

Adaptive Target Tracking in Wireless Sensor Networks Using Metaheuristic-Enhanced Mobility Prediction Scheme

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Abstract: *Wireless Sensor Networks (WSNs) have emerged as critical enablers in a wide array of real-world applications, including surveillance, battlefield monitoring, wildlife tracking, and intelligent transportation. However, mobile target tracking is a complex problem that demands real-time precision, energy efficiency, and adaptability to dynamic network conditions. The limited computational and energy resources of WSN nodes, coupled with the inherent uncertainty in target motion, introduce significant challenges in achieving reliable and long-term tracking. This research presents a multiphase, optimization-driven target tracking framework that addresses these challenges by integrating advanced Kalman filtering techniques with novel metaheuristic algorithms. The research progresses across three well-defined phases: basic prediction-based tracking, distributed adaptive optimization, and robust node-aware tracking.*

In the proposed research, a two-stage tracking scheme was introduced to improve the accuracy and efficiency of tracking mobile targets. The initial stage employed the Adaptive Extended Kalman Filter (AEKF), a widely used estimator capable of handling non-linear system dynamics, to track the target's current position based on sensor data such as Received Signal Strength (RSS) and Angle of Arrival (AoA). Recognizing that mere state estimation is insufficient for anticipating future movements under variable conditions, the second stage introduced a predictive component. To this end, a novel hybrid optimization algorithm named Lion Mutated- Cuckoo Search (LM-CS) was proposed. LM-CS combined the local exploitation ability of the Lion Algorithm with the global search characteristics of the Cuckoo Search Algorithm, thereby enhancing convergence, precision in the prediction of mobile node movement. Performance evaluations demonstrated that the proposed LM-CS-EKF model outperformed traditional approaches like the Elephant Herding Optimizer (EHO) and Particle Swarm Optimization (PSO), achieving lower Mean Absolute Error (MAE) and Mean Squared Error (MSE) under various noise conditions...

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