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Temple University – Safety

Use of Big Data and Machine Learning in Support of the Pennsylvania Strategic Highway Safety Plan

Presented by:

- Dr. Joseph Coe – Department of Civil and Environmental Engineering

  Joseph Thomas Coe, Jr. is an Assistant Professor within the Department of Civil and Environmental Engineering at Temple University in Philadelphia, Pennsylvania. Prior to joining the faculty at Temple University, he taught for two years at The Citadel in Charleston, South Carolina. He obtained his B.S., M.S., and Ph.D. degrees from the University of California, Los Angeles. Joseph Coe has more than 10 years of experience in civil engineering, particularly in areas related to nondestructive evaluation and rehabilitation of foundations, bridge scour, urban seismic hazards, geophysical site characterization, and statistical modeling. He is the recipient of the 2014 Deep Foundations Institute (DFI) Young Professors Paper Award. He is also a member of the ASCE Engineering Geology and Site Characterization Committee and Deep Foundations Committee.

- Dr. Joseph Picone – Department of Electrical and Computer Engineering

  Joseph Picone is currently a professor in the Department of Electrical and Computer Engineering at Temple University. He received his Ph.D. in Electrical Engineering in 1983 from the Illinois Institute of Technology. His primary research interests are machine learning approaches to automatic interpretation of biological signals. Dr. Picone directs the Institute for Signal and Information Processing and is the Associate Director of the Neural Engineering Data Consortium, both of which currently reside at Temple University. Since 2012 he has been actively engaged two related efforts: (1) the development of an evaluation-driven research paradigm in bioengineering that parallels his previous contributions in this area in human language technology and (2) the development and commercialization of technology to automatically interpret EEG signals. His primary expertise is in statistical modeling with applications in signal processing, specifically acoustic modeling in speech recognition. A common theme throughout his research career has been a focus on fundamentally new statistical modeling paradigms.

  His research group is known for its commitment to open source speech technology and released the industry's first state of the art open source speech recognition system in 1997. The ISIP web site is well known for its open source software, coursework and educational materials. He currently collaborates with the Temple School of Medicine, and has previously collaborated with many academic institutions (e.g., the Linguistic Data Consortium, Johns Hopkins), government agencies (e.g., Department of Defense, DARPA) and companies (e.g., MITRE, Texas Instruments). The National Science Foundation, DoD, DARPA and several commercial interests have funded his research. He has spent significant portions of his career in academia, research and the government, giving him a very balanced perspective on management of R&D. Dr. Picone is a Senior Member of the IEEE and has been active in several professional societies related to human language technology. He has published over 200 technical papers and holds 8 patents. See www.isip.piconepress.com and www.nedcdata.org to learn more about his research and teaching.

Additional team members:

- Dr. Benjamin Seibold –Department of Mathematics
  - Non-equilibrium traffic flow theory; understanding of phantom jams and stop-and-go traffic waves; implications on safety and system performance metrics (throughput, fuel consumption, emissions)
  - Traffic flow control via low density (below 5% CAV penetration rate) connected and automated vehicles
  - String (in)stability; human driving; truck platooning; bus bunching
  - Data-fitted macroscopic models for highway traffic flow; realistic network coupling conditions for highway ramps

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- Interconnections between micro (vehicle) scale and macro (city level, road network) scale; 2d traffic flow; non-local models (communication)
- Data processing: accurate vehicle velocity and acceleration reconstruction from camera data
- Traffic experiments: stop-and-go traffic waves; heterogeneous systems (human drivers and CAVs); adaptive cruise control platooning
- Quantifying macroscopic impacts of moving bottlenecks
- Autonomous systems; scaled vehicle robotic test beds

Highway Incident Timeline Detection (WO TEM 009):
The Pennsylvania Department of Transportation (PennDOT) maintains information on road conditions through its Road Condition Reporting System (RCRS). The effectiveness of RCRS is dependent on the quality of information and the timeframe in which it is provided. PennDOT is consequently interested in the average time for notification of highway incidents from emergency dispatch centers. This information would support PennDOT in a number of ways: (1) Reduce the overall time to clear incidents and the time gap between when a highway closure occurs and when the public is informed; (2) Provide information to aid PennDOT in policy and decision making process related to traffic incident management; (3) Identify potential key elements and any critical missing information related to traffic incident management; and (4) Improve operation at statewide, regional, and district traffic management centers. Based on the preceding discussion, the general objective of this project was to evaluate the highway incident detection timeline along a number of major highways in the Commonwealth of Pennsylvania, including Primary Interstate Highway I-76, I-80, I-81, and I-95, and Auxiliary Interstate Highway I-78 and I-83. This was accomplished by comparing emergency dispatch records and the PennDOT RCRS for incidents along the aforementioned highways over several years.

The major results from this research project included the following:

- The time difference between RCRS entries and 911 call records is not normally distributed, necessitating the use of the median value to accurately describe the central tendency in the data.
- The overall median time difference between matched RCRS and 911 entries was 12 minutes.
- 75% of all matched records have a time difference less than approximately 28 minutes.
- Generally, counties with smaller time differences tended to exhibit smaller variability in their distributions.
- Areas of the Commonwealth traversed by I-95, I-83, the southernmost section of I-81, and I-76 generally exhibited smaller time differences. Sections of I-81 heading north from Lebanon County (and the only counties for which 911 data was procured along I-80 in this study) exhibited larger time differences.

Since the RCRS system is a major tool with which PennDOT monitors highways, the statistical results from this study can aid PennDOT in developing best practices for policy and procedural decisions related to traffic incident management and safety, which can improve operation at the statewide, regional, and district traffic management centers.

Complementary projects:

- "CPS: Synergy: Collaborative Research: Control of Vehicular Traffic Flow via Low Density Autonomous Vehicles" (PI Seibold, Funded by NSF). This project develops new models, computational methods, software tools, and engineering solutions to employ autonomous vehicles to detect and mitigate traffic events that adversely affect fuel consumption and congestion. The approach is to combine the data measured by autonomous vehicles in the traffic flow, as well as other traffic data, with appropriate macroscopic traffic models to detect and predict congestion trends and events.
- "Integration of Pennsylvania's Traffic Records Systems" – (White Paper to PennDOT). There are three major aspects of the proposed integration of Pennsylvania traffic record systems: (1) identification of databases and data structures; (2) decentralized database integration; and (3) data analytics and statistical modeling. This white paper describes how Temple University intends to approach the multitude of research questions that arise and the potential barriers that may need to be overcome in developing an integrated traffic record system in the Commonwealth of Pennsylvania.