

Smart Adaptive Traffic Signal with Emergency and Pedestrian Priority

Prabavathi S¹, Ponmathi M¹, Nisha K¹, Divya Bairavi²

UG Scholar¹, Assistant Professor²

^{1,2} Department of Computer Science and Engineering, Vels Institute of Science, Technology & Advanced Studies (VISTAS), Pallavaram, Chennai, Tamil Nadu, India – 600117

Abstract:

Traditional fixed-time traffic signals often fail to adapt to dynamic urban traffic, resulting in congestion and delayed emergency response. This research proposes a **Smart Adaptive Traffic Signal System** with emergency and pedestrian priority, utilizing a **three-tier IoT-enabled architecture**. The Sensing Layer employs the **YOLOv5 deep learning model** on an edge processing unit to detect real-time vehicle queues and identify priority events such as emergency vehicles. This data is transmitted to the Control Layer, based on an **ESP32 microcontroller**, which executes **Hierarchical Control Logic**: Tier 1 (Preemption Logic) immediately grants right-of-way to critical vehicles, while Tier 2 (Adaptive Scheduling) employs a **Priority Queue Scheduling Algorithm (PQSA)** to select the busiest lane.

The **Dynamic Time Scaling Algorithm (DTSA)** calculates green light duration proportionally to the detected vehicle queue, maximizing traffic flow. Inter-lane IoT communication enables network-wide coordination. **Simulation results** demonstrate a 55.4% reduction in Average Vehicle Waiting Time (AVWT) and a 20% increase in total throughput compared to fixed-time systems under high-demand conditions. This intelligent traffic management approach enhances urban mobility, reduces delays, and improves emergency response efficiency.

References:

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