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(57) Abstract :

Battery health assessment is a critical aspect in a wide array of applications, spanning from the realm of portable electronics to the domains of electric vehicles and renewable energy systems. Ensuring the accurate and timely evaluation of battery health stands as a linchpin for guaranteeing safety, optimal performance, and a prolonged lifespan of batteries in these diverse contexts. Electrochemical Impedance Spectroscopy (EIS) has emerged as an invaluable tool in this pursuit, offering deep insights into the intricate electrochemical processes transpiring within batteries. Nevertheless, the data generated by EIS can be complex and dynamic, and the demand for real-time battery health assessments has spurred the integration of advanced machine learning techniques into battery health monitoring systems. This fusion of traditional electrochemistry and cutting-edge artificial intelligence has given rise to innovative solutions poised to revolutionize the way we assess and manage battery health. At the core of this pioneering research lies a novel battery health assessment device. This device harmoniously combines the fundamental principles of EIS with the prowess of machine learning algorithms, resulting in a system that can rapidly and accurately evaluate the health of batteries. What sets this device apart is its versatility and adaptability – it has been meticulously designed to assess a broad spectrum of battery chemistries and sizes, catering to the diversity of batteries found in various applications. Key to the device's capabilities is its real-time data acquisition system, specifically engineered for capturing EIS measurements. This system adeptly extracts essential information from impedance spectra, which is then harnessed by machine learning models. These models, which may include neural networks and support vector machines, meticulously analyze the data, yielding predictions of critical battery health indicators such as state of charge (SoC), state of health (SoH), and remaining useful life (RUL). One of the pivotal advantages of integrating machine learning with EIS is its ability to transcend the limitations of traditional assessment methods. Methods like Coulomb counting and voltage-based techniques, while valuable, often grapple with issues of accuracy and robustness, especially when faced with dynamic and evolving operating conditions. In stark contrast, the machine learning-enhanced battery health assessment device continuously learns from the battery's behavior. It adapts seamlessly to changing conditions and, most notably, provides early warnings of potential degradation or failure, enabling proactive maintenance and intervention.

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