OHIO TRANSPORTATION CONSORTIUM

NEWS

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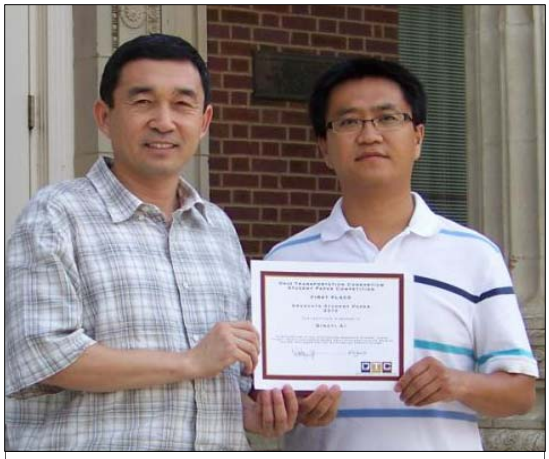
2010 Student Paper Contest Winners

Andre' Morton with advisor Dr. Ramani Kandiah



Qingyi Ai (right) with advisor Dr. Heng Wei

The OTC held its second annual Student Paper Competition this past spring with an impressive array of research papers submitted. The research topics spanned a variety of transportation related specialties. After careful review, two contest winners were chosen: Andre' Morton (undergraduate paper) and Qingyi Ai (graduate paper).

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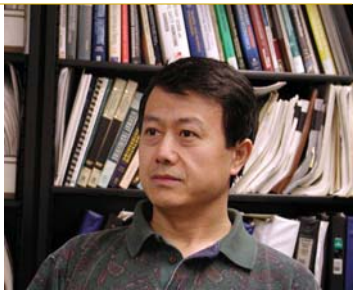
A Message from the Director



Welcome to the fall edition of the OTC newsletter. As part of our continuing education and outreaching effort, OTC conducted earlier this year a student paper contest at both graduate and undergraduate levels and awarded outstanding papers. In November, OTC also coordinated and hosted the 1st Student Research Conference sponsored by the four tier II UTCs in Ohio, which was very well attended and featured student presentations on various topics from nine universities in the state.

We remain deeply committed to making sure OTC funded research projects are addressing our focus areas. In the recent round of research selection, OTC awarded five research initiatives from the participating members towards enhancing traffic mobility and safety, and preserving the environment. I hope you will find the contents informative and I wish you all a happy holiday season and a prosperous New Year!

Ping Yi

CONTACT:
Ohio Transportation Consortium
Akron, OH 44325-6106
Tel: (330) 972-6543
Fax: (330) 972-5449

Email:
OTC@uakron.edu
Online:
www.otc.uakron.edu

Incorporating Traffic Factors into Dual-Loop-Based Vehicle Classification Models

By: Dr. Heng Wei, University of Cincinnati

In the OTC-funded project "Optimal Loop Placement and Models for Length-based Vehicle Classification and Stop-and-Go Traffic," traffic factors influencing the accuracy of vehicle classification by dual loop data are explored. The existing models are pretty fitting the condition if the times detected by two loops of a dual-loop station are close. This is usually the case of free traffic flow condition. However, such an "assumption" does not fit non-free traffic conditions, which is generally categorized into the states of synchronized and stop-and-go congestions. Contributing factors pertinent to the loop system such as sensitivity and other external factors have been identified in previous studies. However, it remains uncertainty how the variation of vehicle movement over the loops impacts the modeling accuracy. Accordingly, a research question is hence raised here, "what potential could be in increasing accuracy of vehicle classification with dual-loop data against congestion?" The video-capture-based approach, along with the software VEVID developed by Dr. Heng Wei and his PhD student, enables the in-depth investigation of this question. The most advantage of the VEVID lies in its capability of providing video-based vehicle event trajectory data. With such video-based data, it becomes possible to have ground truth data to find out traffic reasons of causing the dual-loop errors as comparing with the vehicle lengths resulted from the dual-loop data.

The synchronized flow is viewed as a kind of congested traffic, which has relative low speed and high volume and density. The speed of the synchronized traffic stream fluctuates frequently but its average speed remains a relatively stable trend. The stop-and-go traffic flow is the very congested traffic condition, which has very low speed, low volume and high density. The vehicle speed not only fluctuates frequently, but also stops from time to time. Thus, within the synchronized and stop-and-go traffic flows there is a high probability that vehicles run over the upstream and downstream loops at different speeds. In other words, acceleration or deceleration may exist as the vehicle is running over the dual-loop station. Within the stop-and-go traffic flow some vehicles may also experience multiple stops within the detection area.

Acceleration or deceleration is identified a factor playing an influential role in measuring the vehicle length, and it is therefore incorporated as one of contributing factors in the proposed vehicle classification model for synchronized traffic. This model is termed as **V**ehicle **C**lassification Model under **S**ynchronized Traffic (VC-Sync model). Under the stop-and-go traffic state, vehicles will

stop within the detection area one or more times. The **V**ehicle **C**lassification under **S**top-and-**G**o (VC-Stog) model is developed to estimate vehicle length under the stop-and-go traffic condition. To facilitate the modeling, eight scenarios (Figure 1) are developed depending on the stopping locations of the detected vehicles within the detection area, and then different sub-models are developed compatible with those scenarios as detailed as follows:

Scenario 1: the vehicle runs across the loops without stop;

Scenario 2: the vehicle stops only on the M loop;

Scenario 3: the vehicle stops only on the S loop;

Scenario 4: the vehicle stops only on both the M and S loops;

Scenario 5: the vehicle stops on M loop and then move on, then stop on S loop;

Scenario 6: the vehicle stops only on the M loop, and then stops on both the M and S loops;

Scenario 7: the vehicle stops on both of the M and S loops, and then stops only on S loop; and

Scenario 8: the vehicle stops only on the M loop and then stops on both of the M and S loop, and finally stops only on the S loop.

Scenarios 1 through 4 have been analyzed through the evaluation of the ground truth data and simultaneous dual-loop data. Then, their relevant vehicle classification models have been developed and validated. The other scenarios will be done as sufficient samples are obtained. VC-Sync model could be applied to scenarios 1 through 3 while a Stop-on-Both-Loops-only (SBL) model is developed for Scenario 4. For Scenario 4

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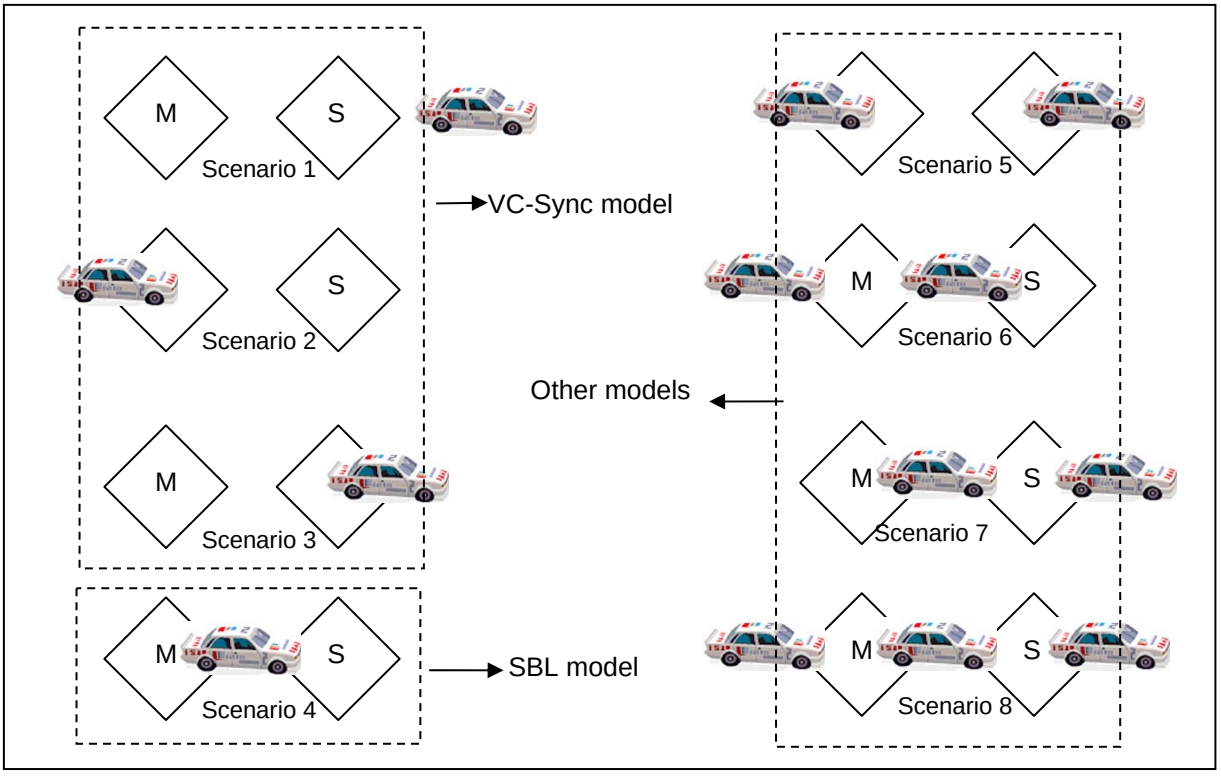

Figure 1. Eight Scenarios of Vehicle Stopping on Loops under Stop-and-go Flow

5 New Research Projects Funded

Evaluation of Dynamic Speed Signs, Dr. Deborah S. McAvoy, Ohio University

Speeding is a major increasing contributing factor in all traffic crashes including local and collector highways. This factor, in addition to restrictive law enforcement agencies' budgets and staff, poses an ever present need for effective, low-cost, speed mitigation measures. Studies have determined that Dynamic Speed Signs (DSS), when used in relation to roadway work zones, can reduce the traveled speed of vehicles. DSS display the approaching vehicle's speed to the driver in addition to the posted speed limit. This study will evaluate the effectiveness, both short-term and long-term, of DSS as a speed reduction measure for local and collector roadways. Different configurations and messages will be examined to determine the most effective DSS. The study will be conducted through the use of a driving simulator obtained through a National Science Foundation grant by the Principal Investigator. The results of this study will provide concepts that can be utilized in the development of Variable Speed Signs for interstates and highways during recurring or nonrecurring congestion in order to limit queuing and poor levels of service.

Developing a Bike-Sharing Program at Kent State University and Kent, Ohio, Dr. David H. Kaplan, Kent State University

Bicycling can provide tremendous mobility while also being environmentally friendly, less costly in terms of parking and roadway infrastructure, and an ideal way of introducing exercise into people's daily lives. However, bicycling for commuting purposes is used by relatively few individuals in American society. Since many people do not have access to working bikes, one of the most effective policies would provide increased access. Programs that put more bicycles on the streets would also work to increase awareness and make bicycling safer for all. Among the most useful interventions is a program that provides operating bicycles for short term usage meant solely for the purpose of getting from one place to another. This proposal looks at the feasibility of initiating a bike-sharing program at Kent State University, in coordination with the city of Kent, Ohio. Results from this study could be used by other universities interested in incorporating similar programs on their own campuses.

An Innovative Non-contact Sensing Platform to Prevent Traffic Accident due to Driver Drowsiness, Dr. Bill Yu, Case Western Reserve University

This research will use an interdisciplinary approach interfacing engineering and psychology to address the transportation safety factor of driver drowsiness. A sensing platform to non-contact monitor the physiological signals of drivers such as the electrocardiography (EKG) and Electroencephalography (EEG) will be developed to study the influence of human factors on transportation under natural driving conditions. The sensing will be based on capacitive coupling of the neural electricity under the human skin. A high sensitivity sensor and electronics will be designed to detect such bioelectricity. A newly acquired high fidelity driving simulator will be used for sensor performance validation. The performance will be evaluated by installation of the sensing device behind the driver seat and on the ceiling. The final product of this project will be an accurate sensing platform to noncontact monitor the EKG and EEG signals of the driver. This signal can then be fused with performance signals from which efficient drowsiness detection and countermeasures will be implemented. With the integration of proper data

fusion algorithm, effective countermeasures can be delivered to the driver for accident prevention.

Integrating Traffic Operation with Emission Impact using Dual-loop Data, Dr. Heng Wei, University of Cincinnati and Dr. Mingming Lu, University of Cincinnati,

Transportation has proven one of the most stubborn challenges in reducing carbon emissions. Vehicle Specific Power (VSP) is the most advanced concept to reflect a vehicle operation impact on emission; however, data for calculating VSP is currently dependent upon the limited samples of testing vehicles equipped with on-board or portable emission measurement system. Dual loops (in-pavement sensors) are widely utilized in collecting continuous traffic data and their outputs could be utilized as a rich data source for calculating VSP. Most existing loop models for measuring speeds and vehicle classifications have been proved accurate against light traffic, but they are not reliable under other traffic conditions like synchronized or stop-and-go congestion. Fortunately, recent studies ("OTC vehicle classification" project) have resulted in positive solutions to ensure the accuracy of loop models leading to the technical promise for developing VSP-based models of estimating micro-level emissions under various traffic operations by using dual-loop data. This project will develop a framework to integrate the improved dual-loop models with VSP-based models into a procedure for estimating emission impact of traffic flow operation over dual-loop monitoring stations in highways. Remote sensing method will be used to monitor CO and CO2 at the "OTC vehicle classification" project site. Meanwhile, VEVID-based approach will be applied to calibrate dual-loop models for generating accurate fleet distributions. Global Positioning System (GPS) Travel Loggers will be employed to check the traffic patterns and relevant VSP profile along the selected section of the highway. The results will be adapted for use in the classroom.

LIDAR Based Vehicle Classification, Dr. Benjamin Coifman, The Ohio State University

The proposed research will continue investigation into the use of LIDAR (Light Detection And Ranging) sensors to scan vehicles passing at speed and develop the necessary algorithms to classify the vehicles accurately. Both probe vehicle mounted LIDAR and wayside mounted LIDAR deployments will be considered. A van instrumented with a pair of LIDAR sensors that sweep vertically across the road in a "speed-trap" configuration will be employed. The probe vehicle based classification data will be collected while the van is driving on pre-defined tours while the wayside mounted classification data will be collected while the van is parked at the study location to collect data over several hours. This proposal picks up where the earlier studies leave off advancing the work on the following fronts: shape based classification, developing the LIDAR classification over a wider range of FHWA axle classes, improving occlusion reasoning, and axle detection and inference.

LIDAR based classification is a promising alternative to supplement existing classification stations. Such an installation could be permanent or temporary, would cost significantly less than a comparable in-pavement system, and will require significantly less setup in the field. Compared to conventional sensors, the LIDAR collect much more information about the passing vehicles. The mobile, probe vehicle mounted LIDAR promises to provide lower resolution information on many more links than are currently available from the fixed classification stations. Such information will help detect problem spots earlier and validate assumptions of transferability of measurements from the fixed locations to other parts of the network.

Student Research Conference is a Success

Over forty individuals from Ohio universities and local companies participated in the first joint effort Ohio UTC Student Research Conference held on The University of Akron campus Friday, November 12th. The conference, sponsored by the OTC, Youngstown State University's Center for Transportation and Materials Engineering, University of Toledo's Intermodal Transportation Institute & University Transportation Center and Cleveland State University's University Transportation Center, highlighted student research in UTC-funded projects. A total of nine universities including three Ohio UTCs were represented at the conference. Seven of the eight OTC participating universities had students present at the conference. Additionally, there were several poster presentations by students representing three Ohio UTCs. Conference and poster topics ranged from environmentally friendly topics such as a campus-wide bicycle sharing program and a Solar Car Project Team to safety issues involving dynamic dilemma zones and work zone drums to datamining and traffic data collection utilizing advanced mobile technology.

The conference provided an invaluable opportunity for students to share their research with one another while gaining experience presenting in a conference setting. Throughout the day, student presenters and attendees spent their time networking with professors and fellow students while gaining insight into different aspects of transportation engineering.

The conference was well received by all in attendance and plans for another student conference next year have already been discussed. The OTC will publish a summary of abstracts for the conference and poster session which will be available on the OTC website under publications. Be sure to look for it at http://www.otc.uakron.edu/publications.php

Classification of Urban Districts based on Mobile Carbon Monoxide Exposure Using Self Organizing Maps

By: Andrè Morton

The paper elaborates the concepts of exploring Self Organizing Maps (SOM) as a tool for studying a few urban 'air districts' in USA with respect to the demography using a single mobile source air pollutant. The methodology is as follows: SOM is employed to cluster the model, *Hazardous Air Pollutant Exposure Model for Mobile Sources, Version 3* (HAPEM-MS3) constructed CO emission data. Annual average CO emission computed using HAPEM-MS3 for each selected demographic group for each county (or air district) was tabulated. A MATLAB based code was written using SOM functions for classification. In the future, for each demographic variable, these counties (or air districts) will be clustered into CO emission level groups using SOM based on the demographic groups of the demographic variable. Within each CO emission level group, each of the demographic group comprising the particular demographic variable can be compared to see the degree of exposure to each demographic group. Using ArcGIS, counties will be geographically mapped, and their proximities to the highways will be looked into within each CO emission level group for similarities. Since this study is in progress, only the SOM theory, description of case study data, methodology and short discussion are provided in this paper.

Dual-Loop Length-Based Vehicle Classification Models against Synchronized and Stop-and-Go Traffic Flows

By: Qingyi Ai

The accurate measurement of vehicle speed and classification is a highly valued factor in traffic operation and management, validation of travel demand models, freight studies, and even emission impact analysis of traffic operation. The capability of measuring vehicle lengths makes dual-loop detectors a potential real-time data source for speed and vehicle classifications. However, the existing dual-loop length-based vehicle classification model has been well evaluated against free traffic but not suitable for non-free traffic conditions (such as synchronized and stop-and-go congestion states). This paper presents an innovative approach to evaluate dual-loop length-based vehicle classification models against concurrent ground-truth video vehicle trajectory data at the selected dual-loop traffic monitoring stations. The software VEVID

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Mr. Andre' Morton, a senior student in the Department of Water Resources Management at Central State University, was chosen as the Undergraduate Student Paper Competition Winner for his paper titled, *Classification of Urban Districts based on Mobile Carbon Monoxide Exposure Using Self Organizing Maps.* His paper elaborates on the concepts of exploring Self Organizing Maps (SOM) as a tool for studying a few urban "air districts" in the USA with respect to the demography using a single mobile source air pollutant.

Before attending Central State University, Mr. Morton received his B.A. in Speech Communications from Miami University of Ohio in 2001 and M.A. in Communication Studies from Bowling Green State University in 2003. Since, he has participated in the National Nuclear Security Administration Hyperspectral Workshop (2008) and Evaportranspiration in Southwestern USA Project of the United States Bureau of Reclamation (2008-2009) as an undergraduate research assistant. In 2009 he completed a summer co-op internship with the Northeast Ohio Regional Sewer District (NEORSD). The co-op experience consisted of analysis of bid contracts and requests for proposals for improvements to be made to NEORSD facilities as well as development of excel spreadsheets of cost saving measures implemented at three NEORSD facilities from 2003-2009. He is currently working with Dr. Ramani Kandiah on the OTC sponsored project *"On-Road Mobile Source Pollutant Emissions: Identifying Hotspots and Ranking Roads"* in ranking of roads based on on-line mobile pollutant emissions using neural network.

Mr. Qingyi Ai, a Ph.D. candidate in Transportation Engineering in the College of Engineering and Applied Science at the University of Cincinnati, was awarded Graduate Student Paper Competition winner for his paper titled, *Dual-Loop Length-Based Vehicle Classification Models against Synchronized and Stop-and-Go Traffic Flows.* His paper presents an innovative approach to evaluate dual-loop length-based vehicle classification models against concurrent ground-truth video vehicle trajectory data at the selected dual-loop traffic monitoring stations.

Mr. Ai joined the Graduate School at UC in September of 2007 under the advisement of Dr. Heng Wei. His research interests include traffic congestion modeling and vehicle classification modeling using high resolution dual-loop data, emergency evacuation, traffic operational impact on emission, and GIS application in transportation system. He received his B.S. in Civil Engineering from Huazhong University of Science and Technology (China) in 1998 and M.S. in Transportation Engineering from Beijing University of Technology (China) in 2006. Before joining UC, he worked as a civil engineer in China for five years and worked on project management of transportation infrastructure and transit network planning of the city of Tianjin. Having comp leted his course work and passed his Ph.D. qualifying and proposal exams in May 2009 and June 2010, he is now under the supervision of Dr. Heng Wei. He is also a student member of ITE and NACOTA.

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(Vehicle Video-Capture Data Collector) is used to extract high-resolution vehicle trajectory data from the videotapes. Meanwhile, a probe vehicle equipped with a Global Positioning System (GPS) traveler data logger is applied to collect traffic pattern data for validating parameters involved in the new vehicle classification models. As a result, new dual-loop length-based vehicle classification models are developed against the synchronized and stop-and-go traffic flows, namely, VC-Sync model and VC-Stog model. Comparing to the obtained ground-truth data, the sample results show that the error of the estimated length by the VC-Sync model is reduced to 8.5% compared to 35.2% produced by the existing model, and the error of the VC-Stog model is reduced to 27.7% compared to 210% generated by the existing model.

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it is assumed that the vehicle stops in the middle between the two loops. After stopping a period of t_s it starts to move again with the acceleration rate a, and then leaves the loop station area. In order to estimate vehicle lengths by using the SBL model, it is necessary to determine the vehicle's acceleration rate (a) and the time period for a vehicle stopping on both of the loops (t_s). In this study, the GPS data gained under stop-and-go traffic flows is employed to set up the acceleration rate a via statistical analysis.

Comparing to the obtained ground-truth data, the sample results show that the error of the estimated length by the VC-Stog model is reduced to 27.7% compared to 210% produced by the existing model. VC-Sync model reduces the vehicle classification error from 35.2% to 8.5% compared to the existing model. To ensure the right use of different models under varied traffic conditions, an algorithm is developed for identifying different traffic states using dual-loop data. In case of stop-and-go traffic, a flowchart is developed for identifying which scenario a vehicle falls in. The thresholds involved in those two algorithms are also recommended based on the statistical analysis of the observed data.

The Principle Investigator (PI) of this OTC-funded project is Dr. Heng Wei, Associate Professor at The University of Cincinnati (UC). Major project participators include: Mr. Qingyi Ai and Mr. Zhixia Li, PhD Candidates at UC; and Mr. Sudhir Reddy Itekyala, M.S. student at UC. The Co-PI is Dr. Deogratias Eustace, Assistant Professor at University of Dayton. The collaborator is Dr. Ping Yi, Professor at University of Akron.

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