

Crack Detection Optimization for False Positives and False Negatives in Faster R-CNN

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Abstract

Pavement crack detection is a critical procedure for the preventive maintenance of road infrastructure. However, factors such as illumination variations, background clutter, and diverse crack morphologies in real-world complex environments lead to high false positive and false negative rates in existing deep learning models, severely compromising the reliability of maintenance decisions. To address the problem of insufficient multi-scale feature extraction capability, this study takes Faster R-CNN as the baseline model and proposes an optimization method that integrates the Bidirectional Feature Pyramid Network (BiFPN) with the Squeeze-and-Excitation (SE) channel attention mechanism. Experimental results on a public crack dataset through ablation and comparative studies demonstrate that, compared with the baseline, the proposed BiFPN+SE model achieves a relative improvement of 26.9% in Precision and 15.4% in F1-score while maintaining a Recall of 71.10%. Meanwhile, the mAP@0.5 reaches 0.6499, outperforming the baseline's 0.6321. The proposed method significantly reduces false positives, better meeting the practical engineering requirement for low false alarm rates. Therefore, this study provides a highly reliable optimization solution for automated crack detection in complex environments, contributing significant value to improving the intelligence level and economic benefits of highway maintenance.

Keywords

Crack Detection, Faster R-CNN, Complex Environment, BiFPN, SE Attention Mechanism, Highway Maintenance