Improving traction and control in electric vehicles

A s humanity begins to ramp up its battle against the critical issues of climate change and air pollution, electric vehicles will likely become an important part of a more environmentally sustainable society. Recently, countries including Norway, Sweden, and Denmark have set dates for sales of vehicles which run on fossil fuels, and in the coming years, other developed nations will be likely to follow. However, with many nations dragging their feet on their commitments to sustainability, it appears that electric vehicles may need to offer more incentives to consumers before other developed nations can be improved beyond the capabilities of fossil fuel burners. Through innovations relating to both tyre adhesion stability and the recycling of braking energy, Professor Xu believes electric vehicles can realistically become safe and reliable features of our transport networks in the near future.

The research includes an improvement of the energy efficiency... for electrically-driven vehicles, and enhancement of the adhesion stability.

and his colleagues at Shanghai University and Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, have identified several areas where electric vehicles offer improvements in safety, control, and energy efficiency over polluting vehicles, paying particular attention to maximising their performance on slippery road surfaces. Through both simulations and real experiments, the researchers have designed and rigorously tested an innovative range of new technologies for realising these improvements. This progress is a result of four key studies published between 2012 and 2016.

A THEORY FOR IMPROVING ADHESION

In their first study, carried out in 2012, Professor Xu’s team developed a vehicle-integrated scheme for controlling traction between tyres and the road, avoiding loss of control on surfaces like ice or mud where friction is greatly reduced. Their research aimed to discover how this friction – named the ‘adhesion force’ – can be controlled by the vehicle itself no matter the surface it is driving on. “This study proposed a new structure for vehicle adhesion control, in which feedback including the adhesion stability state and the maximum adhesion force, maximising their performance on slippery road surfaces. Through both simulations and real experiments, the researchers have designed and rigorously tested an innovative range of new technologies for realising these improvements. This progress is a result of four key studies published between 2012 and 2016.

DETECTING WHEEL SLIPPING

Following on from this earlier work, Professor Xu’s team showed that electric vehicles could be able to automatically detect rates of slipping in their tyres when driving across low-friction surfaces. Slipping occurs when a vehicle’s wheels are rotating either too quickly or too slowly to gain full traction. In a reduction in its speed. From the results of a study published in 2013, the researchers patented a system for detecting slipping rates, simply using data gathered by the vehicle’s drive motor. “These studies proposed a real-time detection method of vehicle adhesion parameters for the first time, including the friction coefficient and wheel slip-ratio, using only the motor’s voltage and current,” says Professor Xu.

IMPROVING VEHICLE STABILITY

Building on this work, Professor Xu and colleagues next worked towards developing systems which could automatically prevent slipping on low-friction surfaces. The team noted that although traction can be gained when a vehicle’s wheels are spinning at just the right speed, road surfaces have widely varying amounts of friction in reality, making it extremely difficult for drivers to manually maintain an optimal rotation. In the 2016 study, Professor Xu’s team aimed to gain new insights into the determination of the ‘Force transfer factor’ – a value which “directly determines the adhesion stability between the tyre and road,” as Professor Xu explains.

RECYCLING BRAKING ENERGY

In addition to these areas relating to slip prevention, Professor Xu’s team have also studied how the braking energy of electric vehicles can be recycled. As they slow down, vehicles convert their kinetic energy into heat in their brakes.
In previous studies, researchers have proposed that electric vehicles could convert this energy back into electricity, allowing for longer journeys without a need for frequent recharging. Such a system would make vehicles highly safe and energy efficient, but presents significant challenges in ensuring that as much of a vehicle’s braking energy is fed back to its onboard energy storage system as possible.

In another 2016 study, Professor Xu and colleagues approached the problem by again considering how the transfer of force can be maximised, this time between the wheels and the brakes. “This study proposed a method for estimating the maximum adhesion based on a knowledge-based methodology in a hierarchical control structure, and a technique for achieving the deep energy recovery of electrified vehicles with the maximum adhesion control,” Professor Xu explains. “Results show that the energy recovery improves the driving range by more than 25%.”

Again, using both simulations and experiments, Professor Xu’s team proved that onboard processing using data from a vehicle’s drive motor can be used to minimise slipping in its brakes. In a successful conclusion to their series of studies, the researchers demonstrated that a stable, high-performance energy recycling system can be integrated into electric vehicles, even in unknown road conditions.

**Promising Potential for Electric Vehicles**

Through these four areas of study, Professor Xu and his colleagues have shown that electric vehicles could realistically allow for greatly improved braking systems and traction control when compared with traditional vehicles. “The significance of the research includes an improvement of the energy efficiency via braking energy recovery for electrically-driven vehicles, and the enhancement of the adhesion stability,” Professor Xu summarises. “The research has made a breakthrough compared with the traditional vehicle dynamics control method, which adjusts the driving braking force based on the mechanical braking force distribution.”

The significant experiments and simulations carried out in the team’s studies prove that these improvements can push the capabilities of electric vehicles beyond those of their fossil fuel-burning counterparts. With the assurance that electric vehicles can be safer, more reliable, and more energy efficient than traditional vehicles, a transition away from traditional cars looks set to ramp up in the near future.

Reference:


Professor Guoqing Xu

**Research Objectives**

Professor Xu’s research interests include electric vehicle control, energy processing, and automotive electronics.

**Bio**

Professor Guoqing Xu received his PhD in electrical engineering from Zhejiang University before joining Tongji University, where he was awarded his Professorship in 2000. He was Research Professor at The Chinese University of Hong Kong, Director of the CAS/CUHK S2 Institute of Advanced Integration Technology, Shenzhen, China, until 2015. He has been a Professor at Shanghai University since 2016.

**Collaborators**

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**References**
