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TRAFFIC SPEED ESTIMATION USING TEMPORAL AND SPATIAL SMOOTHING OF GPS SPEED DATA

CROSS-REFERENCE TO RELATED PATENT APPLICATIONS

This patent application claims priority to U.S. provisional application 61/841,450, filed on Jul. 1, 2013, the contents of which are incorporated in their entirety herein.

FIELD OF THE INVENTION

The present invention relates to traffic speed estimation. Specifically, the present invention relates to a system and method of estimating real-time traffic speed across multiple road segments in a transportation network at any time, by applying a spatial and temporal smoothing process to global positioning system (GPS) data to identify missing speed values in a set of collected GPS data.

BACKGROUND OF THE INVENTION

Existing approaches to traffic speed estimation endeavor to develop speed estimates across traffic networks representing large geographic areas. Each such network is comprised of inter-connected links. There are existing systems that attempt to utilize GPS data to develop such speed estimates, but obtaining complete link speed estimates is hindered by the sparseness of the input data—i.e., GPS data is typically available for only part of the links representing a larger transportation network, and only for part of the time. In other words, collected GPS data is incomplete, making it hard for these existing systems to accurately estimate traffic speed across inter-connected network segments.

An example of such a system is found in U.S. Pat. No. 7,557,730, which discloses systems and methods for automatically collecting, correcting, merging, and publishing information about traffic, transit, weather, public events and other information useful to travelers. This system collects data on a continuous basis at one or more locations and uses GPS receivers of users of a network of traffic segments to do so. One problem with such a collection methodology is that GPS data does not record direction of travel, and there is interference between segments on unrelated routes that are close in latitude and longitude. For at least these reasons traveler information across multiple segments cannot be accurately determined. This prior art solution attempts to match links so that it knows what direction the vehicle is traveling, thereby solving for information that is not provided in GPS data.

Such a prior art system does not address the problem of filling in missing speed information that is normally part of the GPS data set for all links at all times in a transportation network. This prior art solution is therefore focused on a framework for figuring out direction of travel, rather than compensating for the sparseness of speed information due to an incomplete set of GPS data. There is therefore a need in the art for a system and method of using collected GPS data to estimate vehicle speed across an entire network of road segments in real-time where the collected GPS data does not provide complete speed information.

BRIEF SUMMARY OF THE INVENTION

It is therefore one objective of the present invention to provide a system and method of filling in speed values miss-

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ing from sets of GPS speed data. It is another objective of the present invention to provide a framework for determining real-time traffic speed over a plurality of links in a transportation network. It is a further objective of the present invention to determine real-time traffic speed over a plurality of links in a transportation network using missing speed values from GPS data sets.

The present invention provides a system and method of solving for missing speed data using known GPS data points and estimating traffic speed for all links in a transportation network at all time periods. Consider a transportation network for a large geographic area, such as the San Francisco Bay Area. This transportation network is represented as a collection of inter-connected road segments, or links. It is further objective of the present invention is to develop a link traffic speed estimation methodology that applies one or more data processing techniques to accomplish spatial and temporal smoothing of input data, represented by known GPS data points, to present a clearer picture of traffic speed across the entire transportation network. This methodology is embodied in data processing functions executed by one or more processors and embodied in one or more modules configured to model GPS data collected from a plurality of sources and arrive at real-time estimates of traffic speed for all segments at all times.

Complete link traffic speed estimates utilizing the data processing techniques disclosed herein have significant value and utility in the marketplace for consumer applications of such traffic speed data. For example, complete link traffic speed estimates are valuable for dynamic routing applications that aid in congestion alleviation and traffic planning for activities such as road maintenance, mass transit efficiency, and unforeseen event operations, for example during emergencies. Complete link speed estimates are also useful in providing accurate visualizations of congestion maps and animations thereof, and distribution or content generation using these visualizations, such as for example to media outlets and to web applications on mobile devices.

In the present invention, GPS data is acquired and ingested from one or more external sources. This GPS data is prepared for modeling to identify missing speed values in the dataset by applying a procedure to map known GPS data to road links, in a process known as snapping. It then determines neighboring links in the same link network using network distance and road distance limits on the link values. This is followed by steps in which the present invention uses initial data in the GPS data set to build a rescaled speed profile as well as a free-flowing speed estimate. The rescaled speed profile may be compressed via a clustering analysis to reduce storage requirements. The result is a model of rescaled speed that can be applied in real-time to fill in the missing speed values in an input data set by applying the snapping procedure to the GPS data, and then applying a temporal and spatial smoothing procedure to the known speed data using the rescaled speed values to arrive at sufficient estimates for the missing speed values. In cases where there is even less data, the profile-based method is used to infer missing speed values. Once this is accomplished, an accurate traffic speed can be estimated from the incomplete GPS speed data. In other words, the present invention utilizes observed information for one link to estimate neighboring links that are missing observed information, and applies this process to provide a traffic speed estimate for all links at all times.

Other objects, embodiments, features and advantages of the present invention will become apparent from the following description of the embodiments, taken together with the