Original Research Article

Research on estimation method of electric vehicle power battery's state of charge based on BP neural network

Lesheng Liu

School of Mechanical and Electrical Engineering, Wuhan Business University, Wuhan, Hubei, 430056, China

Abstract: BP neural network algorithm can help the battery charged state data estimation, along with the development of the car networking and cloud platform technology, more and more state of the electric car manufacturers of electric vehicles in the vehicle and the battery status information through the car terminal uploaded to the cloud platform, through the analysis of the data of upload, the staff can better grasp the status of the vehicle, early warning to the potential risk of electric cars.If the current SOC is predicted using the battery-related data on the cloud platform and verified with the SOC estimated by BMS, it is of great significance for the online diagnosis of the data monitoring cloud platform.

Keywords: BP neural network; SOC prediction; Electric vehicles; Battery charged

1. Introduction

The charged state of the power battery of an electric vehicle is limited by the wireless communication rate and flow. Generally, the data upload period is 10 seconds.Therefore, the uploaded data cannot reflect the local details of the operation of electric vehicles.How to use sparse sampling data to predict SOC is a challenging task, because most of the existing SOC prediction methods are carried out by standard charging and discharging of batteries in the laboratory, and the sampling period is generally measured in milliseconds, which is often not suitable for sparse sampling data, so it is difficult to obtain accurate SOC prediction value[1].

2. Performance requirements of electric vehicle power battery based on BP neural network

As an important part of new energy vehicle, power battery is used to provide power for the vehicle.Its performance not only affects the range of electric vehicles, but also affects the performance of electric vehicles and other aspects. Therefore, when choosing power batteries, we should focus on the energy density, power density, cycle life and safety of the battery. The following is a brief introduction to some basic requirements of power batteries:

2.1. Energy density (Wh/L and Wh/kg)

Energy density refers to the energy released by a battery per unit volume or mass.The energy released per unit mass of the battery is called mass energy density (Wh/kg), also known as specific energy.The energy released per unit volume of the battery is called the volume energy density (Wh/L), and in many places it is simply called the energy density.The power battery with high specific energy ensures a long range of electric vehicles, as shown in **Figure 1** below:

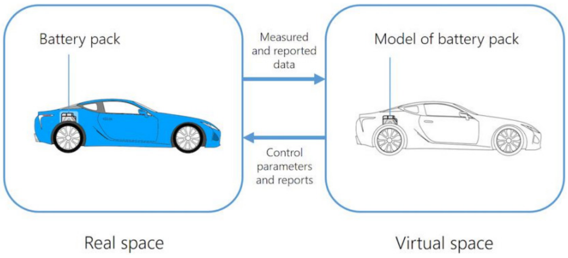

Figure 1. Influence of BP neural network on battery state of electric vehicle.

2.2. Power density (WL and W/kg)

The power output by a battery per unit mass or per unit volume. The power output by a battery per unit mass is also called specific power.The higher the specific power, the better the acceleration performance of the vehicle. The specific power is an important index to evaluate whether the battery meets the acceleration performance of the electric vehicle[2].

2.3. Cycle life

Cycle life refers to the number of times a battery can be charged and discharged in a cycle.The longer the battery cycle life, the lower the maintenance cost of electric vehicles, electric vehicles can be accepted by the majority of consumers.

2.4. Safety

The safety of power battery is very important for electric vehicles, which is directly related to the personal safety of drivers and riders. Safety is the most basic and important condition for electric vehicles.Power batteries should be stable and safe under extremely harsh conditions.For some special cars, the calculation has been based on data, or the use of experimental results of the calculation method, the comprehensive calculation of special vehicles, there are

$$\begin{cases} a = \frac{\sum_{i=1}^{n} m_i x_i}{\sum m_i} \\ b = L - a \end{cases} \tag{1}$$

$$h_g = \frac{\sum_{i=1}^{n} m_i y_i}{\sum m_i} \tag{2}$$

The meaning expressed in the formula is the mass of the first assembly; $m_i i$ x_i The meaning of expression is the distance between the center of mass of the first assembly and the front axle; i

2.5. Battery cost

Battery cost is an important factor affecting whether electric vehicles can be launched into the market on a large scale.The cost of batteries is too high, and the price of electric cars is naturally too high for most consumers to afford.With the continuous development of lithium-ion battery technology, the cost of the battery can be controlled in a reasonable range.

3. Classification of electric vehicle power battery based on BP neural network

The following will be compared from specific energy, specific power, cycle life, safety, cost and other aspects to consider which kind of battery is the first choice for electric vehicle batteries.

Lead-acid battery: relatively early development, relatively mature technology, relatively rich raw materials, high voltage, low cost, large discharge current, large specific power, good safety performance. Disadvantages are lower than the energy, mass and volume, small power, short mileage, short service life, in the process of production and use or even abandoned with a large number of harmful substances[3-5].

Nimh batteries, satisfies the requirement of electric cars have high energy, high power, long life and wide range for a steady job, enough to withstand fast filling fast to put, the battery has no memory effect, green environmental protection no pollution, the disadvantage is that nickel metal hydride battery self-discharge rate is higher, low monomer battery voltage, resistance to overcharge ability is poor, high production cost, wide application.

Nickel-cadmium battery: stable and reliable performance, long cycle service life, low self-discharge rate, the disadvantage is that it can not withstand overcharge and over-discharge, with memory effect, the cathode material of the battery is metal cadmium, not only harmful to human body, but also cause relatively large pollution to the environment.

Lithium ion battery: specific energy and specific power relative to the above three kinds of batteries, higher energy density can be up to 350-400 (Wh/L), far higher than other three batteries, monomer voltage can reach 3.7 v, is 2 times higher than the nickel cadmium battery and nickel metal hydride battery, no memory effect, low self-discharge rate, circulation service life is long, and lithium ion battery does not contain toxic substances, there is no harm to human body.Compared with the other three batteries, lithium-ion batteries have the best overall performance[6-7].

4. Estimation and design of electric vehicle power battery under charge state

At present, lithium iron phosphate (LFP) battery and ternary lithium battery are the main power batteries used in electric vehicles.Lithium iron phosphate battery is widely used in the field of electric vehicles. It has the characteristics of high stability, good safety performance and low cost.However, there are still some shortcomings of lithium iron phosphate batteries: low intrinsic electron conductivity leads to poor LFP multiplier performance;The battery has a low energy density;The operating voltage is about 3.2V, which is relatively low.With the increasing requirements of consumers for the range of electric vehicles, lithium iron phosphate batteries can not meet the needs of consumers and the market due to their insufficient energy density.

Ternary lithium ion battery has the following advantages compared with other lithium batteries: discharge platform, that is, the battery single voltage is high, can reach 3.7V, in a high level of lithium batteries;High specific energy, generally around 160~180Wh/kg, some of the company's products have reached 200Wh/kg;The cycle life is long. At present, after 2000 cycles, the capacity can still maintain 80% of the initial capacity;Low temperature performance is good, the lower limit temperature of ternary lithium battery is -30℃, which is more advantageous than the lower limit temperature of lithium iron phosphate battery -2O ℃.Under the same low temperature condition, the decay of ternary lithium battery is less than 15%, while the decay of lithium iron phosphate battery is more than 30%, and the initial capacity can still reach about 70% at -30℃. For small rate discharge, the discharge capacity decreases little at -20℃.However, compared with other lithium batteries, the safety of ternary lithium batteries is a fatal drawback of this type of battery.Because of the characteristics of ternary lithium battery, its technical requirements are more stringent, and it must be more reliable in safety. It is applied in the following different scenarios:

In recent years, researchers have proposed a variety of SOC estimation methods, the early commonly used SOC estimation methods are discharge experiment method, open circuit voltage method, ampere integral method and so on, with the in-depth study of SOC prediction algorithm, new intelligent algorithms continue to emerge, the more commonly used kalman filter method, neural network method and so on.Each algorithm has its own applicable scope and conditions. The following are the SOC estimation methods one by one:

(1) Discharge test method:Discharge test method, as a relatively simple and reliable method for SOC estimation, is often used in the laboratory.The product of discharge current and time is the remaining electric quantity. The advantage of this method is that it is simple and reliable and suitable for different kinds of batteries, but it has two obvious disadvantages. The first one is that it takes a lot of time to discharge the battery, and the second one is that it cannot be used to calculate the battery in working state[8-9].

(2) When the battery is in actual working state, the CORRESPONDING SOC value can be obtained by searching the OCV-SOC curve according to the terminal voltage of the battery.This method also has its own defects. First of all, when measuring open circuit voltage, it usually takes more than 1 hour to obtain stable terminal voltage by standing the target cell for a period of time.In addition, in the charging and discharging process of lithium battery, the voltage changes greatly in the higher and lower state of battery SOC, while the voltage changes gently in the middle region. If the open-circuit voltage with larger electromotive force is used to estimate SOC, the estimated result is quite different from the real SOC.This method is not applicable to the SOC estimation of the battery in operation as the discharge test method.The open-circuit voltage method is effective in estimating SOC at the beginning and end of charge and discharge.

(3) Ampere-hour integral method is a relatively common method for SOC estimation, which can be expressed by Equation (1) mathematically:

$$f(a) = \frac{1}{2\pi \mathrm{i}} \oint \frac{f(z)}{z-a} dz \tag{1}$$

Where SOC is the SOC value of the initial state of charge and discharge.The ampere-hour integral method is simple and reliable, and can dynamically estimate the SOC value of the battery. However, it also has disadvantages. First, the SOC value of the initial state should be known, and the current should be accurately collected. The influence of charge and discharge rate, self-discharge rate and aging degree on BATTERY SOC should be considered.The error is large under the condition of high temperature and current fluctuation.

(4) Neural network method: The neural network method only needs to extract input and output samples consistent with the working characteristics of the target battery, without studying the internal structure of the battery, and input the samples into the established neural network to obtain the predicted battery SOC value.The neural network is nonlinear and self-learning and can simulate the nonlinear relationship between battery SOC and its input sample[10].

5. Conclusion

To sum up, from the Angle of BP nerve net luo, market and consumers to the electric car trip range of the demand is higher and higher, and the electric car has the space is little, small load, and the characteristics of high sensitivity to the energy density of ternary lithium battery is gradually applied in electric cars, is currently used in new energy passenger car’s fastest-growing lithium battery.Because ternary lithium battery has the advantages of high energy density, high battery voltage and long cycle life, and also has a high state of charge, it will gradually replace lithium iron phosphate battery and become the mainstream technology products in the power battery industry.

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