Subject: MS/PhD and Postdoc/Research Engineer Positions at Georgia Tech Smart City Infrastructure Lab: Infrastructure Asset Management, Transportation Safety, and Senior Mobility

The Georgia Institute of Technology (Georgia Tech or GT) is ranked #1 in Civil Engineering in the U.S. according to the 2025 U.S. News & World Report. The GT Smart City Infrastructure (GT-SCI) Lab is led by Dr. James Tsai, a Professor in the School of Civil and Environmental Engineering (CEE) and an adjunct professor in the School of Electrical and Computer Engineering (ECE) at Georgia Tech.

GT-SCI is actively seeking innovative and self-driven candidates for Master's, Ph.D., and Postdoctoral positions, as well as Research Engineers, who are passionate about applying cutting-edge technologies to solve real-world problems. Our interdisciplinary research team spans Civil and Environmental Engineering (CEE), Electrical and Computer Engineering (ECE), Computer Science (CS), Industrial and Systems Engineering (ISYE), Mechanical Engineering (ME), and is engaged in groundbreaking work. Our research focuses on **developing innovative technologies, methodologies, and applications**, using **a) emerging sensing technologies** (3D laser, Lidar technologies, 2D imaging, smart phone, IMU, Electric Vehicles (EV), Drone, and Connected and autonomous vehicles (CAV), eye tracking devices, etc.), and **b) data science** (AI, computer vision, and GIS spatial-temporal analysis) to address 4 major societal challenges that are the sustainability and resiliency of 1) Infrastructure, 2) Transportation Safety, 3) Safe Mobility of Seniors/Aging Population, and 4) Transportation Energy and Carbon-Emission Reduction. **The primary research focus areas of GT-SCI include:**

1- Sustainability and Resiliency of Infrastructure *(Already changed US policy and professional practices)*

Infrastructure assets, including pavements, signs, sidewalks, bike paths, guardrails, road markings, and more, require a comprehensive asset management system to effectively monitor their condition and maintain them in a state of good repair. In addition, intelligence is essential for emergency responses during hurricane to identify risky areas for timely maintenance and recovery to support society sustainability and resiliency.

1) Infrastructure Inventorying and Condition Assessment for Resiliency: This research area focuses on developing advanced systems to automate the creation of detailed infrastructure asset inventories and assess their condition with high precision. Technologies utilized include 1) sensor/hardware integration, and 2) data processing and analysis for asset detection, classification, feature extraction, measurement, localization, and mapping, using 3D laser LiDAR, smartphone, and drone, computer vision, ML algorithms, GIS spatial analysis, along with localization methods, like SLAM, SFM, etc. for routine maintenance and emergency responses during hurricane to identify risky areas for timely maintenance and recovery.

2) Infrastructure Deterioration Analysis and Performance Modeling: This category involves analyzing the long-term deterioration of infrastructure assets by leveraging multi-year data. By studying patterns of wear and degradation, machine learning models are developed to forecast future asset conditions. These predictive models allow for proactive maintenance planning by predicting when assets will require attention, enabling infrastructure managers to optimize maintenance schedules and extend asset lifespan.

3) Treatment Selection, Prioritization, Budget Allocation, and Optimization: This category focuses on determining the optimal timing, location, and type of treatment for infrastructure assets to support 3R decisions (right locations, timing, and treatments). By optimizing the benefit-to-cost ratio, the decision-making process helps prioritize the most critical treatments. Advanced algorithms and optimization techniques are used to allocate budgets efficiently, ensuring that resources are directed where they will have the greatest impact on infrastructure performance and longevity.

2-* Sustainability and Resiliency of Transportation Safety *(changing US policy and professional practices)

Our research focuses on developing smartphone-aided and driver behavior-based field safety assessments, and predictive models, using mobile devices and/or vehicle sensors collected data, to support a safe system approach and Vision Zero initiatives for proactive safety management to improve safety of curves and intersections for all road users, including vulnerable road users such as pedestrians and motorcyclists.

1) **Roadway safety audit and analysis:** This category includes performing proactive safety audits on roadway curves and intersections using 2D images and IMU in smartphones, eye tracking devices, and Lidar technologies by developing automatic roadway geometry extraction such as alignment, super-elevation, sight distance evaluation, as well as studying driver naturalistic (behavior and patterns). Additionally, we focus on creating intelligent roadway safety evaluation methods through roadway-vehicle kinetic modeling and machine learning (ML) algorithms.

2) **Predictive Safety Modeling and Risk Assessment:** This category includes 1) analyzing the history of crashes and predicting dangerous roadway spots using ML, and 2) developing predictive safety performance functions and forecasting models using crowdsourcing smartphone IMU data, autonomous and connected vehicles' assessable data, or other sensor-derived predictors to enable predictive and proactive safety management.

3) **Roadway departure, collision rate, and crash severity reduction using sensor-based real-time safety score analysis and driver behavior analysis:** The goal is to identify high-risk roadway sections by spatially analyzing crowdsourced safety scores using mobile devices and/or vehicle sensors collected data. These scores incorporate factors such as force margins, driver maneuver identification, real-time collision risk assessment, kinetic energy aspect collision severity level evaluation, and driver behavior ranking based on a historical driver behavior database. Additionally, we are committed to providing numerical and human-understandable driver behavior information for these high-risk areas to support decision-making in roadway geometry improvements systematically and predictively and proactively.

3- Sustainability of Safe Mobility for Seniors/Aging Population *(New Research Area)*

This research focuses on developing a quantitative health assessment methodology that leverages eye-tracking and LiDAR technologies. The goal is to enhance the quality of life for the aging population by assessing both physical and mental health conditions and promoting safer mobility solutions tailored to seniors.

4- Sustainability of Transportation Energy and Carbon-Emission Reduction *(New Research Area)*

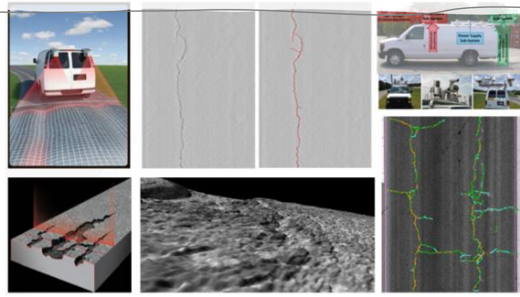
This research focuses on developing smart vehicle data collection system and spatial-temporal analytical methodologies with ML for safe, green, energy-efficient, and cost-effective and logistics to build a sustainable transportation system by reducing energy and carbon-emission. Our preliminary research outcomes through working with the automobile company on analyzing the real-time CAN Bus data and Smart phone data in the trucks/buses show that more than 39% of energy consumption and carbon emission can be reduced.

If you are interested in this opportunity, please contact Prof. James Tsai at james.tsai@ce.gatech.edu with your CV and a brief statement of interest. For more information about Prof. Tsai's research, please visit his profile here: Prof. James Tsai's Research Profile.

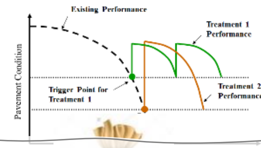
SMART CITIES

(1) Infrastructure

Optimize M&R strategies and asset management using extracted distresses and forecasting models

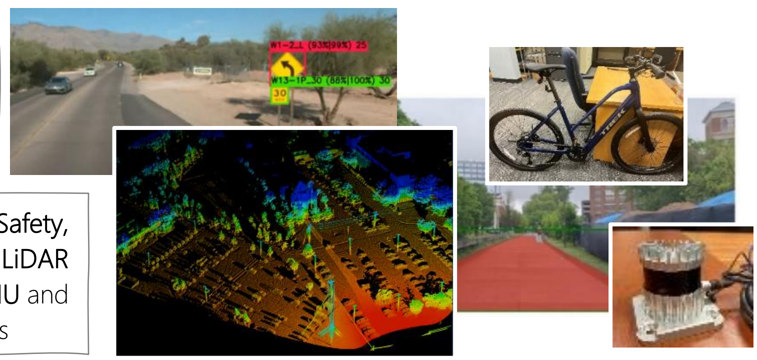


Pavement condition evaluation using high-resolution 3D Laser data, smartphone, and ML technologies by Georgia Tech Sensing Vehicle



Cost-effectively manage infrastructure:
Funding Allocation and M&R Project Selection to optimize 3R (Right time, Right place, Right treatment)

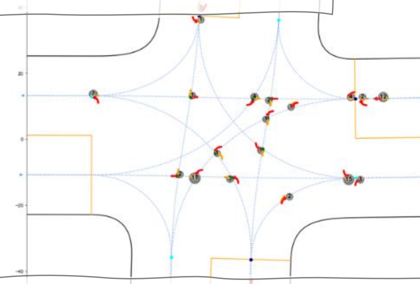
Real-time traffic sign inventory system, integrating various sensors and AI algorithms



Digital Twin on Safety, Mobility. And Health: A LiDAR Bike combining GPS, IMU and high-resolution cameras

(2) Transportation Safety

Identify and visualize dangerous roadway spots on horizontal curves by smartphones, drone, and GIS mapping



Automatic crash diagram generator

Driver behavior analysis on trajectories on Curves and Intersection s

(3) Safe Mobility for Seniors

Developing the technology to quantitatively assess and improve safety and health (physical & mental) condition of seniors

Expectancy to Potential Researchers

The researchers/engineers in the SCI research team have diverse backgrounds in Civil Engineering (Construction and Infrastructure Systems, Structural, and Transportation), Mechanical Engineering, Electrical and Computer Engineering, Computer Science, Industrial and Systems Engineering, etc. We are seeking researchers who are self-motivated in learning new knowledge and technologies seeking creative ideas and solutions, and have a strong interest in the following areas:

- **Software engineering:** Development and deployment of software on the developed ML algorithms and technologies to broad users to produce high society impact
- **Automation:** Applications of Machine Learning, Computer Vision, and GIS spatial analysis. Development of feature extraction algorithms using 3D Line Laser Imaging systems and 3D LiDAR systems, IMU, Smart Phones, Drone, and 4D Radar for real-world applications.
- **Data analytics and GIS spatial analysis:** Forecasting, deterioration analysis, correlation analysis, GIS spatial analysis, driver behavior discovery, risk management, and so on.
- **Sensor technology:** Development of embedded mobile devices, including integration of GPS, IMU, cameras, and other sensors. It also involves hardware integration, data synchronization, and calibration with Lidar technology and with smartphones.
- **Digital Twins (Safety, Mobility and Health):** Implementing sensor technology, wireless communication technology, virtual display technology, and data analysis technology (including AI & ML) into transportation safety systems, transportation mobility systems, and health systems with the industrial 4.0 principle.

Selected research papers and reports: Google Scholar Link

1. **Infrastructure Asset Management**

- Tsai, Y.-C, Wang, Z. (2013) “A Remote Sensing and GIS-enabled Asset Management System”, US DOT final report, https://rosap.ntl.bts.gov/view/dot/28724
- Tsai, Y.-C, Wang, Z. (2014) A Remote Sensing and GIS-enabled Asset Management System) Phase 2, US DOT final report, https://rosap.ntl.bts.gov/view/dot/28735
- Hsieh, Y., Yang, Z., Tsai, Y. (2020) “Convolutional Neural Network for Automated Classification of Jointed Plain Concrete Pavement Conditions”, Computer-Aided Civil and Infrastructure Engineering,1-16.
- Hsieh, Y., Tsai, Y. (2020) “Machine Learning for Crack Detection: review and model performance comparison”, ASCE Journal of Computing in Civil Engineering, 34 (5), 04020038.
- Salameh, R., (Lucas) Yu, P., Yang, Z., & (James) Tsai, Y.-C. (2023). Evaluating Crack Identification Performance of 3D Pavement Imaging Systems Using Portable High-Resolution 3D Scanning. Transportation Research Record, 2677(1), 529-540. https://doi.org/10.1177/03611981221100239
- Mers, M., Yang, Z., Hsieh, Y.-A., & Tsai, Y. (James). (2023). Recurrent Neural Networks for Pavement Performance Forecasting: Review and Model Performance Comparison. Transportation Research Record, 2677(1), 610-624. https://doi.org/10.1177/03611981221100521
- Tsai, Y.-C, Wang, Z., Zhang, X., Yang, Z. (2021). An Enhanced GDOT Pavement Preservation Guide with Optimal Timing of Pavement Preservation. Georgia Department of Transportation, Office of Performance-Based Management & Research, FHWA-GA-20-1406. https://rosap.ntl.bts.gov/view/dot/58692
- Tsai, Y.-C, Chatterjee, A. (2020). Training and Testing of Smartphone-Based Pavement Condition Estimation Models Using 3D Pavement Data. Journal of Computing in Civil Engineering. *34*(6). https://doi.org/10.1061/(ASCE)CP.1943-5487.0000925
- Tsai, Y., Li, F. (2012) “Detecting Asphalt Pavement Cracks under Different Lighting and Low Intensity Contrast Conditions Using Emerging 3D Laser Technology”, ASCE Journal of Transportation Engineering, 138(5), 649–656.
- Ai, C. and Tsai, Y. (2016) “An Automated Sidewalk Assessment Method for the Americans with Disabilities Act Compliance Using 3-D Mobile LiDAR.” *Journal of Transportation Research Record*, National Academy of Sciences, 2016 (2542): 25-32.
- April Gadsby, Ronald Knezevich, Pingzhou Lucas Yu, Yichang James Tsai, John Harvey (2024), A National Survey and Roadmap on Complete Streets Infrastructure Asset Management Policy, Transport Policy, Volume 157, 2024, Pages 86-97, ISSN 0967-070X, https://doi.org/10.1016/j.tranpol.2024.08.005
- Gadsby A., Tsai, Y., Harvey, J. (2022) A Roadmap for Integrating Complete Streets Infrastructure into Pavement Asset Management Systems – Policy Briefs (Sponsored by Caltrans and NCST), https://escholarship.org/uc/item/70d7f1zk
- Gadsby A., Tsai, Y., Harvey, J. (2022) Technology Review and Roadmap for Inventorying Complete Streets for Integration into Pavement Asset Management Systems July 2021, Research Report (Sponsored by Caltrans and NCST), https://escholarship.org/uc/item/99s396gw

2. **Transportation Safety Evaluation and Improvement**

- Tsai, Y., Yang, Z., Yu, P. (2023) Enhancing and Generating GDOT’S MUTCD Curve Sign Placement Design with Curve Finder and Curve Sign Determination, Georgia Department of Transportation, FHWA-GA-23-2022. https://gti.gatech.edu/content/poster-20-22
- Tsai, Y. (James), Wu, Y.-C., P. S., C. P., & Ai, C. (2018). Identification of Site Characteristics for Proactive High-Friction Surface Treatment Site Selection using Sensor-Based, Detailed, Location-Referenced Curve Characteristics Data. Transportation Research Record, 2672(38), 69-80. https://doi.org/10.1177/0361198118780709
- Yang, Z., (Lucas) Yu, P., Shah, R., Knezevich, R., & (James) Tsai, Y.-C. (2024). Crash Prediction on Horizontal Curves: Review and Model Performance Comparison. Transportation Research Record, 0(0). https://doi.org/10.1177/03611981241242075

- Knezevich, R., Yang, Z., Yu, P. (Lucas), & Tsai, Y.-C. (James). (2024). Impact of Ball Bank Indicator on Predicting Rural Curve Crashes. Transportation Research Record, 2678(6), 376-389. https://doi.org/10.1177/03611981231196148
- Tsai, Y.-C, Yu, P., Liu, T., Yang, Z., Steele, A. (2021). An Enhanced Network-Level Curve Safety Assessment and Monitoring Using Mobile. Georgia Department of Transportation, Office of Performance-Based Management & Research, United States, Department of Transportation. Federal Highway Administration, FHWA-GA-21-1917. https://rosap.ntl.bts.gov/view/dot/57398
- Cabe, T. R., Tsai, Y. (2024). Studying Crash Characteristics and Contributing Factors Using Historical Crash Data to Enhance Senior Driver Safety, Accepted for Presentation at Transportation Research Board (TRB) 2024 Annual Meeting (TRBAM-24-03168).
- Steele, A., Pranav, C., Tsai, Y. (2023) "Traffic Sign Retroreflectivity Condition Assessment and Deterioration Analysis Using Lidar Technology", ASCE Journal of Transportation Engineering, Part A: Systems, Vol. 149, No. 5.
- Gadsby, A., Tsai, Y., Watkins, K. (2022). "Influence of Pavement Conditions on Cyclists' Perception of Safety and Comfort: A Combined Survey and Eye Tracking Study," Journal of Transportation Research Record, Vol. 2676, Issue 12.

Selected Research projects:

Infrastructure Health Condition Evaluation and Asset Management

- The competitively selected $3.5 million research projects, "**Remote Sensing and GIS-enabled Asset Management (RS-GAMS) Phases I and II**," (2010-2014), sponsored by the US Department of Transportation Research and Innovative Technology Administration (USDOT RITA) program; these projects were especially recognized for their first-time use of 3D laser technology in the US. Different state of the art scanning laser technologies are equipped on an integrated intelligent Georgia Tech Sensing Vehicle (GTSV). First, 0.5 mm high-resolution downward 3D lasers will be used to develop innovative algorithms for detecting pavement distresses (e.g. rutting, cracks, raveling, etc.) and measure surface macrotexture (in relation to friction), raveling, construction quality, etc. In addition, the sensing vehicle also collects 3D laser cloud data along with 2D image data. Intelligent signal/image processing algorithms will be developed to automatically detect and recognize roadway assets, including signs, pavement markings, cross slopes, etc. In addition, this pavement data is spatially-referenced using GPS, IMU, GPS, DMI, etc. for spatial data integration. And spatial data fusion methods will be developed to extract features of interest, such as pavement distresses, abnormal maco-texture. It is expected we will analyze pavement texture characteristics at macro level and micro level for developing safe, quiet, smooth, and long-life pavements. https://rosap.ntl.bts.gov/view/dot/28724

- "**NCHRP-IDEA 163: Development of an asphalt pavement raveling detection algorithm using emerging 3D laser technology and macrotexture analysis**", competitively selected by the National Academy of Science, National Cooperative Highway Research (NCHRP) Innovations Deserving Exploratory Analysis (IDEA) Program to automatically detect raveling/loss of aggregates using 3D pavement surface data and Machine Learning technologies.

- Competitively selected for the 2017 AASHTO High Value Research (HVR) Award (a national award) because of my research team's successful implementation of 3D laser technologies for automatic pavement condition evaluation with AI technologies, and 3D Lidar technologies for automatic sign inventory and condition evaluation on a large-scale system: "**Implementation of Automatic Sign Inventory and Pavement Condition Evaluation on Georgia's Interstate Highways**", sponsored by the Georgia Department of Transportation.

- The real-time traffic sign inventory system is an innovative solution that integrates various sensors and artificial intelligence algorithms to automatically detect, classify, and localize traffic signs. The smartphone-based system is designed to be mounted on vehicles, allowing for continuous monitoring and updating of traffic signage across vast networks. Leveraging computer vision techniques and multi-modal machine learning, the system can accurately identify and categorize different types of assets. The AI-powered system can distinguish between standard signs, variable message signs, and even temporary or construction-related signage. A real-time device is in development allowing for immediate identification of missing, damaged, or outdated signs, enabling prompt maintenance and replacement. Additionally, the system can track changes in sign placement over time, facilitating long-term infrastructure planning and improvement strategies for their meeting Manual on Uniform Traffic Control Devices (MUTCD) requirement. This technology can significantly reduce manual inspection costs while enhancing road safety through more accurate and frequent monitoring of traffic signage across entire transportation networks to save time and money for transportation agencies to save lives.

- A LiDAR Bike combining GPS, IMU and cameras is currently under development. The LiDAR Bike combines cutting-edge technologies such as GPS, IMU, and high-resolution cameras to create a powerful platform for comprehensive street assessments and digital twin generation. This innovative Bike-mounted system allows for precise mapping and data collection of urban environments, capturing intricate details of sidewalks, road layouts, infrastructure, and surrounding features for assessment of safety and Americans with Disabilities Act (ADA) compliance. By leveraging LiDAR technology, the bike will be used to generate highly accurate 3D digital twins, enabling transportation planners and urban designers to make data-driven decisions for smart city initiatives and infrastructure improvements.

Transportation Safety Evaluation and Management

- "**NCHRP-IDEA 214: An Enhanced Network-level Curve Safety Assessment and Monitoring Using Mobile Devices**", competitively selected (one of six selected projects among a total of 55 proposals) by the National Academy of Science, National Cooperative Highway Research (NCHRP) Innovations Deserving Exploratory Analysis (IDEA) Program to develop a cost-effective method to assess curve safety conditions, using low-cost smart phones. https://www.trb.org/main/blurbs/182610.aspx
- "**NCHRP-IDEA 139: Development of Sensing System for Highway Workzone Hazard Awareness**", competitively selected by the National Academy of Science, National Cooperative Highway Research (NCHRP) Innovations Deserving Exploratory Analysis (IDEA) Program to develop a reliable highway workzone hazard awareness system for vehicles detection and tracking. Innovative driver behavior study can be conducted using the vehicle trajectories acquired from automatic vehicle detection and tracking algorithms. A probabilistic model will be also developed to quantify the estimation and prediction uncertainties caused by sensing technology. Study of work zone driver behavior based on vehicle trajectory analysis. https://onlinepubs.trb.org/Onlinepubs/IDEA/FinalReports/Highway/NCHRP139_Final_Report.pdf
- "**Quantitatively Evaluate Work Zone Driver Behavior Using 2D Imaging, 3D LiDAR, and Artificial Intelligence in Support of Congestion Mitigation Model Calibration and Validation", sponsored by the** USDOT University Transportation Center (UTC) Southeastern Transportation Research, Innovation, Development and Education (STRIDE) to develop an AI-based work zone traffic and driver behavior information extraction system using widely available 2D camera images, machine learning, and computer vision to extract real-world traffic and driver behavior information, including vehicle count, vehicle classification, vehicle speed, time headway, and lane change location. https://stride.ce.ufl.edu/wp-content/uploads/sites/153/2022/08/STRIDE-Final-Report-Project-G2-Tsai-Y.-1.pdf and video recording, https://www.youtube.com/watch?v=siY7Y03ol-U
- **"Crowdsourcing Live Curve Safety Assessment with Intra-agency Vehicles Using Low-cost Mobile Devices with Scalable Advanced Computing for Proactive Safety Improvement**", competitively selected by the National Science Foundation to use low-cost smart phones, AI technologies with roadway-vehicle kinetic modeling to analyze curve safety and determine safe driving speed to identify the locations with safety deficiency, like advisory speed deficiency.
- **"Curve Safety Improvements Using Mobile Devices and Automatic Curve Sign Detection – Phase 1",** sponsored by the Georgia Department of Transportation to automatically extract curve signs for curve sign asset management. https://rosap.ntl.bts.gov/view/dot/53902/dot_53902_DS1.pdf

- Some of our projects are currently leveraging smartphone sensors to develop a cost-effective approach to improving transportation safety. More specifically, smartphones are utilized to collect GPS and IMU data which is processed to calculate the superelevation of horizontal curves, ultimately determining the safe speed (advisory speed) for navigating each curve. Another use case for the same data is to analyze the driver behavior in order to assign a score which can be visualized through GIS mapping. This enables transportation agencies to identify dangerous roadway spots (hotspot areas) to proactively prevent future traffic accidents.