Florida Department of Transportation Research

Synthesis of the Advance in and Application of Fractal Characteristics of Traffic Flow
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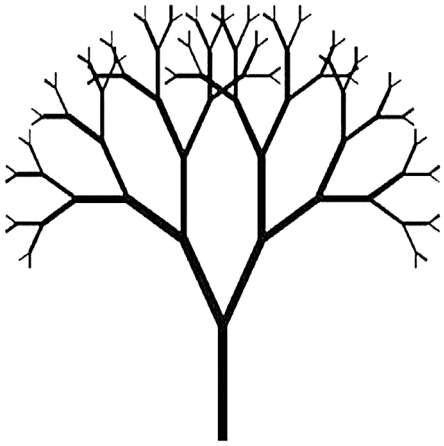
Fractals are geometric objects that are self-similar, meaning that their basic structure remains the same regardless of the scale of magnification. Self-similarity is readily seen in nature, for example, in trees, coastlines, clouds, etc. — fractals are often used to simulate natural landscapes in movies. Fractals were discovered in the 1970s by Benoit Mandelbrot, and at first, they seemed like mere curiosities. But fractals soon developed into fractal geometry, whose unique methods have found many uses, from simulating natural landscapes to analyzing processes.

Florida International University researchers explored the application of fractal theory to traffic management. They asked the basic questions of whether fractal patterns exist in traffic and crash data, whether those patterns could be used predictively, and whether and under what conditions those predictions improved on other methods.



This tree-like structure has fractal properties of self-similarity, which can be found in many natural forms as well as time-dependent data.

The researchers first investigated fractal applications in fields that involve structures similar to transportation networks, for example, electrical networks. Also, they examined other efforts to apply fractals to traffic flow. In surveying these efforts, the researchers collected and developed additional insights on how fractal theory can be applied in traffic management strategies.

Two fractal techniques, fractal dimension and Hurst exponent, were applied to Florida traffic and crash data to detect fractal characteristics. The researchers employed the R software, a programming language and software environment for statistical computing. When they examined traffic volume, speed, and occupancy data obtained from 15-min and 1-hr detector data at two locations in Miami-Dade County, they found fractal characteristics. Furthermore, the speed trend revealed stronger fractal behavior compared to the volume and occupancy trends for the same time period.

Fractal characteristics were detected in both annual and daily crash frequency trends. However, the daily crash trends exhibited stronger fractal behavior than did annual trends, mainly due to the existence of more random fluctuations. The fractal investigation of both annual and three-year-average crash rates at ten randomly selected signalized intersections revealed that the annual crash rate trend exhibited more fractal characteristics than the three-year-average trend.

The results of this project suggest that fractal theory has useful application to many traffic management strategies, such as managed lanes, ramp metering, crash analysis, and travel time reliability. Compared to traditional models, fractal theory could yield more precise estimates of performance measures. Areas with special promise include predicting short-term traffic flow, identification of high-crash locations, and prediction of crash rates at specific locations.

This project opens the door to a new and more precise set of tools for analysis and prediction in traffic management. The result will be a safer, more efficient roadway network for the people of Florida.

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