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Simulated fire observables as indicators for optimizing wireless sensor networks in wildfire risk monitoring

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Abstract-

Uncontrolled wildfires cause significant damage and economic costs. Wireless Sensor Networks (WSNs) can mitigate these impacts by detecting fires early across extensive wildland areas. This work presents a simulation-driven optimization framework for localizing WSNs to enhance early wildfire detection and minimize potential damage. Formulated as a Multi-Objective Optimization Problem (MOOP) and solved using the Non-dominated Sorting Genetic Algorithm II (NSGA-II), the method utilizes dynamic wildfire simulations and considers stochastic variables such as ignition likelihood and weather conditions. The methodology is general and independent of the simulation model or the studied region. The framework supports decision-making under uncertainty, ensuring the designed networks remain effective across varying conditions. A practical case study with validated fire behaviour demonstrates the robustness of the approach to identify the most efficient and cost-effective sensor locations. Results show significantly better performance compared to uniform sensor grids and WSNs designed for fixed-weather scenarios, highlighting the benefits of this approach for wildfire management.

Index Terms- Wildfire simulation; Optimization; Early wildfire detection system; Wireless sensor network; NSGA-II

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