

WILDGUARD: A HOLISTIC AI-IOT SURVEILLANCE SYSTEM FOR PROACTIVE WILDLIFE PROTECTION AND VEHICLE COLLISION AVOIDANCE



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Abstract:

Wildlife-vehicle collisions remain a major road safety and conservation problem. WildGuard is an integrated roadside framework for wildlife detection, warning, and deployment planning. The main validated contribution is RGB-thermal feature-fusion detection on edge hardware. Supporting modules include radar-assisted motion confirmation, cellular vehicle-to-everything (C-V2X) alert delivery, hotspot classification, and conditional acoustic deterrence. Detection uses a TensorRT-optimized YOLOv8 model on an NVIDIA Jetson Xavier. Radar measurements support motion confirmation and range estimation in low-visibility or partially occluded scenes and are not quantified as a separate source of detection gain. A Random Forest classifier assigns spatiotemporal road cells to hotspot and non-hotspot classes for planning support. Evaluation used a corpus of 13,462 synchronized RGB-thermal image pairs covering eight wildlife classes, with 2,019 real pairs held out for testing. Experimental evaluation was simulation-based. Under the tested configuration, the detector achieved mean Average Precision of 95.6 percent at an intersection-over-union threshold of 0.5, 81.3 percent averaged over thresholds from 0.5 to 0.95, and throughput of about 32 frames per second. The communication module achieved about 42 milliseconds alert latency and about 300 meters effective range under the tested setup. The hotspot classifier reached 88.6 percent accuracy on the tested planning grid, and the deterrence module produced a modeled retreat rate of 78 percent against 60 percent for the baseline. Results support the value of integrated roadside sensing and warning under controlled daytime and nighttime scenarios.

Keywords: Wildlife-Vehicle Collision, RGB-Thermal Feature Fusion, Radar-Assisted Sensing, Edge AI, C-V2X, Hotspot Classification, Acoustic Deterrence

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