# DeepCrack: a new hierarchical CNN-based method for crack segmentation

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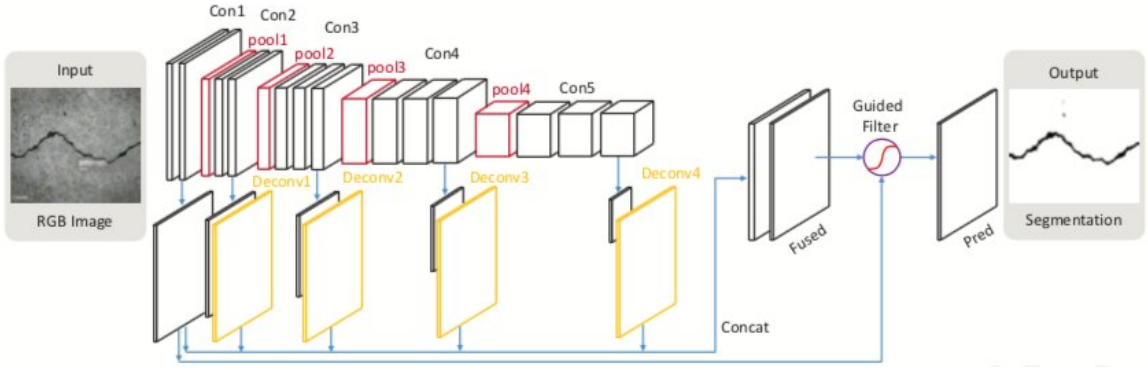


An illustration of the proposed DeepCrack architecture. In this architecture, there are no fully connected layers, the side-output layers are inserted after the convolutional layers, deep supervision is applied at each side-output layer and then all of them are concatenated to form a final fused output. In this way, the final output layer acquires multi-scale and multi-level features as the plane size of the input of side-output layers becomes smaller and the receptive field size becomes larger. The fused prediction is refined by guided filtering with the first side-output layer. Credit: Liu et al.

Detecting and analyzing cracks in man-made structures is an important task that can help to ensure that buildings are safe and well-maintained. As employing human workers to inspect buildings regularly can be very expensive, researchers have been trying to develop tools that can detect

cracks automatically.

Researchers at the Computer Vision and Remote Sensing (CVRS) Lab of Wuhan University, in China, have developed a new deep hierarchical convolutional neural network (CNN) to predict pixel-wise crack segmentation. Their approach, called DeepCrack, is outlined in a paper recently published in *Neurocomputing*.

"We propose a deep hierarchical convolutional neural network (CNN) called DeepCrack to predict pixel-wise crack segmentation in an end-to-end method," the researchers wrote in their paper. "During training, the elaborately designed model learns and aggregates multi-scale and multi-level features from the low convolutional layers to the high-level convolutional layers, which is different from the standard approaches of using only the last convolutional layer."

Detecting cracks in natural images typically requires different 'levels' of visual processing. Therefore, designing a universal method that can detect cracks in a variety of scenes has so far proved fairly challenging.

Past studies have introduced numerous computer vision methods for crack detection, which can be grouped into two broad categories: local-feature-based and global-feature-based approaches. Local-feature-based methods work by exploiting local features such as intensity, gradient, local variance and local texture anisotropy, while global-feature-based methods extract crack curves in an overall view of the building via dynamic programming, optimizing target functions based on specific criteria. Despite the promising results obtained by some of these methods, they do not always deal well with noise caused by stains, spots, poor illumination, blurring and other factors.

Recent studies have found that convolutional neural networks (CNNs) can achieve state-of-the-art performance in a variety of advanced

computer vision tasks, including image recognition, object detection and semantic segmentation. CNNs can aggregate multiple visual levels, hence could be particularly effective for crack detection and segmentation.

The team of researchers at Wuhan University has proposed a new crack segmentation method based on CNNs, which can effectively learn hierarchical features of cracks in multiple scenes and at different scales. To refine the prediction of their CNNs, the researchers used guided filtering (GF) and conditional random fields (CRFs) techniques.

DeepCrack, the new approach introduced by the researchers, consists of extended fully convolutional networks (FCNs) and deeply-supervised nets (DSNs). The DSN component of their model provides direct supervision for multi-level features learning, facilitating the feature learning of each convolutional layer.

In their study, the researchers also introduced a public benchmark dataset with manually annotated images of cracks, which can be used to evaluate crack detection systems. In addition, they established complete metrics to evaluate crack detection systems, such as semantic segmentation tests, a precision-recall curve and a receiver operating characteristic (ROC) curve.

The researchers evaluated DeepCrack and compared it with other approaches for crack segmentation, using the dataset and metrics devised by them. In these evaluations, their method performed as well as other state-of-the-art techniques. They are now planning to develop their method further, while also adding more images of false crack regions to their benchmark dataset, to make it more comprehensive.

**More information:** Yahui Liu et al. DeepCrack: A Deep Hierarchical Feature Learning Architecture for Crack Segmentation, *Neurocomputing*

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