OHIO TRANSPORTATION CONSORTIUM

OTC NEWS

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UA's *Roo Bus* Goes Electric

The University of Akron is working closely with its partners FirstEnergy, and the Akron Metropolitan Transportation Authority on electric vehicle readiness in Akron and in Northeast Ohio. As part of this, the City of Akron, in partnership with the Ohio Transportation Consortium, successfully applied for inclusion in Project Get Ready at The Rocky Mountain Institute, one of the nation's most prominent leadership collaborations for regional readiness strategies in electric transportation. As a result, the OTC is considered a leader in the state for electric vehicle initiatives. This was clear when, in early September 2011, The Ohio Department of Development was competitively awarded a major Department of Energy planning grant with a plan of work that includes analysis of charging station deployment throughout Northeast Ohio by the OTC. FirstEnergy used its membership in the Electric Power Research Institute (EPRI) to bring to The University of Akron an opportunity to purchase an all electric shuttle bus for its Roo Bus fleet with 50% cost share by The Department of Energy. The bus, which is being constructed on a Ford chasse through Myers Motors and a battery from Azure Dynamics, is scheduled for delivery in the third quarter 2012. Three Level II (240v) electric vehicle charging stations will be installed on campus by Recharge Power LLC which is headquartered in Northeast Ohio. Recharge Power manufactures Dual-Vehicle 240V Recharge Stations™ capable of fast charging two electric

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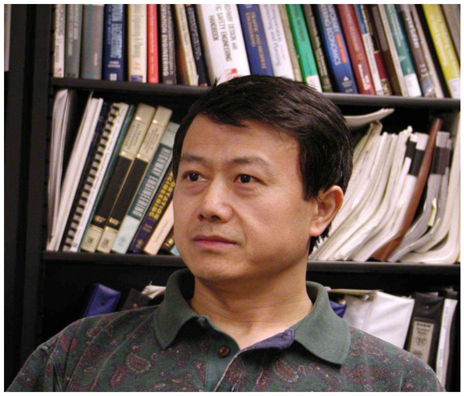
A Message from the Director



The faculty and students in the OTC participating universities continue to engage in research and education activities to improve the performance of our transportation system and prepare the future workforce. Our researchers and students have participated in many local, regional, national and international conferences and workshops, and will continue to be featured in presentations and publications in the coming Transportation Research Board Meeting on January 22, 2012.

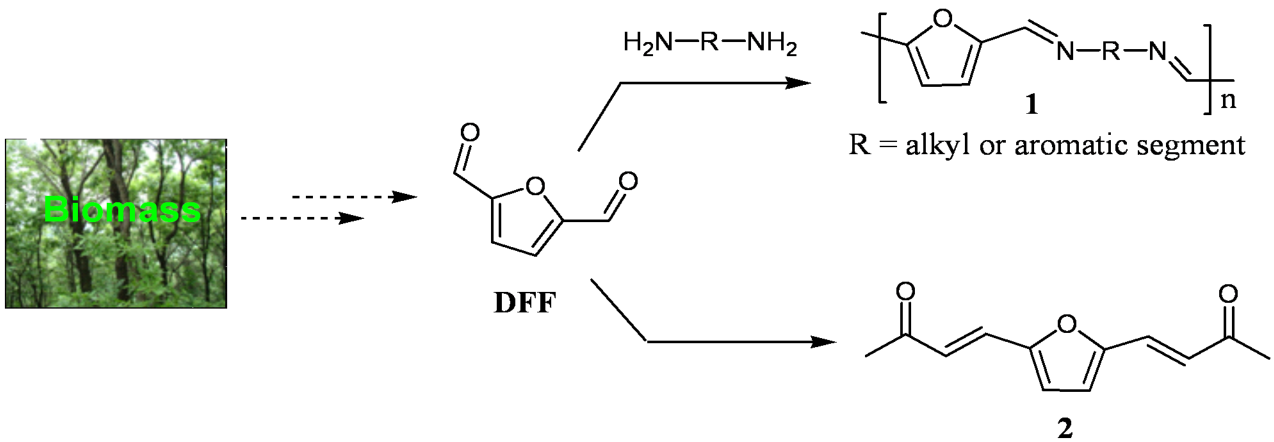
Our research activities continue to target practical problems in the planning, operation, and maintenance process of transportation infrastructure for improved safety, efficiency, and economic and environmental sustainability. Our collaborations with state and local transportation agencies as well as the private industry to promote use of alternative energy and green transportation have been fruitful. As the new year starts we are pleased to present you this issue of our newsletter, which features mainly recent research by our graduate students.

Ping Yi

OTC Board of Directors

Developing Furan-Based Materials for High Performance Anti-Corrosion

By: Tengfei Xiang, Graduate Student, The University of Akron



Research Progress Summary

In our efforts to develop high performance anti-corrosion materials, we have recently discovered that the renewable diformylfuran (DFF) compound can react with a diamine to give Schiff base polymer I (via –C=N- bond formation). The "R" group can be an alkyl chain or an aromatic segment. The reaction can occur at about room temperature, indicating the great potential of forming a room-temperature curable polymeric coating. The polymerization gave insoluble polymers under the condition used. Efforts are currently directed toward optimization of the experimental conditions to achieve high quality films, and evaluation of the performance. Along the direction of developing polymer films, vinyl furan has been synthesized and shown to have the ability to be polymerized. The study is on the way to further characterize the polymerization, and to evaluate its anticorrosion properties.

Tengfei Xiang is a Ph.D. student in Chemistry at The University of Akron.

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cars simultaneously. Two of the stations will be used for overnight charging of the Roo bus, and a third as a public access charging station at the corner of Wolf Ledges and Carroll Street. This compliments the location of the Center for the Advanced Vehicles and Energy Systems in the new Wolf Ledges Engineering building, and is one of the busiest intersections on campus, allowing for high visibility of the charging station. The photo to the right demonstrates what the proposed charging station will look like once it is complete.

As a result of these initiatives, the university's participation in electric vehicle readiness is among the highest of any university in Ohio.

Identifying and Correcting Pulse Breakup Errors from Freeway Loop Detectors

By: Ho Lee, Graduate Student, Ohio State University

Loop detectors are the most common sensors used to collect freeway management data. There has been considerable research to screen the quality of loop detector data, but some significant detector errors have not received much attention due to the difficulty of identifying their occurrence. This paper examines one such error, pulse breakup: what should be a single pulse from a vehicle breaks up into two or more pulses because the detector momentarily drops out. We develop an algorithm to identify the presence of individual pulse breakup events. The algorithm is based on the nature of pulse breakup revealed from individual vehicle actuations with concurrent video ground truth. The algorithm begins with the comparison of the *on-times* from the two successive pulses bounding a given short *off-time*. To differentiate between pulse breakup and tailgating, the algorithm includes several comparisons of the adjacent on-times with respect to the ambient traffic conditions. A total of six steps are included in the algorithm. If two successive pulses satisfy all of the steps, these pulses are a suspected pulse breakup. Otherwise, these pulses are considered to arise from non-pulse breakup. The process is repeated over all pulses at each detector. The results can be used both to correct for the suspected pulse breakup events and the rate of suspected pulse breakup events provides an indication of the detector's health. The algorithm was tested over 68,281 actuations with concurrent video ground truth, in both free flow and congested conditions, from 15 detector stations (22 directional stations) and the algorithm demonstrated good performance.

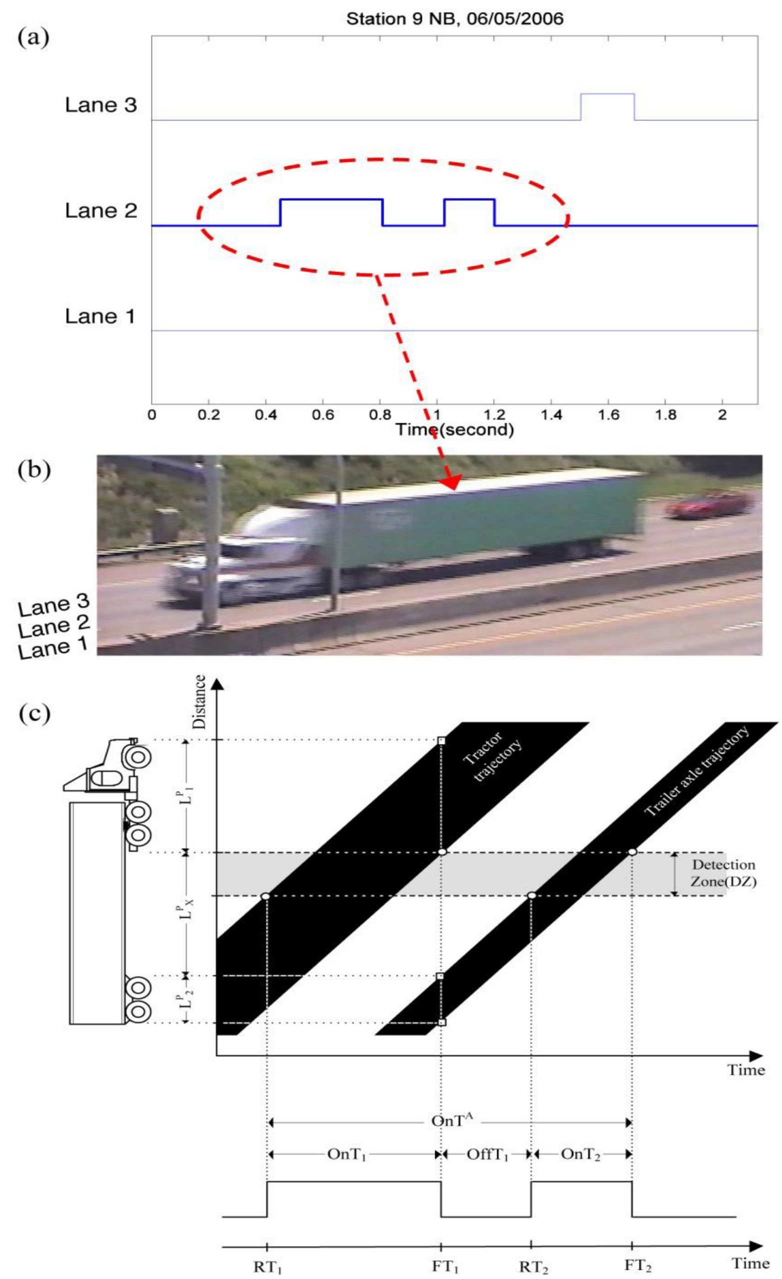


FIGURE 1 (a) A plot of transition pulses with pulse breakup recorded at station 9 northbound, (b) a concurrent video frame showing the two vehicles that gave rise to the three pulses, and (c) a time-space diagram illustrating a hypothetical example of pulse breakup and the associated detector's response.

For the complete paper, please go to http://www.otc.uakron.edu/docs/PulseBreakup_Paper_OSU_Ho[1].pdf

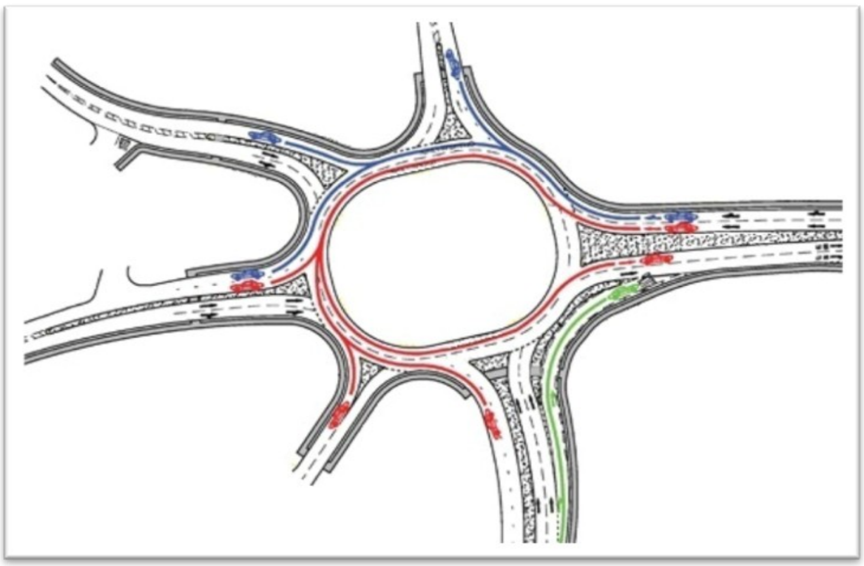
Adaptive Signal Control for Safety and Efficiency at Roundabouts

By: Peng Liu, Graduate Student, University of Akron

Modern roundabouts are becoming increasingly popular because of two major reasons: safety and operational efficiency. Roundabouts slow vehicle approaching speeds and reduce conflict points by transforming crossing conflicts into merging conflicts; traffic control is also simplified because the only control regulation is for the entering vehicles to yield to circulating traffic.

However, both safety and efficiency of a roundabout may be compromised under certain traffic conditions such as heavy flows or unbalanced approach volumes. A research project is underway at OTC which looks into the effect of traffic signals in helping improve roundabout operation and safety under such conditions. Traffic signals may help create necessary gaps to aid vehicles entry from uncontrolled approaches; they may also be able to balance incoming flows in difference approaches to reduce delays. Nonetheless, because fixed-time control may not have the operational flexibility to provide the overall benefits, signal control should be activated only when needed and deactivated otherwise. Therefore, traffic adaptive control is the methodological focus for the objective of minimizing traffic delay and improving safety.

The accompanying figure shows a two-lane roundabout with the conceptual setup of an adaptive signal control system, which can switch between signalized and unsignalized control based on prevalent traffic conditions. Further technical work and findings will be reported in a future issue of the OTC newsletters.



2011 Student Paper Contest Winner

Ho Lee, a Ph.D. candidate in the Transportation Engineering program in the Department of Civil and Environmental Engineering and Geodetic Science at the Ohio State University, was presented with the 2011 OTC Student Paper Competition award for his paper, "Identifying and Correcting Pulse Breakup Errors from Freeway Loop Detectors". He is now under the supervision of Dr. Benjamin Coifman. His research interests include intelligent transportation systems and application of advanced technologies to transportation.

He received his B.S in Transportation Engineering (2000) and M.S in Transportation Planning (2002) from Hanyang University in South Korea. After receiving a master degree, Lee worked as a research associate in the Korea Railroad Research Institute, South Korea. In 2007, he graduated from the Ohio State University with a second M.S in Transportation Engineering. Presently, he is working on LIDAR (Light Detection And Ranging) based vehicle classification that is a promising alternative to the existing classification station.

Recently Completed Research

LIDAR Based Vehicle Classification (Benjamin Coifman, PhD, Associate Professor, The Ohio State University and Ho Lee, PhD Candidate, Graduate Research Associate, The Ohio State University)

Vehicle classification data are used for numerous transportation applications. Most of the classification data come from permanent in-pavement sensors or temporary sensors mounted on the pavement. Moving out of the right-of-way, this study develops a LIDAR (light detection and ranging) based classification system with the sensors mounted in a side-fire configuration next to the road. The first step is to distinguish between vehicle returns and non-vehicle returns, and then cluster the vehicle returns into individual vehicles. The algorithm examines each vehicle cluster to check if there is any evidence of partial occlusion from another vehicle. Several measurements are taken from each non-occluded cluster to classify the vehicle into one of six classes: motorcycle, passenger vehicle, passenger vehicle pulling a trailer, single-unit truck, single-unit truck pulling a trailer, and multi-unit truck. The algorithm was evaluated at six different locations under various traffic conditions. Compared to concurrent video ground truth data for over 27,000 vehicles on a per-vehicle basis, 11% of the vehicles are suspected of being partially occluded. The algorithm correctly classified over 99.5% of the remaining, non-occluded vehicles. This research also uncovered emerging challenges that likely apply to most classification systems: differentiating commuter cars from motorcycles. Occlusions are inevitable in this proof of concept study since the LIDAR sensors were mounted roughly 6 ft above the road, well below the tops of many vehicles. Ultimately we envision using a combination of a higher vantage point (in future work), and shape information (begun herein) to greatly reduce the impacts of occlusions.

An Innovative Non-contact Sensing Platform to Prevent Traffic Accident due to Driver Drowsiness (Bill X. Yu, Associate Professor, Case Western Reserve University)

This project conducted pilot investigations on the development of an in-vehicle measurement system that monitors the physiological signals (i.e., heart rate, heart rate variation, breathing and eye blinking) of drivers. These physiological signals will be utilized to detect the onset of driver fatigue, crucial for timely application of drowsiness countermeasures. Fatigued driving is one of the most significant factors causing traffic accidents. Clinical research has found physiological signals are effective indicators of drowsiness. A conventional bioelectrical signal measurement system requires the electrodes to be in contact with the human body. This not only interferes with normal driver operation, but also is not feasible for long term monitoring purpose. This study developed a non-contact sensing platform that can remotely detect bioelectrical signals in real time. With delicate sensor electronics design, the bioelectrical signals associated with electrocardiography (ECG), breathing and eye blinking can be measured. The current sensor can detect the ECG signals with an effective distance of up to 30 cm away from the body. It also provides sensitive measurement of physiological signals such as heart rate, breathing, eye blinking etc. The sensor performance was validated on a high fidelity driving simulator. Digital signal processing algorithms have been developed to decimate the signal noise and automate signal analyses. The characteristics of physiological signals indicative of driver fatigue, i.e. the heart rate (HR), heart rate variability (HRV), breath frequency and eye blinking frequency, can be determined. A robust drowsiness indicator will be developed by coupling the multiple physiological parameters to achieve high reliability in drowsiness detection.

Work Zone Speed Reduction Utilizing Dynamic Speed Signs (Deborah S. McAvoy, Ph.D., P.E., PTOE, Assistant Professor, Ohio University)

A simulator study was used in this research to determine speed compliance based upon dynamic speed design and presence. The scenarios designed for this research simulated driving through a highway work zone with a right lane closure. Each participant drove through a control scenario and four experimental scenarios subdivided into five areas for data collection. The four experimental scenarios included dynamic speed signs in place of the regulatory speed limit sign as follows: (1) Steady 'SLOW DOWN 45', (2) Flashing 'SLOW DOWN 45', (3) Steady 'SPEED LIMIT 45' and (4) Steady 'SPEED LIMIT 65'. The five areas included the following: (1) Before the first work zone sign, (2) Between the first work zone sign and the dynamic speed sign, (3) Between the dynamic speed sign and the lane closure, (4) Between the lane closure and the end of the work zone, and (5) After the work zone. Comparisons were made of the measures of effectiveness (speed, lane position, acceleration, deceleration, gap, time to collision, latency of visual detection, average fixation durations and the proportion of target fixations) to assess compliance with the speed limit and changes in driver behavior. When using dynamic message signs stating 'SLOW DOWN 45', participants maintained the speed limit prior to entering the work zone and through the work zone as compared to scenarios using regulatory signs or dynamic message signs displaying the speed limit. The dynamic message signs did not create unsafe driving conditions based upon the analysis of the other measures of effectiveness studied.

The final research reports for these and all completed OTC-funded projects are located at http://www.otc.uakron.edu/publications.php **.**

OTC Faculty & Students Share Research

In addition to the OTC researchers who will take part in the 2012 TRB meeting in Washington, DC, several others have been busy sharing their results in a variety of other venues.

Central State University's Tinina Hale and Dr. Ramanitharan Kandiah recently presented, "Modeling of Noise Created by Road Construction and Mantenance Works on Interstate Route 75 in Dayton, OH" at the ERC Symposium in October. Dr. Kandiah also presented his research, "Classifying Ohio Counties Based on Highway Traffic Related Pollution" at Wright State University in October.

University of Cincinnati's Dr. Heng Wei had several collaborative papers included in the ASCE Proceedings of the 12th COTA International Conference of Transportation Professionals in Beijing China August 3-6, 2011. Among them were: "Modeling Combined Safety and Operational Effect of Detection Solution to Signal Dilemma Zone Problems" (Li, Z., Wei, H., and Xiong, H.), "Clarifying Traffic Flow Phase for Vehicle Classifications Using Dual-loop Data" (Liu, H., Wei, H., Ai, Q., Li, Z., Coifman, B., Wang, H.), and "Estimating Emission Impact of Traffic Flow Operation with Dual-loop Data" (Liu, H., Wei, H., Yao, Z., Ai, Q.). Dr. Wei, along with Hirikishan Perugu, also presented, "Development of An Integrated Model to Estimate Link Level Truck Emissions" at Futura 2011 - Annual International Users Conference in Palm Springs, CA this past fall. This paper was also selected as the 1st prize winner of the 2011 Cube Student Challenge Competition.

Case Western Reserve University's Dr. Xiong (Bill) Yu presented his research, "An Innovative Non-contact Sensing Platform to Prevent Traffic Accident due to Driver Drowsiness" at the Road Safety and Simulation conference in Indianapolis in September.

Look for Us at TRB

Several OTC professors and graduate students will be presenting their research at the 91st Annual Meeting of the Transportation Research Board held in Washington D.C. from January 22 - 26, 2012. Stop by one of the following presentations to learn more about the exciting innovations in which our researchers are involved.

- Lee, H., Coifman, B., "Side-Fire LIDAR Based Vehicle Classification," [accepted for presentation and publication in] Proc. of the 91st Annual Meeting of the Transportation Research Board, 2012. (The Ohio State University)
- Perugu, H., Wei, H. and Rohne, A. (2012). "Modeling Roadway Link $PM_{2.5}$ Emissions with Accurate Truck Activity Estimate for Regional-Level Transportation Conformity Analysis." Compendium of Papers CD-ROM for 91st Transportation Research Board Annual Meeting, Washington, D.C., January 22-26, 2012. (University of Cincinnati)
- Coates, A., Du, Yunke, Koganti, S.G., "Maximizing Intersection Capacity and Improving Pedestrian Safety Through Unconventional Geometric Design of Continuous-Flow Intersections," Presented at the 91st Transportation Research Board Annual Meeting, Washington, D.C., January 22-26, 2012. (University of Akron)
- Kandukuri, Y., Cordill, A., Yi, P. , "A Dynamic GIS Model for Location Selection of Battery Electric Vehicle Charging Stations in Public Places," Presented at the 91st Transportation Research Board Annual Meeting, Washington, D.C., January 22-26, 2012. (University of Akron)
- Sarker, P. Abbas, A. R., Singh, P., and J. Roth (2011), "Wet Night Performance of Pavement Markings in Ohio" Presented at the 91st Transportation Research Board Annual Meeting, Washington, DC, January 22-26. (University of Akron)
- Sturges, T. R., Frankhouser, A., and Abbas, A. R. (2011), "Dowel Bar Misalignment in Two-Step Dowel Bar Inserters," Presented at the 91st Transportation Research Board Annual Meeting, Washington, DC, January 22-26. University of Akron)

Additionally, Dr. Ala Abbas and Dr. Ping Yi will be chairing the following presentations:

- "Dynamic Modulus and Permanent Deformation of Asphalt Mixtures" Sponsored By the "Characteristics of Asphalt Paving Mixtures to Meet Structural Requirements (AFK50)" Committee in the Transportation Research Board (TRB) 91st Annual Meeting, January 22-26, 2011, Washington, DC. (chaired by Dr. Ala Abbas, University of Akron)
- "Information Technology Applications in Transportation: Recent Research" Lectern Session in the Transportation Research Board (TRB) 91st Annual Meeting, January 22-26, 2011, Washington, DC. (Dr. Ping Yi, Presiding Officer)