Pixel-level Road Crack Detection and Segmentation Based on Deep Learning

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Abstract

This paper proposed an integrated framework for detecting and segmenting road cracks in complex backgrounds. Based on the latest real-time object detection algorithm, YOLOv5l6, a modified U-Net embedded Bottleneck and Attention mechanism modules was developed to segment crack pixels from the detected crack regions. Validation of the proposed approach was conducted based on a total of 150 images, which were taken from different backgrounds, angles, and distances. Based on the computation, the results derived from the YOLOv5l6-based crack detection had a mean average precision of 92%, and the mean intersection of the union of the modified U-Net was 87%, which is at least 11% higher than the original U-Net model. The results showed the integrated approach could be a potential basis for an automated road-condition evaluation scheme for road operation and maintenance.

Keywords: road engineering; object detection; crack segmentation; deep learning.

1 Introduction

Cracks, as a common defect during the road serving process, have posed an adverse influence on driving comfort and transportation safety [1]. Road management and maintenance departments generally collect images and confirm diseases by the traditional manual method, which involves high cost, high risks, and high subjectivity. With gradually increasing demand and diverse detection scenarios, there is an urgent need for an economical, efficient, and accurate method of road crack detection to assess road performance [2-4].

Convolutional neural networks (CNNs), a deep learning algorithm simulating the top-level arithmetic logic of the human brain, possess unique superiority compared with conventional methods in the machine vision field [5,6]. Road crack detection tasks based on CNN are divided into three categories, including image classification, object detection, and pixel segmentation [7], and the latter two were studied in this work.

Object detection means identifying crack objects in an image and locating their position with bounding boxes. Cha et al. [8] used the faster region proposal convolutional neural network (Faster R-CNN) for automatic crack detection and showed it well-performing with an average accuracy of 94.7%. Du et al. [9] proposed a road surface detection and classification method based on the You Only Look Once (YOLO) algorithm, which can rapidly identify and classify road surface defects. However, due to the irregularity of crack distribution path, shape, and density, the object detection algorithm simply

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