

**Transportation Northwest at the University of Washington
Research Project Descriptions
Year 20: July 1, 2007-June 30, 2008**

Contract Number	61-5921
Source Organization	Transportation Northwest (TransNow)
Sponsor Organization	University of Washington
Title	Simulation and Experimental Study of 802.11a/RA based Networking for Vehicular Management and Safety
Principle Investigator	Daniel J. Dailey
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External project contact, address, telephone number	Doug Brodin WSDOT 310 Maple Park Ave SE PO Box 47372 Olympia, WA 98504 360-709-7972
Subject Categories	Operations and traffic management, vehicles, safety and human factors
Project Objective	The goals for this project are to build a traffic simulator that can model an ad-hoc data network traffic between vehicles, build a traffic simulator that can model an ad-hoc data network traffic between vehicles and the roadside, calibrate the parameters in the model using measurements from real network equipment in real traffic, and simulate delivery of services ranging from safety services to convenience services.

Abstract:

This proposal focuses on the use of new wireless networking techniques for their potential impact in providing information for traffic management, control and public safety goals. The premise of this work is based on the reasonable expectation that vehicles in the near future will be equipped with integrated wireless communication and positioning capabilities, enabling vehicle-to-vehicle (v2v) and vehicle-to-roadside (v2r) communications based on the emerging IEEE 802.11a/RA standard.

TRB Keywords:

Wireless, DSRC, Safety, Traffic Management

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Contract Number	61-5914
Source Organization	Transportation Northwest
Sponsor Organization	University of Washington
Title	Green Roads - an Environmental Ratings System for Roadway Design and Construction
Principle Investigator	Stephen Muench
Institution	University of Washington
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PI's E-mail address	stmuench@u.washington.edu
External project contact, address, telephone number	Kim Willoughby WSDOT 310 Maple Park Ave SE PO Box 47372 Olympia, WA 98504 360-705-7978
Subject Categories	Design, construction, energy and environment
Project objective	The goal for this project is to refine, test and calibrate the Green Roads ratings standard for use in Washington State. This involves refining credit requirements to correspond to existing research and industry potential, determining the certification score of current WSDOT road projects, the potential of such projects to reach silver, gold or evergreen certification standards, and the potential inclusion of Green Roads scores as a standard rating category for WSDOT's entire 7,049 mile road network in WSPMS. The end result would be a logical rating system that has been tested and calibrated for Washington State with the capability to (1) allow decision makers to assess the sustainability and environmental impact of roadway projects, and (2) a means to measure and track sustainable and environmental aspects of WSDOT's route system over time.

Abstract:

In 2005, the U.S. put in place over \$93 billion of transportation-related construction. While the idea of sustainable infrastructure has caught on in the building world (US Green Building Council, LEED standards, Built Green, etc.) it remains in its infancy in the transportation infrastructure world. Recently, Martina Soderlund, a master's student at the University of Washington developed an environmental ratings system for roadway design and construction, tentatively called "Green Roads". Her work led to the discovery of gaps in information necessary for proper sustainability evaluation.

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This research will address several of those gaps: (1) the amount of energy consumed during transportation infrastructure construction, (2) a life-cycle analysis of warm mix asphalt, and (3) case studies to determine the appropriateness of Martina's proposed ratings system. Addressing these vital gaps builds the Green Roads concept into a more robust tool with better prospects for adoption. The ultimate goal is to fully develop the concept and have it adopted as the first environmental ratings system for roadway design and construction in the U.S.

TRB Keywords:

Sustainability, Environment, Construction, Roads, Pavement

**Transportation Northwest at the University of Washington
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Year 20: July 1, 2007-June 30, 2008**

Contract Number	61-6022
Source Organization	Transportation Northwest (TransNow)
Sponsor Organization	University of Washington
Title	Development of a Statewide Traffic Data System
Principle Investigator	Yinhai Wang
Institution	University of Washington
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External project contact, address, telephone number	Doug Brodin WSDOT 310 Maple Park Ave SE PO Box 47372 Olympia, WA 98504 360-705-7972
Subject Categories	Data and information technology, operations and traffic management
Project objective	This research targets improvements to traffic detector data, data collection, and data management that will make WSDOT traffic sensor data across the state better and more consistent. Specifically, the objectives of this study are: <ul style="list-style-type: none"> • To investigate the causes of detector errors; • To design an algorithm for identifying and correcting the loop sensitivity problems; • To develop a computer application that implements and automates the proposed algorithm; and • To establish an online database system for loop detector data management and statewide traffic data sharing.

Abstract:

This research targets improvements to data, data collection, and data management that will make WSDOT traffic data across the state better and more consistent. It involves a series of data analysis, data management, data query tasks, and data transmission tasks.

The basic problem being examined is how to obtain data from multiple data sources and databases currently supported by WSDOT, identify those data which are invalid, remove those data from further analysis, and provide a common interface that can be used by WSDOT staff to obtain roadway performance measures. None of these tasks is currently done in a standardized way right now within WSDOT. The successful research will need to develop and apply consistent data quality tests, develop meta-data standards for WSDOT, and develop (or recommend the purchase of) software tools that can function across unlike data structures.

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TRB Keywords:

Traffic detector, data management, inductance loop, data error, database

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Contract Number	430820
Source Organization	Transportation Northwest (TransNow)
Sponsor Organization	University of Washington
Title	Ultrasonic Detection of Cross-Section Loss in Tieback Rods Due to Corrosion
Principle Investigator	David Pollock
Institution	Washington State University
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PI's E-mail address	dpollock@wsu.edu
External project contact, address, telephone number	George Comstock WSDOT 310 Maple Park Ave SE PO Box 47372 Olympia, WA 98504 360-705-7181
Subject Categories	Design, maintenance, materials, structures
Project objective	The goal of this project is to determine optimum ultrasonic transducer parameters (frequency; diameter) for propagating bulk longitudinal waves in typical tieback rods, determine characteristics of reduced cross-section (length of rod affected; severity of corrosion) at typical corrosion locations in tieback rods, evaluate key ultrasonic signal characteristics (changed time interval between trailing echoes; changes in signal-to-noise ratio) associated with actual corrosion versus simulated loss of cross-section, develop ultrasonic inspection procedure for detecting corrosion in tieback rods, and to disseminate information regarding ultrasonic inspection procedure to the WSDOT Bridge Preservation Office, and to other interested parties.

Abstract:

Corrosion of tieback rods in sheet piling systems can compromise the reliability of associated transportation structures due to loss of cross-section and reduced strength of the tieback rods. Common inspection techniques currently involve excavating to the location of a few tieback rods for visual appraisal. This process is typically expensive and labor-intensive. Furthermore, the actual condition of the vast majority of tieback rods in a sheet piling system remains unknown, since only a few tieback rods are typically inspected.

Ultrasonic inspection of tieback rods will provide a more comprehensive technique for detecting loss of cross-section associated with corrosion. Ultrasonic inspection is already used to successfully detect fracture of anchor bolts in transportation

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sign structures by coupling ultrasonic transducers to one end of an anchor bolt and propagating a bulk wave along the bolt length. Cracks and fractures are detected by reflected signals that arrive prior to reflections from the back wall (far end) of the anchor bolt. The proposed research regarding tieback rods will involve similar propagation of bulk ultrasonic waves at the exposed end of a tieback rod. However, instead of looking for “early echoes” in the signal associated with cracks or fracture, the portion of the ultrasonic signal following the back wall echo will be investigated for evidence of loss of cross-section due to corrosion. In particular, signal characteristics such as change in spacing between trailing echoes and signal-to-noise ratio are expected to provide indicators of loss of cross-section. These signal indicators will be correlated to actual variations in cross-section dimensions, in order to estimate the residual capacity of corroded tieback rods.

The development of an effective ultrasonic technique for inspecting tieback rods in sheet piling systems has the potential to save money by avoiding the costs of periodic excavation. Furthermore, an efficient ultrasonic inspection technique will improve safety and structural reliability by facilitating condition assessment of every tieback rod in a sheet piling system.

TRB Keywords:

Tieback rods, corrosion, ultrasonic, nondestructive, sheet piling

**Transportation Northwest at the University of Washington
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Contract Number	61-5915
Source Organization	Transportation Northwest (TransNow)
Sponsor Organization	University of Washington
Title	Rapid Construction of Earthquake-resistant Bridges
Principle Investigator	John Stanton
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External project contact, address, telephone number	Jugesh Kapur WSDOT 310 Maple Park Ave SE Po Box 47372 Olympia, WA 98504 360-705-7207
Subject Categories	Construction, safety and human factors, intermodal, materials
Project objective	The objectives of the work are to develop details for the connection region of the Hybrid bridge column system that will allow the columns to rock without local crushing or sliding failure. This is the local behavior that must be achieved if the system is to display the intended global behavior.

Abstract:

Earthquakes cause damage to bridges. In many cases that damage is repairable, but the bridge is permanently deformed and may be unusable while it is brought back into plumb and the repairs are made. For example, the Alaskan Way Viaduct in Seattle had to be closed after the 2001 Nisqually earthquake because of a large offset at the joint between two parts of the structure at Bent 97.

This proposal addresses the adaptation to bridges of a technology that would ensure minimal residual seismic deformations of the bridge, thereby permitting its use in the critical hours after the earthquake strikes. The technology also leads to seismic damage levels that are much lower than those that typically occur in conventional construction. When used in combination with precasting techniques, it also allows a significant reduction in on-site construction time. This feature provides benefits to DOTs by minimizing both traffic congestion and exposure of workers to hazardous conditions. The system thus provides three benefits at once (rapid construction, immediate post-earthquake use and low earthquake damage and repair costs).

The concept was first developed (at UW) in the 1990s for beams in building frames. It uses conventional materials, combined in an innovative way, to give the structure “self-righting” or “self-healing” properties. Many buildings, including the tallest concrete

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building in San Francisco, have now been constructed using it. Building codes are now being changed to allow its use without special proof-testing and permitting. We propose here to adapt it for use in bridge columns.

The technique depends on using a combination of unbonded post-tensioned tendons and bonded mild steel reinforcement ('rebar') to provide the structure's resistance to seismic loads. UC Berkeley has conducted some work towards adapting it for bridges, but has found difficulty in developing satisfactory connections between the members. We propose to use the experience gained with frame buildings to solve the connection problems in bridge columns, and to do so in a way that is consistent with the demands of rapid construction. The work will consist of physical testing and structural analysis. The research will support a parallel Rapid Construction study for the WSDOT that is being conducted on bridge columns systems that do not have the self-righting feature described here.

TRB Keywords:

Bridge, rapid construction, precast concrete, prestressed, seismic

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Contract Number	61-5913
Source Organization	Transportation Northwest (TransNow)
Sponsor Organization	University of Washington
Title	Washington State Freight System Resiliency Study
Principal Investigator	Anne Goodchild and Eric Jessup
Institution	University of Washington
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External project contact, address, telephone number	Barbara Ivanov WSDOT 310 Maple Park Ave SE PO Box 47372 Olympia, WA 98504 360-705-7931
Subject Categories	Freight, finance and economics, marine
Project objective	The goal of this research is to develop an empirical approach and methodology that can be used to estimate the vulnerability of different industry sectors within the Washington State economy to disruptions in the transportation system. This freight transportation system includes infrastructure outside of the control of WSDOT for example the state's marine ports and rail lines. We will consider freight flows of three major types; "Global Gateways," "Made in Washington," and "Delivering Goods to You," as defined by the WSDOT Office of Freight Strategy and Policy. We will also consider the prominent industries within these categories such as the state's fuel delivery system, pulp and paper and agricultural products. By conducting this research we will develop: 1) an empirical approach and methodology that can be used to estimate the vulnerability of different economic industry sectors to disruptions in the transportation system, and 2) results from applications of this methodology to three to five examples in Washington State. The emphasis of the research will not be on providing results to develop prevention strategies, but to response strategies given disruptions occur.

Abstract:

The economic viability and well-being of Washington State is significantly influenced by the freight transportation system serving the region. An increased understanding of the

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vulnerability of this freight system to natural disasters, weather, terrorist acts, work stoppages and other potential freight transportation disruptions will provide the State with the information necessary to assess the resiliency of the transportation system, and provide policy makers with the information required to improve it. This research project will:

- a) Identify a set of threats or categories of threats to be analyzed.
- b) Assess the likelihood of each event occurring within certain time horizons.
- c) With the threats and their probabilities, analyze the resiliency of the Washington transportation system. This will include 1) identifying the most valuable and least valuable components, both infrastructure and operational characteristics, of the transportation system with respect to moving freight, 2) identify the most likely events and the impact of those events, and 3) develop strategies for making WSDOT investments that would support improvements in the resiliency of the transportation system.

Deliverables may include the following:

- v. Identification of the most likely events and failures
- ii. Identification of the weak points in the transportation system
- iii. Identification of improvements that will have the largest benefits in terms of the state's ability to move freight when faced with a transportation system failure
- iv. Identification of the most important elements of the transportation system in terms of the state's ability to move goods
- v. Provide suggestions as to how WSDOT investments can best improve the resiliency of the transportation system.

The outcome of this research effort will help shape and guide transportation policy and infrastructure investment decisions in the future.

TRB Keywords:

Freight transportation, resilience, disruption, transportation, planning, economic analysis

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Contract Number	61-6021
Source Organization	Transportation Northwest (TransNow)
Sponsor Organization	University of Washington
Title	A Self-Adaptive Toll Rate Algorithm for High Occupancy Toll (HOT) Lane Operations
Principle Investigator	Yinhai Wang
Institution	University of Washington
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PI's E-mail address	Yinhai@u.washington.edu
External project contact, address, telephone number	Shuming Yan WSDOT 401 2 nd Ave S, Suite 300 Seattle, WA 98104
Subject Categories	Highways, operations and traffic management, vehicles
Project objective	The objectives of this study are: <ul style="list-style-type: none"> ▪ To explore the feasibility of applying control theories for optimal HOT operations; ▪ To develop a self-adaptive toll rate algorithm, SATRA, based on the feedback control theory for real-time toll rate calculations using real-time traffic measurements, such as lane occupancy, speed, and flow rate; and ▪ To implement SATRA in a VISSIM simulation model and compare simulation results with those from other algorithms, such as the transplanted ALINEA algorithm, for performance evaluation.

Abstract

There are about 1285.3 miles of High Occupancy Vehicle (HOV) lanes in the US. Research on the usage of HOV lanes indicates that HOV facilities are frequently underutilized even when General Purpose (GP) lanes of the same section are congested. HOV lanes have the room to play a bigger role in addressing urban traffic congestion.

Over the past decade, a new concept called High Occupancy Toll (HOT) lane has been developed for better utilizing these HOV facilities. A HOT lane allows Single Occupancy Vehicles (SOVs) to use it, but on basis of a toll. Through adjusting the toll rate, demand on a HOT lane can be effectively controlled and congestion can be avoided. Converting HOV lanes to HOT lanes is widely accepted as a fast and cost-effective solution to traffic congestion issues in urban areas.

Setting the toll rate properly is crucial for HOT lane operations. On the one hand, if the toll rate is set too high, the HOT lane capacity may not be fully utilized. On the other hand, if it is too low, the HOT lane may break down and reduce the total throughput of

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the road. Therefore, the strategy for setting up the toll rate should be carefully determined. Unfortunately, very few studies can be found on toll strategies for HOT lane operations. Existing studies typically borrow concepts from ramp metering control or simply use inductance loop inputs for toll determination. These approaches are empirical and lack of theoretical basis.

In this study, the PI is motivated to develop a new toll rate determination algorithm using the state-space-based optimization theory. Direct traffic measurements from on-road sensors, such as speed, volume, and occupancy, and variables calculated from them, such as travel time and vehicle delay, are used to establish a discrete control state space. Based on the principal associations among these variables and the system identification theory, the difference equation group comprising the observation equation and control equation can be set up in the state space. Objectives of this control system are to maximize traffic throughput and minimize system delay. The optimization theory can be utilized to achieve the best control performance. This toll rate algorithm is expected to generate system-optimal toll rate dynamically based on real-time traffic detector measurements and predicated traffic information.

TRB Keywords

Toll, freeway operations, hot lane, feedback control, traffic assignment

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Contract Number	61-5916
Source Organization	Transportation Northwest (TransNow)
Sponsor Organization	University of Washington
Title	De-Bonding Cracking in Hot Mix Asphalt Pavement
Principle Investigator	Stephen Muench
Institution	University of Washington
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PI's E-mail address	stmuench@u.washington.edu
External project contact, address, telephone number	Joe Mahoney UW Box 352700 Seattle, WA 98195 206-685-1760
Subject Categories	Maintenance, pavements
Project objective	This project will work with the Washington State Department of Transportation (WSDOT) and the Hawaii Department of Transportation (HDOT) to identify and perform forensic analyses on pavement sections specifically chosen because they are thought to suffer from de-bonding cracks. This effort will establish the relative significance and prevalence of de-bonding cracking and form the basis for future, in-depth research.

Abstract

Recent evidence in Washington State, Hawai'i, the National Center for Asphalt Technology and elsewhere indicates that a significant portion of cracking in thick hot mix asphalt (HMA) pavements is due to a previously uninvestigated phenomenon: bottom-up cracking of a de-bonded HMA surface layer. This cracking results when a surface HMA layer is not adequately bonded to underlying HMA layers (often through the inadequate or inappropriate use of tack coat) and behaves as an independent and extremely thin HMA layer. This de-bonding can shorten pavement life and cost agencies and taxpayers substantial money. Evidence from other pavement studies suggest de-bonding is much more prevalent and influential than previously thought. Potential benefits include: an understanding of this failure phenomenon, better specifications and practice for tack coat application to combat this failure, and ultimately better pavements with lower life-cycle costs.

This study is the first known investigation into the significance, prevalence and performance impact of what we are calling "de-bonding cracks". We are working with the Washington State Department of Transportation (WSDOT) to identify and perform statistical and forensic analyses on pavements thought to suffer from de-bonding cracks. This effort will establish the relative significance and prevalence of de-bonding cracking and form the basis for future, in-depth research.

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TRB Keywords

De-Bonding, asphalt

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Contract Number	430846
Source Organization	Transportation Northwest (TransNow)
Sponsor Organization	University of Washington
Title	Incorporation of Forward-Directivity into Seismic Hazard Analysis
Principle Investigator	Adrian Rodriguez-Marek
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External project contact, address, telephone number	Kim Willoughby WSDOT 310 Maple Park Ave SE PO Box 47372 Olympia, WA 98504 360 705 7978
Subject Categories	Structures, societal, intermodal
Project objective	The project is divided in two parts, the first of which will be performed during the first year of the project, and the second which will be proposed for a second year of funding pending the appropriate re-authorization. Tasks for both years are included in this proposal, although further discussion of the tasks for the second year is left for a follow-up proposal to be submitted next year. Research in year one is restricted to study the effect of FDGMs to simple structural and geotechnical systems (e.g. nonlinear SDOF systems and MDOF systems, and similarly simplified geotechnical structures). Research in the second year will be targeted to more specific structural or geotechnical systems (e.g., a problem of immediate relevance to the WSDOT).

Abstract

Recent earthquakes have shown that pulse-type earthquake ground motions that result from forward-directivity effects can result in significant damage to structures. These observations have recently been corroborated by experimental evidence and analytical research. Forward-directivity (FD) effects at a site occur when fault rupture propagates towards a given site and the directions of rupture and slip coincide. While FD effects are confined to within 20 miles of a fault, many urban centers in the U.S. are built on top of faults; hence FD can have significant impact on the vulnerability of transportation infrastructure. Various bridges in the cities of Seattle and Tacoma, as well as other sites in Washington State, are vulnerable to damage due to FD effects. Current research at WSU has identified some of these bridges and preliminary results have shown that FD

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motions can control design loads in these bridges.

In a typical design project, seismic demand is characterized by the Equal Hazard Spectrum (EHS) and is determined using Probabilistic Seismic Hazard Assessment (PSHA). Due to the inherent complexity of PSHA, the interactive web features made available by the USGS are often used to determine the EHS. However, FD effects are not necessarily accounted for in the USGS analysis and this becomes a problem when a fault that potentially can generate FD ground motions controls a significant portion of the hazard at a site. Moreover, it is often necessary to obtain full time histories for design or for analysis of geotechnical problems. When the potential for FD exists, there are no guidelines as to how these ground motions should be selected.

The approach taken by designers is to obtain a design spectrum using probabilistic analyses and then modify this spectrum to account for FD using coefficients obtained from deterministic analyses. The problem with this methodology is that there are no guidelines as to how to couple deterministic and probabilistic analyses and to determine design time-histories. The goal of the proposed research is to provide a methodology for incorporating FD effects into PSHA and provide guidelines for the selection of FD time histories for design. The proposed methodology will lead to a more rigorous treatment of FD motions in PSHA, and thus to a better evaluation of seismic hazard for sites affected by FD.

TRB Keywords

Seismic Hazard, seismic design, ground motions, near-fault, forward-directivity

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Contract Number	61-6020
Source Organization	Transportation Northwest (TransNow)
Sponsor Organization	University of Washington
Title	Occlusion Robust Vehicle Tracking Using Motion-based Features
Principle Investigator	Yinhai Wang
Institution	University of Washington
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Subject Categories	Operations and traffic management, vehicles
Project objective	The objectives of this study are: (1) To explore the feasibility of collecting traffic data through vehicle tracking using surveillance video camera images; (2) To develop an effective approach for vehicle tracking under conditions with severe traffic occlusion problems; and (3) To build up a computer system that implements the proposed tracking algorithm and automates the vehicle tracking process.

Abstract

It is of fundamental importance to track vehicles for traffic data collection and operations. For example, if a vehicle can be tracked at intersections, its control delay can be accurately measured. However, most traffic detectors are point sensors and do not have the tracking capability. GPS-equipped vehicles can be tracked, but there are only very few of such vehicles on roadways. The widely deployed surveillance video cameras enable a means to track vehicles on major arterials. Most video-based vehicle tracking algorithms, however, are based static features extracted from edge detection and background subtraction. These algorithms do not perform well when vehicles are occluded or when camera vibrates. Considering that both vehicle occlusion and camera shaking are common phenomenon on current roadways, a more robust video image processing algorithm for vehicle tracking is desired.

In this study, an occlusion robust vehicle tracking algorithm using motion-based features are proposed. In the proposed algorithm, the Kanade-Lucas-Tomasi (KLT) feature tracking algorithm is employed for motion feature extraction. An improved K-means

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algorithm is applied to classify feature points into groups. Each feature group corresponds to one vehicle. Bayesian Information Criterion (BIC) is used as the selection criteria for choosing the optimal number of clusters.

The proposed algorithm is functional on highways under even light changing conditions because most feature points tracked will not be affected by luminance change. It is also robust to camera vibrations due to relaxed requirements of the stable background.

TRB Keywords

Vehicle tracking, video image processing, vehicle occlusion, camera vibration, feature tracking

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Contract Number	61-6023
Source Organization	Transportation Northwest (TransNow)
Sponsor Organization	University of Washington
Title	Developing an Area-Wide System for Coordinated Ramp Meter Control
Principle Investigator	Yinhai Wang
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Subject Categories	Data and information technology, traffic management, highways
Project objective	The objective of this study is to develop an area-wide system for coordinated ramp-meter control using the AIMD mechanism. The VISSIM simulation tool will be used to evaluate the effectiveness of the proposed strategy. This AIMD-based strategy will be compared with the fuzzy logic and ALINEA algorithms.

Abstract

From 1980 to 2003, yearly vehicle miles traveled increased by 89% from 1,527,295 million to 2,890,450 million, while road mileage increased only about 3% from 3,859,837 miles to 3,974,107 miles. The enlarging gap between travel demand and infrastructure supply has increased the level of congestion nationwide. Ramp metering has been broadly accepted and deployed as an effective countermeasure against both recurrent and non-recurrent congestions on freeways. However, current ramp metering algorithms tend to optimize only freeway travels using local detectors' inputs and overlook the negative impacts on local streets. This may generate two problems: 1) the optimal local settings may not result in a system-wide optimum in terms of traffic operations; and 2) the increased congestion on local streets due to ramp metering may counteract the gains in freeway operations. To solve these problems, we propose an area-wide ramp metering system to coordinate the previously isolated ramp meters for system-wide optimization. The Additive Increase and Multiplicative Decrease (AIMD) mechanism used for computer network congestion control is applied to calculate ramp metering rate. The effectiveness of this new ramp metering strategy will be evaluated using the VISSIM simulation tool.

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TRB Keywords

Ramp meter, traffic control

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Contract Number	61-5907
Source Organization	Transportation Northwest (TransNow)
Sponsor Organization	University of Washington
Title	Improved Freight Modeling of Containerized Cargo Shipments between Ocean Port, Handling Facility, and Final Market for Regional Policy and Planning
Principle Investigator	Anne Goodchild
Institution	University of Washington
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External project contact, address, telephone number	Barbara Ivanov WSDOT Office of Freight Strategy and Policy PO Box 47322 Olympia, WA 98504 360-705-7931
Subject Categories	Freight, planning, marine
Project objective	The objective of this project is to develop an understanding of freight flows and how they will develop over time, and contribute to the efficacy of local transportation planning.

Abstract

The proposed research will address an emerging need by local, state and regional transportation planners and policymakers to better understand the transportation characteristics, functions and dynamics of ocean port-to-handling facility and handling facility-to-final market freight movements. The research will also address a gap in the academic literature for freight transportation models that capture underlying economic forces. This research effort will focus on the development and refinement of a regional freight model of urban container movements from the port to a handling facility and beyond. Existing regional transportation planning models and analytical tools have evolved from passenger travel demand models that are ill-suited to fully capture the business decisions and economic influences driving urban freight flows and have been further constrained by access to appropriate freight data. This research activity proposes a modeling approach which will capture the fundamental economic choices individual shippers consider when trading-off the marginal benefits/costs associated with warehouse inventory management/control relative to transportation access and flow while incorporating the primary freight generation activity centers (warehouse/distribution centers) in the Puget Sound region. This work will identify, evaluate and incorporate data for the Puget Sound region recently available from a variety of existing sources. Some data collection may also be necessary.

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The final product of this research study will be an improved tool to understand current and future freight movements through the Puget Sound region, and a methodology which will expand the current state of knowledge, and may be applied in other regions, both domestic and international. It will allow more in-depth and timely evaluation and analysis of different local/regional transportation policy initiatives such as the impact of migration of the main warehousing region, and development of inland inter-modal port facilities.

TRB Keywords

Containerized cargo, goods movement, freight modeling, freight planning, freight flow

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Contract Number	463258
Source Organization	Transportation Northwest (TransNow)
Sponsor Organization	University of Washington
Title	Structural Health Monitoring of Reinforced Concrete Columns Confined with FRP
Principle Investigator	Mohamed ElGawady
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PI's E-mail address	melgawady@wsu.edu
External project contact, address, telephone number	Kim Willoughby WSDOT 310 Maple Park Ave SE PO Box 47372 Olympia, WA 98504 360-705-7978
Subject Categories	Structures, Construction
Project Objective	The main objective of the proposed research is to confirm the capability of using Lamb waves to detect delamination of FRP from RC. The specific objectives are as follows: (1) Determine the effective way for generating Lamb waves to detect failure of RC members that failed due to FRP delamination; (2) Experimentally measure the waveform characteristics corresponding to different delamination sizes and position; (3) To develop preliminary conclusions and best-practice for FRP delamination detection. The three categories that potentially influence the Lamb waves are the actuator and sensor geometry, actuation pulse, and specimen properties. The scope of the proposed research will be to study the effects of these three categories with emphasis on the second category; and (4) Gain the required experience to use Lamb waves and planning for more significant funding for using Lamb waves for SHM during cyclic testing of RC columns confined using FRP.

Abstract

In the last few decades, an extensive research has been carried out to develop strengthening techniques for reinforced concrete (RC) infrastructures using fiber reinforced polymer (FRP). When a RC structure is strengthened with externally bonded FRP, the bond between FRP and concrete plays a crucial role in the performance of the strengthened structure. Debond of FRP reduces the strength and stiffness of the strengthened member and leads to a brittle failure. Early detection of debond using

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structural health monitoring (SHM) of the strengthened member is the key to avoid such brittle failure. SHM will provide information concerning the development of debond, which can be used to implement timely action for maintenance/repair to ensure the safety of structures. The research proposed here aims to perform SHM of RC structures strengthened with FRP using Lamb wave. Piezoelectric wafers active sensors (PWAS) will be used for both wave transmitters and receivers. A series of damage configurations including different lengths of debond, different types of defects ,i.e., debond of FRP and delamination of concrete substrata, the distance between the PWAS and the debonded section, and the thickness of FRP layer will be investigated through an experimental work on small-scale specimens, which represent RC columns strengthened using FRP overlay on its surface. The expected outcome is the ability to identify the changes in the wave forms and interpret them in relation with the changes of physical properties of the strengthened structure including the ability to distinguish different delamination types and sizes.

TRB Keywords

Structures, Construction

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Contract Number	61-6327
Source Organization	Transportation Northwest (TransNow)
Sponsor Organization	University of Washington
Title	Truck Performance Measures
Principle Investigator	Ed McCormack
Institution	University of Washington
PI's telephone number	206-543-3348
PI's E-mail address	edm@u.washington.edu
External project contact, address, telephone number	
Subject Categories	
Project Objective	The Truck Performance Measure Research project will pilot development of freight performance measures that matter to customers: freight shippers and truck carriers. It will evaluate the capabilities of existing technologies to track freight system performance against customers' goals. If successful, the research will give the state legislature better information to make informed decisions about the state's freight investments and to track the effectiveness of those investments.

Abstract

The State of Washington began to test truck performance measures in 2004, and this project will build upon lessons learned from that effort. The Washington State Department of Transportation (WSDOT) and the Freight Mobility Strategic Investment Board funded the earlier study at the University of Washington to develop a data collection system to cost effectively measure truck movements along specific roadway corridors against preset benchmarks. The study assumed that the proposed benchmarks could be used both as part of the project selection process and to report on speed and volume improvements resulting from completed infrastructure investments. The findings from that report recommended that with a much higher density of data points and clear goals set by freight customers, on-board GPS devices may allow the public sector to track performance against goal(s), and the use of these devices will form the foundation for this project.

With the growth in transponder, satellite, and cellular phone technology since 2004, it may now be feasible to track trucks at a lower cost. Tracking truck trips from origin –to destination will help locate, measure, and analyze causes of delay and other performance attributes to determine where problems exist and whether highway improvements are closing performance gaps for freight customers. Combining data from these new

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technologies with more traditional sources of truck data, such as roadside counters and surveys, may increase the feasibility of developing useful performance measures.

This new TransNow and WSDOT research project will organize existing trucking and freight data, and work with freight shippers and the trucking industry to collect new freight data to track performance measures that have value to them. After suitable performance measures have been developed, this effort will use truck data gathered by new technology devices to demonstrate the feasibility of a truck-based freight performance monitoring system. This pilot will test GPS tracking system(s) in Central Puget Sound rather than in a smaller city, as the research project's success will be more likely if researchers have access to a large sample size on the identified bottleneck, both before and after improvements.

TRB Keywords

Freight