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THERMAL CONTROL OF LITHIUM-ION BATTERIES FOR AGRICULTURAL UAVS

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Thermal runaway is the primary safety hazard. High-current discharge in a high-temperature environment can easily trigger a chain of internal side reactions, leading to a sharp rise in temperature. At the same time, there is a contradiction between the demand for lightweighting and heat dissipation efficiency: the heat dissipation efficiency of traditional air-cooled systems drops by more than 35% at an ambient temperature of 40°C, while enhancing heat dissipation will increase the system weight and affect flight time.

At present, research on thermal management of drone batteries mainly focuses on two methods: passive cooling and active cooling [1].

(1) Passive heat dissipation: such as phase change material (PCM) wrapping, which alleviates temperature rise through heat absorption and release processes, but the material has limited heat capacity and is difficult to cope with long-term high load operations [2].

(2) Active cooling, such as wind cooling and liquid cooling, reduces battery temperature through forced convection, but consumes more energy and is not optimized in conjunction with discharge strategies, which may further shorten battery life. Active heat dissipation technology, represented by liquid cooling, can significantly improve heat dissipation uniformity through bionic flow channel design. Passive heat dissipation technology does not rely on external energy input, and mainly relies on technologies such as phase change materials and heat pipes for thermal management [3].

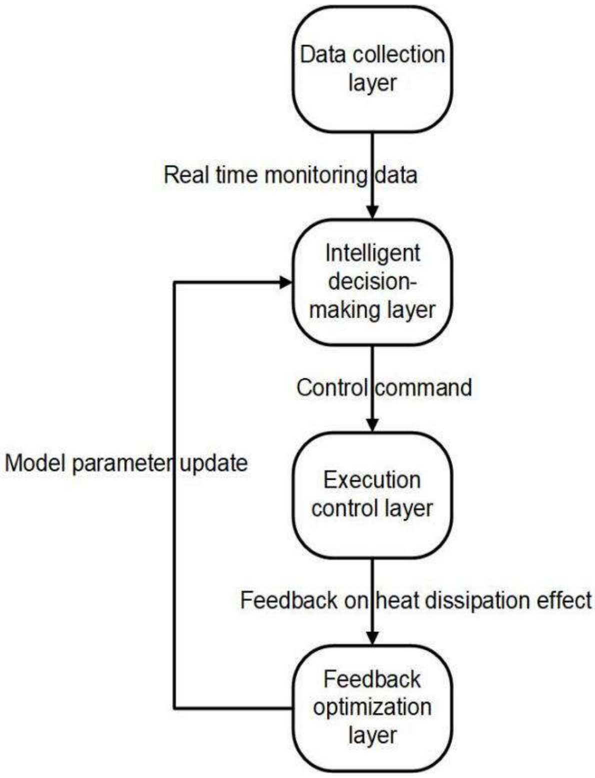
Lifecycle adaptive thermal management is a key direction for future development. Such systems can dynamically adjust thermal management strategies based on the battery's health status, environmental conditions, and mission requirements. The core lies in establishing a digital twin model of the battery's thermal behavior, enabling precise temperature control driven by real-time data.

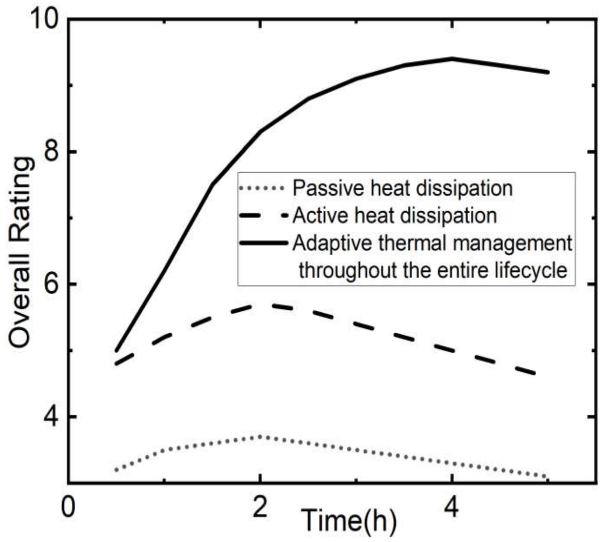
This intelligent control system based on multi parameter feedback can significantly improve energy efficiency and extend battery life.

The future thermal management system architecture will achieve full-life-cycle adaptive regulation, and its system composition is shown in Figure 1.

This system collects real-time battery health status data through a multi-source sensor network and realizes multi-scale predictive thermal management regulation from cells to modules based on the digital twin model. At the same time, the performance evolution path of different thermal management technologies is shown in Figure 2.

Among them, traditional active and passive heat dissipation technologies mainly solve the temperature control problem under static working conditions, while full-life-cycle adaptive thermal management achieves optimal energy efficiency under dynamic working conditions, reaching the best balance between heat dissipation efficiency and system life.





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