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Machine Learning for Enhanced Energy Efficiency in Smart Cities Through Metaheuristics Algorithms

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Abstract:

Energy efficiency is a cornerstone of sustainable smart city development, requiring intelligent systems capable of managing complex urban energy dynamics. This study presents a machine learning framework integrated with metaheuristic optimization algorithms to enhance energy efficiency across various sectors of smart cities, including transportation, infrastructure, and residential systems. Machine learning models are trained on real-time data collected from IoT-enabled devices and sensors to predict energy consumption patterns and identify inefficiencies. Metaheuristic algorithms such as Genetic Algorithms, Particle Swarm Optimization, and Ant Colony Optimization are employed to optimize energy distribution, reduce peak loads, and prioritize energy-saving interventions. The hybrid approach supports adaptive decision-making and scalable solutions for urban planners and policymakers. Results indicate that the proposed methodology significantly improves energy utilization, reduces environmental impact, and aligns with global sustainability goals.

Keywords:

Machine learning, energy efficiency, smart cities, metaheuristics, optimization, sustainable development.

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