////**Title: Recycling Braking Energy Using Big Data for Efficient Electric Cars**

////**Standfirst:**

Electric vehicles may be championed as an essential component of a decarbonised economy, but there is still a long road ahead before they can become widely accessible to all drivers. Dr Ronghui Zhang and colleagues at Sun Yat-sen University in China are exploring one way in which this transition could be accelerated, through more sophisticated techniques for recycling the abundant energy released in braking. With the smart use of big data, the researchers believe that the amount of energy recaptured in this process can be maximised, without sacrificing the safety or comfort of the driver.

////**Main text:**

Currently, humanity's efforts to mitigate climate change are dominated by the push to obtain all of our electricity from renewable sources. Even if this goal were achieved, however, a significant issue appears: the vast amount of greenhouse gases emitted from transport.

One of the most widely explored solutions to this problem is the development of electric vehicles, which store their energy within rechargeable batteries, instead of fuel tanks. The technology has seen significant improvements in recent years, as well as increasing levels of commercialisation, but many challenges remain before they can realistically become a widespread replacement for fossil fuel-burning vehicles.

The fundamental issue posed by electric vehicles is their driving range. Limitations in battery storage mean that they can only travel so far before they need to be recharged, making them less desirable than conventional vehicles for most consumers. Current efforts to solve this issue have mainly focused on increasing the amount of energy capable of being stored in easily transportable batteries. However, such new innovations are typically expensive – placing these longer-range vehicles out of reach for many drivers.

In a recent study published in the journal *Complexity*, Dr Ronghui Zhang and colleagues at Sun Yat-sen University explore a different technique: allowing for both low costs, and extensive driving ranges.

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When a car decelerates, its kinetic energy doesn't simply disappear; instead, most of it is transferred to its brakes in the form of heat. In conventional vehicles, this heat simply dissipates into the surrounding air, being ultimately wasted. Recently, however, a growing field of research has focused on how this energy can be recycled in electric vehicles. For this to happen, the vehicle's engine can momentarily act as a motor – converting its kinetic energy back into electricity, which can in turn be used to charge its battery.

Currently, most research into this innovative technology has studied how kinetic energy can be recycled in uniaxial vehicles, which are driven by just one motor operating on the front pair of wheels. However, for vehicles where each axle is driven by its own motor, the situation becomes more complex. To deal with the arising challenges, Dr Zhang's team acknowledges the call for a more sophisticated, data-driven approach to braking energy recycling.

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In biaxial electric vehicles, the efficiency of braking energy recovery is affected by many different factors, including the speed of the motors, the rotational forces they exert on their axles, and the present state of charge of the battery. Because of this complexity, it is difficult for the vehicle to determine a suitable relationship between mechanical braking, which slows it down, and braking that recycles energy. In turn, this makes the necessary distribution between the braking force required for the front and rear axle less clear.

If this relationship is not optimised for each axle's motor, the vehicle will either waste braking energy, defeating the point of energy recovery, or decelerate too quickly. Therefore, an unsuitable distribution can neither guarantee that the vehicle's battery will be recharged during braking, nor ensure the safety and comfort of the driver as it slows down. Dr Zhang believes that the problem cannot be solved using conventional engineering techniques alone.

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In recent years, it has become increasingly clear that big data holds the key to innovation in a vast variety of new technologies. The idea is that if the habits of a smart device's user, as well as its surrounding conditions, can be expressed numerically, the device will be better informed about how it can be more useful. For Dr Zhang's team, the case for braking energy recovery is no different, since braking is influenced by many factors relating to both the driver and the vehicle's surrounding environment – all of which can be represented using data.

In their study, the team analysed the behaviours of many drivers in a variety of different road and weather conditions, which were picked up by a big data platform. Using the safety regulations drawn out by the Economic Commission for Europe as a constraint condition, the researchers then aimed to develop a system that used these data as its inputs. If implemented correctly, this would allow the vehicle to smartly determine the braking force requirements of each axle's motor, without any conscious input required from the driver.

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To achieve these goals, Dr Zhang's team has established a basis for a computer simulation that first processes the driver and environmental information gathered by the big data platform. The simulation's algorithms then use these values to calculate the most suitable distribution between mechanical and recovery braking force for each axle in a virtual vehicle. Finally, this information is fed back to each simulated axle's motor, allowing it to adjust its braking force appropriately.

After running the simulation, the researchers confirmed that it can cause an electric vehicle's energy recovery efficiency to be better matched to the individual behaviours of drivers, as well as road and weather conditions. Overall, it could raise the average efficiency of biaxial motor systems by over 3% compared with previous techniques, and by over 10% compared with uniaxially-driven vehicles. Having demonstrated the success of their simulation, the researchers now hope that it will act as a reference for even more sophisticated braking feedback control systems in the future.

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In the coming years, electric vehicles look set to become a crucial component of our efforts to curb greenhouse gas emissions to safe levels. Through their data-based approach towards the recovery of braking energy, Dr Zhang and colleagues are making this transition away from fossil fuel-burning vehicles look more feasible. Through the framework of their simulation, electric vehicles may soon be able to undertake ever longer voyages, without incurring the costs of expensive new battery technologies.

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