STREET

The model city of Newark, N.J., with its signalized intersections, access ramps and mix of roads and highways, is a novel assessment platform designed by Jo Young Lee, an associate professor of civil engineering, to evaluate the impacts of connected and automated vehicles (CAVs) on drivers and passengers in autonomous cars as well as pedestrians.

The Rise of Intelligent Transportation

As cities boom, congestion builds. Traffic safety, air quality and productivity suffer. Managing this growth, while mitigating its harm, is one of the central goals of the sustainability movement. On NJIT's campus, civil, mechanical and electrical engineers, computer scientists, physicists and industrial designers are attacking the problem from several angles. Their goal is to create smarter cars and saner streets with technologies that guide autonomous cars, optimize rideshare networks and defuse traffic jams.

SMARTS:

GUIDING AUTONOMOUS VEHICLES WITH INVISIBLE CUES

When an auto-piloted Tesla Model X collided with a truck in California in 2018, the crash alerted the public to an unsettling reality: the near-total absence of dynamic "smart signaling" in the nation's transportation infrastructure. The car's onboard computer, safety inspectors determined, failed to distinguish between the white paint of the truck and the brightly lit sky behind it.

A team of physics, information-security, robotics and built-environment researchers has proposed a solution: novel optical coatings, or tags, which would be invisible to the human eye, but convey instantaneous messaging about a car's environment and objects within it in the form of reflected light.

While still scanning for visible information, an autonomous car would emit infrared light, comparable to flashes on a camera, that would be reflected back in a specific wavelength by the optical tags embedded in the environment. The car's sensor would recognize the particular signals and be able to identify, for example, the type and location of the car that sent it.

"The tags can be used as coded information, like a QR code, but invisible, and provide more information because they can have multiple layers within them," explained Mathew Schwartz, an assistant professor of industrial design, who is working with Jan Lagerwall and his team at the University of Luxembourg to identify a broad range of potential applications for their technology.

The tiny spherical shells of cholesteric liquid crystal, which would receive and reflect light in every direction, can be manufactured to reflect only certain wavelengths of light, such as infrared, and cancel out the ambient light so sensors only see the invisible tags.

ARTIFICIAL INTELLIGENCE TAKES TO THE STREETS

With urban populations booming and the impact of congestion spiraling, computer scientists have joined engineers, physicists and industrial designers in a technology enhanced campaign against idling engines, fender benders and wasted time. Their principal tools are connected vehicles, intelligent sensor networks and smart mobile devices, and controllers capable of learning on the job to improve their performance. Prompting transportation signals to adjust dynamically to improve traffic flow is an early application.

"Now that we can collect traffic data with tools such as vehicular networks and smartphones to feed to artificial intelligence (AI), these systems are evolving from infant to adult. We expect to see the impact of intelligent devices throughout our transportation networks in reduced congestion and enhanced safety," said Guiling "Grace" Wang, a professor of computer science who specializes in both distributed systems and deep-learning algorithms. Here are two:

Pinpointing Rider Demand: In recent years, transportation companies have had a difficult time accurately predicting rider demand and thus struggle to optimize their resources — vehicles and drivers — to meet it. By fusing all related factors such as weather, time and conditions on the road, Wang and her collaborators aim to model the complex interactions among them through a learning device invented by the team known as a "deep spatio-temporal fuzzy neural network."

GPS Blackouts: Wang has proposed a grid-based localization system in which cars with and without accurate GPS would be equipped with a wireless interface and self-organize into vehicle networks that would allow them to exchange location and distance information.

NJIT engineering students are gutting toy trucks, SUVs, sedans and two-door Mini Coopers and refitting them with custom-designed systems: laser-cut side mirrors, wheels that can parallel park and a braking system that employs algorithms to control an electric motor, thus enabling soft and hard braking, idling and taxiing.

SHARING THE ROAD WITH DRIVERLESS CARS

Jo Young Lee, an associate professor of civil engineering, is working with Guiling "Grace" Wang, professor of computer science, and Cong Wang, an assistant professor of electrical and computer engineering, to develop a novel assessment platform that evaluates the impacts of connected and automated vehicles (CAVs) on drivers, passengers and pedestrians.

While the goal of CAV technology is to make driving safer and more efficient, there is still little information on human responses to these cars. Without understanding their sense of safety and comfort, as well as their physical reactions, such as steering and braking, it will be difficult to deploy them on the road.

Existing evaluations depend heavily on computer simulations, which can't fully capture reactions. With backing from a National Science Foundation grant, the team is building a platform between a simulation and a street test that would use a crowdsourced cyber-physical reality that relies on visual and force feedback from human subjects to improve upon it. It would connect the human testers with miniature environments through virtual reality and measure their emotional responses, such as safety awareness and degree of comfort, and their behavioral reactions, such as steering maneuvers and their accelerating or decelerating activities.

"Integrating our platform with the development of CAV can create a positive feedback loop between design, development and assessment of CAV, and thus enable its real on-road deployment," Lee said. "We foresee the adoption of our platform has big impacts on transportation such as better intersection and highway design for the deployment of CAVs in the near future."

INTEGRATED CONNECTED URBAN CORRIDOR

NJIT and the City of Newark are collaborating on a project aimed at improving mobility, safety and air quality along congested urban routes. Called the Integrated Connected Urban Corridor (ICUC), the system would include state-of-the-art traffic detection, air pollution sensors and vehicle-to-infrastructure (V2I) communications along arterial roadways with traffic lights. The goal is to reduce

Cong Wang, an assistant professor of electrical and computer engineering and a co-investigator of the project, views data collected by a vehicle feedback system – speed, LIDAR position, distance readings and camera feedback – which appears on the main display screen at a gaming-style steering wheel and pedal control stations, where remote drivers guide cars around the model city.

the number of congestion- and emissions-producing stops, vehicle idling and delays at traffic signals.

The system's devices would securely transmit traffic and air quality data, including traffic signal timing, to a cloud-based data analysis system developed by the ITS Resource Center, a research center at NJIT. The ICUC system would provide this traffic signal data and analytics to Newark's Division of Traffic and Signals, as well as to motorists, pedestrians and bicyclists, in real time. It could be used by the city to optimize traffic operation strategies, noted Branislav Dimitrijevic, a co-principal investigator on the project and professor of civil and environmental engineering, which is funded by the New Jersey Department of Transportation.

The ICUC pilot test bed is located in downtown Newark, along a 1.2-mile section of Raymond Boulevard and a 0.7-mile section of Warren Street, the 1st Street exit off I-280 and Newark Penn Station. It includes 13 signalized intersections that have been instrumented with devices enabling high-fidelity V2I communications.

Based on the preliminary estimates developed by the U.S. Department of Transportation, the connected vehicle applications enabled by ICUC alone have the potential to reduce crashes and fatalities by more than 5%, travel time in signalized corridors by 25% and vehicle emissions and fuel consumption by 10%. ■

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USHERING IN A CARBON-NEUTRAL ECONOMY WITH NEXT-GENERATION BATTERIES

The stakes for next-generation batteries that are high-capacity, long-lived and affordable could not be higher; the promise of a carbon-neutral economy depends on their success. While newer batteries can store 10 times as much energy as their graphite predecessors, they fade too quickly. The breakdown occurs at the interfaces between the polymers and the active materials that sustain electrochemical reactions; when these particles become electrically isolated, a battery's charging capacity and overall longevity are curtailed.

Siva Nadimpalli, the director of NJIT's Micro and Nano Mechanics Laboratory, uses novel techniques to reveal how battery electrodes break down in real time, rather than after they degrade. His custom-made cell enables electrochemical and stress measurements simultaneously and his thin-film electrodes – 10,000 times thinner than a human hair – capture real-time, uniform readings when a cell is running.

He aims to advance the development of multiphysics mathematical models, which capture a battery's mechanical behavior and the electrochemical activity of its electrodes, to predict how mechanical forces impact chemical reactions in battery materials, and to assess their corresponding electrical performance on, say, the current supplied by batteries at any voltage.

"If we can solve these problems, we will see new generations of battery-powered machines such as electric cars become commercially viable options," said Nadimpalli.