Needs Statement 566 – Loop Detectors and Vehicle Classification: Literature Search
Thursday, June 20, 2019

Prepared for: Marcus Bekele
Prepared by: Jim Byerly, Electronic Resources Librarian

Resources searched: Library catalog, ASCE Database, TRID, Rip, Transport Database, Web

Summary: Results are compiled from the databases named above. Links are provided for full-text, if applicable, or to the full record citation. I completed my searches using the following terminology: inductive loop, induction loop, loop detector, vehicle classification. I’ve divided the results into the categories most relevant and least relevant.

Most Relevant Results

Library Catalog


- **Contributor:** National Research Council (U.S.). Transportation Research Board, sponsor.
- **Description:** "TRB's Transportation Research Record (TRR): Journal of the Transportation Research Board, No. 2443 consists of 16 papers that summarize vehicle length measurements and length-based vehicle classifications in congested freeway traffic; traceability and confidence intervals in vehicle detector evaluations; weekly similarities of traffic flow for different temporal scales using a hybrid prediction approach; and the identification of network sensor locations for estimation of traffic flow. This issue also covers algorithms for detector-error screening on basis of temporal and spatial information; a process to determine locations for motorcycle counts; software-based vehicle reidentification with existing loop infrastructure; and the effect of traffic load input level on mechanistic-empirical pavement design. Additionally, this TRR explores the bias in traffic data aggregation resulting from transition of traffic states; a semi-automated tool for extraction of microlevel traffic data from a videographic survey; reidentification of trucks on the basis of axle-spacing measurements to facilitate analysis of weigh-in-motion accuracy; and the estimation of average annual daily bicycle traffic with adjustment factors. This issue examines the estimation of spatially and temporally continuous bicycle volumes by using sparse data; an automated analysis of pedestrians' nonconforming behavior and data collection at an urban crossing; bicycle and pedestrian monitoring programs in three states; and the application of seasonal adjustment factors to subsequent year data." -- publisher description.
Investigating inductive loop signature technology for statewide vehicle classification counts

- **Creator:** Liao, Chen-Fu.
- **Contributor:** Minnesota. Department of Transportation. Research Services and Library.; Minnesota Local Road Research Board.; University of Minnesota. Department of Mechanical Engineering.
- **Description:** An inductive loop signature technology was previously developed by a US Department of Transportation (DOT) Small Business Innovation Research (SBIR) program to classify vehicles along a section of the roadway using existing inductive loop detectors installed under the pavement. It was tested and demonstrated in California that the loop signature system could obtain more accurate, reliable and comprehensive traffic performance measures for transportation agencies. Results from the studies in California indicated that inductive loop signature technology was able to re-identify and classify vehicles along a section of roadway and provide reliable performance measures for assessing progress, at the local, State, or national level. This study aimed to take advantage of the outcomes from the loop signature development to validate the performance with ground truth vehicle classification data in the Twin Cities Metropolitan Area (TCMA). Based on the results from individual vehicle class verification, class 2 vehicles had the highest match rate of 90%. Possible causes of classification accuracy for other vehicle classes may include types of loops, sensitivity of inductive loops that generates a shadow loop signal on neighboring lanes, and classification library that was built based on California data. To further understand the causes of loop signature performance and improve the classification accuracy, the author suggests performing additional data verification at a permanent Automatic Traffic Recorder (ATR) site. There is also an opportunity to investigate the classification algorithm and develop an enhanced pattern recognition methodology based on the raw loop signature profile of various types of vehicles in Minnesota.
- **Publisher:** St. Paul, Minn. : Minnesota Department of Transportation, Research Services & Library
- **Publication Date:** 2018

**TRID**

Increasing Accuracy of Vehicle Speed Measurement in Congested Traffic over Dual-Loop Sensors

Coifman, Benjamin; Wu, Lan; Wei, Heng

**Abstract.** Classified vehicle counts are a critical measure for forecasting the health of the roadway infrastructure and for planning future improvements to the transportation network. Balancing the cost of
data collection with the fidelity of the measurements, length-based vehicle classification is one of the most common techniques used to collect classified vehicle counts. Typically the length-based vehicle classification process uses a pair of detectors in a given lane to measure effective vehicle length. While the calculation is simple and seems well defined, this study demonstrates that small changes in the calculations can lead to large differences in performance during challenging conditions. In particular, most conventional calculations assume that acceleration can be ignored, which simply is not the case in congested traffic. As a result of this fact, many operating agencies are reluctant to deploy classification stations on roadways where traffic is frequently congested. This study examines six variations of the conventional vehicle length calculation and develops a seventh that also estimates constant acceleration. It then highlights two of these approaches that work well in extreme conditions on freeways for speeds down to 15 mph. This range should be sufficient for most applications. Then using empirically collected data the authors find that the extreme events were uncommon and even the conventional method did quite well in stop-and-go traffic since the slower traffic moves, the lower the flow during that period. In any event, the key to success is the use of well-tuned detectors.

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Increasing Accuracy of Vehicle Detection from Conventional Vehicle Detectors-Counts, Speeds, Classification, and Travel Time
Coifman, Benjamin; Wu, Lan; Wei, Heng

Abstract. Vehicle classification is an important traffic parameter for transportation planning and infrastructure management. Length-based vehicle classification from dual loop detectors is among the lowest cost technologies commonly used for collecting these data. Like many vehicle classification technologies, the dual loop approach works well in free flow traffic. Effective vehicle lengths are measured from the quotient of the detector dwell time and vehicle traversal time between the paired loops. This approach implicitly assumes that vehicle acceleration is negligible, but unfortunately at low speeds this assumption is invalid and length-based classification performance degrades in congestion. To addresses this problem, the authors seek a solution that relies strictly on the measured effective vehicle length and measured speed. The authors analytically evaluate the feasible range of true effective vehicle lengths that could underlie a given combination of measured effective vehicle length, measured speed, and unobserved acceleration at a dual loop detector. From this analysis the authors find that there are small uncertainty zones where the measured length class can differ from the true length class, depending on the unobserved acceleration. In other words, a given combination of measured speed and measured effective vehicle length falling in the uncertainty zones
could arise from vehicles with different true length classes. Outside of the uncertainty zones, any error in the measured effective vehicle length due to acceleration will not lead to an error in the measured length class. Thus, by mapping these uncertainty zones, most vehicles can be accurately sorted to a single length class, while the few vehicles that fall within the uncertainty zones are assigned to two or more classes. The authors find that these uncertainty zones remain small down to about 10 mph and then grow exponentially as speeds drop further. Using empirical data from stop-and-go traffic at a well-tuned loop detector station the best conventional approach does surprisingly well; however, this new approach does even better, reducing the classification error rate due to acceleration by at least a factor of four relative to the best conventional method. Meanwhile, this approach still assigns over 98% of the vehicles to a single class.

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Supplemental Notes: This document was sponsored by the U.S. Department of Transportation, University Transportation Centers Program.

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Multiple-Classifier Systems for Truck Body Classification at WIM Sites with Inductive Signature Data
Hernandez, Sarah; Tok, Andre; Ritchie, Stephen G

Abstract. Transportation agencies tasked with forecasting freight movements, creating and evaluating policy to mitigate transportation impacts on infrastructure and air quality, and furnishing the data necessary for performance driven investment depend on quality, detailed, and ubiquitous vehicle data. Unfortunately, commercial vehicle data is either missing or expensive to obtain from current data resources. Leveraging existing infrastructure, Hernandez et al. (8) developed a novel, readily implementable approach of integrating two exceptionally complementary data collection devices, Weigh-in-Motion (WIM) systems and advanced inductive loop detectors (ILD), to produce high resolution truck data. For each vehicle traversing a WIM site, an inductive signature was collected along with WIM measurements such as axle spacing and weight. As a case study, the researchers derived truck body configuration from this combined data source. Since body configuration can be linked to commodity carried, drive and duty cycle, and other distinct operating characteristics, body class data is undeniably useful for freight planning and air quality monitoring. Several significant improvements to the body classification model are made in this paper. First, a multiple classifier systems (MCS) method was adopted to increase the classification accuracy for minority body classes. Second, the model was expanded to all truck classes in the axle-based FHWA classification scheme. In all, eight separate body classifications models were developed from an extensive data set of 18,967 truck records distinguishing an unprecedented total of 23 single unit truck and 31 single and semi-trailer body
configurations, each with over 80% correct classification rates (CCR). Remarkably, the body class model for five axle semi-tractor trailers – the most diverse truck category – achieves CCRs above 85% for several industry specific classes including refrigerated and non-refrigerated intermodal containers, livestock, and logging trailers.

Abstract. While motorized traffic counts are systematic and comprehensive, bicycle and pedestrian counts are often unknown or inaccurate. This research presents recommendations to increase bicycle and pedestrian count accuracy while integrating bicycle and pedestrian counting with existing Oregon Department of Transportation (ODOT) traffic counting. Three bicycle counting technologies – pneumatic tubes, inductive loops and thermal cameras – were tested in a controlled environment as well as mixed traffic condition. Test results indicate that all bicycle counting technologies are adequate to count bicycles under controlled, favorable conditions. However, in mixed traffic conditions only the pneumatic tubes were able to count bicycles with less than 20% error. Bicycle counts in mixed traffic conditions with pneumatic tubes are more accurate when bicycle-specific vehicle classification schemes are used and when counting bicycle traffic within 10 feet tube length of the counting device. Two pedestrian counting technologies – passive infrared and pedestrian phase actuations – were tested and attained satisfactory results.
An Improved Inductive Loop Detector Design for Efficient Traffic Signal Operations and Leaner Space Requirements
Yogesh, Goli Koti Veera; Sharma, Anuj; Vanajakshi, Lelitha

Abstract. Inductive loop detectors (ILDs) are one of the most widely deployed traffic sensors. At present, for lane-by-lane detection, ILDs require separate connecting cables for each loop (each lane) and separate data acquisition systems or detector channels to process them. This becomes problematic with limited conduit and cabinet space. In most cases, transportation agencies use ILDs connected in series to avoid these constraints, in which case the lane-by-lane information is lost. However, research has shown that lane-by-lane detection can lead to safer and more efficient operations at signalized intersections. In order to ease the application of lane-by-lane detection, the current study proposes a solution that uses electronic circuit modification to convert the existing serially connected loops to carry out lane-by-lane detection. This system achieved 100% accuracy of lane-by-lane detection in test runs. The paper also proposes an improved loop design, for future installations, that can be used for vehicle classification and wrong way detection. The study implemented machine-learning algorithms for vehicle classification and direction determination with an accuracy of 99.6% and 78.57%, respectively, using single loop configuration.

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Real-Time Magnetic Length-Based Vehicle Classification: Case Study for Inductive Loops and Wireless Magnetometer Sensors in Oklahoma State
Balid, Walid; Refai, Hazem H

Abstract. Providing reliable, real-time vehicle volume and classification information is vital for 21st century intelligent transportation systems (ITS). Large vehicles have a major impact on traffic flow, as well as road maintenance. Information about passenger car versus truck volume is crucial for all transportation agencies. The work presented here provides a comprehensive method to develop length-based vehicle classification (LBVC) techniques that could be implemented using inductive loops (IDL) or magnetometer sensors (MAG). Distinctive LBVC schemes were developed to bin vehicles into groups based on structural similarity and statistical characteristics. Data collection, including vehicle magnetic length (VML) estimates using IDL and MAG, was performed at different sites located on Oklahoma highways and rural roadways to capture various
traffic characteristics. Video images were utilized as ground-truth for accurate data labeling. Extensive data analyses, including machine learning methods and probabilistic modeling, were conducted to define decision boundaries for developed LBVC schemes. Three scenarios were developed for determining optimal thresholding methods: total classification accuracy maximization, per-group classification error minimization, and equal classification error optimization. Evaluation revealed consistent and accurate performance for all developed schemes. Classification accuracies of 97.70% and 99.00% were reported using MAG and IDL, respectively. The developed classification models are computationally efficient and can provide real-time LBVC data. The models are intended to supplement or replace axle-based data collection methods used throughout Oklahoma. The methodology developed in this work will also benefit other states and territories interested in developing LBVC schemes.

Truck Body-Type Classification using Single-Beam Lidar Sensors
Asborno, Magdalena I; Burris, Collin G; Hernandez, Sarah

Abstract. Understanding commodity flow through a region is key for estimating the demand for freight transportation facilities and services, forecasting energy consumption, analyzing safety risks, and addressing environmental concerns. Transportation planners and decision makers use commodity flow data to develop and implement long-term freight plans and manage infrastructure. State-of-the-practice commodity flow estimations based on regional socioeconomic data and periodic surveys have limited spatial and temporal coverage. Moreover, no existing methods tie vehicles to commodity movements at the link level. Although intrusive inductive loop detectors can identify the industry served (or commodity carried) by trucks based on the truck’s body type, intrusive sensor performance is limited by pavement quality. Unfortunately, poor pavement conditions are common in locations with high truck volumes. This paper investigates the use of a non-intrusive traffic sensor, Lidar, for high-resolution truck body-type classification. This paper develops a proof-of-concept Lidar sensor and a truck body-type classification model capable of classifying five-axle tractor-trailers into distinct body types: van and container, platform, low-profile trailer, tank, and hopper and end dump. These body-class groups link to commodity movements and provide insight into link-level commodity flows. Data for model development and validation were collected along a major interstate corridor and a low-speed local road. The classification model achieves an 81% true positive rate (TPR) with class-specific TPR as high as 94% and average volume accuracy of 87% for the primary test location. Overall, the
The proposed sensor represents an adequate proof of concept to evaluate the industry served by trucks on a network link.

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Calibration of Unifiable Multi-lane Multi-class Fundamental Diagrams Using Inductive Signature Technologies
Yan, Qinglong; Li, Yiqiao; Tok, Andre; Jin, Wen-Long

Abstract. Traffic on freeways can be categorized into multiple commodities according to their associated lanes and vehicle type characteristics. Both observations as well as theoretical and empirical studies show that different commodities have dissimilar impacts on the mobility, safety, emissions, human health, and costs. In this study, the authors present a calibration method of multi-lane multi-class fundamental diagrams using a novel traffic flow theory, emerging inductive signature data source, and advanced data processing techniques to provide a better understanding of the multi-commodity traffic. First, the authors review the theory of multi-commodity fundamental diagrams with unifiable and non-first-in-first-out (non-FIFO) properties and provide some guidelines for property verification. Then the authors apply signature-based technologies to individual vehicle speed estimation and body type classification from inductive signature data and identify near-stationary states of commodities and total traffic from converted time series. In the process of calibration, the authors empirically verify the unifiable and non-FIFO properties, calibrate a fundamental diagram of total traffic, and model commodity relative speed ratio functions with multivariate linear regression and model selection criteria. Through the validation, the authors show that the calibrated unifiable multi-lane multi-class fundamental diagrams are well-fitted, physically meaningful, and have a robust performance on the estimation of commodity flow-rates. Finally, the authors conclude their study with highlights and future directions.

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Supplemental Notes: This paper was sponsored by TRB committee AHB45 Standing Committee on Traffic Flow Theory and Characteristics.
Corporate Authors:
Transportation Research Board
Monitoring Motor Vehicle Driver Fatigue

Abstract. Minnesota Department of Transportation (MnDOT) staff are required to complete a wide range of driving tasks, and MnDOT is interested in determining how fatigue affects an individual’s ability to drive safely. To better understand the relationship between fatigue and unsafe driving, MnDOT would like to learn more about the methods, tools and technologies used to predict, diagnose and monitor driver fatigue. To meet this need, CTC & Associates conducted a review of recently published research and supporting documents that examine the characteristics of driver fatigue and how to predict and monitor it. There is a wealth of information on the topic of fatigue monitoring—especially with regard to commercial drivers—and the research highlighted in this report is only a sampling of the available information. It is also important to note that advancements in technology make for a rapidly changing landscape. The information in this report is organized by topic to allow for a more comprehensive and concise review of each topic area. Citations in each topic area may include both domestic and international research as well as research focused on different vehicle classes (commercial and passenger). This report is divided into the following sections: Training Resources; General Research on Fatigue Monitoring Technologies; Out-of-Vehicle Fatigue Monitoring; In-Vehicle Fatigue Monitoring; Fatigue Management in Winter Operations; and Techniques to Avert Fatigue.

Record Type: Publication
Record URL: http://www.dot.state.mn.us/research/TRS/2015/TRS1501.pdf;
/common/images/covers/large/1409224.png
Corporate Authors: CTC & Associates

Serial: Transportation Research Synthesis
Publisher: Minnesota Department of Transportation
URL: http://www.research.dot.state.mn.us

Pilot testing a naturalistic driving study to investigate winter maintenance operator fatigue during winter emergencies
Camden, M C; Hickman, J S; Hanowski, R J
**Abstract.** Although numerous research studies have investigated the effects of fatigue in commercial motor vehicle drivers, research with winter maintenance (WM) drivers is sparse. This study pilot-tested the feasibility of evaluating WM operator fatigue during winter emergencies using naturalistic driving data. Four WM operators participated in the study and drove two instrumented snow plows for three consecutive winter months. The operators also wore an actigraph device used to measure sleep quantity. As this was a pilot study, the results were limited and only provided an estimation of what may be found in a large-scale naturalistic driving study with WM operators. Results showed the majority of safety-critical events (SCEs) occurred during the night, and approximately half of the SCEs occurred when participants were between 5 and 8 h into their shifts. Fatigue was identified as the critical reason in 33% of the SCEs, and drivers were found to average less sleep during winter emergencies versus winter non-emergencies. However, one participant accounted for all fatigue-related SCEs. Although data were limited to two instrumented trucks and four drivers, results support the approach of using naturalistic driving data to assess fatigue in WM operators. Future on-road research is needed to understand the relationship between fatigue and crash risk in WM operators.

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**Transport Database**

Result 6.

**Title**  
Vehicle Classification Using the Discrete Fourier Transform with Traffic Inductive Sensors.

**Source**  
Sensors. 2015. 15(10) pp 27201-27214 (Figs., Photos., Tabs.)

**URL**  
[http://dx.doi.org/10.3390/s151027201](http://dx.doi.org/10.3390/s151027201)

**Abstract**  
Inductive Loop Detectors (ILDs) are the most commonly used sensors in traffic management systems. This paper shows that some spectral features extracted from the Fourier Transform (FT) of inductive signatures do not depend on the vehicle speed. Such a property is used to propose a novel method for vehicle classification based on only one signature acquired from a sensor single-loop, in contrast to standard methods using two sensor loops. The authors proposal will be evaluated by means of real inductive signatures captured with the authors hardware prototype.
Result 10.

Title Mutually coupled multiple inductive loop system suitable for heterogeneous traffic.


URL http://dx.doi.org/10.1049/iet-its.2013.0055

Abstract A magnetically coupled multiple inductive loop detector system is presented in this study. Automated detection, classification and measurement of speed of vehicles are challenging tasks, in a no-lane disciplined and heterogeneous traffic. This study proposes an inductive loop sensor wherein multiple numbers of small loops are placed within a large outer loop, for measurement of traffic parameters under such traffic. In the new system the outer loop alone is connected to the measurement unit and all the small loops are coupled inductively to the outer loop. This scheme is simple and effective and can be employed to convert an existing single loop system to a multiple loop system, suitable for heterogeneous traffic. The measurement is based on a synchronous detection method. A special excitation that ensures parallel resonance of the inductive system is employed, which keeps the power consumption minimum. The new system correctly sensed the vehicles, categorised and counted them in undisciplined traffic. The proposed system has been also extended to detect the direction of travel and speed of the vehicles. Results from the prototype developed were found to be accurate proving its practicality in real time traffic monitoring and intelligent transportation system (ITS) applications under a heterogeneous scenario.

Publication Year 2014

Result 12.

Title Improved vehicle classification from dual-loop detectors in congested traffic.

Source Transportation Research Part C: Emerging Technologies. 2014/9. 46(0) pp 222-234 (Figs., Refs., Tabs.)

URL http://dx.doi.org/10.1016/j.trc.2014.04.015

Abstract Vehicle classification is an important traffic parameter for transportation planning and infrastructure management. Length-based vehicle classification from dual loop detectors is among the lowest cost technologies commonly used for collecting these data. Like many vehicle classification technologies, the dual loop approach works well in free flow traffic. Effective vehicle lengths are measured from the quotient of the detector dwell time and vehicle traversal time between the paired loops. This approach implicitly assumes that vehicle acceleration is negligible, but unfortunately at low speeds this assumption is invalid and length-based classification performance degrades in congestion. To address this problem, the authors seek a solution that relies strictly on the measured effective vehicle length and measured speed. They analytically evaluate the feasible range of true effective vehicle lengths that could underlie a given combination of measured effective vehicle length, measured speed, and unobserved acceleration at a dual loop detector. From this analysis they find that there are small uncertainty zones where the measured length class can differ from the true length class, depending on the unobserved acceleration. In other words, a given combination of measured speed and measured effective vehicle length falling in the
uncertainty zones could arise from vehicles with different true length classes. Outside of the uncertainty zones, any error in the measured effective vehicle length due to acceleration will not lead to an error in the measured length class. Thus, by mapping these uncertainty zones, most vehicles can be accurately sorted to a single length class, while the few vehicles that fall within the uncertainty zones are assigned to two or more classes. The authors find that these uncertainty zones remain small down to about 10 mph and then grow exponentially as speeds drop further. Using empirical data from stop-and-go traffic at a well-tuned loop detector station the best conventional approach does surprisingly well; however, the new approach does even better, reducing the classification error rate due to acceleration by at least a factor of four relative to the best conventional method. Meanwhile, their approach still assigns over 98% of the vehicles to a single class.

Publication Year 2014

Result 15.

Title Length-based vehicle classification using event-based loop detector data.

Source Transportation Research Part C: Emerging Technologies. 2014/1. 38(0) pp 156-166 (Figs., Refs., Tabs.)

URL http://dx.doi.org//10.1016/j.trc.2013.11.010

Abstract Length-based vehicle classification is an important topic in traffic engineering, because estimation of traffic speed from single loop detectors usually requires the knowledge of vehicle length. In this paper, the authors present an algorithm that can classify vehicles passing by a loop detector into two categories: long vehicles and regular cars. The proposed algorithm takes advantage of event-based loop detector data that contains every vehicle detector actuation and de-actuation "event", therefore time gaps between consecutive vehicles and detector occupation time for each vehicle can be easily derived. The proposed algorithm is based on an intuitive observation that, for a vehicle platoon, longer vehicles in the platoon will have relatively longer detector occupation time. Therefore, longer vehicles can be identified by examining the changes of occupation time in a vehicle platoon. The method was tested using the event-based data collected from Trunk Highway 55 in Minnesota, which is a high speed arterial corridor controlled by semi-actuated coordinated traffic signals. The result shows that the proposed method can correctly classify most of the vehicles passing by a single loop detector.

Publication Year 2014

Least Relevant Results

Transport Database

Result 1.

Title Lifespan Evaluation of Traffic Detector for Automated Traffic Recorders Based on Weibull Distribution.

Abstract

An automatic traffic recorder (ATR) makes it easy to detect a vehicle’s speed and the number of axles because it produces highly precise data; thus, it can be used to obtain major traffic characteristics for several purposes such as vehicle classification. However, the failure of a piezo sensor or inductive-loop sensor often results in missing data. Moreover, there is no method available for evaluating the life of a sensor installed in a pavement. Therefore, such sensors require maintenance after a failure occurs, resulting in a large amount of missing traffic volume data. If the quantified life expectancy of a sensor could be obtained, a maintenance and rehabilitation strategy could be established and the economic feasibility could be determined. In this study, the 5-year maintenance history of a sensor newly installed in a national highway was reviewed. Normal, gamma, lognormal, and Weibull distributions were fitted to the data, and the results were compared. The Weibull distribution was used to predict the life. When the maintenance histories of piezo and inductive-loop sensors were fitted to the Weibull distribution, the scale parameters were 79.23 and 89.72 and the shape parameters were 3.28 and 2.83 for the piezo sensor and loop sensor, respectively. The mean life and median life of the piezo sensor were calculated to be 71.05 and 70.85 months, respectively. Those of the loop sensor were 79.92 and 78.82 months, respectively.

Result 2.

Title

Soft Radial Basis Cellular Neural Network (SRB-CNN) based robust low-cost truck detection using a single presence detection sensor.

Source

Transportation Research Part C: Emerging Technologies. 2016/12. 73 pp 105-127 (Figs., Refs., Tabs.)

Abstract

This paper does present a comprehensive concept for a robust and reliable truck detection involving solely one single presence sensor (e.g. an inductive loop, but also any other presence sensor) at a signalized traffic junction. Hereby, two operations modes are distinguished: (a) during green traffic light phases, and (b) a much challenging case, during red traffic light phases. First, it is shown how difficult the underlying classification task is, this mainly due to strongly overlapped classes, which cannot be easily separated by simple hyper-planes. Then, a novel soft radial basis cellular neural/nonlinear network (SRB-CNN) based concept is developed, validated and extensively benchmarked with a selection of the best representatives of the current related state-of-the-art classification concepts (namely the following: support vector machines with radial basis function, artificial neural network, naive Bayes, and decision trees). For benchmarking purposes, all selected competing classifiers do use the same features and the superiority of the novel CNN based classifier is thereby underscored, as it strongly outperforms the other ones. This novel SRB-CNN based concept does satisfactorily fulfill the hard industrial requirements regarding robustness, low-cost, high processing speed, low memory consumption, and the capability to be deployed in low cost embedded systems.
Title  Integration of Weigh-in-Motion (WIM) and inductive signature data for truck body classification.

Source  Transportation Research Part C: Emerging Technologies. 2016/7. 68 pp 1-21 (Figs., Maps., Refs., Tabs.)

URL  http://dx.doi.org/10.1016/j.trc.2016.03.003

Abstract  Transportation agencies tasked with forecasting freight movements, creating and evaluating policy to mitigate transportation impacts on infrastructure and air quality, and furnishing the data necessary for performance driven investment depend on quality, detailed, and ubiquitous vehicle data. Unfortunately in the US, currently available commercial vehicle data contain critical gaps when it comes to linking vehicle and operational characteristics. Leveraging existing traffic sensor infrastructure, the authors developed a novel, readily implementable approach of integrating two complementary data collection devices, Weigh-in-Motion (WIM) systems and advanced inductive loop detectors (ILD), to produce high resolution truck data. For each vehicle traversing a WIM site, an inductive signature was collected along with WIM measurements such as axle spacing and weight which were then used as inputs to a series of truck body classification models that encompass all truck classes in the most common axle-based Federal Highway Administration (FHWA) classification scheme in the US. Since body configuration can be linked to commodity carried, drive and duty cycle, and other distinct operating characteristics, body class data is undeniably useful for freight planning and air quality monitoring. A multiple classifier systems (MCS) method was adopted to increase the classification accuracy for minority body classes. In all, eight separate body classifications models were developed from an extensive data set of 18,967 truck records distinguishing an unprecedented total of 23 single unit truck and 31 single and semi-trailer body configurations, each with over 80% correct classification rates (CCR). Remarkably, the body class model for five axle semi-tractor trailers - the most diverse truck category - achieved MCS CCRs above 85% for several industry specific classes including refrigerated and non-refrigerated intermodal containers, livestock, and logging trailers.

Publication Year  2016

Result 13.

Title  Using high-resolution event-based data for traffic modeling and control: An overview.

Source  Transportation Research Part C: Emerging Technologies. 2014/5. 42(0) pp 28-43 (Figs., Refs.)

URL  http://dx.doi.org//10.1016/j.trc.2014.02.001

Abstract  Research on using high-resolution event-based data for traffic modeling and control is still at early stage. In this paper, the authors provide a comprehensive overview on what has been achieved and also think ahead on what can be achieved in the future. It is their opinion that using high-resolution event data, instead of conventional aggregate data, could bring significant improvements to current research and practices in traffic engineering. Event data records the times when a vehicle arrives at and departs from a vehicle detector. From that, individual vehicle's on-detector-time and time gap between two consecutive vehicles can be derived. Such detailed information is of great importance for traffic modeling and control. As reviewed in this paper, current research has demonstrated that event data are extremely helpful in the fields of detector error diagnosis, vehicle classification, freeway travel time estimation, arterial performance measure, signal control optimization, traffic safety, traffic flow theory, and environmental studies. In addition, the cost of event data collection is low compared to other data collection techniques.
since event data can be directly collected from existing controller cabinet without any changes on the infrastructure, and can be continuously collected in 24/7 mode. This brings many research opportunities as suggested in the paper.

Publication  2014
Year