CoolSmart AI: Predictive Cooling Control for Energy-Efficient Data Center Systems

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Data centers experience increasing heat generation and energy consumption as artificial intelligence (AI) workloads expand. Traditional cooling systems operate reactively, activating only after a predetermined temperature threshold is reached, which results in inefficient energy use and unstable thermal conditions. This project investigated whether predictive AI-based cooling can reduce overheating while maintaining more stable server operation compared to traditional reactive cooling methods. A Python-based simulation was developed to model key aspects of data center operation, including server workloads, heat generation, and cooling system behavior. A Random Forest regression model was trained using temperature, workload, and cooling data to predict near-future temperatures. A rule-based control system then used these predictions to adjust cooling levels proactively before temperature thresholds were exceeded. The predictive system was evaluated against a reactive baseline under identical workload conditions. Performance metrics included maximum temperature, average temperature, time above 80 degrees Celsius, and total cooling usage. The predictive system reduced maximum temperature from 107.76 degrees Celsius to 90.87 degrees Celsius, reduced time above 80 degrees Celsius from 1193 seconds to 188 seconds, and lowered average temperature from 79.95 degrees Celsius to 63.71 degrees Celsius. However, total cooling usage increased from 958 to 1080 units. These results indicate that predictive cooling improves thermal stability and system safety by anticipating temperature changes and responding earlier than reactive systems, although this approach requires increased cooling usage to prevent overheating.

Awards Won:
Association for the Advancement of Artificial Intelligence: AAAI Membership for the School Libraries of All 8 Winners (in-kind award / part of 1st-3rd prize and honorable mentions' prize)
Association for the Advancement of Artificial Intelligence: First Award of $1,500