TOWARDS REAL-TIME CRACK DETECTION USING A DEEP NEURAL NETWORK WITH A BAYESIAN FUSION ALGORITHM

Fen Fang; Liyuan Li; Mark Rice; Joo-Hwee Lim

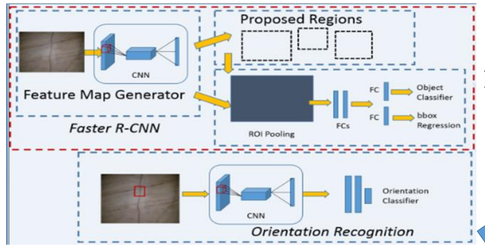
*Institute for Infocomm Research (I²R), A*STAR, Singapore*

Introduction

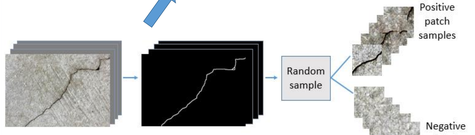
The detection of surface cracks have wide commercial applications in road safety, building, transportation and off-shore inspection. To perform real-time crack detection and segmentation, we follow the below steps:

- First, we follow a semi-automatic sampling procedure to generate dense bounding boxes of crack patches in raw images.
- We use Faster R-CNN to obtain a crack detection model, while training a ConvNet to recognize detected crack patch orientations.
- We develop a Bayesian fusion algorithm to remove false alarms from detected crack patches, and apply a morphology operation to obtain crack segmentation masks in images.

Our Approach



Faster R-CNN with Resnet 101 as backbone



Dense crack patches as input for Faster R-CNN

Detected crack patches

Bayesian Fusion Algorithm

Based on the consistency of the spatial and orientation of two adjacent detections, xj and xi to suppress false alarm.

$$p_{i,j}^{sp} = e^{-\|\mathbf{x}_i - \mathbf{x}_j\|^2/(2\sigma_x^2)},$$

$$p_{i,j}^{oc} = e^{-|\phi_i - \phi_j|/2}$$

$$p_{ij} = (p_j^c \cdot p_{i,j}^{sp})(p_j^o \cdot p_{i,j}^{oc})$$

$$P_c(\mathbf{x}_i|\{\mathbf{x}_j\} : \mathbf{x}_j \in \mathcal{N}_i) = \frac{1}{|\mathcal{N}_i|}\left(p_i^c + \sum\nolimits_{\mathbf{x}_j \in \mathcal{N}_i} p_{ij}\right)$$

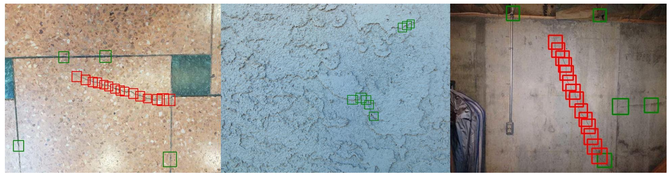


Fig.1 Illustration of Bayesian fusion effect in sample images.

Crack Mask Extraction

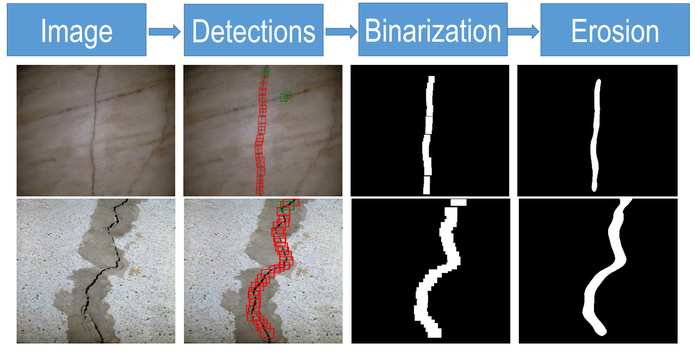


Fig.2 Illustration of the crack segmentation mask extraction.

Results

Table 1. The evaluation on the crack segmentation.

Method	Precision	Recall	F_1-score	IoU
FCN8s	0.5313	0.5860	0.5573	0.3863
SegNet	0.0768	0.2848	0.1209	0.0643
PSPNet	0.4193	0.1107	0.1752	0.0960
U_Net	0.2792	0.5504	0.3705	0.2274
Dilate_ResNet	0.5105	0.3281	0.3994	0.2496
Mask R-CNN	0.3520	0.4601	0.3989	0.2491
Our method	**0.5960**	**0.7827**	**0.6767**	**0.5114**

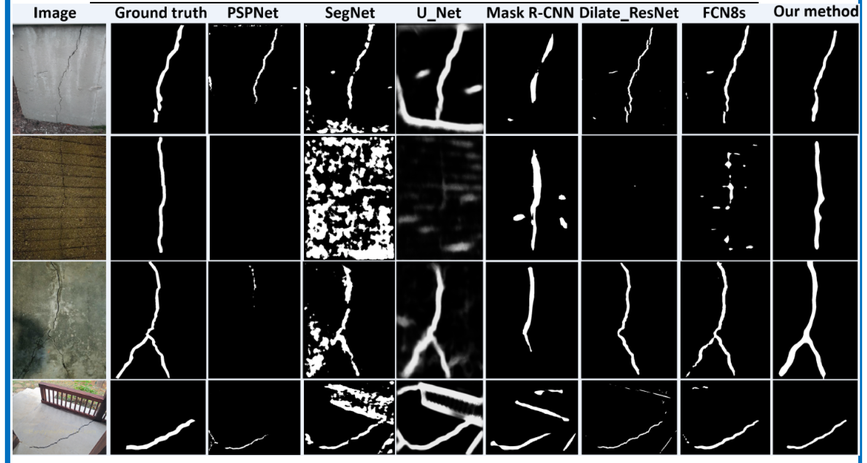


Fig.3 A comparison of results using selected crack images.

Reference

[1] L. Zhang, F. Yang, Y.D. Zhang, and Y.J. Zhu, "Road crack detection using deep convolutional neural network," ICIP, 2016.

[2] Y. Li, H. Li, and H. Wang, "Pixel-wise crack detection using deep local pattern predictor for robot application," Sensor, 2018.