Program Progress Performance Report
for University Transportation Centers

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Office of the Assistant Secretary for Research and Technology
UTC Program

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Signature:
1. Accomplishments

Major Goals and Objectives of the Program

Research, Development and Deployment by the T-SET UTC

The CMU-Penn T-SET UTC focuses on research, development and ultimately deployment of technologies for safe and efficient transportation. The thrusts of the T-SET UTC are structured along 5 core areas: In-Vehicle Technologies, Infrastructure Technologies, Human-Vehicle Interactions, Mobility/Data Analytics and Policy. Each of the 16 research projects has identified Year 1 and Year 2 Desired Outcomes and Metrics.

Metrics

- Number of publications and citations of faculty work in transportation-related areas.
- Number of new hires, new research initiatives, and special projects that build on intellectual leadership in fields related to the mission of the UTC.
- Research collaborations in related fields.
- Quantified impact of technology deployments and transfers.

Education and Workforce Development

Education and workforce development are important compliments of the T-SET research program.

Metrics

- Number of institutional educational partnerships
- Number of participants in workforce and educational programs
- Number of related degrees awarded at our institutions
- Number of new educational programs established
- Number of job placements through workforce development programs.

Technology Transfer

The CMU-Penn UTC will fully use the resources and experience of these university centers to promote enterprises arising from its research program. Faculty who has already created startups in the past will serve as mentors to colleagues interested in this activity.

Metrics

Involvement of faculty in technology transfer activities.

- Number of conferences, meetings, and formal discussions that focus on end users of ITS
- Number of patent applications filed
- Number of startups created
- Number of technology licenses issued

Collaboration

Collaboration is the heart of the entire T-SET program. Carnegie Mellon and the University of Pennsylvania seek to ensure our research and development program leads to deployment of technologies in the transportation systems serving our communities and state, providing pilots applications for global use. The CMU-Penn team will collaborate with related centers on the two campuses, state and local public partners, non-profit community partners, educational partners and industry partners.

Metrics

- Number and diversity of members of the T-SET Consortium
- Number and impact of deployments achieved through collaboration

Diversity

T-SET projects will focus on transportation users in both rural areas and center cities, in suburban commuters and on residents of small communities with limited transportation options.

Metrics

- Participation by students and faculty of color and women in UTC research projects
- Projects focused on rural, city, and suburban residents
- Number of projects targeted at aging populations and persons with disabilities
Accomplishments Under the Major Goals

See Appendix A for specific research project accomplishments

Education and Workforce Development

Below is a listing of specific additional Education and Workforce Development efforts T-SET personnel have engaged in over the past six months:

- Brought on second Women In Transportation Fellow at the Heinz College
- Held first advisory committee meeting for the Heinz Systems Synthesis Capstone Project on Autonomous Shuttles
- Faculty Seminar Series presented T-SET research to student body at three lectures
- T-SET held an open house for students to come meet Women in Transportation Fellows and Directors of the center to learn how to get involved
- Dana Peck defended her thesis, “Data-driven Analyses and Implications in the Transportation World”. Dana is the 2015 CUTC Student of the Year.
- The Transportation Club reached out to new students at both the Undergraduate and Heinz Activity Fairs.
- Created the Women in Transportation Scholarship for the Robotics Institutes Summer Scholar Program
- Pennsylvania Governor’s School Intelligent Transportation Class for Summer 2015
- Hosted a faculty meeting to discuss transportation energy at CMU
- Video Interview for Student Project on Autonomous Vehicle Policy
- Meeting with Indian Railways to Discuss Workforce Development
- Hosted Women Transportation Seminar board meeting
- Taught at for the Summer Engineering Experience for girls at CMU

Technology Transfer and Collaboration

In partnership with the Traffic21 Institute and the Center for Innovation and Entrepreneurship at CMU, T-SET has developed an Entrepreneur in Residence program to enhance its technology transfer efforts.

In addition T-SET has:

Hosted the Following

- Intelligent Transportation Society of America Annual Meeting
- Visit to CMU by Secretary Foxx
- US DOT Staff Visit and Technical Tour
- Technology Showcase for US House Commerce Committee Staff
- Traffic21/T-SET Advisory Council Meeting
- Technical tour at IHEEP Annual Meeting
- Pittsburgh Urban Magnet Project (young professional group)
- Meeting with Delegation of Swedish Transportation Leaders
- Local Government Academy Tour of UTC Research
- National Infrastructure Week Event Featuring Former PA Governor Ed Rendell
- ITSA Technical Tour of Autonomous Vehicle

Presented at the following:

- Briefings to USACE, TRB Executive Comm., House and Senate for NRC Reinvesting in Inland Waterways
- Beijing University of Technology; Chang’an University
- ITE Great Lakes Regional Conference
- Eastern Regional Meeting of the American Association of Motor Vehicle Administrators
- Envision Downtown (Pittsburgh) Technical Committee
- CMU-City of Pittsburgh municipal data workshop
• Cummins Science and Technology Summit
• Traffic21 Faculty Seminar Series on Connected Vehicle Technology
• Capitol Hill Meetings with Members of Congress to Discuss UTC Research
• Pennsylvania Coalition of Transportation Universities Research Workshop with PennDOT and FHWA
• Envision Downtown Task Force to identify actions that will produce a complete streets environment in downtown Pittsburgh
• National Association of County Engineers Annual Meeting
• Pittsburgh on the Move Conference
• ITS America Annual Meeting
• Briefing of T-SET UTC research for the PA House of Representatives Transportation Committee
• Cumberland Region Tomorrow Annual Summit
• HNTB THINK Infrastructure Forum

Participated in the following:
• Envision Downtown Advisory Committee
• Ohio State University UTC Annual Meeting
• State Transportation Innovation Council Meeting
• ITS America Strategic Visioning Meeting
• University of Pittsburgh Institute of Politics Annual Elected Officials Retreat
• Local Government Academy Recognition Lunch
• Attend the University of Michigan Mobility Transformation Center Academic Partners Workshop
• CMU’s Bicycle Advisory Committee
• Congressman Keith Rothfus Transportation Roundtable
• Pittsburgh P4 Conference
• Intelligent Transportation Society of America Leadership Circle Meeting
• Join Pittsburgh and Philadelphia Chambers of Commerce Public Officials Reception
• Pittsburgh Mayor Peduto Innovation Session
• Vehicle to Infrastructure Development Coalition Workshop
• Pennsylvania State Transportation Innovation Council Meeting
• Southwestern PA Commission Operations and Safety Committee Meeting

Held meetings with the following:
• Southwestern Pennsylvania Commission to Discuss Ridesharing
• Pittsburgh Penguin Hockey Team and Verizon to Discuss Smart Cities Deployments
• Pittsburgh Sports and Exhibition Authority to Discuss SURTRAC Deployment
• John Halikowski and ADOT to discuss collaboration
• Dutch Cycling Fellowship from the Dutch Embassy, Pascal van den Noort
• Butler Transit to discuss collaboration
• Met with McKees Rocks Development Corp to discuss collaboration
• Pittsburgh International Airport to discuss collaboration
• City of Pittsburgh DPW to discuss collaboration
• Meeting and Tour at the Community College of Allegheny County Automotive Center

Diversity
• The Women in Transportation Scholarship for the Robotics Institute Summer Scholars program was a success, we placed a young, undergraduate women in a robotics lab focused on transportation research for the summer. This program gives students unparalleled experience in research.
The second Women in Transportation Fellow at the Heinz College started in September.
WTS International selected CMU to lead the Challenge Activity for the WTS Transportation You Summit in Washington, DC for 2016.

2. Products

See Appendix A for specific research project products including publications, technologies, and inventions.

General Program Products

- Weekly distribution of research news articles and T-SET promotions in weekly newsletter (1,571 subscribers)
- Presence on social media: T-SET has 539 followers and 3,217 tweets.

T-SET in the Media

September 23, 2015 - South Australia gears-up for driverless cars
September 16, 2015 - Bosch Group ups investment in CMU
September 14, 2015 - CMU, city to lead creation of new national initiative
September 4, 2015 - Google is much more optimistic than automakers about self-driving cars
August 18, 2015 - CMU-developed app assesses road damage at lower cost than PennDOT tech
August 17, 2015 - Technology that may help potholes get fixed faster

August 5, 2015 - New Technology Could Help Cities Inspect and Maintain Streets More Efficiently
July 27, 2015 - Raj Rajkumar at CMU: Leading the Way for Autonomous Cars
July 21, 2015 - First driveless car trials in Southern Hemisphere to be held in Adelaide, coinciding with international conference
July 9, 2015 - 6 Questions for Carnegie Mellon AutonomousCar Prof Rajkumar
July 8, 2015 - This almost-but-not-quite-driverless car is smarter than your car
July 3, 2015 - Will Self-Driving Cars Spell the End of the American Road Trip?

June 30, 2015 - Episode 171: Johnnycab (Automation Paradox, pt. 2)
June 22, 2015 - Bright Green Autopods: The Newest Way To Get Around Downtown
June 1, 2015 - Welcome to Pittsburgh, ITS. Welcome to the Future, America.
May 31, 2015 - Driving toward the future
May 31, 2015 - Transportation group meets here this week
May 28, 2015 - CMU, Pittsburgh's Surtrac program aims to ease traffic congestion
May 27, 2015 - A Robot to Help Visually Impaired Passengers Navigate Public Transit
May 18, 2015 - Exclusive: Uber leases former Restaurant Depot space for Pittsburgh robotics center
April 27, 2015 - Car headlights of the future won't blind other drivers (Engadget)
April 25, 2015 - Driven from distraction
April 25, 2015 - Driven from distraction (The Economist)
April 23, 2015 - DOT secretary 'bullish' on CMU transportation technology (Pittsburgh Business Times)
April 23, 2015 - During Pittsburgh visit, transportation chief says infrastructure should 'outrage' Americans (Pittsburgh Post-Gazette)
April 23, 2015 - Transportation chief visits Pittsburgh to view new research, technology
April 22, 2015 - Band-Aid approach to infrastructure can't continue, U.S. transportation chief says in Pittsburgh
Stan Caldwell discusses CMU's autonomous vehicle with KDKA radio
See Appendix A for specific research project products including publications, technologies, and inventions.

3. Participants and Other Collaborating Organizations

We continue to grow our Consortium and now have over 50 organizations from public organizations, government and industry.

T-SET’s advisory committee was held on August 16, 2015, which includes a Diverse group of 12 senior transportation leaders from around the US which serves as an advisory body for the UTC’s research topics.
Appendix A -- Research Projects Accomplishments, Products and Participants

Adaptive Routing of Autonomous Vehicles for Safe Transportation, Siyuan Liu, Sean Qian, CMU

Participant Organizations: MSRA

Journal publications:

Other publications, conference papers and presentations:
2. Lingyang Chu, Shuhui Wang, Siyuan Liu, Qingming Huang, Jian Pei. ALID: Scalable Dominant Cluster Detection. The 41st International Conference on Very Large Data Bases (VLDB 2015). 2015, Hawai’i, USA.

Goals & Timelines
- Stage 1: 2 months. Tasks include data integration from Twitter and traffic data, anomaly detection, and travel risk estimation.
- Stage 2: 2 month. Tasks include design and test of Gaussian process dynamic congestion model.
- Stage 3: 2 months. Tasks include design and test of the adaptive routing for individual vehicles and the more efficient routing subroutines.
- Stage 4: 2 months. Tasks include design and test of system adaptive routing for optimal traffic and the adaptive pricing strategy on the value of exploration.
- Stage 5: 4 months. Tasks include design and development of the prototype. Our partners in Microsoft will keep close collaboration with us to improve the prototype. Sharing economy researchers will also keep close collaboration with us to give insights into the adaptive routing patterns and sharing economy.

Efficient 3D Accident Scene Reconstruction, Luis Navarro-Serment, Christoph Mertz, CMU

Participant Organizations: Pittsburgh Police

Other Dissemination Activities: Presented our work to following groups:
- Local Government Academy (invited speaker)
- Secretary Fockx
- Delegation of PA representatives
- Toyota
- Vinny White (Senior Policy Advisor, Office of the Secretary, USDOT)
- Pittsburgh Police

Website: http://www.cs.cmu.edu/afs/cs.cmu.edu/project/reconstruction/www/index.html

Technologies / Techniques: 3D reconstruction. How-to documentation and links to software repositories are on the above mentioned website.

Impact: Our techniques will allow every investigator to create 3D models of accidents and use them in their investigation. They already have all the necessary hardware, namely a computer and a camera.

Impact in other disciplines: 3D reconstruction from images can be used in many other fields, e.g. crime scene investigation, 3D mapping.

Goals & Timelines:
Reconstruction Seminar Oct. 13-15; Goal: collect data from staged collisions, reconstruct accident scene, present to class
Goal: determined the crush of one vehicle from an actual accident and compared it with the current method used by Pittsburgh accident investigators. Timeline: By end of year.

Driver Status Monitoring In Autonomous Vehicles Using In-Seat Inertial Sensors, Hae Young Noh, Pei Zhang

Participant Organizations: Renault Innovation Silicon Valley

Other Collaborators: Pierre Delaigue from Renault

Other Dissemination Activities
1. We presented our work and had a demo to the CEO of Renault & Nissan at their Renault American Research Center Review, January 2015.
2. We presented our work to the vice president of Nokia, February 2015.
3. We gave a talk on our project at Virginia Tech, Blacksburg, VA, March 2015.
4. We presented our work at The 2015 Internal Workshop of Cyber Physical Systems, DGIST, Daegu, South Korea, June 2015.
5. We presented our work at the Tsinghua-UC Berkeley Shenzhen Institute Workshop: Big Data in Networks, Tsinghua University, Shenzhen, China, July 2015.

Technologies / Techniques
We are developing a sensing system that consists of a network of small vibrational sensors distributed inside car seats and seat belts to monitor the driver's physiological status, such as posture, breathing rate, attention level, etc. In particular our system has the following key features:

- Inference-based sensing hardware system to enable non-intrusive in-car deployments.
- Non-intrusive measurement of driver posture and physiological information.
- Combining signal processing and machine learning (data-driven) with models of automotive vibrations and human body (physics-based) to further distinguish signals of interest.

Impact
By monitoring the state of the driver through her/his movements and other physiological variables, we enable the autonomous cars to understand the capability of the driver to take the control back in dangerous and/or unexpected situations. In addition, the algorithms developed for removal of large amplitude noise from small signals that overlaps in frequency can be applied to a number of sensing applications in realistic scenarios.

Impact in other disciplines
Our research has impacts in many other disciplines. First, the development of our sensing system can be applied to other fields for non-intrusive indirect monitoring through vibration, such as wearable suits for muscle monitoring in sports activities, smart furniture to sense human activities, etc. Second, the inference algorithm to extract driver's status from noisy vibration data can be applied to the areas, which requires signal decomposition to separate various components in the vibration measurements, such as vehicle-infrastructure interaction, manufacturing, infrastructure monitoring, etc.

Goals & Timelines
Full scale evaluation in real-world driving: Nov 1, 2015 - Dec 31, 2015

In-Car Cell Phone Detection, Bernardo R. Pires, CMU

Other Dissemination Activities
Testimony on "Enhancing the Safety of Highway Workers, Drivers and Pedestrians" at the Joint Hearing before the Senate Transportation Committee and the House Transportation Committee
Website: http://www.contrib.andrew.cmu.edu/~bpires/phonodetect.html


Impact
The primary impact of this project is a contribution to in-car safety and crash prevention by creating cost-effective methods for distraction detection due to use of electronic devices.

Impact in other disciplines
In addition to the primary impact on in-car safety and distraction detection due to use of electronic devices, this project will push forward the state of the art on the Computer Vision and Machine Learning Fields, by creating new classifiers tailored specifically to the detection of electronic displays inside the car, as well as a body of classified visual data.

Goals & Timelines
Completed
- Selection and purchase of equipment
- Review of methods in the literature
- Development of data labeling tool (shared with Pedestrian / Bike Detection project)
Collection of over-the-shoulder view dataset
Ongoing. On track for Completion by Dec. 31, 2015
- Labeling and preparation of dataset
- Training and testing of cell phone detector

Evaluating the Opportunities for Cost Savings and Environmental Benefits of Coupling Solar Energy and Electric Vehicles in City of Pittsburgh Municipal Operations, Constantine Samaras

Participant Organizations: City of Pittsburgh
Other Collaborators: Jeremy Michalek (MechE/EPP)
Other Dissemination Activities
- 9 June 2015: Working meeting with Grant Ervin and Ariel Lattanzi of the City of Pittsburgh. Discussed project scoping and research questions. Maintained ongoing email contact with this office during the course of the project.
- 29 July 2015: Delivered progress presentation to Grant Ervin of the City of Pittsburgh, Chris Holt from the Pittsburgh Parking Authority, Aurora Sharrard from the Green Building Alliance, and other representatives of the Stadium and Exhibition Authority, Urban Redevelopment Authority, the Downtown Pittsburgh Partnership, and others, during a meeting of the Pittsburgh Green Garage group in the City County Building. Brainstormed how our research could add value to ongoing other efforts downtown.
- 23 September 2015: Phone meeting with Michael Kirven of the EV Users group at the request of the City of Pittsburgh. Discussed ongoing efforts and potential collaboration.
- 6 October 2015: Delivered progress presentation to Grant Ervin and Ariel Lattanzi of the City of Pittsburgh, and representatives from the Pittsburgh Parking Authority, Pittsburgh Region Clean Cities, and others, in the City-County Building.

Technologies / Techniques: Energy and environmental systems engineering and analyses
Impact: The modeling work will enable evaluation of the opportunity for the City of Pittsburgh to meet multiple economic and environmental objectives through the use of electric vehicles in the municipal fleet, as well as provide a signal to businesses and residents on the wider potential for PEV charging and use downtown.
Impact in other disciplines: This work potentially enables work on smart sensing and telematics for EV charging infrastructure.

Goals & Timelines:
This 6 month project began on 1 July 2015 and will end on 31 December 2015
Task 1. Project Months 1-3. Collect and assemble data set of City of Pittsburgh light duty vehicles in the municipal fleet. Collect, assemble and map data on existing available land area in municipal fleet garages and parking lots. Collect and assemble ensemble of PEV and solar technology options for municipal implementation, including capital cost, operating cost, energy consumption, energy generation, and life cycle environmental air pollutant and greenhouse gas emissions.
Task 2. Project Months 3-6. Model the changes in life cycle local and regional air pollutant and greenhouse gas emissions of multiple PEV and solar PV technology options for the City of Pittsburgh. The model will also include financial outcomes relevant to City decisionmakers, including expected capital outlays, and changes in operations and maintenance expenses.
Task 3. Project Month 6. Generate final report for the City of Pittsburgh and discuss results with stakeholders.

Sensor-based Assessment of the In-Situ Quality of Human-Computer Interaction in the Cars (previously, “In-Situ Monitoring of Driver Workload”), SeungJun Kim, Anind K. Dey, CMU

Participant Organizations
Two academic institutions (CMU & UNIST), one international research institute (KETI), and one school of driving in the local area (Cindy Cohen School of Driving)
- CMU, Human-Computer Interaction Institute (HCII), Ubiquitous Computing Lab
  - Provided the KETI matching/leverage fund
  - Provided an in-kind support (e.g., wearable sensor devices used in the data collection) and personnel support (e.g., post-doc researchers, undergraduate research assistants)
- Performed collaborative research on 1) "sensor-based assessment of in-situ driver interruptibility", 2) "sensory augmentation systems in cars", and 3) "visual analytics and machine learning tool for time-series sensor data"

- UNIST, Interactions Lab, South Korea (director: Prof. Ian Oakley)
  - Participating as a NON-CMU deployment partner
  - Will provide an in-kind support – a sensor-embedded steering wheel under development
  - Still performing collaborative research on "Drive-aware: sensing and responding to in-car steering postures"

- KETI (Korea Electronics Technology Institute)
  - Participating as a NON-CMU deployment partner
  - Assisted human-subject recruitment for our survey study on "Development of UI/UX Technology to Overcome the Limitations of Wearable Device UIs"
  - Performing collaborative research on "Sensor-based UI (user interface) / UX (user experience) assessment method during real-world tasks in a real-world setting (e.g., home, office, street, and cars)"

- Cindy Cohen School of Driving, LLC
  - Participating as a NON-CMU deployment partner
  - Provided an in-kind support – permitted to deploy study fliers for the recruitment of study participants (e.g., novice drivers) for our two studies on "Exploring the value of information delivered to drivers" and "A smartphone-based sensing platform to model aggressive driving behaviors"

Other Collaborators
- More than 11 research fellows at CMU, HCI Institute, Ubicomp Lab
  - Two postdocs - Dr. Jaemin Chun and Dr. Sunyoung Cho
  - Two visiting scholars - Allan Stisen and Jung Wook Park
  - More than 7 undergraduate or graduate students such as international interns, research assistants, or students for their independent studies (e.g., Nikola Banovic, Jae-won Kim, Vigneshwar Maheshwaran, Pulkit Bhuwalka, Jimin Zheng, Sumeet Kumar, Yeon Soo Kim, Nana Choi, etc)

- Collaborators from the current or future non-CMU deployment partners
  - Dr. KyungTaek Lee (KETI, Contents Convergence Research Center, South Korea)
  - Prof. Ian Oakley (UNIST, Interactions Lab, South Korea)
  - Cindy Cohen (Cindy Cohen School of Driving, LLC)
  - Leonard S. Coeh (TAKATA Corporation)
  - Seo-ho Choi (Hyundai Motor Group – Human Factors and Device Research Team in the R&D division)

Journal publications


Other publications, conference papers and presentations


Other Dissemination Activities

• Press
  o "Road safety. Driven from distraction - How to save phone-using from themselves", The Economist, Science and technology (Apr 25, 2015; by Paul Marks)

• Invited talks or presentations
  o Topic 1 – "Improving user experience in ubiquitous human-computer interaction situations"
  o Topic 2 – "Value estimation for information delivered to drivers"
  o Topic 3 – "Usability evaluation for wearable device (smart watch)"
  o https://www.ht.sfc.keio.ac.jp/cmu-keio15

• Post QoLT meeting (Aug 6, 2015)
  o Topic – "Introduction to our Wearable UI/UX project - Development of UI/UX Technology to Overcome the Limitation of Wearable Device Uls"

• KETI kick-off meeting (Apr 29, 2015)
  o the lead group of the international joint project on wearable UI/UX, supporting the matching/leverage funds of this project
  o Topic – "Improving user experience in ubiquitous human-computer interaction situations"

• Samsung S/W center (Apr 23, 2015)
  o Topic 1 – "Improving user experience in ubiquitous human-computer interaction situations: sensor-based approach to better understand human capability in attention and cognition"
  o Topic 2 – "Sensor know when to interrupt you in the car: Detecting driver interruptibility through monitoring of peripheral interactions"

• Visitors from Equos Research Co., Ltd. (20 Mar 2015)
  o Topic 1 – "Improving user experience in ubiquitous human-computer interaction situations: sensor-based approach to better understand human capability in attention and cognition"
  o Topic 2 – "Sensor know when to interrupt you in the car: Detecting driver interruptibility through monitoring of peripheral interactions"

• MIPS (Mobile Interfaces and Pedagogical Systems Group), Department of Computer Science, University of Pittsburgh, Pittsburgh, USA (28 Jan 2015)
  o Topic – "Improving user experience in ubiquitous human-computer interaction situations - Sensor-based approaches to better understanding human capability in attention and cognition")

• On-line or on-site conference meetings
  o More than 5 conference meetings with the current or potential non-CMU deployment partners (e.g., KETI, Contents Convergence Research Center, Cindy Cohen School of Driving, LLC; Hyundai Motor Group – Human Factors and Device Research Team in the R&D division; and Draper Labs)

Website
UTC websites
  - Sensor-based Assessment of the In-Situ Quality of Human-Computer Interaction in the Cars (2015, active; http://utc.ices.cmu.edu/utc/projectitem.asp?ID=169)
  - In-Situ Monitoring of Driver Workload (2014, completed; http://utc.ices.cmu.edu/utc/projectitem.asp?ID=92)

Other websites of the research team
  - PI and Co-PI research areas and details
    - Seung-Jun Kim (http://www.cs.cmu.edu/~sjunkim/)
    - Anind K. Dey (http://www.cs.cmu.edu/~anind/)

Project websites
  - Human-Vehicle Interaction (http://ubicomplab.org/project/human-vehicle-interaction-2)
  - Multisensory Augmentation (http://ubicomplab.org/project/multisensory-augmentation/)
  - DriveCap Navigator (http://www.cmu.edu/qoli/Research/projects/current-projects/drivecap-nav.html)

Technologies / Techniques
1. Human-vehicle interaction technology (focus: sensor-based real-time detection, prediction, and assessment)
2. Sensor fusion, visual-analytic, and machine-learning technology (focus: big sensor data streams in vehicles)
3. Ubiquitous computing technology in cars (focus: interruptions)
4. User-centric automotive UI technology (focus: in-vehicle information systems)
5. Sensory augmentation technology (focus: haptics and augmented reality)

Invention / Patent applications / Licenses
- Invention disclosure

Other Products associated
- Video / Audio: Videos of road traffic and their in-car activities during driving sessions
- Databases: An initial version of database of route guidance and local landmark information
- Data & Research Material: Rich sensor data streams during naturalistic driving (i.e., OBD, body motion, physiological responses, videos, audios, smartphone sensors, etc.)
- Instruments or equipment: In-car sensing and feedback prototypes
- Physical Collections: Participant responses for a set of questionnaires, experimental sensors or wearable devices from Non-CMU deployment partners, etc.
- Software: a series of visual analytic tools

Impact
- Presents an enabling technology to create an in-vehicle sensing platform for estimating driver’s in-situ capability for dual-task demands in mobile contexts
- Develops an elemental technology to detect appropriate breakpoints for prompting drivers to participate in experience sampling tasks or to interact with pushed information while driving
- Demonstrates the feasibility of a sensor-based assessment of the quality of human-computer interaction in cars
- Provides new hypotheses and use case scenarios for future works and new project items (e.g. contacts from Equus Research Co., Ltd, Hyundai Motors Group, TAKATA Cooperation, Draper Laboratory, etc.)

Impact in other disciplines
- Has an impact in Ubiquitous computing domain, Human-computer interaction domain, Internet of things domain, and Machine-learning domain, especially on 'intelligent interruption' research, 'driver-centered automotive UIs' research, 'sensor fusion and data analytics' research, and 'big sensor data streams from the field and human-subjects experiments – i.e., naturalistic with high complexity and uncertainty' research, respectively.
- Presents a key enabling technology for developing mobile cyber-physical systems that are human-centered, by coordinating the interventions of intelligent systems or services to adapt to users’ in-situ capabilities in cognition and attention – contributing to improving user acceptance or appreciation.

Goals & Timelines
- Goal 1 – Engineering tasks for sensor and analytic tool design (1 month through November)
Automation Detection of Objects in Rearview Camera Images, Vijayakumar Bhagavatula, CMU

Participant Organizations: Carnegie Mellon University, Department of Electrical and Computer Engineering

Other Collaborators: Dr. Sheyok Chakraborty

Technologies / Techniques

To detect objects in the rearview camera images, we assume that we are given a collection of images depicting a clear background (e.g., captured at the time of parking). Our goal is to detect objects of arbitrary shapes and sizes close to the rear side of the vehicle. We use two different algorithms (background subtraction and ground surface classification) to detect objects and then combine the predictions from the two methods to obtain the final prediction.

1. Background Subtraction: Background subtraction is a technique in the field of computer vision to detect objects from static cameras. The fundamental idea behind this approach is that of detecting objects from the difference between the current frame and a reference frame called the “background image” or the “background frame”. We use the Mixture of Gaussians (MoG) approach for background subtraction in our work. In this strategy, each pixel in the image is modeled using a mixture of Gaussians and an online approximation is used to update the model. The distributions are then analyzed to determine which are most likely to result from a background process and which represent the objects.

2. Ground Surface Classification: The idea behind this approach is to train a classification model to recognize ground surface pixels. Given a test image, each pixel is classified as ground/non-ground to detect the presence of any objects. An algorithm was developed to obtain superpixels from the image and then to extract features from superpixels.

3. Information Fusion: Given the predictions from the background subtraction and ground surface classification modules, a fusion scheme is used to produce the final result. Our empirical results indicate that the OR fusion scheme (predicting a pixel to be an object pixel if either of the modalities classify it as an object pixel) produces the best results.

Impact

A system which can robustly detect the presence of objects in rear-camera images has tremendous potential in reducing the number of backover accidents.

Impact in other disciplines

The proposed framework can be viewed as a generic object detection system. It can also be used in several other applications including security and surveillance to detect abandoned or removed objects in airports and other public places.

Goals & Timelines

1. Collection of a rear-camera image database (December 31, 2014);
2. Development of ground surface classification methods (March 31, 2015);
3. Development of background subtraction technique (June 30, 2015);
4. Development and evaluation of an information fusion method (December 31, 2015)

Bumper-To-Bumper: A Vision-Based System For High Efficiency Vehicle Platoons in Metropolitan Areas, Srinivasa Narasimhan, James Hoe, Rohat Tamburo, CMU

Participant Organizations: Carnegie Mellon University, RI, Carnegie Mellon University, ECE

Technologies / Techniques

A technique was developed to estimate distance to a preceding vehicle with a vision-based system. The technique works even in the brightest conditions, which is often the failure point of vision-based systems. The system also has less measurement uncertainty than sensors typically used for the proposed applications. Simulations were conducted to study the impact our system would have on traffic congestion and vehicle emissions.
Impact
With further system development, our system can outperform other sensors typically used for platooning, adaptive cruise control, and collision avoidance for improved safety. Further simulations with other traffic technology (e.g., adaptive traffic lights) will offer compelling support.

Goals & Timelines
- Test prototype on moving vehicle: By end of November.
- Write technical report describing prototype and simulations: By end of 2015.
- Assess performance characteristics and accuracy of prototype system: By end of 2015.

Modeling Transit Patterns via Mobile App Logs, Anthony Tomasic, Aaron Steinfeld, John Zimmerman, Afsaneh Doryab, CMU

Participant Organizations: CMU
Other Collaborators: PAAC, Tiramisu Transit LLC
Other publications, conference papers and presentations:
Other Dissemination Activities
Invited Non-Publication Presentations

Slated for week of Oct 19, 2015:

Press:
- Pittsburgh as a driving force behind transportation technology, Pop City. February, 6, 2015. http://www.popcitymedia.com/features/transportation_amandawaltz.aspx (Note, other UTC/Traffic21 projects are in this too)

Website: http://www.tiramisustransit.com

Technologies / Techniques
Our core goal is to develop good models for predicting the Origin and Destination (O-D) pairs for trips using either prior knowledge of O-D trips and/or data about where people are requesting transit information. We developed preliminary models for this using data gathered from the Tiramisu Transit smartphone app. Unfortunately, we are dissatisfied with the performance of these models. A big problem seems to be higher variability in real-life O-D patterns than previously expected. We are now trying to identify what parts of the O-D prediction challenge are feasible to do with high reliability.

Other Products associated: The already Tiramisu Transit app (iPhone and Android) serves as this project’s test bed. Tiramisu is publicly deployed and in use by citizens of Pittsburgh on a daily basis. Transit information has been accessed by users over a million times and users have contributed over 195,000 trip observations. These information requests and contributions are the raw data used for the effort within this project.

Impact
As mentioned, the Tiramisu app is used frequently and heavily by citizens of Pittsburgh. This allows the team to have a positive impact on the community while also collecting valuable research data.

**Impact in other disciplines**
Most of the papers published from Tiramisu work are in the fields of Human-Computer Interaction, technology for people with disabilities, and transportation. The former two often include generalizable knowledge relevant to other large-scale participatory systems.

**Goals & Timelines**
Due to the shift in Task structures, the original schedule is somewhat obsolete. Our plan is to continue exploration of models and their resulting performance with the hope that we can improve performance to where they are useful to stakeholders.