2020 CAMMSE Virtual Research Symposium

FINAL PROGRAM

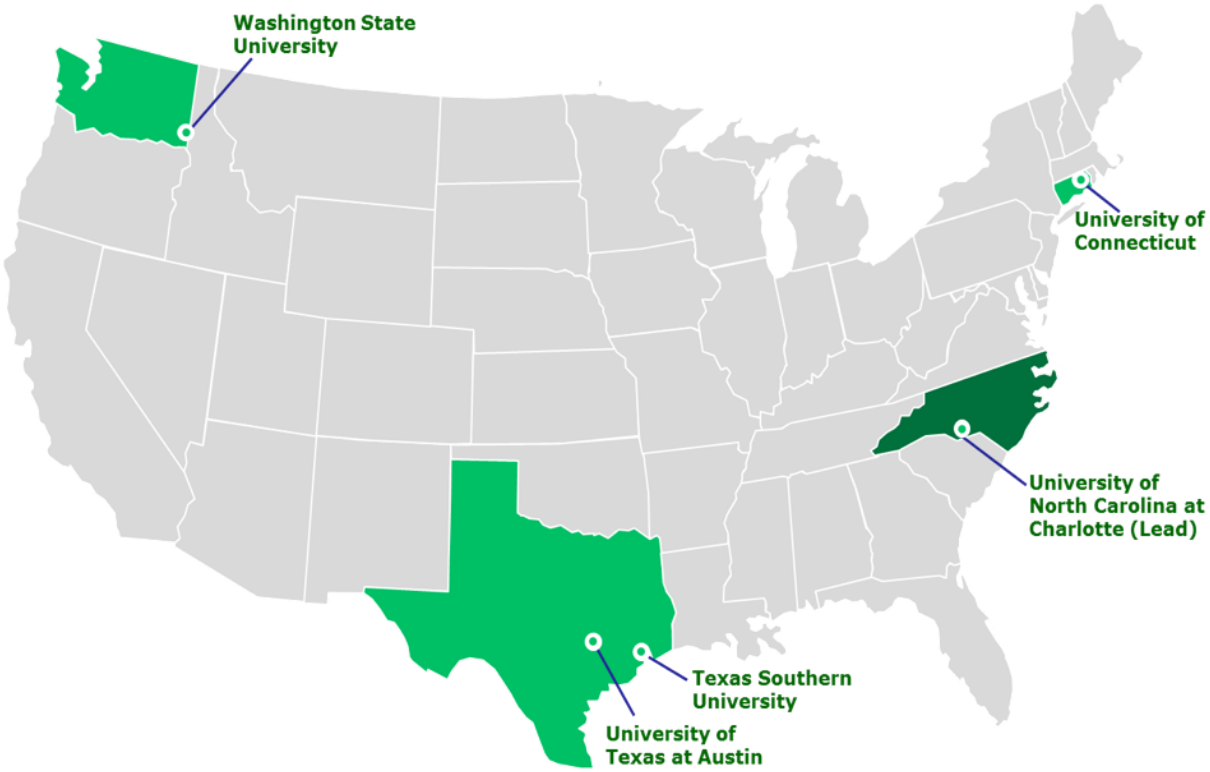
November 5-6, 2020

Charlotte, NC, USA

Center for Advanced Multimodal Mobility Solutions and Education

A Consortium of Five Universities:

The University of North Carolina at Charlotte (Lead)
The University of Texas at Austin
University of Connecticut
Washington State University
Texas Southern University



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Welcome Message from CAMMSE Director

It is truly an honor to welcome you, our dear CAMMSE family members, colleagues and friends, and general participants that are coming from the Northwest, Southwest, and Northeast to the Southeast part of the country. Even though we are unable to meet in person during this unprecedented time, I am truly glad that we can still hold this important event remotely! Thank you for attending our third Annual CAMMSE Research Symposium with the main purpose to share results and findings of recent and ongoing research funded by the Center for Advanced Multimodal Mobility Solutions and Education (CAMMSE). CAMMSE is a five year multi-campus Tier 1 University Transportation Center (UTC) funded by USDOT that began operations in November 2016 under the FAST ACT. We are a consortium of five universities, including The University of North Carolina at Charlotte (UNCC) as the lead, the University of Texas at Austin (UT Austin), the University of Connecticut (UConn), Washington State University – Pullman (WSU), and Texas Southern University (TSU) each with unique records as education and research hubs engaging diverse populations and nurturing the success of our students. The main focus or theme of CAMMSE is to address the FAST Act research priority area of "***Improving Mobility of People and Goods***" by conducting multi-disciplinary, multi-modal research, education and workforce development, and technology transfer. It has already been almost three years since CAMMSE was established at UNCC back in November 2016 and significant progress has been made in all activities, including research, education and workforce development, and technology transfer. I am confident that this symposium will provide a great opportunity for CAMMSE researchers, graduate students, and the community at-large who are interested in multimodal mobility to share their recent and on-going research in multimodal mobility solutions.

This booklet provides the symposium program and general information we hope is useful to you as you explore the event. The one and a half day program includes three technical sessions, and one student lightning presentation session, as well as one workshop session. On the first day, the morning sessions will be on "emerging mobility services, technologies and operations" and "connected and autonomous vehicle and machine learning applications", and the afternoon session will focus on "improving multimodal mobility: leveraging data and advanced analytics". In addition the program will include a graduate student lightning presentation session in the afternoon where we hope students and faculty can engage in productive discussions with constructive feedback to our students. On the second day, we will have two workshops entitled "Are E-Scooters a Transit Last-Mile Solution?" and "Signal Timing and Geometric Design at Intersections with Contraflow Left-Turn Lanes". All technical sessions and workshops will offer Professional Development Hours (PDHs).

In closing, I hope that this virtual event will provide an opportunity to exchange ideas, foster collaborations, and generate new ideas. Participants from industry and the government are highly encouraged as they will further enable opportunities for technology transfer. On behalf of the symposium organizing committee, we are glad to have you join us and I hope that you will enjoy this symposium. Thank you very much and again and stay safe!

Sincerely,

Wei (David) Fan

Symposium Planning Committees

General and Technical Chair: Dr. Wei Fan, UNC Charlotte

Organizing and Planning Committee:

Dr. Wei Fan, UNC Charlotte

Dr. Martin Kane, UNC Charlotte

Dr. David Weggel, UNC Charlotte

Ms. Kim Wilson, UNC Charlotte

Student Lightning Session Committee:

Dr. Wei Fan, UNC Charlotte

Mr. Pengfei Liu, UNC Charlotte

Mr. Yang Li, UNC Charlotte

Mr. Zijing Lin, UNC Charlotte

Workshop Committee:

Dr. Wei Fan, UNC Charlotte

Dr. Randy Machemehl, UT Austin

Dr. Yi Qi, Texas Southern University

Technical Support:

Mr. Pengfei Liu, UNC Charlotte

Mr. Yang Li, UNC Charlotte

Mr. Zijing Lin, UNC Charlotte

Third Annual CAMMSE Research Symposium - FINAL PROGRAM

Day 1: Thursday, November 5 (8:50AM-4:30PM)

8:50-9:00AM **Opening Remarks** (*Dr. Wei Fan, CAMMSE Director*)

9:00-10:20AM **Technical Session #1: *Emerging Mobility Services, Technologies and Operations***
Moderator: Dr. Nicholas Lownes, University of Connecticut

"Understanding E-Scooter Paths in Urban Infrastructure"
Speaker: Randy Machemehl, Ph.D., P.E., University of Texas at Austin

"Bicycle Network Connectivity and Accessibility: A Study on the Effects of Bike Infrastructures on Bicycle Sharing System Demand"
Speaker: Mehdi Azimi, Ph.D., P.E., Texas Southern University

"Evidence of Ridesourcing Increasingly Being Used for Commuting in New York City's Low-Income Communities"
Speaker: Carol Atkinson-Palombo, Ph.D., University of Connecticut

"Development of a Progression-Based, Signal-Timing Strategy for Continuous Flow Intersections"
Speaker: Yi Qi, Ph.D., Texas Southern University

Registration Link: https://uncc.zoom.us/webinar/register/WN_hWLJ-tDZTrOfS-7gBqOZLw
Notes: Any participants can join this Zoom meeting as early as 8:30 AM (EDT); however, our symposium will not start until 8:50 AM (EDT).

10:20-10:40AM **Break**

10:40-12:00PM **Technical Session #2: *Connected and Autonomous Vehicle and Machine Learning Applications***
Moderator: Dr. Randy Machemehl, University of Texas at Austin

"Assessment of Parcel Delivery Systems using Unmanned Aerial Vehicles"
Speaker: Stephen Boyles, Ph.D., University of Texas at Austin

"Extreme Gradient Boosting (XGBoost) Model for Vehicle Trajectory Prediction in Connected and Autonomous Vehicle Environment"
Speaker: Wei (David) Fan, Ph.D., P.E., University of North Carolina at Charlotte

"Prioritizing People - Mixed Equilibrium Assignment for AV Based on Occupancy"
Speaker: Nicholas Lownes, Ph.D., P.E., University of Connecticut

"Social-STGCNN: A Social Spatio-Temporal Graph Convolutional Neural Network for Human Trajectory Prediction"
Speaker: Claudel Christian, Ph.D., University of Texas at Austin

Registration Link: https://uncc.zoom.us/webinar/register/WN_K1xGAyp6RaW4hVFmqP_-sQ
Notes: Any participants can join this Zoom meeting at 10:30 AM (EDT); however, this second technical session will not start until 10:40 AM (EDT).

Day 1 (Continued):

Noon-1:30PM **Lunch**

1:30-2:50PM **Student Research: Lightning Presentations**
Moderator: Mr. Pengfei Liu, University of North Carolina at Charlotte
(*See Student Lightning section in Page 24 of this booklet for more information on presentation titles. For the abstracts see pages 25 to 36.*).

Registration Link: https://uncc.zoom.us/webinar/register/WN_pu2d818rSJaxsgcp0Tu9QA

2:50-3:10PM **Break**

3:10-4:30PM **Technical Session #3: *Improving Multimodal Mobility: Leveraging Data and Advanced Analytics***
Moderator: Dr. Yi Qi, Texas Southern University

"Estimation of Pedestrian Volume Using Geospatial and Traffic Conflict Data"
Speaker: John Ivan, Ph.D., P.E., University of Connecticut

"Highways and Wealth Distribution: A Geospatial Analysis"
Speaker: Jeffrey P. Cohen, Ph.D., University of Connecticut

"Developing Friction Data to Support the Optimal Use of Pre-Wet Deicing Salt in Pacific Northwest"
Speaker: Xianming Shi, Ph.D., P.E, Washington State University

"Entropy-based Diversity Quantification of Multimodal Transportation Systems: Physical Infrastructure Perspective versus Travel Behavior Perspective"
Speaker: Jin Zhu, Ph.D., University of Connecticut

Registration Link: https://uncc.zoom.us/webinar/register/WN_jw5-7kANTES3L709Kh5uzA
Notes: Any participants can join this Zoom meeting at 3:00 PM (EDT); however, this third technical session will not start until 3:10 PM (EDT).

4:30-4:40PM **Recap of Day 1** (*Dr. Wei Fan, CAMMSE Director*)

4:40PM **End of Day 1**

Notes: - End of Day 1 marks the end the research component of the CAMMSE Research Symposium. Workshop will be offered in Day 2.

Day 2: Friday, November 6 (9:00AM-12:00PM)

9:00-9:15AM Opening Remarks (*Dr. Wei Fan, CAMMSE Director*)

9:15-10:15AM Workshop #1: "**Are E-Scooters a Transit Last-Mile Solution?**"
Speaker: Randy Machemehl, Ph.D., P.E., University of Texas at Austin

Registration Link: https://uncc.zoom.us/webinar/register/WN_Sc7vCmJNSV6aJnHWCds5xQ
Notes: Any participants can join this Zoom meeting at 9:00 AM (EDT) at which time the CAMMSE director will deliver opening remarks, and the first workshop will then start at 9:15 AM (EDT).

10:15-10:45AM **Coffee Break** (*Atrium*)

10:45-11:45AM Workshop #2: "**Signal Timing and Geometric Design at Intersections with Contraflow Left-Turn Lanes**"
Speaker: Yi Qi, Ph.D., Texas Southern University

Registration Link: https://uncc.zoom.us/webinar/register/WN_uvU0yq7iSSWG4_g6EUoGGQ
Notes: Any participants can join this Zoom meeting at 10:30 AM (EDT); however, this second workshop will not start until 10:45 AM (EDT).

11:45-12:00PM Closing Remarks (CAMMSE Director)

12:00PM Conference Ends

TECHNICAL SESSIONS & ABSTRACTS FOR FACULTY PRESENTATIONS:

Technical Session #1: - November 5, 9:00-10:20AM
Emerging Mobility Services, Technologies and Operations
Registration Link: https://uncc.zoom.us/webinar/register/WN_hWLJ-tDZTrOfS-7gBqOZLw
Notes: Any participants can join this Zoom meeting as early as 8:30 AM (EDT); however, our symposium will not start until 8:50 AM (EDT) at which time the CAMMSE director will deliver opening remarks.

9:00 – 9:20 AM:
Understanding E-Scooter Paths in Urban Infrastructure
Speaker: Randy Machemehl, Ph.D., P.E., University of Texas at Austin
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9:20 – 9:40 AM:
Bicycle Network Connectivity and Accessibility: A Study on the Effects of Bike Infrastructures on Bicycle Sharing System Demand
Speaker: Mehdi Azimi, Ph.D., P.E., Texas Southern University
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9:40 – 10:00 AM:
Evidence of Ridesourcing Increasingly Being Used for Commuting in New York City's Low-Income Communities
Speaker: Carol Atkinson-Palombo, Ph.D., University of Connecticut
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10:00 – 10:20 AM:
Development of a Progression-Based, Signal-Timing Strategy for Continuous Flow Intersections
Speaker: Yi Qi, Ph.D., Texas Southern University
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Technical Session #2: - November 5, 10:40-12:00PM
Connected and Autonomous Vehicle and Machine Learning Applications
Registration Link: https://uncc.zoom.us/webinar/register/WN_K1xGAyp6RaW4hVFmqP_-sQ
Notes: Any participants can join this Zoom meeting at 10:30 AM (EDT); however, this second technical session will not start until 10:40 AM (EDT).

10:40 – 11:00 AM:
Assessment of Parcel Delivery Systems using Unmanned Aerial Vehicles
Speaker: Stephen Boyles, Ph.D., University of Texas at Austin
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11:00 – 11:20 AM:
Extreme Gradient Boosting (XGBoost) Model for Vehicle Trajectory Prediction in Connected and Autonomous Vehicle Environment
Speaker: Wei (David) Fan, Ph.D., P.E., University of North Carolina at Charlotte
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11:20 – 11:40 AM:
Prioritizing People - Mixed Equilibrium Assignment for AV Based on Occupancy
Speaker: Nicholas Lownes, Ph.D., P.E., University of Connecticut
Abstract Page 17

11:40 – 12:00 PM:
Social-STGCNN: A Social Spatio-Temporal Graph Convolutional Neural Network for Human Trajectory Prediction
Speaker: Claudel Christian, Ph.D., University of Texas at Austin
Abstract Page 18

Technical Session #3: - November 5, 3:10-4:30PM
Improving Multimodal Mobility: Leveraging Data and Advanced Analytics
Registration Link: https://uncc.zoom.us/webinar/register/WN_jw5-7kANTES3L709Kh5uzA
Notes: **Any participants can join this Zoom meeting at 3:00 PM (EDT); however, this third technical session will not start until 3:10 PM (EDT).**

3:10 – 3:30 PM:
Estimation of Pedestrian Volume Using Geospatial and Traffic Conflict Data
Speaker: John Ivan, Ph.D., P.E., University of Connecticut
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3:30 – 3:50 PM:
Highways and Wealth Distribution: A Geospatial Analysis
Speaker: Jeffrey P. Cohen, Ph.D., University of Connecticut
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3:50 – 4:10 PM:
Developing Friction Data to Support the Optimal Use of Pre-Wet Deicing Salt in Pacific Northwest
Speaker: Xianming Shi, Ph.D., P.E, Washington State University
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4:10 – 4:30 PM:
Entropy-based Diversity Quantification of Multimodal Transportation Systems: Physical Infrastructure Perspective versus Travel Behavior Perspective
Speaker: Jin Zhu, Ph.D., University of Connecticut
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Understanding E-Scooter Paths in Urban Infrastructure

Technical Session #1: Emerging Mobility Services, Technologies and Operations

9:00 – 9:20 AM - Speaker: Randy Machemehl, Ph.D., P.E., University of Texas at Austin

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Abstract:
This research considers using E-Scooter trajectory data to identify path choices within an urban infrastructure without compromising personally identifiable information (PII). The study uses trip trajectory data from an E-scooter company, and infrastructure geographic inventory information to determine the frequency of E-Scooter users choosing among sidewalk, bike lane, and roadway paths. The analysis uses 11+ million location points from approximately 80 thousand e-scooter trips made over one year (1.4 percent of the total e-scooter trips made in the city). Results suggest that an average E-scooter trip is split among sidewalks (18%), bike lanes (11%), and roadways (33%), with 38% choosing other paths. Approximately 60% of the roadway trips are made on Principal Arterials, and those choosing bike routes prefer paths with medium to high level of comfort. The analysis suggests that the mean speed of trips on sidewalks is slightly lower (6-8%) than on other path choices, and speeds are higher on weekdays and AM peak hours. The study provides insight to the potential use of trajectory data to help understand and regulate emerging mobility services. Even though the analyses were conducted using raw data points, procedures for using partially aggregated data to provide similar insights are provided.

Bicycle Network Connectivity and Accessibility: A Study on the Effects of Bike Infrastructures on Bicycle Sharing System Demand

Technical Session #1: Emerging Mobility Services, Technologies and Operations

9:20 – 9:40 AM - Speaker: Mehdi Azimi, Ph.D., P.E., Texas Southern University

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Abstract:
A bicycle-sharing system (public bicycle system, or bike-share scheme) is a service in which bicycles are made available for shared use to individuals on a short term basis for a price or free. Many bike share systems allow users to borrow a bike from a station and return it at another station belonging to the same system. The goal is to encourage cycling as a mode of transportation as well as recreation. As a result, the bicycle infrastructure investments grow with more cyclists on the road. The city planning agencies expect to know the future cycling patterns before carrying out bike lane expansion plan, and the bike share operations would like to forecast the system demand as the new bike infrastructure planned. It is necessary to explain how much bike-share ridership across the city will increase as a result of installing extra bike lanes. In order to measure the marginal cost of building bike lanes or bike paths on bike share demand at a network-wide level over time, a longitudinal analysis is needed to study the effects of bike infrastructures, particularly bike lanes and bike paths, on bicycle sharing system demand.

Evidence of Ridesourcing Increasingly Being Used for Commuting in New York City's Low-Income Communities

***Technical Session #1*: Emerging Mobility Services, Technologies and Operations**

9:40 – 10:00 AM - Speaker: Carol Atkinson-Palombo, Ph.D., University of Connecticut

Authors:

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Norman Garrick, Professor, Civil & Environmental Engineering, 261 Glenbrook Road Unit, 3037, Storrs, CT 06269
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Abstract:
Ridesourcing services such as Uber and Lyft have seen a large growth in New York City's outer boroughs. As an on-demand service, ridesourcing has potential to fill gaps in areas where service by public transit is poor and residents also have limited access to personal automobiles. New York City requires ridesourcing services to report trip origin and destination information to the New York City Taxi and Limousine Commission which then makes this data publicly available. This data shows shifting usage patterns from 2015 to 2018. Focusing on 2018, it also shows distinct time-of-day and day-of-the-week patterns for different types of areas within New York City. Outer borough neighborhoods show heavier usage patterns during the morning and afternoon commuting times than their Manhattan neighbors. GIS-based analysis also shows a strong "distance decay" effect with the highest percentage of trips being localized within the same taxi zone and tapering off sharply in farther zones. The results point to ridesourcing increasingly being used for commuting in neighborhoods with strong minority populations. If this type of essential travel is being relegated to ridesourcing services out of necessity and lack of other viable options, this becomes a transportation equity issue as private ridesourcing companies are largely unregulated and currently functioning on unsustainable pricing structures. With the use of these services still growing, a shift to higher prices could have disproportionate negative effects on already underserved communities.

Development of a Progression-Based, Signal-Timing Strategy for Continuous Flow Intersections

***Technical Session #1*: Emerging Mobility Services, Technologies and Operations**

10:00 – 10:20 AM - Speaker: Yi Qi, Ph.D., Texas Southern University

Authors:

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Abstract:
Since continuous flow intersections (CFIs) are relatively new intersection design, there are few existing guidelines for designing signal-timing for CFIs. An appropriate signal-timing plan will maximize the capacity of the intersection, reduce congestion, and improve safety. This research developed a new signal-timing strategy for CFIs that is based on traffic progression. This new CFI signal-timing strategy was evaluated by conducting traffic simulation-based experiments, and the results of the evaluation showed that it outperformed the signal timing plan provided by a commonly used existing signal timing optimization tool. The proposed signal-timing strategy can reduce average traffic delay by 24%, average vehicle travel time by 8.5%, and average queue length by 28.8% at the studied CFI.

Assessment of Parcel Delivery Systems using Unmanned Aerial Vehicles

Technical Session #2: Connected and Autonomous Vehicle and Machine Learning Applications

10:40 – 11:00 AM - Speaker: Stephen Boyles, Ph.D., University of Texas at Austin

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Abstract:
The idea of deploying electric vehicles and unmanned aerial vehicles (UAVs), also known as drones, to perform "last-mile" delivery in logistics operations has attracted increasing attention in the past few years. In this paper, an electric vehicle travelling salesman problem with drone (EVTSP-D) is formulated as a mixed-integer/linear program to aid logistics organizations with a new method of delivering parcels which can extend the driving range of both vehicles, exploit their advantages and reduce the operation cost. An iterative heuristic algorithm with different search strategies is also developed, which can solve an instance with 25 customers. Results of numerical experiments show that the heuristic is much more efficient than ILOG CPLEX solver and incorporating UAVs into EV-based routing was found to reduce average delivery times by up to 40% for the instances tested. A real-world case study on the Austin network along with the sensitivity analysis of different parameters is also conducted and presented and the results indicate that UAV speed has a greater effect on delivery time compared to UAV operation limit and EV driving range.

Extreme Gradient Boosting (XGBoost) Model for Vehicle Trajectory Prediction in Connected and Autonomous Vehicle Environment

Technical Session #2: Connected and Autonomous Vehicle and Machine Learning Applications

11:00 – 11:20 AM - Speaker: Wei (David) Fan, Ph.D., P.E., University of North Carolina at Charlotte

Authors:

Wei (David) Fan, Ph.D., P.E. **(Corresponding Author)**
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Abstract:
Connected and autonomous vehicles (CAVs) have the ability to receive information on their leading vehicles through multiple sensors and vehicle-to-vehicle (V2V) technology and then predict their future behavior thus to improve roadway safety and mobility. In this study, XGBoost model is developed to predict the acceleration rate that the object vehicle should take based on the current status of both the object vehicle and its leading vehicle. Next Generation Simulation (NGSIM) datasets are utilized for training the proposed model. The XGBoost model is compared with the Intelligent Driver Model (IDM), which is a prior state-of-the-art model. Root Mean Square Error (RMSE) and Mean Absolute Error (MAE) are applied to evaluate the two models. The results show that the XGBoost model outperforms the IDM in terms of prediction errors. The analysis of the feature importance reveals that the longitudinal position has the greatest influence on vehicle trajectory prediction results.

Prioritizing People - Mixed Equilibrium Assignment for AV Based on Occupancy

Technical Session #2: Connected and Autonomous Vehicle and Machine Learning Applications

11:20 – 11:40 AM - Speaker: Nicholas Lownes, Ph.D., P.E., University of Connecticut

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Abstract:
Autonomous Vehicles (AV) have the potential to revolutionize transportation operations mode choice. In June 2017, Connecticut Public Act No. 17-69 "An Act Concerning Autonomous Vehicles" authorized the testing of AVs on Connecticut roads. In April 2018, Connecticut launched the Fully Autonomous Vehicle Testing Pilot Program (FAVTPP), which set the permitting and testing requirements for AVs on public roads. Although there is optimism that introduction of AVs will mitigate traffic congestion and vastly improve safety, the transition to a completely AV fleet - which will take time - presents non-trivial problems. In the United States, automobiles did not begin to outnumber horses on roadways until the late 1920's, twenty years after the first Model T rolled off the production line. If a similar timeline for AV deployment and market penetration holds, we won't see AVs outnumber human-driven vehicles until sometime in the 2030's and won't see a completely autonomous fleet until somewhat later. This means that for the next 20+ years we will be operating in a mixed traffic environment including human-driven vehicles, occupied AVs and unoccupied AVs.

Some AVs will operate as part of a centrally owned, shared autonomous fleet in which vehicles are routed according to real-time requests similar to current human-driven e-hailing services. However, a not insignificant portion of AVs will continue to be owned by a single household. The availability of an AV in a household may allow them to own fewer vehicles at a considerable cost savings, as a single AV could be used to meet multiple household members' tripmaking needs provided it could reach the next household member in time to get them to their destination on time. This means that a significant portion of the AV travel time will be unoccupied, depending on the tripmaking needs of the household. These unoccupied AVs will impact the travel times of occupied AV and human-driven vehicles. It seems obvious that the travel needs of occupied vehicles (AV and human-driven) should be prioritized, and that empty AVs should be routed to minimize the impacts on occupied vehicles. However, if unoccupied AVs are assigned a route that is too circuitous, it may not be able to meet a household's tripmaking needs – requiring additional vehicles and eliminating the cost savings for the household of owning an AV.

The focus of this presentation is: How do we route unoccupied AVs to minimize the impacts on occupied vehicles without disproportionally hurting households that own an AV?

Social-STGCNN: A Social Spatio-Temporal Graph Convolutional Neural Network for Human Trajectory Prediction

Technical Session #2: Connected and Autonomous Vehicle and Machine Learning Applications

11:40 – 12:00 PM - Speaker: Claudel Christian, Ph.D., University of Texas at Austin

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Abstract:
Better understanding of pedestrian paths leads to safer and more efficient interactions between pedestrians and vehicles. Pedestrian trajectories are not only influenced by the pedestrian itself but also by its interactions with surrounding pedestrians and vehicles. Previous methods modeled these interactions by using a variety of aggregation methods that integrate different learned pedestrians states. We propose the Social Spatio-Temporal Graph Convolutional Neural Network (Social-STGCNN), which substitutes aggregation methods by a graph based model. Our results show more accurate predictions of future pedestrian positions, using drone-captured video datasets. In particular, Social-STGCNN leads to a 20\% improvement over state-of-the-art methods on the Final Displacement Error (FDE) and an improvement on the Average Displacement Error (ADE), with 8.5 times less parameters and up to 48 times faster inference speed than previously reported methods. In addition, this model is data efficient, and exceeds previous state of the art on the ADE metric with only 20\% of the training data. We propose a kernel function to embed the social interactions between pedestrians within the adjacency matrix. Through qualitative analysis, we show that the model encodes social behaviors that can be expected between pedestrians and other vehicles.

Estimation of Pedestrian Volume Using Geospatial and Traffic Conflict Data

Technical Session #3: Improving Multimodal Mobility: Leveraging Data and Advanced Analytics

3:10 – 3:30 PM - Speaker: John Ivan, Ph.D., P.E., University of Connecticut

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Abstract:
To increase the share of walking in urban areas, it is important that people feel safe walking in the road environment. Crossing a road results in interactions between vehicles and pedestrians. This study uses the severity of these interactions between pedestrians and vehicles to represent the safety perceived by the pedestrians at a crosswalk to help predict how much walking occurs there. Interactions between pedestrians and motor vehicles observed at 105 crosswalks in the municipalities of Hartford, Waterbury, and Ansonia in the State of Connecticut, USA are used in the analysis. The relationship between the odds of getting into a severe conflict with a vehicle at the crosswalk and the pedestrian volume observed at the crosswalk is determined while also considering contributions of the land use in the vicinity. It is found that crosswalks with higher odds of getting into severe conflicts experienced lower pedestrian volume while controlling for the effects of land use. Therefore, it is concluded that severe conflicts at a crosswalk have a negative impact on the perception of safety at the crosswalk resulting in lower pedestrian counts.

Highways and Wealth Distribution: A Geospatial Analysis

Technical Session #3: Improving Multimodal Mobility: Leveraging Data and Advanced Analytics

3:30 – 3:50 PM - Speaker: Jeffrey P. Cohen, Ph.D., University of Connecticut

Authors:

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Abstract:
Wealth distribution within U.S. cities is an issue that has come to the forefront of policy debate. In addition to impacting wealth distribution through different patterns of the accumulation of real estate wealth, highways have changed America's land use patterns, affected travel behavior, shaped domestic and international trade, and influenced the development of the manufacturing sector, as well as other industries. The magnitude of highway investment economic impacts remains subject to significant debate because of a great deal of variance in the estimates of the impacts. But relatively little research has been published on the wealth distribution effects of the introduction of the U.S. interstate highway system on household-level real estate values. A major focus of this research is to leverage geospatial analysis to assess the net benefits households have received from living near highways (which may be positive or negative). Housing is the largest expenditure item for many American households, and it is one of the major mechanisms for households to accumulate wealth. The introduction of new highways can substantially change land use patterns and the values of real estate nearby. Geospatial analyses are crucial tools to examine highways, land use, and wealth distribution.

This study first develops an extensive dataset of nearly 2,500 residential properties in the City of Hartford that sold in the 1960's (after the development of the two major interstates, I-84 and I-91) and matched the data for each of these properties to the corresponding property in the 1940 U.S. Census. So for each property address, there are 2 observations on that property's estimated value – one before the development of the interstate highway system (in 1940) and one after the opening of the two major interstate highways that run through Hartford (in the 1960's). After geocoding these properties, several geospatial maps are developed, demonstrating how the changes in values in these properties over time are different in various parts of the city. Included among these maps is one showing properties that appreciated and one showing dollar ranges for the home value appreciation. While some patterns are evident from visual inspection of these maps, a more rigorous analysis using multiple regression analysis finds the following. First, properties closer to the nearest exit of I-84 have experienced appreciation between 1940 and the 1960's. Second, proximity to the nearest point on the highway (opposed to the nearest exit) leads to lower appreciation in property values, likely because of noise and air pollution. Next, properties that were

worth more in 1940 actually appreciated less between the period of 1940 and the 1960's, after controlling for highway proximity and drive time to the highway. The racial composition of the Census tract in 1940 had no significant effect on individual property value appreciation between 1940 and the 1960's. Finally, we also develop a Lorenz Curve to demonstrate the level of inequality in the distribution of real estate wealth that has accrued due to the development of the new highway.

Developing Friction Data to Support the Optimal Use of Pre-Wet Deicing Salt in Pacific Northwest

Technical Session #3: Improving Multimodal Mobility: Leveraging Data and Advanced Analytics

3:50 – 4:10 PM - Speaker: Xianming Shi, Ph.D., P.E, Washington State University

Authors:

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Abstract:

More than 70% of the U.S. roads and about 70% of the U.S. population are located in cold regions, where winter weather tends to reduce both the average traffic speed and traffic volume, whereas the implementation of winter road maintenance operations tends to mitigate such reductions. Applying pre-wet deicers to roads during adverse winter weather is a cost-effective tactic to improve transportation safety and mobility in cold climates. Pre-wet deicers have a small amount of liquid product applied to solid salt or salt/sand mixture which speeds up the process of ice melting and ice penetration and significantly reduces deicer bounce-and-scatter loss. Pre-wetting keeps the deicer product on the pavement and improves the ability of plows to remove compacted snow and ice. While many roadway agencies use pre-wet deicers, there is not enough reliable data to determine optimal pre-wetting rates or product type.

This study first presents the results of an in-depth survey of the Pacific Northwest Northwest (Oregon, Washington, Alaska, and Idaho) on pre-wetting practices and then presents laboratory tests that quantified the ice melting, frictional behavior, and variation in snow–pavement bond strength of salt pre-wetted with various liquid deicers and at various rates. Pre-wetting is commonly performed by Pacific Northwest state departments of transportation with 10–12 gal./t being the most common pre-wetting rate. An ice melting test is a broadly accepted method to gauge the basic performance of deicers in a laboratory. More sophisticated laboratory tests on asphalt pavement samples with realistic snow and representative trafficking motion and forces were conducted. The laboratory tests confirmed that the pre-wetting liquid-to-solid application rate in the range of 8–16 gal./t is reasonable for increasing the speed and total ice melting capacity (IMC) of solid salt. Relative to dry salt, pre-wetting significantly reduced snow–pavement bond strength but did not show a consistently beneficial effect of increased friction. The best performing pre-wetting liquid concerning friction and snow–pavement bond was beet juice modified salt brine at a pre-wetting rate of 8.7 gal./t. While this laboratory investigation provided insights and friction data to support optimal use of pre-wet deicer, field testing should be conducted to assess the effects of various pre-wetting liquid-to-solid

application rates and specific liquid products to: (1) reduce bounce-and-scatter, (2) reduce overall salt application rates, (3) improve friction, (4) reduce the time to regain bare pavement, and (5) increase the longevity of winter traction materials under variable speed traffic.

Entropy-based Diversity Quantification of Multimodal Transportation Systems: Physical Infrastructure Perspective versus Travel Behavior Perspective

Technical Session #3: Improving Multimodal Mobility: Leveraging Data and Advanced Analytics

4:10 – 4:30 PM - Speaker: Jin Zhu, Ph.D., University of Connecticut

Authors:

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Abstract:
Multimodal transportation serves diverse needs, and enhances the efficiency and fairness in travel. Despite the increased demands in multimodal transportation development, there lacks an integrated framework and associated quantitative methodology to assess the level of diversity of a multimodal transportation system.
To this end, the objective of this study is to develop an integrated framework to assess the diversity of a multimodal transportation system from both physical infrastructure perspective and travel behavior perspective. From the physical infrastructure perspective, the functional richness and evenness of each transportation mode in a region are calculated and aggregated into one diversity measurement using entropy weight method. From the travel behavior perspective, the diversity of travelers' behaviors in a region is quantified based on the number of trips made by each mode using entropy method. The proposed framework was implemented in a case study of the city of Hartford, CT. The physical infrastructure diversity and travel behavior diversity of multimodal transportation systems in six zip code areas of Hartford were calculated and compared. The case study results showed that the physical infrastructure diversity and travel behavior diversity revealed similar trends in most areas in the case study, with some exceptions which could potentially be explained based on socio-economic factors of different regions. The proposed framework could help transportation planners and decision makers in obtaining a holistic understanding of the diversity level of a multimodal transportation system, and considering planning strategies to enhance diversity in travel.

STUDENT LIGHTNING SESSION & ABSTRACTS FOR PRESENTATIONS:

Lightning Session: Thursday, November 5 (1:30-2:50PM)
(Coordinator: Dr. Pengfei Liu)
Registration Link: https://uncc.zoom.us/webinar/register/WN_pu2d818rSJaxsgcp0Tu9QA

ID	Authors	Title	Institution
L01	Mehrdad Tajalli	Dynamic Speed Harmonization in Connected Urban Street Networks: Improving Mobility	WSU
L02	Enamul Karim Fayek	Impact of Non-Motorized vehicle on Road Network Performance in Heterogeneous Traffic System	TSU
L03	Jinli Liu	Analysis of Factors Contributing to the Severity of Large-Truck Crashes	TSU
L04	Juan Li	COVID-19 on International Shipping: Impacts, Countermeasures and Recommendations	TSU
L05	Sruthi Mantri	Prioritizing people – mixed equilibrium assignment for AV based on occupancy	UCONN
L06	Asadul Tanvir	Using Computational Biology to Mitigate Path Overlap in Transit Assignment	UCONN
L07	Jenny Hall	Forecasting Bicycle Facility Demand	UT Austin
L08	Kun Qian	Real-time Mobile Sensor Management Framework for City-Scale Environmental Monitoring	UT Austin
L09	Suyash Vishnoi	Variable Speed Limit and Ramp Metering Control of Highway Networks using Lax-Hopf Method: A Mixed Integer Linear Programming Approach	UT Austin
L10	Bo Qiu	Travel Time Forecasting on a Freeway Corridor: a Dynamic Information Fusion Model based on the Random Forests Approach	UNCC
L11	Shaojie Liu	Investigating Factors Affecting Injury Severity in Bicycle-Vehicle Crashes: A Day-of-Week Analysis with Partial Proportional Odds Logit Models	UNCC
L12	Li Song	Exploring Pedestrian Injury Severities at Pedestrian-Vehicle Crash Hotspots with an Annual Upward Trend: A Spatiotemporal Analysis with Latent Class Random Parameter Approach	UNCC

See Abstracts for lightning presentations in Pages 25 through 36.

Abstracts for Student Lightning Presentations:

Lightning L01:

Dynamic Speed Harmonization in Connected Urban Street Networks: Improving Mobility

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Abstract:
Connected vehicle and other advance communication technologies create possibilities to facilitate the movement of vehicles through transportation networks and reduce their travel time. Optimizing the speed of vehicles throughout the network not only increases the utilization of network capacity, but also improves the mobility of the system to achieve a "smoother" flow of traffic. However, network-wide speed harmonization is a complex problem due to its nonlinear nature and abundance of decision variables. In addition, controlling vehicles speeds in the network in real time is a complicated problem.

This study formulates the Dynamic Speed Harmonization (DSH) problem using the Cell Transmission Model (CTM) as a macroscopic network-loading model. A nonlinear mathematical multi-objective program is developed aiming at improving traffic operations as well as harmonizing vehicles speeds temporally and spatially. We have converted the nonlinear problem into a linear program utilizing the fundamental flow-density relationship. As a result of this reformulation, the complexity of the problem is significantly reduced. We tested the proposed formulation and solution technique in a realistic case study network of 20 intersections under several demand patterns. The algorithm reduced the travel time by up to 5.4%, speed variance by 19.8%-29.4%, and number of stops by 8.3-18.5%. At the same time, DSH increased the average speed and number of completed trips by up to 5.9% and 4%, respectively in our case study network under all tested demand patterns.

Lightning L02:

Impact of Non-Motorized vehicle on Road Network Performance in Heterogeneous Traffic System

Enamul Karim Fayek
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Abstract:
In developing countries, the traffic is composed of both motorized vehicles and non-motorized vehicles using the same roadway, hence the resulting traffic system is non-lane-based and heterogeneous. The motorized or fast-moving vehicles are mostly buses, cars, taxis, trucks whereas the slow-moving vehicles referred to as non-motorized vehicles (NMV) consist of rickshaws and bicycles, which is different in driving behavior and shows a lack of lane discipline. Even though the proportion of NMV varies from 10-80 percent, it has a major impact on the traffic characteristics and operations at the signalized intersections. NMV not only reduces the roadway capacity and speed of the motorized vehicle but also induces congestion at signalized intersections while discharging and affects the queue length and delay time. Dhaka the capital city of Bangladesh. The Dhaka Metropolitan Area (DMA) has a population of 10.7 million (7.5% of the total population of the country in 2006). Currently, urban transportation in DMA mostly relies on road transport, where the car, bus auto-rickshaw, rickshaw, etc. are coexistent. This creates serious traffic congestion in addition to the health hazard caused by traffic including air pollution. Several expressways and flyovers have been constructed and are being operated for a considerable period. Also, to improve public transportation, a good number of buses are now introduced in the network along with taxicabs. But the strategies have not been proved effective as expected so far resulting in the persistence of congestion. The most dominating reason behind the failure of all the strategies taken to alleviate traffic congestion is due to heterogeneous characteristics of the traffic stream using the same right of way. The stream comprises slow non-motorized vehicles at one extreme and the fast-moving motorized cars at the other, with many intermediate types of vehicles depicting a wide variation in static and dynamic characteristics. The outcome of this study is that it can be used as a good reference to visualize the effect of Non-Motorized Vehicle on MV in a road network in terms of delay, queue length, and travel time. Through this study, one can visualize and quantify the effect of countermeasure taken to minimize the adverse effect of NMV on the network, so that the evaluation of alternatives can be done effectively.

Lightning L03:

Analysis of Factors Contributing to the Severity of Large-Truck Crashes

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Abstract:
Crashes that involved large trucks often result in immense human, economic, and social losses. To prevent and mitigate severe large truck crashes, factors contributing to the severity of these crashes need to be identified before appropriate countermeasures can be explored. In this research, we applied three tree-based machine learning (ML) techniques, i.e., random forest (RF), gradient boost decision tree (GBDT) and Adaptive Boosting (AdaBoost), to analyzing the factors contributing to the severity of large truck crashes. Also, a mixed logit model has been developed as a baseline model to compare with the factors identified by the ML models. The analysis was performed based on the crash data collected from the Texas Crash Records Information System (CRIS) from 2011 to 2015. The results of this research demonstrated that the GBDT model outperforms other ML methods in terms of its prediction accuracy and its capability in identifying more contributing factors that were also identified by the mixed logit model as significant factors. Besides, the GBDT method can effectively identify both categorical and numerical factors, and the directions and magnitudes of the impacts of the factors identified by the GBDT model are all reasonable and explainable. Among the identified factors, driving under the influence of drugs, alcohol, and fatigue are the most important factors contributing to the severity of large-truck crashes. In addition, the exists of curbs and medians, and lanes and shoulders with sufficient width can prevent severe large-truck crashes.

Lightning L04:

COVID-19 on International Shipping: Impacts, Countermeasures and Recommendations

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Abstract:
The outbreak of COVID-19 marks as an unanticipated epidemic all over the world, launching a huge impact on people's lives, families, and communities. So far, over 16 million people worldwide have been infected and over 650,000 people died of the virus. This widespread pandemic has had a devastating impact on industries of all fields globally. International shipping is one of the majorly affected industries in this outbreak. Vessels, crew, and cargoes are subjected to quarantine during the transportation process to prevent the escalation of COVID-19 and this disrupted the trade chains. Blank sailings increased, capacity slashed, freight rates increased and COVID-19 pandemic has created havoc in the industry and resulted in unprecedented curtailment levels. Companies related to international shipping will need to become agile and adaptable to this changing situation and focus on building effective response strategies and plans. This paper first analyses the impacts of COVID-19 on international freight shipping, such as blanking sailing, demurrage and detention, and ocean freight rate. Then corresponding countermeasures are introduced, including implementing preventive measures in ports, promoting digital customs clearance, and facilitating access to essential medical goods. Finally, to alleviate further impacts and to cope with future catastrophes, recommendations, and emergency plans are put forward for reference.

Lightning L05:

Prioritizing people – mixed equilibrium assignment for AV based on occupancy

Sruthi Mantri
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Abstract:
Autonomous Vehicles (AV) have the potential to revolutionize transportation operations mode choice. In June 2017, Connecticut Public Act No. 17-69 "An Act Concerning Autonomous Vehicles" authorized the testing of AVs on Connecticut roads. In April 2018, Connecticut launched the Fully Autonomous Vehicle Testing Pilot Program (FAVTPP), which set the permitting and testing requirements for AVs on public roads. Although there is optimism that introduction of AVs will mitigate traffic congestion and vastly improve safety, the transition to a completely AV fleet - which will take time - presents non-trivial problems. In the United States, automobiles did not begin to outnumber horses on roadways until the late 1920's, twenty years after the first Model T rolled off the production line. If a similar timeline for AV deployment and market penetration holds, we won't see AVs outnumber human-driven vehicles until sometime in the 1930's and won't see a completely autonomous fleet until somewhat later. This means that for the next 20+ years we will be operating in a mixed traffic environment including human-driven vehicles, occupied AVs and unoccupied AVs.

Some AVs will operate as part of a centrally owned, shared autonomous fleet in which vehicles are routed according to real-time requests similar to current human-driven e-hailing services. However, a not insignificant portion of AVs will continue to be owned by a single household. The availability of an AV in a household may allow them to own fewer vehicles at a considerable cost savings, as a single AV could be used to meet multiple household members' trip making needs provided it could reach the next household member in time to get them to their destination on time. This means that a significant portion of the AV travel time will be unoccupied, depending on the trip making needs of the household. These unoccupied AVs will impact the travel times of occupied AV and human-driven vehicles.

It seems obvious that the travel needs of occupied vehicles (AV and human-driven) should be prioritized, and that empty AVs should be routed to minimize the impacts on occupied vehicles. However, if unoccupied AVs are assigned a route that is too circuitous, it may not be able to meet a household's trip making needs – requiring additional vehicles and eliminating the cost savings for the household of owning an AV. The focus of this project is route unoccupied AVs to minimize the impacts on occupied vehicles without disproportionally hurting households that own an AV. Differential route assignment for occupied versus unoccupied vehicles while considering impacts of unoccupied AV route choice on AV owners was proposed in this work.

Lightning L06:

Using Computational Biology to Mitigate Path Overlap in Transit Assignment

Asadul Tanvir
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Abstract:
Path overlap is a well-recognized issue in transit route choice modeling. Modeled passengers often fail to identify the level of independence in routes when choice sets have overlapping segments or shared characteristics. This is prevalent in schedule-based transit assignment models where incorrect path estimation can occur systemically. Several modifications to the logit models (i.e. path-size logit) have been proposed so far for overcoming this issue.

In this study, an alternative approach is proposed which will capture the direct dependency of the paths both sequentially and spatially in the path generation step. All the viable paths between OD pairs are generated first using an importance sampled branching tree search algorithm. The pairwise comparison of all the paths is then computed using the longest common subsequence similarity (LCSS) algorithm. Based on the similarity metric found from this pairwise LCS comparison, the paths of similar costs and attributes are then bundled together as k-dissimilar paths. A dimensional reduction technique such as multi-dimensional scaling (MDS) plots can be used to visualize the k-dissimilar path outputs. This method is much more robust and it calculates the level of spatially overlapped stops ahead of time in the preprocessing stage, this will eliminate the need for overlap correction factor used in the existing transit route choice models.

Lightning L07:

Forecasting Bicycle Facility Demand

Jenny Hall
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Abstract:
Executive Order 12898: Environmental Justice in Minority Populations and Low-Income Populations was officially issued on February 11, 1994, by President Clinton. This order "requires each federal agency to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations" (Federal Register, 1994).

Some efforts to address the problem of environmental injustice toward minority and low-income populations include the incorporation of bicycle facilities into an infrastructure. Some well-known positive impacts that come with bicycle facilities are better health, an increase in food availability, employment access, and ultimately regional sustainability. To begin the process of identifying all the other positive impacts that could come with the implementation of bicycle facilities one must estimate how many users these bicycle facilities will attract, in other words, forecast the user demand of these bicycle facilities. This study focuses on off-street bicycle facilities and began this report by evaluating current and past predictive models that are used for forecasting off-street bicycle facility demand. Noting these past models, we created multiple statistical models from locally sourced data that can connect bicycle facility counts to time, demographics, and weather data. Due to the lack in the sheer number of off-street bicycle counters throughout the City of Austin, the demographic data was unable to correlate to the Austin off-street bicycle counts, yet it was determined that all three demand models can be applied to different off-street bicycle facilities only if locally sourced data is acquired.

Lightning L08:

Real-time Mobile Sensor Management Framework for City-Scale Environmental Monitoring

Kun Qian
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Abstract:
Environmental disasters such as flash floods are becoming more and more prevalent and carry an increasing burden to human civilization. They are usually unpredictable, fast in development and extend across large geographical areas. The consequences of such disasters can be reduced through better monitoring, for example using mobile sensing platforms that can give timely and accurate information to first responders and the public. Given the extended scale of the areas to monitor, and the time-varying nature of the phenomenon, we need fast algorithms to quickly determine the best sequence of locations to be monitored. This problem is very challenging: the present informative mobile sensor routing algorithms are either short-sighted or computationally demanding when applied to large scale systems. In this paper, a real-time sensor task scheduling algorithm that suits the features and needs of city-scale environmental monitoring tasks is proposed. The algorithm is run in forward search and makes use of the predictions of an associated distributed parameter system, modeling flash flood propagation. It partly inherits the causal relation expressed by a search tree, which describes all possible sequential decisions. The computationally heavy data assimilation steps in the forward search tree are replaced by functions dependent on the covariance matrix between observation sets. Taking flood tracking in an urban area as a concrete example, numerical experiments in this paper indicate that this scheduling algorithm can achieve better results than myopic planning algorithms and other heuristics-based sensor placement algorithms. Furthermore, this paper relies on a deep learning-based data-driven model to track the system states, and experiments suggest that popular estimation techniques have very good performance when applied to precise data-driven models.

Lightning L09:

Variable Speed Limit and Ramp Metering Control of Highway Networks using Lax-Hopf Method: A Mixed Integer Linear Programming Approach

Suyash Vishnoi
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Abstract:
This paper presents a novel optimization formulation to solve the problem of variable speed limit control on road networks modeled by the Lighthill-Whitham-Richards (LWR) partial differential equation. It also presents some mathematical rules that allows for a reduction in the size and computational time of the optimization problem. Using the analytical solutions to the LWR model, an optimization problem is formulated for the variable speed limit and ramp metering control of traffic on highway networks using the Lax-Hopf algorithm. The resulting problem, which is non-linear in the decision variables, is transformed into a Mixed Integer Linear Program. An example is presented to show the effectiveness of the approach, including its application to a real-world highway network with multiple ramp connections. The method is also compared to a classical Link Transmission Model formulation of the variable speed limit control problem. Lastly, the possibility of linear relaxation of integer variables in the problem is considered.

Lightning L10:

Travel Time Forecasting on a Freeway Corridor: a Dynamic Information Fusion Model based on the Random Forests Approach

Bo Qiu
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Abstract:
Recently, the need for travel time prediction has become indispensable due to the increasing congestion in the roadway network. However, travel time prediction is highly complex as it is affected by a wide variety of factors. The acquisition and popularization of big data in the field of transportation have enabled the collection and diffusion of real-time traffic information. Different machine learning approaches have been employed by different researchers, and the results indicate that such approaches can give better performances than traditional models. However, such machine learning methods are practically faced with an overfitting problem that is difficult to overcome. Especially, when the traffic conditions greatly change, the prediction results are often unsatisfactory. In addition, the random forests (RF) method has a very good Bias-Variance trade-off which can help avoid the overfitting problem. This research develops an RF method to predict the freeway travel time by using the probe vehicle-based traffic data, and therefore helps to gain a better understanding of how different contributing factors might affect travel time on freeways. Detailed information about the input variables and data pre-processing is presented. Parameters of the RF model are estimated, the parameter tuning process is also discussed, and the relative importance of each variable and their ranks in the RF model are also presented. Results indicate that RF always produces more accurate travel time prediction.

Lightning L11:

Investigating Factors Affecting Injury Severity in Bicycle-Vehicle Crashes: A Day-of-Week Analysis with Partial Proportional Odds Logit Models

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Abstract:
Cyclists are vulnerable road users and prone to experience severe injury when accidents occur. Both driving and riding behaviors of drivers and cyclists could vary in different days of week, which further influences the injury severity of crashes involving cyclists.
Cyclist riding behaviors are likely to present different patterns in different time periods, such as day of week, which could have an impact on injury severities. Since few studies have been conducted on the injury severity analysis of crashes involving cyclists in terms of days of week,
This study aims to investigate the factors that affect injury severity in crashes involving cyclists on weekdays and weekends separately using police-reported data ranging from 2007 to 2018 in North Carolina.

The impact of cyclist, driver, vehicle, road, environment, and crash characteristics on injury severities are explored. Ordered logit model and partial proportional odds (PPO) logit models are developed respectively for the injury severities of crashes on weekdays and weekends. Different sets of significant factors are identified for weekdays and weekends. For the common factors identified for both weekdays and weekends, the influencing extent of significant variables varies significantly between weekdays and weekends. Older-aged cyclists, riding direction, pickup, older-aged drivers, male drivers and periods of 0-5:59 and 10:14:59 are only found significant on weekdays while speed limits of 45-55mph, piedmont areas, commercial development, head-on, and non-roadway locations are only found significant for injury severities of crashes on weekends. Speed limits, time of day, alcohol usage are found to have different or even opposite impacts on the injury severities of crashes on weekdays and weekends.

Lightning L12:

Exploring Pedestrian Injury Severities at Pedestrian-Vehicle Crash Hotspots with an Annual Upward Trend: A Spatiotemporal Analysis with Latent Class Random Parameter Approach

Li Song
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Abstract:
With the increasing trend of pedestrian deaths among all traffic fatalities in the past decade, there is an urgent need for identifying and investigating hotspots of pedestrian-vehicle crashes with an upward trend. To identify pedestrian-vehicle crash locations with aggregated spatial pattern and upward temporal pattern (i.e. hotspots with an upward trend), this paper first uses the average nearest neighbor and the spatial autocorrelation tests to determine the grid distance and the neighborhood distance for hotspots, respectively. Then, the spatiotemporal analyses with the Getis-Ord Gi* index and the Mann-Kendall trend test are utilized to identify the pedestrian-vehicle crash hotspots with an annual upward trend in North Carolina from 2007 to 2018. Considering the unobserved heterogeneity of the crash data, a latent class model with random parameters within class is proposed to identify specific contributing factors for each class and explore the heterogeneity within classes. Significant factors of the pedestrian, vehicle, crash type, locality, roadway, environment, time, and traffic control characteristics are detected and analyzed based on the marginal effects. The heterogeneous results between classes and the random parameter variables detected within classes further indicate the superiority of latent class random parameter model. This paper provides a framework for researchers and engineers to identify crash hotspots considering spatiotemporal patterns and contribution factors to crashes considering unobserved heterogeneity. Also, the result provides specific guidance to developing countermeasures for mitigating pedestrian-injury at pedestrian-vehicle crash hotspots with an upward trend.

Workshops: Friday, November 6, 9:00 – Noon

Workshop #1: **Are E-Scooters a Transit Last-Mile Solution?**
9:15-10:15AM - Speaker: Randy Machemehl, Ph.D., P.E., University of Texas at Austin
Registration Link: https://uncc.zoom.us/webinar/register/WN_Sc7vCmJNSV6aJnHWCds5xQ
Notes: Any participants can join this Zoom meeting at 9:00 AM (EDT) at which time the CAMMSE director will deliver opening remarks, and the first workshop will then start at 9:15 AM (EDT).

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Abstract:
Travel from trip origin to a bus stop and from destination bus stop to the final trip destination is often called the "transit last mile". E-scooters appear to be a suitable mode for the last-mile, yet E-scooter impacts on transit are not well understood. This research considers the interaction of E-scooter and bus transit services and provides an overview of e-scooter trips and user characteristics. Publicly available datasets are used to identify and evaluate the relationship between E-scooter and transit trips. Identifying this relationship can be challenging because of many confounding factors that affect demand for both modes. A methodological framework describing E-scooter last-mile models is developed by isolating confounding variables from transit trips using gradient boosting regression and non-linear relationships. A revealed-preference survey was conducted to evaluate E-scooter usage near the University campus which is one of the highest demand areas. The survey indicated that 12 percent of the e-scooter users employed transit to complement their trips. Users in this area tend to be young, they traveled mainly for work-related purposes, and presented a gender gap with 18 percent more male than female users. The analyses examined population characteristics, modal shift, and mode interaction. Findings suggest the proposed modeling framework can be used to identify areas with potential E-scooter and transit interaction. A statistically significant relationship was found near the University campus and downtown areas.

Workshop #2: **Signal Timing and Geometric Design at Intersections with Contraflow Left-Turn Lanes**

10:45-11:45AM - Speaker: Yi Qi, Ph.D., Texas Southern University

Registration Link: https://uncc.zoom.us/webinar/register/WN_uvU0yq7iSSWG4_g6EUoGGQ

Notes: Any participants can join this Zoom meeting at 10:30 AM (EDT); however, this second workshop will not start until 10:45 AM (EDT).

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Abstract:
An innovative intersection design, Contraflow left-turn lane (CLL), designed for increasing the left-turn capacity has been increasingly implemented at the signalized intersections. This presentation is to introduce a systematic method for determining the length of CLL and the signal timing plan for implementing CLL at signalized intersections. At first, the signal timing and geometric design requirements in the implementation of CLL were analyzed. Then, these requirements were thoroughly considered in the development of the proposed method. A case study was conducted for evaluating the operational benefits of redesigning a real-world CLL intersection using the recommended signal timing plan and CLL lengths. The results of the case study show that the redesigned CLL intersection outperforms the existing CLL intersection in terms of the average traffic delay, average vehicle travel time, and average queue length, and the CLL intersection can achieve its best performance at the recommended CLL lengths.