Computer-Vision-Based Real-Time Rock Fragment Recognition During Tunnel Excavation

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Abstract

Timely recognition of rock fragments can help predict the deformation of the tunnel during tunnel boring machine (TBM) tunneling. Traditional manual inspection highly relies on subjective judgments of operators and conducting sieving tests is not real-time. Rock fragments in the real-world are often observed against a dark background, distributed with high size diversity, complicatedly distributed, and blocked by each other. This study proposes a computer vision-based method for on-site rock fragments recognition. The proposed method consists of an image pre-processing module, an instance segmentation model, and a post-processing module. The results show that the pixel-level rock fragment recognition takes 0.15s for processing a 512×512 patch on average and 88% of rock fragments can be recognized. The predicted size distributions of the major and minor axis lengths of the rock fragments fit well with the ground-truth ones statistically.

Keywords: tunnel boring machine tunnelling; rock fragment recognition; computer vision; instance segmentation.

1 Introduction

During TBM tunneling, operators often need to adjust the excavation parameters and ensure construction safety according to the mechanical properties of the rock mass. One way is involving operators making decisions after manual inspection of rock fragments by the naked eyes. Another way is conducting a sieving test to obtain the particle size distribution, which is not real-time and energy-consuming. Although structural health monitoring systems have been widely implemented in large-scale tunnels to assess structural conditions [1-3], they cannot function during the excavation process. With the booming development of computer vision techniques, a potential solution is using cameras to capture on-site rock fragment images and accomplishing real-time vision-based recognition to provide additional support for determining rock properties and excavation parameters. Huang et al. systematically highlighted the recent significant progress in computer vision techniques in tunnel construction [4]. A few related studies on the identification of particulate size from images have been conducted. For example, Amankwah et al. segmented rock images using a Voronoi diagram, and rock edge detection was achieved using the watershed transform [5]. Bai et al. employed the watershed algorithm, k-nearest-neighbors algorithm, and

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