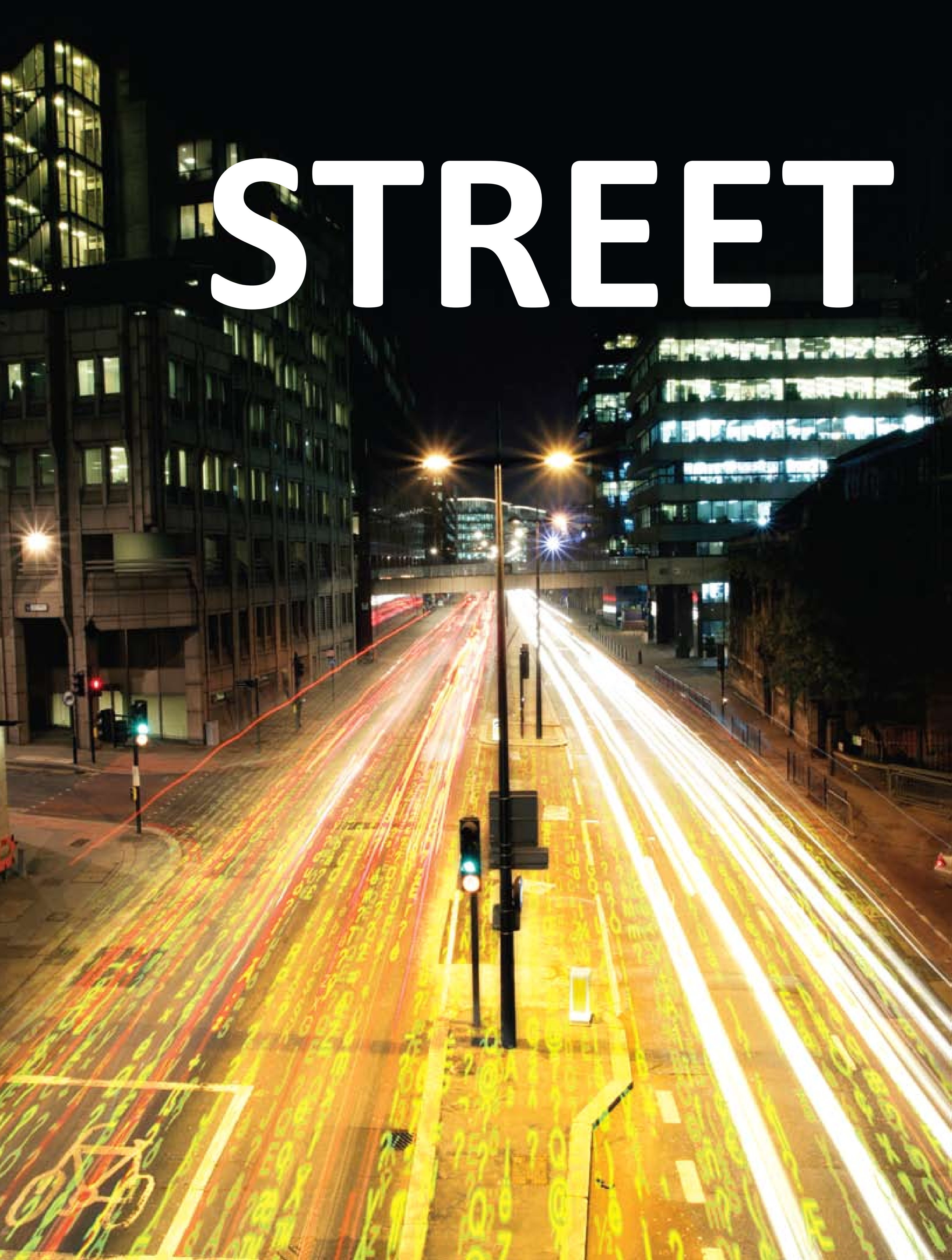
STREET



SMARTS

UF COMPUTER ENGINEERS ARE DEVELOPING WAYS FOR ROADS AND CARS TO TALK TO EACH OTHER

By Megan E. Gales

Red means stop. Green means go. Yellow ... well, yellow might be out of a job.

Imagine a system of roads connected to each other through a wireless network. With sensors at every intersection, on road signs and — potentially — in cars themselves, information flowing freely among them all.

With a grant of more than half a million dollars from the National Science Foundation and funded by the American Recovery and Reinvestment Act of 2009, computer engineer Shigang Chen and transportation engineer Yafeng Yin hope to develop a system that's part transportation, part communication, and spans entire cities.

The idea is to turn a city's existing pervasive traffic infrastructure into a pervasive communications infrastructure, Chen says. The sensors and wireless nodes would need power. Traffic lights and telephone poles carry power.

"So if we can install wireless devices at these places, we have the power supply," Chen says. "And these wireless devices would be able to communicate among themselves or with other nearby wireless devices to form a wireless network."

And because the wireless nodes would be right there with the sensors, they could easily share the information the sensors collect. Applications become virtually limitless because the Intelligent Road's communication network would be a two-way street.

Chen, an associate professor at the University of Florida, says the network would create a real-time traffic map, from which congestion could easily be monitored. If a wireless device — maybe a souped-up GPS unit — in a vehicle tapped into the map, the driver could pick a route based on distance and traffic conditions, and avoid what could have been an unpleasant commute.

Cameras and other sensors could help dispatchers send the right kind of emergency personnel because accidents could be assessed remotely. The architecture of the network would not require the video to be sent back to a central location only; video feeds could be accessed from anywhere in the city.

Gone would be the yellow-light dilemma zone, where a driver must quickly decide between a difficult stop or the risk of running a red light, says Yin, a civil engineer who brings transportation systems expertise to the iRoad project. Because sensors would communicate with each other, the traffic light would realize a car was approaching, and could postpone the yellow light slightly to give the driver a chance to make it through the intersection without feeling the need to slam on the brakes.

By sending a signal to a wireless device in a vehicle, sensors on road signs could warn a driver of impending danger — such as a sharp curve in the road for a car traveling at a high speed, or a car approaching too quickly from the other direction when making an unprotected left turn.

ONE-WAY STREET

Many modern roads already have sensors in the pavement at intersections. When vehicles travel across them, the magnetic field of the vehicles triggers the sensor and sends a signal to a control box on the side of the road. The controller in turn assigns green light times for the signal accordingly. These sensors measure traffic volume, density and flow, but they have no way of communicating with each other.

Lily Elefteriadou is director of UF's Transportation Research Center, a nearly 40-year-old highly respected interdisciplinary research center sought out for its ability to analyze and solve transportation issues.

"New technologies help us predict traffic flows better — better than the flow that's at the intersection, and help us coordinate better because you can anticipate the amount of traffic that you're going to have much better," Elefteriadou says.

She says there is a lot of research being done in transportation technology right now, either to provide additional information about traffic in order to more effectively optimize the system, or to provide drivers with more information so they can manage their travel more efficiently. TRC studies show people are generally not bothered if they know how long their trip will take and can plan accordingly.

"People get frustrated when they think that their trip is going to take half an hour, and it takes an hour and a half," Elefteriadou says. "That's the most frustrating part."

The 95 Express project in Miami is an example of one way technology can be used to ease congestion on crowded roads. The first phase of the project was launched in January, and the second phase is expected to follow in a couple of years. It uses a variable pricing strategy, where express lanes on Interstate 95 are reserved for those willing to pay a toll to use the lanes. Mass transit vehicles and registered carpoolers can use the express lanes for free. Drivers who don't want to pay and aren't carpooling or driving a city bus can use the general purpose lanes for free.

"But if you're in a hurry and you're willing to pay, then you can use the managed lanes," Elefteriadou says. "And the worse the congestion, the higher the price."

Right now, tolls range between 25 cents and $2.65, but may go as high as $6.20 in extreme conditions.

Elefteriadou says the project is an attempt to minimize congestion, as well as to encourage people to use mass transit. TRC is currently working on a project to analyze the impact of 95 Express, but she says generally speaking it seems successful.

Another approach is Orlando's new variable speed limit project on Interstate 4. In this case, transportation authorities attempt to manage congestion as well as safety by managing speeds.

"When they detect that there's congestion at one point, they're trying to lower the speeds upstream so that you don't have rear-end collisions as people are approaching the congested area," Elefteriadou says.

It's like a crowd trying to leave a packed stadium after a game. When everyone is doing their own thing, it takes a long time. Get people to follow an established order, and everyone gets out of the stadium faster. Follow the order, increase the throughput.

"If everyone follows the speed limit, you actually end up traveling faster," says Yin, an assistant professor at UF.

Practically speaking, though, getting drivers to comply with the variable speed limit can be difficult, he says.

But what if the variable speed limit was also connected to sensors in vehicles that physically limited the maximum speed? It's this kind of question that keeps Yin awake at night. The network he and Chen propose would be capable of imposing such restrictions, if auto manufacturers equipped vehicles with the right sensors. It's a touchy subject at best, though.

"On the one hand, I think people don't like to have their vehicles being controlled," Elefteriadou says. "However, from a traffic and a systems perspective, you can optimize operations much better if you have that kind of control over vehicles."

There would be no bottlenecks, there would be no congestion. Think of how a large crowd of people moves slowly up a staircase, but quickly on an escalator — as long as no one treats the escalator like stairs.

SPEED BUMPS

Words like bandwidth, protocol and frequency roll off Chen's tongue like water, and he explains how wireless networks work with elementary ease. But setting up a citywide wireless communications network isn't as simple as Chen's explanation makes it sound. It takes a lot more digital oomph to keep a network of this kind of caliber going. So much so that wireless network's capacity for data transfer — its bandwidth — becomes an issue. Bandwidth is fundamentally limited by the frequency range made available for wireless communication. It's easy to increase a non-wireless network's bandwidth: just run more cables. But adding more wires isn't exactly an option for wireless systems.

Wireless networks transmit information using radio waves of a certain frequency. A wireless device, whether it's a laptop in the living room or a piece of hardware on top of a traffic light, encodes information as radio signals and sends it to a router. The router receives the information, decodes it and sends it through a wired connection to the Internet. Because information flows both ways, the process works in reverse, too.

Similarly, devices like radios, televisions, cell phones and even garage door openers rely on certain radio frequencies to send and receive information. The trick is that technology in all of its forms must share the air. If they all tried to

Ray Carson

Shigang Chen believes integrated transportation and communication systems will help speed traffic through busy intersections like this one in Gainesville.

use the same frequency, they would block each other's signal and none would work. In the United States, the Federal Communications Commission regulates the use of frequencies and allocates to wireless networks a specific, finite frequency range. And just as the amount of cable in a wired network determines its capacity, so the frequency spectrum dictates a wireless network's bandwidth. The Average Joe's wireless home network transmits at a frequency of 2.4 GHz and uses a networking standard called the 802.11 protocol. Most wireless technology, in fact, is geared toward this kind of wireless networking, Chen says.

But trying to use this kind of protocol for a system as robust as the one the researchers envision is like trying to use a garden hose to extinguish a house fire.

Therein lies Chen's challenge: to establish a new theory in protocols for the sophisticated management of wireless communication bandwidth.

"Even though a lot of research has been done," Chen says, "not many large-scale wireless network systems like this have been deployed."

The trick, Chen says, is to manage the traffic on the network in order to make better use of the bandwidth. Various kinds of traffic — still on the network, not the road — will need to be prioritized, also. For example, emergency services would always need to be able to send and receive the information it needs. If digital congestion slows the network, the system must be able to detect the bottleneck and reroute network traffic around it in order to recover.

Another red flag the system must be able to detect is compromised nodes. Chen says his team will develop secure protocols to protect the system, study all possible attacks they can think of and program it accordingly. But to truly ensure the security of the system, there must be a way to detect and isolate any node featuring the fingerprints of a hacker.

Programmers with good intentions will be encouraged to develop applications. Chen says the researchers plan to develop an engineering framework that will allow efficient leverage of the system.

Chen hopes to take iRoad to prototype stage in about three years. In many ways, the implementation of this kind of technology depends on government, auto makers and consumers. Yin calls it a chicken-and-egg problem: who will come first? Toward that end, the U.S. Department of Transportation created a program called IntelliDrive. The program brings together the three groups in an effort to connect vehicles and roadway infrastructure and make transportation in the U.S. easier and safer — and perhaps even crashless. IntelliDrive resonates with the iRoad researchers.

"That's the vision we have," Yin says. "We think the next generation of transportation should be this way."

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