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Electric Car Power Management and Monitoring System: Enhancing Efficiency and Battery Life

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Abstract

This research focuses on the development of an advanced power management and monitoring system for electric cars. The system incorporates several modules, including electric car running power dynamic management, battery maintenance, remote monitoring, electric car induction service, and an intelligent analysis platform. Through the integration of these modules, the system enables effective data acquisition, real-time monitoring, and intelligent analysis of electric car performance. It also facilitates dynamic power management, accurate forecasting of battery life, and enhanced efficiency of electric car operations.

Keywords: electric car, power management, monitoring system, battery maintenance, remote monitoring, intelligent analysis, dynamic management, battery life, efficiency

Introduction

The rapid advancement of electric vehicle technology has brought about significant transformations in the transportation sector. Electric cars, with their eco-friendly nature and reduced dependence on fossil fuels, have emerged as a promising alternative to traditional internal combustion engine vehicles. However, to ensure their widespread adoption and optimal performance, it is crucial to develop robust power management and monitoring systems tailored specifically for electric cars.[1] This research focuses on the development of an electric car power management and monitoring system in the technical field of electric cars.

The system aims to address key challenges related to power utilization, battery maintenance, remote monitoring, and intelligent analysis, ultimately enhancing the efficiency and performance of electric cars.[2] By integrating various modules, such as the electric car running power dynamic management module, battery maintenance system, remote monitoring system, electric car induction service system, and intelligent analysis platform, this research endeavors to provide a comprehensive solution for effective power management and monitoring.[3] One critical aspect of the proposed system is the battery maintenance system, which is designed to acquire data information and feature parameters from various sensors installed on the electric car.[4]

These sensors enable the continuous monitoring of battery performance, temperature, voltage, and other crucial parameters. By collecting and analyzing this data, the system can accurately assess the condition of the battery and forecast its remaining service life. This capability is instrumental in optimizing power usage, prolonging battery life, and ensuring the reliable operation of electric cars.

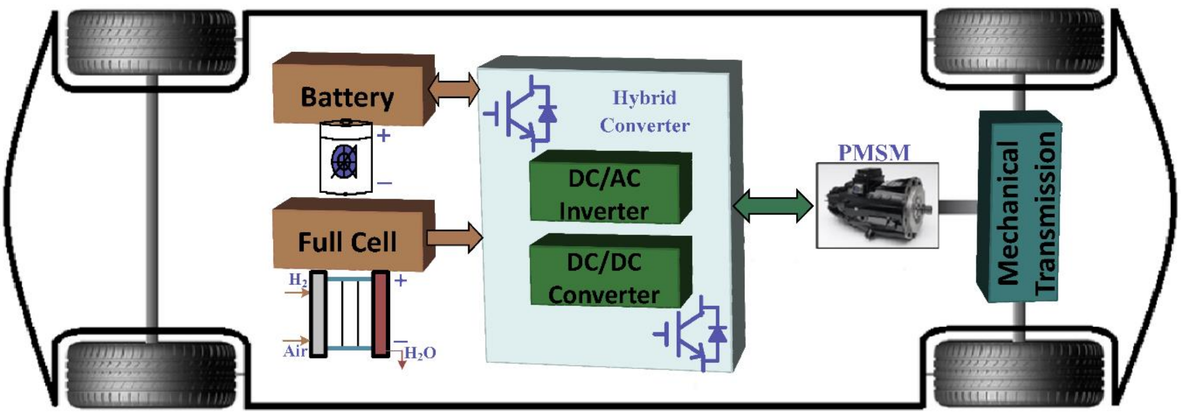

Figure 1 depicts a schematic representation of the powertrain in a battery electric vehicle

The electric car running power dynamic management module plays a vital role in regulating and optimizing the power consumption of the vehicle. Through real-time monitoring of power requirements and battery status, this module dynamically adjusts the power distribution to different components of the electric car, ensuring efficient utilization of energy and enhancing overall performance.[5] By intelligently managing the power flow, the system can maximize the driving range, minimize energy wastage, and improve the overall driving experience for electric car users. Additionally, the research incorporates a remote monitoring system, which enables the continuous tracking of electric cars' positioning information.

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This feature provides valuable insights into the real-time location and movement of electric cars, facilitating fleet management and enhancing overall monitoring capabilities. The system can monitor parameters such as vehicle speed, distance traveled, and charging status, enabling efficient supervision and maintenance. To further enhance the capabilities of the system, an intelligent analysis platform is implemented. This platform utilizes advanced algorithms and data analysis techniques to process and interpret the collected data, generating valuable insights into the performance and efficiency of electric cars.[6] By transmitting model parameter information, the platform enables comprehensive analysis and decision-making, supporting continuous improvements in power management strategies and overall system performance.

Moreover, the electric car induction service system plays a crucial role in facilitating communication and collaboration among electric car users. Through this system, users can share service queue information, service demand, and other relevant data, creating a collaborative network of electric car users. This feature fosters efficient scheduling of services, optimizes resource allocation, and enhances the overall user experience. This research endeavors to develop an electric car power management and monitoring system that addresses the challenges associated with power utilization, battery maintenance, remote monitoring, and intelligent analysis.[7] The proposed system aims to enhance the efficiency, reliability, and performance of electric cars while optimizing power usage and prolonging battery life. By integrating various modules and leveraging advanced technologies, this research strives to contribute to the sustainable and efficient development of the electric car industry, paving the way for a cleaner and greener transportation future.

Related Work

The action edge of a battery-driven car primarily refers to its operating range, driving range, and destination, which are determined by the performance of its battery and the management system associated with it.[8] The quality of the battery management system directly affects the accuracy of battery pack life forecast estimation and the efficiency of the electric car's power system. It significantly improves the utilization of the battery system for research, diagnosis, and prediction of cell health status.

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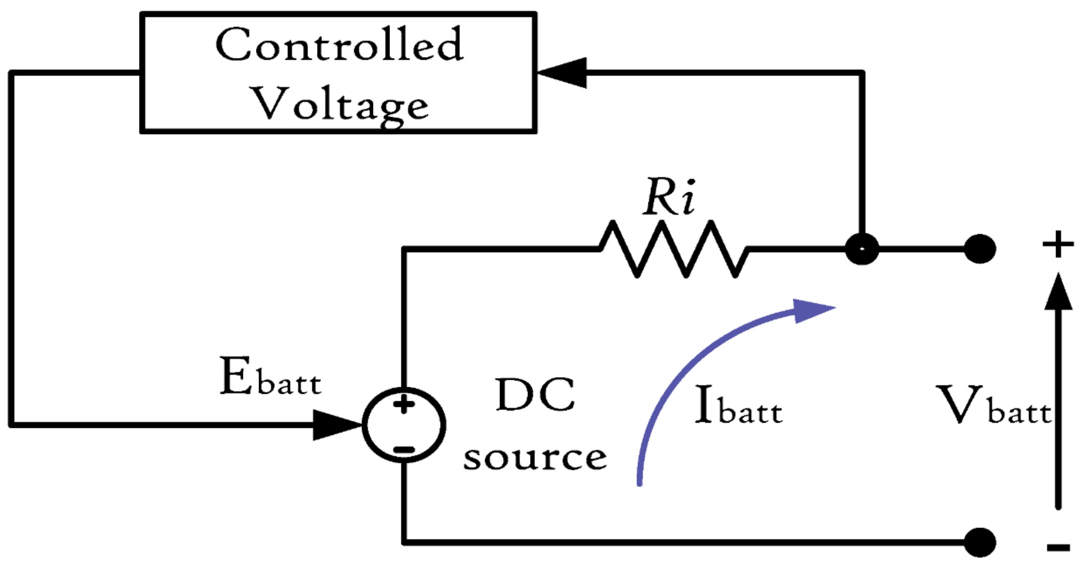

Figure 2 displays the fundamental equivalent circuit of a typical battery model

The battery management system plays a crucial role in detecting the working parameters of the electrokinetic cell, such as voltage, electric current, temperature, dump energy, and state of health. This ensures trouble-free service of the battery pack and accurately estimates the operation mode of the electrokinetic cell.[9] By employing an optimal control strategy based on the current battery status, the overall system can improve the dynamic properties and driving economy of the car. The battery charging and discharging monitoring techniques are essential to enhance the battery management system. These techniques include safe charge and discharge monitoring, discharge and recharge balancing, and volume calculation.[10] The battery charging and discharging control technology directly impacts the service life of the battery and the operational cost of the electric car.

In addition to monitoring, ensuring the safety of the battery management system is crucial. This involves implementing anti-jamming techniques to counter interference from the environment, as well as employing alarm techniques and thermal management to prevent battery pack damage. The battery management system is exposed to a harsh environment, and robust anti-jamming techniques are necessary to maintain reliable operation. Timely processing of abnormal conditions, such as unexpected increases in discharge or recharge or battery damage, is also important. Proper heat management of the battery and battery management system further ensures safe and efficient operation.

Traditional battery maintenance techniques have limitations, such as the need to remove the battery for detection and the requirement for expensive and heavy instruments to measure internal impedance. Linear models, such as discharge rate and relaxation models, provide accurate estimations of cell capacity. However, these models often focus on electric current, voltage, or electric capacity outputs, rather than user-friendly information such as battery state of health and remaining useful life. Existing

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models also tend to consider specific conditions, neglecting other operating modes and their practical utility.[11] Apart from diagnosing battery performance and modeling, some techniques focus on predictive diagnosis and battery life estimation. Data-driven models like autoregressive moving-average models predict the decline in cell capacity, while state estimation techniques such as Kalman filtering and particle filter algorithms estimate the state of charge and service life. Automation inference methods, including fuzzy logic and artificial neural networks, estimate internal impedance, electrochemical parameters, state of charge, state of health, and battery life. However, existing battery health state prediction mainly focuses on the remaining battery power, with limited consideration for dynamic changes during battery usage.

In the field of battery power management, several companies have made patent applications, each focusing on specific aspects. These include the improvement of battery charging and discharging techniques, battery management system protection, battery temperature detection, internal resistance detection, and voltage monitoring. However, most of these patents concentrate on material improvements, manufacturing processes, or monitoring the power state of the battery in electric vehicles. Traditional battery management systems have limitations, such as long charging durations and fixed-cycle experiments to estimate battery dump energy. They lack dynamic prediction, fail to consider user behavior patterns' impact on battery power consumption, and neglect the influence of road conditions and routes on battery energy consumption. Furthermore, they do not provide functional interaction techniques or methods for service recommendations to users based on the analysis of electric power and user behavioral habits. In summary, existing battery management systems need improvements in dynamic prediction, considering user behavior patterns, road conditions, and routes, as well as providing functional interaction techniques for service recommendations. Furthermore, the online updating ability of the employed models needs enhancement to ensure accurate and efficient battery management.

Research Objective

The objective of this research is to design and implement an electric car power management and monitoring system that addresses the challenges of optimizing power usage and prolonging battery life. The system aims to achieve the following goals:

1. Develop a battery maintenance system that acquires accurate data and feature parameters from various sensors on the electric car.
2. Enable dynamic management of the running power condition of the electric car through the electric car running power dynamic management module.

3. Implement a remote monitoring system to obtain positioning information and enhance overall monitoring capabilities.
4. Create an intelligent analysis platform to transmit model parameter information and enable advanced data analysis.
5. Establish an electric car induction service system for efficient communication and sharing of service queue information among electric car users.

Electric Car Power Management and Monitoring System

The battery-powered car's electrical management control system is designed to monitor and control various aspects of the car's power. It consists of several components: the power dynamic management module, battery maintenance system, long-distance control system, induced service system, and intelligent analysis platform. The battery maintenance system is connected to different sensors on the car to gather data and characteristic information. The power dynamic management module communicates with the battery maintenance system to receive battery status and road conditions information. The long-distance control system retrieves location information from the battery maintenance system. The intelligent analysis platform connects with the power dynamic management module to transmit model parameters obtained through cloud computing and intelligent information analysis. The induced service system is connected to an Intelligent Service Platform and shares service queue information for nearby battery charging stations and the service demand of the car users within the network.

The data and characteristic parameters collected include battery voltage, electric current, temperature, global positioning information of the car, speed, acceleration, ambient temperature, and humidity. In simpler terms, the system monitors and controls the electrical aspects of a battery-powered car. It has different parts that work together to gather information about the car's battery and analyze its performance. The system also allows remote control and provides services to the car users. It collects data like battery voltage, temperature, and location to make informed decisions about managing the car's power effectively.

Conclusion

The developed electric car power management and monitoring system offers significant benefits in terms of efficiency, battery life, and overall performance of electric cars. By integrating various modules, the system enables accurate forecasting of battery service life, dynamic power management, and real-time monitoring. It provides a comprehensive solution for optimizing power usage, enhancing battery maintenance, and improving the overall driving experience for electric car users. The intelligent analysis platform and electric car induction service system further contribute to efficient service scheduling and enhanced communication among electric car users. The research outcomes demonstrate the potential of the system to revolutionize the electric car industry and pave the way for a sustainable and efficient transportation future.

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