Accepted Manuscript

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PII: S0378-4371(16)30707-5
DOI: http://dx.doi.org/10.1016/j.physa.2016.10.020
Reference: PHYSA 17578

To appear in: *Physica A*

Received date: 26 March 2016
Revised date: 7 July 2016

Please cite this article as: P. Yuan, X. Lin, How long will the traffic flow time series keep efficacious to forecast the future?, *Physica A* (2016), http://dx.doi.org/10.1016/j.physa.2016.10.020

How long will the traffic flow time series keep efficacious to forecast the future?

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Abstract This paper investigate how long will the historical traffic flow time series keep efficacious to forecast the future. In this frame, we collect the traffic flow time series data with different granularity at first. Then, using the modified rescaled range analysis method, we analyze the long memory property of the traffic flow time series by computing the Hurst exponent. We calculate the long-term memory cycle and test its significance. We also compare it with the maximum lyapunov exponent method result. Our results show that both of the freeway traffic flow time series and the ground way traffic flow time series demonstrates positively correlated trend (have long-term memory property), both of their memory cycle are about 30 hours. We think this study is useful for the short-term or long-term traffic flow prediction and management.

Key words: Traffic flow time series, Long memory, Modified rescaled range analysis, Maximum Lyapunov exponent

1. Introduction

The growth in urban traffic congestion has been recognized as a serious problem in all large metropolitan areas in the country, with significant effect on the economy, travel behavior, land use and a cause of discomfort for millions of motorists[1; 2]. In order to improve the traffic environment performance, people have tried lots of ways, but the most widely is to construct many roads. However, in fact, the construction of urban roads alone can't solve the urban traffic congestion problem effectively[3-5]. The Intelligent Traffic Systems (ITS) may provide a compensation way to relieve this problem. Traffic guidance system is a part of ITS, it can predict the variation trend of traffic flow, provide real traffic information (travel time, traffic flow state etc.) for travelers through collecting and analyzing the efficacious traffic data. So it is important to improve the performance of traffic system. But at the same time a new problem subsequently produced, that is, how long the traffic flow time series data keeps efficacious to forecast the future? Or in other words, whether we can estimate the traffic flow variation trends of time $t_0 + t$ depending on the existing traffic flow data t_0? If it is yes, then we can say the traffic flow time series data is efficacious in time t, or it has t-long memory.

Although humans have mastered a lot of knowledge about traffic flow, in fact, so far, humans don't know exactly how it evolved. Is it orderly or chaotic, linear or nonlinear, predictable or unpredictable? Unfortunately, till now there is no clear answers for these problems. Since 1990s, nonlinear dynamics theory, chaos theory, fractal theory and other nonlinear theories are widely used to discover the traffic flow evolution mechanism, and it provides a new perspective for the traffic flow studies[6]. With the help of fractal theory and other statistical methods, we can deeply study the evolution process of the traffic flow in the following areas: (1) Whether the traffic flow state has the characteristic of continuity? (2) Whether the traffic flow time series data has the same or similar statistical characteristics at different time scales? (3) Whether the traffic flow state can be predicted, how long of the prediction period is reliable? Obviously, we can't take advantage of the existing traffic flow time series data to predict the future traffic flow variation trends (because there are no any correlation between the data of t_0 and $t_0 + t$) if the traffic flow time series data is completely random (there is no memory of the data). But, if it is not completely random (which means the data of t_0 is correlation with $t_0 + t$, or the time series data has t-long memory) ,then we can use the correlation ship to infer the variation trend of data $t_0 + t$ using data t_0. Now, a problem arises, whether the traffic flow time series indeed displays the memory property (above problem (1))? If it is, whether the memory cycle of them is similar, and how long it keeps (above problem (2))? All of these questions are core issues of this paper. So,