

Comparative Analysis of YOLOv8, ResNet, and Enhanced EfficientNet-B4 + U-Net

for Automated Road Damage Detection and Segmentation

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Abstract— Automated detection and segmentation of road surface damage are critical for modern smart-city infrastructure and maintenance management. Manual road inspections are often expensive, infrequent, and prone to human error, motivating the use of deep-learning vision systems for consistent and scalable monitoring. This research presents a comparative evaluation of three deep neural models a ResNet-based segmentation baseline, YOLOv8 object detector, and a proposed Enhanced EfficientNet-B4 + U-Net hybrid architecture on a unified pothole segmentation dataset curated from Farzad Nekouei's Pothole Image Segmentation Dataset. The dataset comprises 780 annotated images (720 train / 60 validation) encompassing diverse illumination, texture, and damage conditions.

The proposed EfficientNet-U-Net integrates compound-scaled EfficientNet-B4 encoders, channel-attention skip connections, and deep supervision to improve boundary precision and convergence stability. Training was performed using AdamW optimization, cosine-decay learning rate scheduling, and composite BCE + Dice loss under consistent preprocessing and augmentation protocols. Experimental results demonstrate that the proposed model achieves 94% accuracy, Dice = 0.74, and IoU = 0.62, outperforming ResNet (Dice = 0.67, IoU = 0.54) and YOLOv8 detection baselines (IoU = 0.47).

Ablation studies confirm that attentive skip connections reduce shallow-layer noise, while deep supervision accelerates convergence. Benchmark comparisons (2020–2025 literature) indicate the proposed model's superior trade-off between segmentation accuracy and computational cost. Qualitative results reveal sharper pothole boundaries and better region overlap, highlighting the model's potential for automated road-quality mapping, municipal maintenance planning, and fleet-based geo-monitoring. Future work will expand the dataset across geo-graphic domains, integrate IMU / stereo depth fusion for volumetric estimation, and develop edge-optimized variants for real-time deployment on embedded systems.

Keywords— Deep Learning, Road Damage Detection, EfficientNet, U-Net, YOLOv8, Semantic Segmentation, Pothole Detection, Computer Vision.