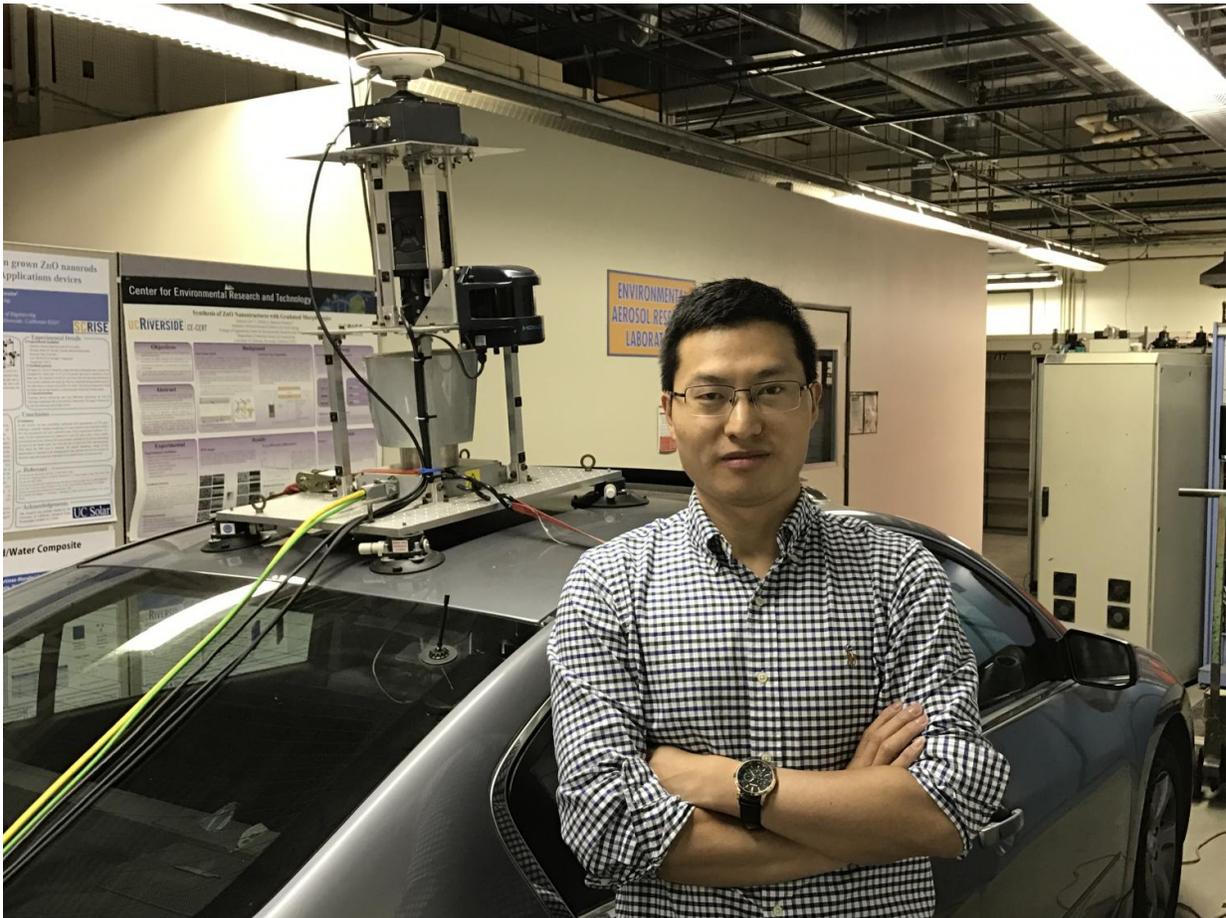


New technology will cut plug-in hybrid fuel consumption by one third

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Xuewei Qi and a team of UCR researchers are using vehicle connectivity and evolutionary algorithms to improve the efficiency of Plug-In Hybrid Electric Vehicles. Credit: UC Riverside

Engineers at the University of California, Riverside have taken inspiration from biological evolution and the energy savings garnered by birds flying in formation to improve the efficiency of plug-in hybrid electric vehicles (PHEVs) by more than 30 percent.

Titled "Development and Evaluation of an Evolutionary Algorithm-Based Online Energy Management System for Plug-In Hybrid Electric Vehicles," a paper describing the research was recently accepted for publication in the journal *IEEE Transactions on Intelligent Transportation Systems*. The work was led by Xuewei Qi, a postdoctoral researcher at the Center for Environmental Research and Technology (CE-CERT) in UCR's Bourns College of Engineering, and Matthew Barth, CE-CERT director and a professor of electrical and computer engineering at UCR.

PHEVs, which combine a gas or diesel engine with an electric motor and a large rechargeable battery, offer advantages over conventional hybrids because they can be charged using mains electricity, which reduces their need for fuel. However, the race to improve the efficiency of current PHEVs is limited by shortfalls in their [energy management](#) systems (EMS), which control the power split between engine and battery when they switch from all-electric mode to hybrid mode.

While not all plug-in hybrids work the same way, most models start in all-electric mode, running on electricity until their battery packs are depleted, then switch to hybrid mode. Known as binary mode control, this EMS strategy is easy to apply, but isn't the most efficient way to combine the two power sources. In lab tests, blended discharge strategies, in which power from the battery is used throughout the trip, have proven more efficient at minimizing fuel consumption and emissions. However, their development is complex and, until now, they have required an unrealistic amount of information upfront.

"In reality, drivers may switch routes, traffic can be unpredictable, and

road conditions may change, meaning that the EMS must source that information in real-time," Qi said.

The highly efficient EMS developed and simulated by Qi and his team combines vehicle connectivity information (such as cellular networks and crowdsourcing platforms) and evolutionary algorithms—a mathematical way to describe natural phenomena such as evolution, insect swarming and bird flocking.

"By mathematically modeling the energy saving processes that occur in nature, scientists have created algorithms that can be used to solve optimization problems in engineering," Qi said. "We combined this approach with connected vehicle technology to achieve [energy savings](#) of more than 30 percent. We achieved this by considering the charging opportunities during the trip—something that is not possible with existing EMS."

The current paper builds on previous work by the team showing that [individual vehicles can learn how to save fuel from their own historical driving records](#). Together with the application of evolutionary algorithms, vehicles will not only learn and optimize their own energy efficiency, but will also share their knowledge with other vehicles in the same traffic network through connected vehicle technology.

"Even more importantly, the PHEV energy management system will no longer be a static device—it will actively evolve and improve for its entire life cycle. Our goal is to revolutionize the PHEV EMS to achieve even greater fuel savings and emission reductions," Qi said.

The work was done by Qi and Barth, together with Guoyuan Wu, assistant research engineer at CE-CERT, and Kanok Boriboonsomsin, associate research engineer at CE-CERT. This project was supported in part by the National Center for Sustainable Transportation.

The UCR Office of Technology Commercialization has filed patents for the inventions above.

More information: Xuewei Qi et al, Development and Evaluation of an Evolutionary Algorithm-Based Online Energy Management System for Plug-In Hybrid Electric Vehicles, *IEEE Transactions on Intelligent Transportation Systems* (2016). [DOI: 10.1109/TITS.2016.2633542](https://doi.org/10.1109/TITS.2016.2633542)

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