Detection of Concrete Structural Surface Cracks Based on VQ-VAE-2

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Abstract

The deep learning models can detect surface cracks of concrete structures efficiently, but training sets which include a great number of crack pictures generally are relied on when training the deep learning models. This paper presents a detection method based on VQ-VAE-2, an unsupervised learning model, which requires no cracks when trained. Firstly, a VQ-VAE-2 model is trained on a training set which only contain pictures of normal concrete structural surfaces. The VQ-VAE-2 model is expected to produce low reconstruction error for pictures of normal concrete structural surfaces and high reconstruction error for ones of concrete structural surface cracks. Then the reconstruction error of test set is computed by the VQ-VAE-2 as the judgment criteria. Lastly, the model is evaluated by precision, recall, F1 and accuracy. The result shows the method based on VQ-VAE-2 can achieve the crack detection without crack samples.

Keywords: computer vision; crack detection; unsupervised learning; vector quantized variational autoencoder (VQ- VAE).

1 Introduction

Concrete cracking is one of the main diseases of concrete structures. Crack detection is of great significance for bridge health monitoring. However, the traditional detection method for concrete surface cracks depends on manual inspection, which is inefficient and inaccurate. Therefore, a variety of methods based on computer vision technology have been proposed and tested in some concrete structures. Aside from typical computer vision algorithms, various classical deep learning models of computer vision technologies, such as AlexNet, GoogLeNet, ResNet, and YOLO [1-3], have been used to replace traditional crack detection. Those modes detect cracks belong to the precision-based model. Although precision-based models are quite good at detecting apparent cracks of concrete, they won't operate if there aren't enough crack samples available.

Considering the lack of concrete crack samples, unsupervised anomaly detection methods should be presented and applied. Some unsupervised techniques detect cracks by building a detailed profile of normal concrete pictures, like k-nearest neighbor method [4] and GMM [5]. Different from those methods, other unsupervised techniques detect cracks relying on the higher reconstruction error when crack samples are reconstructed by a model trained only on normal concrete data. Autoencoder (AE), such as MemAE and VAE, is recognized as a powerful tool to achieve reconstruction so it has been adopted to detect anomaly in various fields [6]. Surface cracks are abnormal compared with normal concrete surface data and can also be detected by AEs. Therefore,

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