Fractional order modeling may reduce electric car drivers' battery charge anxiety

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With rapidly diminishing fossil fuels, it's not impossible to imagine a future of battery-powered cars. But to get there, scientists and engineers will have to solve a very important problem that affects drivers' peace of mind as well as their safety: Knowing just how much charge is left on their battery while driving. A branch of mathematics known as fractional order calculus may hold the answer. By suppressing the errors normally observed in methods for estimating charge, fractional order models could ultimately spell the difference between getting home safely and being stranded on the road.

It's virtually impossible to know the exact interior state of batteries as they powers devices like phones, laptops or cars. Batteries can't be opened without killing power. And even if it were possible, there are complex chemical interactions, temperature effects and mechanical changes to consider. That's why researchers use more roundabout ways of estimating charge. These methods typically involve measuring external properties such as voltage or current to derive the charge. Each measurement, however, carries a small amount of error, and because many measurements are made per second, such errors quickly pile up. Although more advanced methods, such as Kalman filtering, use mathematical models to reduce these inaccuracies, they still produce errors of greater than 1 percent. The problem is that the underlying equations, which are based on integer order calculus, don't fully capture the complex electrochemical reactions that occur in a battery. These processes are better described with fractional order calculus. And by using this more exotic form, researchers developed a more accurate

technique for estimating the amount of charge left in a battery while it's in use.

First, the scientists took measurements of the battery's actual behavior while charging and discharging. Then, based on those measurements, they created a simple circuit model that replicated the battery's performance. Then they formulated fractional order equations to describe the activity of each element in the circuit. When researchers tested this model, they found that the estimated charge was much closer to reality than previously used methods—just .5 percent off, compared to as much as 3 percent when using integer order calculus.

Although research on larger batteries is needed to further test the model, the initial results look promising, and they could go a long way to reducing drivers' anxiety when they're on the road.

More information: Fractional modeling and SOC estimation of lithium-ion battery, DOI: 10.1109/JAS.2016.7508803 , ieeexplore.ieee.org/document/7508803/

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