RESCON 2025 CMS 79

LIGHTWEIGHT AND EFFICIENT SRI LANKAN TRAFFIC SIGN DETECTION USING PRUNED AND QUANTIZED YOLOv12-N

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Traffic signs play a crucial role as a universal visual language in ensuring road safety, and neglecting or missing them can significantly contribute to accidents. To address this challenge, Traffic Sign Detection and Recognition (TSDR) has become a key feature in Advanced Driver Assistance Systems (ADAS). This study presents an optimised lightweight deep learning model for real-time traffic sign detection, specifically tailored for Sri Lankan traffic signs and traffic lights, with deployment potential in low-computational environments such as edge devices and embedded systems. Three model variants, YOLOv8n, YOLOv11n and YOLOv12-N, were trained on the dataset using the Ultralytics framework. The YOLOv12-N model was selected as the base model for its optimal balance between detection accuracy and computational efficiency. Structured pruning and post-training quantisation, two key model compression techniques, were then applied for optimisation. The computational cost (FLOPs) was reduced by 50% through L1-norm-based channel sparsity pruning, while maintaining critical validation metrics such as mean average precision at IoU 0.5 (MAP: 83.53%), precision (86.23%), and F1-score (81.31%). Dynamic quantisation further reduced the model size by 70.64%, with the final quantised model retaining strong detection capability (MAP: 78.38%, F1-score: 75.96%). The results confirm that YOLOv12-N can be effectively compressed and deployed without significant accuracy loss. This demonstrates the potential of combining pruning and quantisation to develop an efficient real-time traffic sign detection system suitable for low-computation platforms. Future integration into ADAS could enhance road safety, while applications in driver behaviour monitoring tools could support adherence to traffic regulations.

Keywords: Lightweight, Model pruning, Post-training quantization, Traffic sign detection and recognition, YOLOv12-N