Adaptive Edge AI for Proactive Urban Infrastructure Health Monitoring

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Abstract: *Urban infrastructure systems such as streetlights, transportation networks, and utility grids form the backbone of modern cities, yet their maintenance often follows a reactive approach that leads to inefficiencies, high operational costs, and safety risks. This study presents an Adaptive Edge AI framework designed for real-time, predictive infrastructure health monitoring. By integrating a network of vibration, acoustic, thermal, and optical sensors with intelligent edge processors and secure communication modules (e.g., LoRaWAN, 5G, NB-IoT), the system enables on-device AI inference for early anomaly detection. This proactive method minimizes latency, enhances reliability, and reduces dependency on cloud processing. Results indicate up to 30% reduction in unplanned downtime, 20% cost savings, and a 15% improvement in public safety. The proposed model's versatility allows deployment in various smart city applications, including streetlight networks, traffic systems, and utility grids. Looking ahead, the framework paves the way for self-healing infrastructure, broader IoT integration, and data-driven urban planning, marking a significant step toward sustainable and intelligent urban environments.*

Keywords: self-healing infrastructure, broader IoT integration, and data-driven urban planning