Deep convolutional neural networks for image-based detection of concrete surface cracks

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1. Introduction

Automatic image-based detection of surface defects such as concrete cracks is an important part of the vision-based structural health monitoring systems and condition assessment of civil infrastructure. Surface defects may indicate severe degradation processes being in progress in a structure. To this end, various image-based detection strategies of surface defects using computer vision and image processing methods were proposed. Currently, the most promising tools for fully automatic image-based defects detection are built with convolutional neural networks [1, 3, 5-7].

The main obstacle in the successful application of DCNNs for such problems is the lack of massive training datasets which are necessary to train large DCNNs from scratch. However, in the case of a small dataset it is still possible to build a reliable classifier and obtain the best results. It can be achieved by using a large ConvNet pretrained on a massive dataset from a similar domain [2].

In this work, we show the comparison of convolutional neural network architectures and training methods for detecting cracks in concrete pavements in the case of a small dataset. The comparison is based on the public benchmark dataset SDNET2018 [4].

2. Image-based detection of cracks

Image-based automatic detection of cracks can be formulated as a binary classification and solved by a classifier based on a neural network. The first step in building such a classifier is to collect images of structural parts containing cracks and without cracks. The second step is to build the classification model. Then we can apply the trained model to classify new images. In this work, we use deep convolutional neural networks for building an image-based classifier of concrete cracks. A schematic diagram illustrating this approach is shown in Fig. 1.

3. Experimental study

In this study, we compare four strategies for building a binary classifier for detecting cracks in images with a deep convolutional neural network (ConvNet):

1) a small ConvNet built from scratch,

2) a small ConvNet built from scratch with data augmentation,

3) a large pretrained ConvNet with data augmentation,

4) a large pretrained ConvNet with data augmentation and fine-tuning.

In this work, we consider the case of a small dataset containing only a few thousands of images of pavements with crack and without crack and a balanced set of 5200 samples of images was prepared. The experiments were done using Keras on a Dell Inspiron 15 laptop computer with 64-bit operating system Windows 10, 32 GB RAM memory, Quad-Core Intel Core i7 processor and NVIDIA GeForceGTX 1060 Ti (4 GB) graphics processing unit (GPU).

Finally, the best ConvNet, with respect to validation accuracy, was checked using the testing set. The generalization accuracy for this ConvNet was close to 94%, which confirms that the best strategy for this problem was to apply the pretrained large network with fine-tuning.

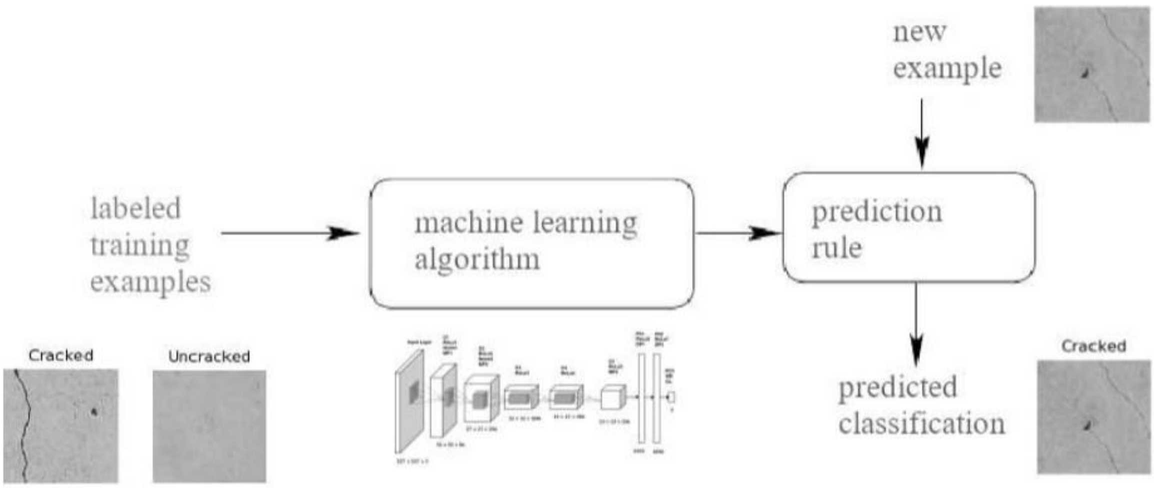

Figure 1. Diagram for image-based detection of concrete cracks using DCNN-based classifier.

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