NCDOT Center of Excellence on Mobility and Congestion

Center Overview
Outline

• Foundational principals
• Team formation
• Project development
• Team structure
• Center communications
Foundational Principals

- Exploit the ITRE/NCSU expertise and leadership in traffic operations, management, and control to build and lead a Mobility and Congestion CoE team.
- Select the team members and develop the center projects to be fully responsive to the NCDOT goals of –
  - Leveraging “multi-disciplinary skills and knowledge across multiple universities”
  - Including “Historically Black Colleges and Universities and Minority Serving Institutions”
  - Providing “a long-term view and cutting-edge approach”
  - Addressing the multifaceted research areas outlined in the request for proposals.
Team Formation

- Goal of at least two HBCU/MSI team members
- Build on current relationships
- Nurture new relationships
Team Institutions

NC State University

The University of North Carolina at Chapel Hill

Fayetteville State University

North Carolina Agricultural and Technical State University

Duke
Project Development

- The RFPs five research areas were mapped to three themes.
- All interested researchers (~40) across the five universities were invited to submit research ideas.
- Fourteen research ideas emerged and were evaluated and ranked by all participants.
- This process resulted in the three projects included in the center proposal – One project for each theme.
Team Structure – Center Leadership

- **Director**
  - Billy M. Williams, Ph.D., P.E. – NC State University/ITRE
- **Associate Directors**
  - Mary (Missy) Cummings, Ph.D. – Duke University
  - Sambit Bhattacharya, Ph.D. – Fayetteville State University
  - Maranda McBride, Ph.D. – NC A&T State University
- **Co-Associate Directors**
  - Noreen McDonald, Ph.D. – University of North Carolina at Chapel Hill
  - Randa Radwan, Ph.D. – University of North Carolina at Chapel Hill
Collaborative Project Team Structure

- **NCSU/ITRE**
  - Leading Project 3
  - Co-PI on Project 3
  - Researchers on all projects
- **Duke**
  - Leading Project 2
- **Fayetteville State University**
  - Leading Project 1
  - Researchers on Project 1 and Project 3
- **NC A&T State University**
  - Co-PI on Project 1 and Project 3
  - Researcher on Project 3
- **UNC-CH**
  - Co-PI on Projects 1 and 3

- **Project 1**
  - Led by Fayetteville State University
  - Collaboration from NCSU/ITRE and NC A&T State University
- **Project 2**
  - Led by Duke
  - Collaboration by NCSU/ITRE and UNC-CH/HSRC
- **Project 3**
  - Led by NCSU/ITRE
  - Collaboration by Fayetteville State University, NC A&T State University, and UNC-CH/DCRP
Center Communications

• A secure Google Shared Drive is established
• Monthly center meetings timed to follow project meetings
• Most meetings will be held using the Zoom video conferencing system
• Face-to-face meetings will be held as needed
• Meetings with NCDOT will be coordinated as needed with Dr. Curtis Bradley
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Project 1
Deep Learning Software for Traffic State Prediction
Project Team

- Principal Investigator – **Sambit Bhattacharya, Ph.D.**
  - Professor of Computer Science – Fayetteville State, Dept of Math & Computer Science
  - Director – Intelligent Systems Lab (ISL)
- Co-Principal Investigators
  - **Ali Hajbabaie, Ph.D.** – NC State, Assistant Professor in the Department of Civil, Construction, and Environmental Engineering
  - **Noel Greis, Ph.D.** – NC State, Research Full Professor, Poole College of Management
  - **Hyoshin (John) Park, Ph.D.** – NC A&T, Assistant Professor in the Department of Computational Science & Engineering
- Senior Researchers
  - **Murat Adivar, Ph.D.** – Fayetteville State, Associate Professor, Broadwell College of Business & Economics
  - **George List, Ph.D.** – NC State, Professor in the Department of Civil, Construction, and Environmental Engineering
  - **Thomas Chase, Ph.D.** - NC State, Research Associate in the Institute for Transportation Research and Education
Project Goals

• Develop edge computing and deep learning software which utilizes video, loop detector and Bluetooth sensor data to better estimate traffic states on arterials
• Test software with traditional signal control and a CV-enabled signal control algorithm in VISSIM
• These capabilities will assist in
  – improved performance measures for integration into existing tools like ATSPM
  – temporary deployment for signal retiming or loop detector calibration
  – driver information through connected vehicle applications
Methodology

• Deep/machine learning AI approach to prototype software design
• Steps will include –
  – Data collection on real and simulated traffic
  – Develop single stream video analytics
  – Develop multi stream video analytics
  – Develop data fusion methods
  – Test hypothesis that advanced traffic signal control algorithm performs better optimization with this traffic state estimate
Communication Tools

• Bi-weekly team meetings – Teleconference and face-to-face
• NCDOT & Committee Members - interim meetings
• External communication
  – Leverage existing educational programs for high school and undergraduate students targeted at STEM majors
  – Key results made available to transport policy organizations at both the state and federal levels
Final Project Outputs

• Video analytics pipeline
• Robust data fusion techniques
• Prototype application that integrates software and hardware using “edge-computing” design
• Simulation environment for loop testing
• Comprehensive dataset to include all data collected
• Presentation and recorded webinar on the project findings and results
• Final report that documents all findings of the research
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Project 2
Smart Connected and Automated Vehicle Fleet Management: Developing Regional Dispatch Decision Support for Congestion Mitigation
Project Team

• Principal Investigator – Mary “Missy” Cummings, Ph.D.
  – Professor – Duke University
    • Department of Electrical and Computer Engineering
    • Department of Computer Science
    • Robotics program
    • Institute for Brain Sciences
  – Director – Humans and Autonomy Lab (HAL)
• Co-Principal Investigators
  – Eleni Bardaka, Ph.D. – NC State, Assistant Professor in the Department of Civil Construction and Environmental Engineering
  – Raghavan “Srini” Srinivasan, Ph.D. – UNC-CH, Senior Transportation Research Engineer at the Highway Safety Research Center
• Senior Researcher – Nagui Rouphail, Ph.D. – NC State, Professor in the Department of Civil Construction and Environmental Engineering
Project Goals

- Develop a supervisory capability in regional dispatch center
- Provide state and/or local authorities with monitoring of and direct communications with traditional, connected, and autonomous vehicles
- These capabilities will assist dispatcher/operators in –
  - Developing mitigation actions to reduce congestion
  - Managing planned and urgent/emergent scenarios
Methodology

• Systems engineering approach to prototype system design

• Prototype design steps will include –
  – Concept of operations analysis for NC’s statewide and regional traffic management centers
  – Develop a dispatch operator interface linked to traffic flow models and AI-empowered solution searching
  – System testing across various concept of operations and edge case scenarios
Communication Tools

- Monthly team meetings – Teleconference and face-to-face
- External communication
  - Journal and conference papers
  - Participation in appropriate conferences and symposia
  - Outreach events
    - Internship opportunities for undergraduate and high school students
    - Participation in regional STEM activities such as NC A&T’s Summer Transportation Institute
Final Project Outputs

- Concept of Operations (CONOPS) for regional monitoring and dispatch in a mixed traffic (TV/CV/AV) environment describing the –
  - Operational needs
  - System characteristics
  - Functional requirements
- AI-based algorithms for managing mixed traffic flow
- Prototype decision tool that embeds the AI algorithms and focuses on resource allocation and path planning
- Documentation of algorithm and decision tool testing
- Recommendations for state-level implementation
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Project 3
Transit and MaaS Role in Improving Economic and Healthcare Access for Underserved Populations
Project Team

- Principal Investigator
  - Kai Monast, MRP, Director, Public Transportation Group – NCSU/ITRE
- Co-Principal Investigator
  - Noreen McDonald, Ph.D. – Thomas Willis Lambeth Distinguished Chair, UNC-CH, Department of City and Regional Planning
  - Hyoshin (John) Park, Ph.D. – Assistant Professor, NC A&T, Department of Computational Science and Engineering
- Senior Researchers –
  - Eleni Bardaka, Ph.D. – Assistant Professor, NCSU, Department of Civil, Construction, and Environmental Engineering
  - Burcu Adivar, Ph.D. – Assistant Professor, Fayetteville State University, Broadwell College of Business and Economics
  - Trung Tran, Ph.D. – Assistant Professor, Fayetteville State University, Department of Intelligence Studies, Geospatial Sciences, Political Science, and History
Project Goals

• Determine how changes in health care policy (e.g. Medicaid Transformation) and transportation service delivery (e.g. MaaS) impact:
  – Individuals
  – Health systems
  – Public transportation

• Identify how transport system innovation impacts health care access by:
  – Modeling existing services
  – Developing operational scenarios
  – Conducting pilot analysis of patient travel preferences based on the scenarios
  – Assessing needs for transportation information aggregation for patients and care managers
  – Building a decision support tool
Methodology

• Mixed method approach combining:
  – Historic quantitative spatial data trip origins and destinations with tabular data operating statistics
  – Contemporary qualitative perspectives of transport system users and health care systems
  – Operational models for scenario planning
  – Stated preference surveys
Communication Tools

• Monthly team meetings – Teleconference and face-to-face
• Quarterly meetings with the NCDOT and the project committee
• External communication
  – Journal and conference papers
  – Participation in appropriate conferences and symposia
  – Outreach events
    • Webinar on the methodology, findings and implementation concerns
Final Project Outputs

• Final report:
  – Detailing the efforts
  – Interpreting the findings
  – Assisting with implementing the findings/recommendations

• Simulation code, parameters, models, and databases

• Journal article(s)