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TRAFFIC BOTTLENECK DETECTION AND CLASSIFICATION ON A TRANSPORTATION NETWORK GRAPH

CROSS-REFERENCE TO RELATED PATENT APPLICATIONS

This patent application claims priority to U.S. provisional application 61/879,165, filed on Sep. 18, 2013, the contents of which are incorporated in their entirety herein.

FIELD OF THE INVENTION

The present invention relates to traffic congestion detection and analysis. Specifically, the present invention relates to a system and method of detecting bottlenecks on a roadway network, and classification of bottlenecks and bottleneck-like traffic features according to their complexity.

BACKGROUND OF THE INVENTION

Bottlenecks in traffic congestion are locations on a roadway where there is a temporary or permanent drop in capacity (defined as the maximum number of vehicle throughput per second) compared to immediately-adjacent downstream locations on the same roadway. Such circumstances can lead to traffic congestion and the formation of a queue of slow or stopped vehicles behind, or upstream of, the bottleneck. The detection and removal of bottlenecks is often a priority for organizations responsible for managing roadway networks, such as state departments of transportation or private entities operating toll roads. These organizations have an interest in knowing where a bottleneck is, how long the queue of vehicles behind it is, its duration (on a given day or period of interest) and how often it recurs (such as daily, occasionally, rarely).

A bottleneck head, often referred to as the bottleneck location or just bottleneck, is the point downstream of which roadway capacity increases and traffic again flows freely. The bottleneck head is therefore the point furthest along the roadway for which capacity is reduced. A bottleneck queue is the set of points on the roadway upstream of the bottleneck head in which traffic is moving slowly (or stopped) due to the reduced capacity at the bottleneck. The bottleneck head can therefore also be thought of as simply the most downstream point in the bottleneck queue.

A sustained bottleneck is one that persists for more than one time period of interest (such as 5 minutes). For example, a bottleneck may persist for several time periods adding up to a total of 45 minutes. A recurrent bottleneck is a bottleneck that is detected at an identical or similar place, and possibly time, over multiple days.

There are several established prior art methods of analyzing bottlenecks in traffic congestion. One well-known property of a bottleneck is a sudden increase in the speed of traffic as vehicles move downstream of (i.e., beyond) the front, or head, of the bottleneck. Existing techniques have used this property to detect bottlenecks from data generated from a linear sequence of detectors (such as inductive loop detectors placed every mile or so along a stretch of freeway). In one example, the bottleneck head may be defined as a point where the detected speed of downstream traffic is at least 20 mph faster than the detected speed of upstream traffic. The bottleneck queue is defined as all points immediately upstream of the bottleneck head for which the detected speed is less than 40 mph. This method, however, only applies to data on a linear sequence of points (such as inductive loop detector

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locations), typically corresponding to a single named roadway. There is no existing methodology for analyzing data to detect bottlenecks in a non-linear sequence of data points, and no existing methodology for analyzing complex bottlenecks comprised of more than one single named roadway.

The above-mentioned technique also attempts to examine recurring bottlenecks on the same or different days. For example, when for 5 out of 7 consecutive time periods, a bottleneck is detected with a head at location X, then the bottleneck is “sustained”. When a sustained bottleneck occurs on two different days, it is “recurrent”. This existing methodology checks for bottlenecks that are sustained or recurrent at exactly the same location during each time period or day. It does not, however, detect bottleneck head locations that vary across multiple time periods during the same day (e.g. 5 minute time periods), or across multiple days.

BRIEF SUMMARY OF THE INVENTION

The present invention discloses a system and method of detecting traffic bottlenecks on a roadway network. Traffic congestion due to bottlenecks often aggravates and/or influences traffic conditions on a section of the roadway network that are not limited to a single roadway segment, or linear sequence of links. In this embodiment of the present invention, a roadway network is a directed graph of one-way links for which GIS data about the roadway network is available in directed graph or “link-node” form, for example for purchase from third-party vendors. Data representative of “link-speed” on such a directed graph representing a roadway network is used to detect bottlenecks and generalized “bottleneck-like” recurring traffic features, even where data for certain roadway links is incomplete. The link-speed data supplies estimates of the average traffic speed on all or most of the road links at regular intervals, such as for example every 5 minutes. Additional embodiment of the present invention further comprise classifying bottlenecks and bottleneck-like traffic features according to the shape of their queue, and identifying “sustained” or “recurring” bottlenecks even when the location, or head, of the bottleneck varies slightly across multiple time periods (e.g. 5 minute time periods) or across multiple days.

In light of the limitations among the prior art techniques, it is therefore one objective of the present invention to provide a system and method of detecting bottlenecks on a roadway network that is not linear or limited to a single named road. It is another objective to provide a system and method of detecting the head and queue of bottlenecks on a road network comprised of a directed graph of roadway links, given access to speed data on all or most of the links for each of several time periods. It is yet another objective of the present invention to provide a system and method of classifying bottlenecks and bottleneck-like traffic features according to their complexity. It is a further objective of the present invention to provide a system and method of identifying sustained or recurring bottlenecks even if the bottleneck head location varies slightly from day to day or during a single day.

Other embodiments, features and advantages of the present invention will become apparent from the following description of the many embodiments, which illustrate, by way of example, the principles of the invention.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate several