sciforum-125307: Development of AIoT-integrated Smart Monitoring Platform for Modular Batteries in Small Electric Vehicles

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The widespread adoption of electric vehicles, especially smaller mobility solutions such as scooters and e-bikes, is driving the demand for compact and modular battery systems that are easily replaceable. Unlike conventional fixed, large battery packs, modular battery systems not only minimize the time required for charging but are also able to optimize battery configurations for different environmental and driving conditions. To respond to this demand, this study investigates an AIoT-integrated smart monitoring platform for modular batteries specialized for small electric vehicles.

The main objective of this study is to analyze and predict the performance of batteries through real-time monitoring to improve the safety, efficiency, and lifetime of battery modules. The battery performance prediction and monitoring platform utilizes data from the battery management system (BMS) and from carbon nanotube (CNT) sensors embedded in the battery module enclosure to analyze battery health and predict performance. Initially, the AI model was trained using an open-to-public battery dataset combined with simulated operating scenarios. Time series deep learning algorithms, including long short-term memory (LSTM) and gated recurrent units (GRUs), were used to accurately predict state of charge (SOC) and state of health (SOH) under simulated conditions.

To facilitate practical application, we designed a cloud-based visualization system to provide intuitive monitoring and early detection of potential battery faults. This system will be further refined through the development of modular battery prototypes and linkage with operational data.

The results of this study have important implications for future urban electric mobility by providing a flexible alternative to conventional battery management approaches. The proposed platform is expected to not only improve operational reliability and user-friendliness but also advance battery performance prediction and management techniques, contributing broadly to the sustainability and practicality of small electric vehicles.