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Alex Wright

Automotive Autonomy

Self-driving cars are inching closer to the assembly line, thanks to promising new projects from Google and the European Union.

AT THE 1939 World's Fair, General Motors' fabled Futurama exhibit introduced the company's vision for a new breed of car "controlled by the push of a button." The self-driving automobile would travel along a network of "magic motorways" outfitted with electrical conductors, while its occupants would glide along in comfort without ever touching the steering wheel. "Your grandchildren will snap across the continent in 24 hours," promised Norman Bel Geddes, the project's chief architect.

Seventy years later, those grandchildren are still waiting for their self-driving cars to roll off the assembly lines. Most analysts agree that commercially viable self-driving cars remain at least a decade away, but the vision is finally coming closer to reality, thanks to the advent of advanced sensors and onboard computers equipped with increasingly sophisticated driving algorithms.

In theory, self-driving cars hold out enormous promise: lower accident rates, reduced traffic congestion, and improved fuel economy—not to mention the productivity gains in countless hours reclaimed by workers otherwise trapped in the purgatory of highway gridlock. Before self-driving cars make it to the showroom, however, car manufacturers will need to clear a series of formidable regulatory and manufacturing hurdles. In the meantime, engineers are making big strides toward proving the concept's technological viability.

The European Union-sponsored SARTRE project is developing technologies to allow cars to join organized platoons, with a lead car operated by a human driver.

One of Google's seven self-driving, robotic Toyota Priuses steers its way through a tight, closed circuit course.

PHOTOGRAPH BY STEVE JURVETSON

For the past year, Bay Area residents have noticed a fleet of seven curious-looking Toyota Priuses outfitted with an array of sensors, sometimes spotted driving the highways and city streets of San Francisco, occasionally even swerving their way down the notoriously serpentine Lombard Street.

Designed by Sebastian Thrun, director of Stanford University's AI Laboratory currently on leave to work at Google, the curious-looking Priuses could easily be mistaken for one of Google's more familiar Street View cars. The Googlized Prius contains far more advanced technology, however, including a high-powered Velodyne laser rangefinder and an array of additional radar sensors.

The Google car traces its ancestry to Thrun's previous project, the Stanley robot car, which won the U.S. Defense Advanced Research Project Agency's (DARPA's) $2 million grand challenge prize after driving without human assistance for more than 125 miles in desert conditions. That project caught the attention of executives at Google, who have opened the company's deep pockets to help Thrun pursue his research agenda.

At Google, Thrun has picked up where the Stanley car left off, refining the sensor technology and driving algorithms to accommodate a wider range of potential real-world driving conditions. The Google project has made important advances over its predecessor, consolidating down to one laser rangefinder from five and incorporating data from a broader range of sources to help the car make more informed decisions about how to respond to its external environment.

"The threshold for error is minuscule," says Thrun, who points out that regulators will likely set a much higher bar for safety with a self-driving car than for one driven by notoriously error-prone humans. "Making a car drive is fundamentally a computer science issue, because you're taking in vast amounts of data and you need to make decisions on that data," he says. "You need to worry about noise, uncertainty, what the data entails." For example, stray data might flow in from other cars, pedestrians, and bicyclists—each behaving differently and therefore requiring different handling.

Google also has a powerful tool to help Thrun improve the accuracy of his driving algorithms: Google Maps. By supplementing the company's publicly available mapping data with details about traffic signage, lane markers, and other information, the car's software can develop a working model of the environment in advance. "We changed the paradigm a bit toward map-based driving, whereby we don't drive a completely unknown, unrehearsed road," Thrun explains. Comparing real-time sensor inputs with previously captured data stored at Google enables the car's algorithms to make more informed decisions and greatly reduce its margin of error.

Although the trial runs are promising, Thrun acknowledges that the cars must be put through many more paces before the project comes anywhere close to market readiness. He freely admits the Google car is a long way from rolling off an assembly line. "We are still in a research stage," says Thrun, "but we believe that we can make these cars safer and make driving more fun."

At press time, Google had hired a lobbyist to promote two robotic car-related bills to the Nevada legislature. One bill, an amendment to an existing electric vehicle law, would permit the licensing and testing of self-driving cars. The second is an exemption to allow texting during driving.

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Europe's Car Platoons

If the Google project ultimately comes to fruition, it may do more than just improve the lives of individual car owners; it could also open up new possibilities for car sharing and advanced "highway trains" in which cars follow each other on long-distance trips, improving fuel efficiency and reducing the cognitive burden on individual drivers.

Researchers in Europe are pursuing just such an approach, developing a less sophisticated but more cost-efficient strategy in hopes of bringing a solution to market more quickly. The European Union-sponsored SARTRE project is developing technologies to allow cars to join organized platoons, with a lead car operated by a human driver. Ultimately, the team envisions a Web-based booking service that would allow drivers of properly equipped vehicles to search for nearby platoons matching their travel itineraries.

Two earlier European projects successfully demonstrated the viability of this approach using self-driving trucks. SARTRE now hopes to build on that momentum to prove the viability of the concept for both consumer and commercial vehicles.

By limiting the project's scope to vehicles traveling in formation on a highway, the project team hopes to realize greater gains in fuel economy and congestion reduction than would be possible with individual autonomous cars. "We wanted to drive these vehicles very close together because that's where we get the aerodynamic gains," says project lead Eric Chan, a chief engineer at Ricardo, the SARTRE project's primary contractor.

By grouping cars into platoons, the SARTRE team projects a 20% increase in collective fuel efficiency for each platoon. If the project ultimately attracts European drivers in significant numbers, it could also eventually begin to exert a smoothing effect on overall traffic flow, helping to reduce the "concertina effect," the dreaded speed-up and slow-down dynamic that often creates congestion on busy highways.

To realize those efficiency gains, the SARTRE team must develop a finely tuned algorithm capable of keeping a heterogeneous group of cars and trucks moving forward together in near-perfect lockstep. "The closer together, the less time you have to respond to various events," says Chan, "so cutting down latency and response times is critical." To achieve that goal, the system enables the vehicles to share data with each other on critical metrics like speed and acceleration.

Chan says the team's biggest technological hurdle has been developing a system capable of controlling a vehicle at differing speeds. "When you're controlling the steering system at low speed versus high speed, the dynamics of the vehicle behave differently," Chan says. "You have to use the controls in a slightly different way. At high speeds the vehicle dynamics become quite different and challenging."

In order to keep the platoon vehicles in sync at varying speeds, the team has developed a system that allows the vehicles to communicate directly with each other as well as with the lead vehicle. The systems within the lead vehicle act as a kind of central processor, responsible for managing the behavior of the whole platoon. The space between each vehicle is controlled by the system depending on weather or speed, but the lead driver can also exert additional influence through manual overrides.

In hopes of bringing the solution to market within the next few years, the SARTRE team is focused on developing with relatively low-cost systems and sensors that are production-level or close to it, as opposed to the more expensive, laser-scanning sensors used in the Google and DARPA projects.

The larger challenge for the SARTRE project may have less to do with sensors and algorithms than with addressing the potential adoption barriers that might prevent consumers from embracing the platoon concept. After all, part of the appeal of driving a car lies in the freedom to go where you want, when you want. But will drivers be willing to adjust their driving behavior in exchange for the benefits of a kind of quasi-public transportation option?

"There's a big human factors aspect to this project," says Chan, who acknowledges that predicting market acceptance is a thorny issue. The team has been trying to understand the psychological impact of autonomous driving on the human occupants formerly known as drivers. The developers have been running trials with human subjects to see how people react to different gap sizes between cars, trying to identify potential psychological issues that could affect users' willingness to relinquish control of their vehicles. "How comfortable do people feel driving a short distance from another car?"

A human factors issue for the SARTRE project is whether consumers will embrace its car platoon concept.

asks Chan. "How much control should the operator really have?"

The team is also considering the potential impact on other drivers outside the platoon, since the presence of a long train of vehicles will inevitably affect other traffic on the freeway. For example, if the platoon is traveling in the slow lane on a multilane freeway, it will inevitably have to react to occasional interlopers.

Whether consumers will ultimately embrace self-driving cars will likely remain an open question for years to come, but in the meantime the underlying technologies will undoubtedly undergo further refinement. For the next few years, self-driving cars will continue to remain the province of researchers, while the rest of us can only dream of someday driving the magic motorway to Futurama. ◼

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Alex Wright is a writer and information architect based in Brooklyn, NY.

Public Policy

U.S. Calls for Global Cybersecurity Cooperation

Whether it's thieves trading in stolen credit card information, spammers planting malicious code on computer networks, or hostile governments hacking into sensitive systems, cybersecurity is a growing issue in an increasingly networked world. In late May, for instance, the world's largest defense contractor, Lockheed Martin, announced it had been the target of a "significant and tenacious attack" on its Maryland-based servers. One result is the Obama administration is calling for an international effort to strengthen global cybersecurity. In a strategy report released in May, the White House called for governments to work together to develop standards that ensure privacy and the free flow of information while preventing theft of information or attacks on systems.

"We know that the Internet is changing, becoming less American-centric and maybe more dangerous. This lays out a path to make it more secure while preserving important values like openness and connectivity," says James Lewis, director of the Technology and Public Policy Program at the Center for International Strategic Studies. "Most importantly, it reverses our old policy of wanting unilateral 'domination' and replaces it with engagement with other countries, consistent with the Obama national security strategy."

During President Obama's visit to the United Kingdom on May 25, he and Prime Minister David Cameron issued a joint statement pledging cooperation on cybersecurity. They also announced that the U.K. had signed on to the Budapest Convention on Cybercrime, a treaty signed by the U.S. and 30 other countries. The U.S. strategy calls for expanding the convention's reach.

Fred Cate, a law professor and director of the Center for Applied Cyber Security Research at Indiana University Bloomington, says the administration deserves credit for taking a first step, but doesn't feel the proposal goes very far. "I think we'd like to have seen more, not just detail, but also a more aggressive strategy."

He says domestic law provides almost no incentive to take even the simplest steps toward better security, such as shipping cable modems with a firewall turned on by default. If there were a system of domestic legal liabilities, tax credits, and safe harbor provisions for companies to engage in good practices—the sort of mix of regulations and incentives that apply to health-care and financial institutions—that would give the country a good starting point for better international policies, Cate says. Even a requirement to report cyberattacks to a central clearinghouse, so companies and institutions could learn from others' experiences, would be useful.

"Right now we don't know how many cyber events there are," Cate says.

On the other hand, the U.S. Chamber of Commerce worries that the regulation could have a negative effect on business. "Layering new regulations on critical infrastructure will harm public-private partnerships, cost industry substantial sums, and not necessarily improve national security," the U.S. Chamber of Commerce said in a response to the domestic policy proposal.

—Neil Savage