponents；in synchronized condition，system is chaotic or hyper chaotic there are one or more positive Lyapunov exponents；in jammed condition，system is not chaotic because all Lyapunov exponents are smaller than zero.

Key words chaotic time series Lyapunov exponent spectrum Least-Squared Support Vector Machine（LS-SVM） traffic flow hyper chaotic

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