Crack Detection via Salient Structure Extraction from Textured Background

Structure Health Monitoring of Intelligent Infrastructure

Conference 2017, Brisbane, Australia

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Contents

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Background review

- Visual bridge condition inspections - assessing current deterioration status and assigning maintenance tasks - ensure ongoing serviceability.

- Limited government investment into new transport infrastructure placed increasing importance upon routine visual inspections.

- Significant amount of inspection data to be collected by inspectors, assessed by engineers and stored for future use.

Source: Friday Marks 7 Years Since I-35W Bridge Collapse (2014)

Background review

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- Human vision-based bridge inspections - subjective and rely upon inspector to accurately capture all information.
- Entire manual process - costly and time-consuming.
- A number of safety risks are associated with field inspectors.
- Inspection requires experienced and highly trained personnel - shortage of required level of qualified inspectors.

https://uavamerica.com/bridge-inspection

Background review

- Curvilinear features extraction - Sobel algorithm + Canny edge detector (Ayenu-Prah & Attoh-Okine 2008; Zhao et al. 2010)

- More advanced features extraction - Wavelet (Zhou et al. 2006) and saliency (Xu et al. 2013)

- Unsupervised crack detection method based on learning from some samples to classify non-overlapping image blocks as either containing crack pixels or not (Oliveira and Correia (2013)

Background review

- Minimum path to detect cracks if this minimal path follows crack pixels (Avila et al. 2014; Amhaz et al. 2016)

- 2D/3D + visual appearance/geometrical information crack detection approach (Medina et al. 2014)

- Deep learning based method provides better crack detection performance compared with traditional feature extraction methods (Zhang et al. 2016)

Research objectives

Developing improved image processing techniques to allow detection of cracks and other defects, with the novelties being:

- Presenting the crack detection as a structure extraction problem
- Modelling the global distribution of textures
- Distinguishing the cracks as foreground structures, from background surface textures

Methodology

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1. Extracting the structure and texture features at each pixel via a sliding window:

    a). Local Structure Extraction ⇒ Structure map (crack-map-S)

    b). Global Texture Distribution ⇒ Texture map (background-map-F)

** Background textures (materials) are widely distributed over the whole image, but the structures (cracks) only appear in some parts of the image

Methodology

2. Defining the Saliency map (C) by fusing structure map (S) and texture map (F):

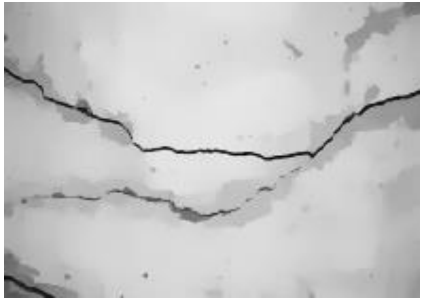
$$\boldsymbol{C} = (\mathbf{1} - \boldsymbol{\alpha})\boldsymbol{S} + \boldsymbol{\alpha}\boldsymbol{F} \quad \text{(}\alpha\text{ is the fusion parameter)}$$

3. Converting the saliency map into a binary crack map (Binarisation)

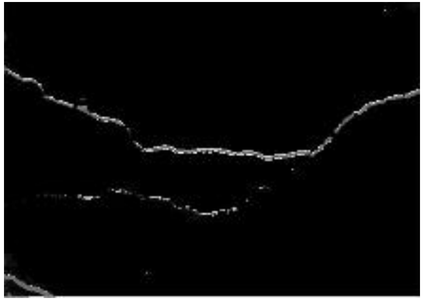
Rationale

Sample crack image

Local structure extraction result



Global texture distribution result

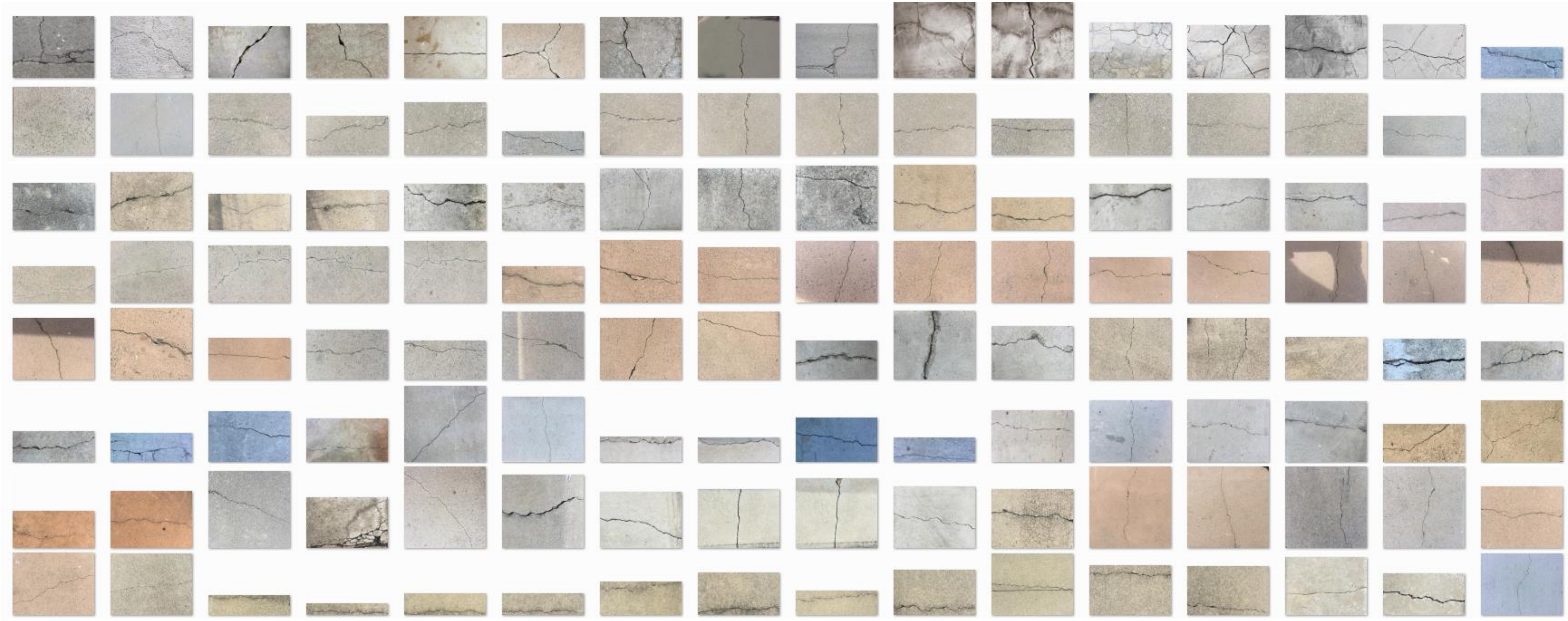


Fusion result

Binarisation result

Summary of findings

As per this rationale, we tested our method using 130 crack images (different size, resolution, contrast)



Summary of findings

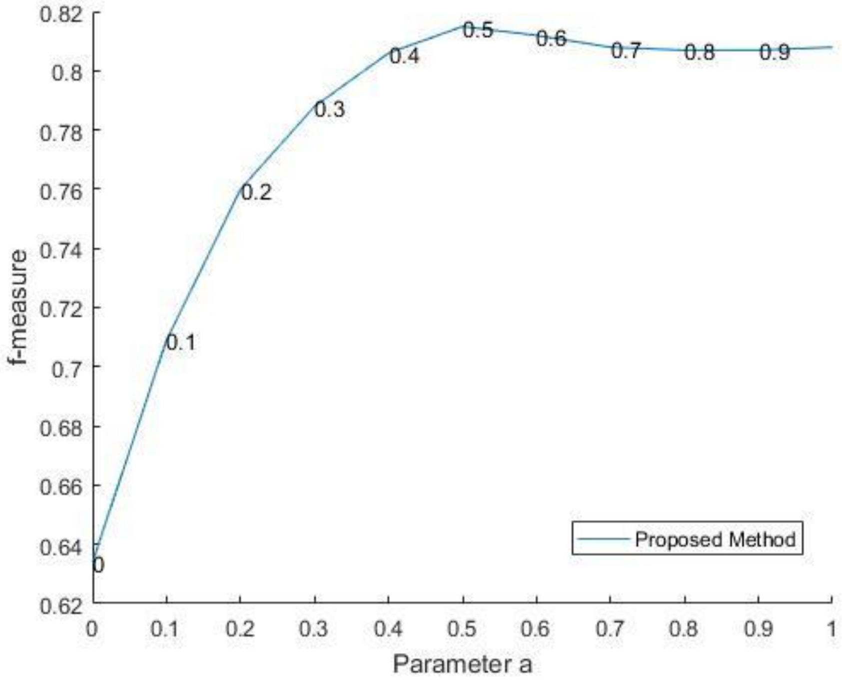
Influence of the fusion parameter α

$$C = (1 - \alpha)S + \alpha F$$

$$\text{Precision} = \frac{\text{correct detected pixels}}{\text{all detected pixels}}$$

$$\text{Recall} = \frac{\text{correct detected pixels}}{\text{all ground truth pixels}}$$

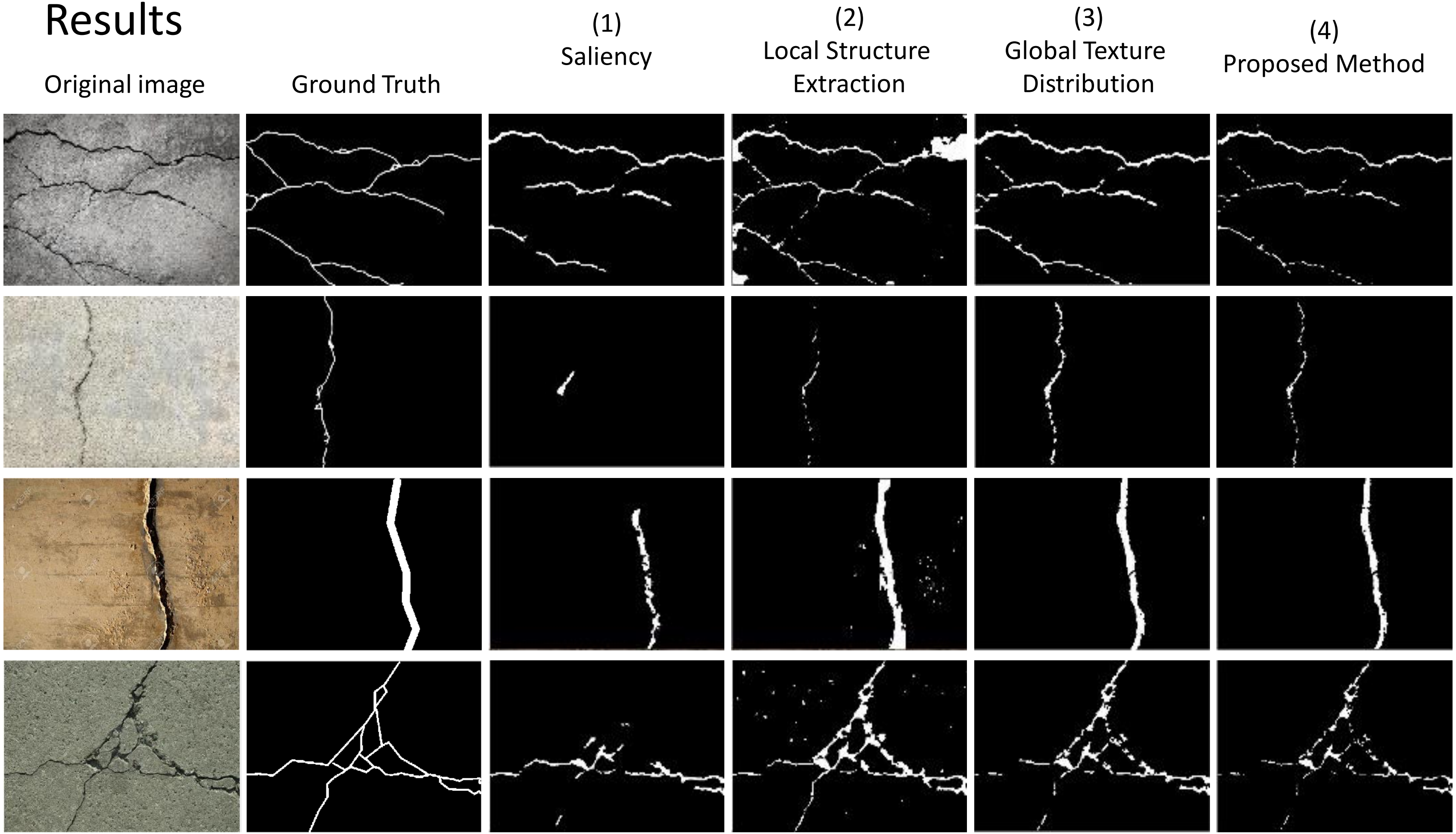
$$\text{F-Measure} = 2 \times \frac{\text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}$$



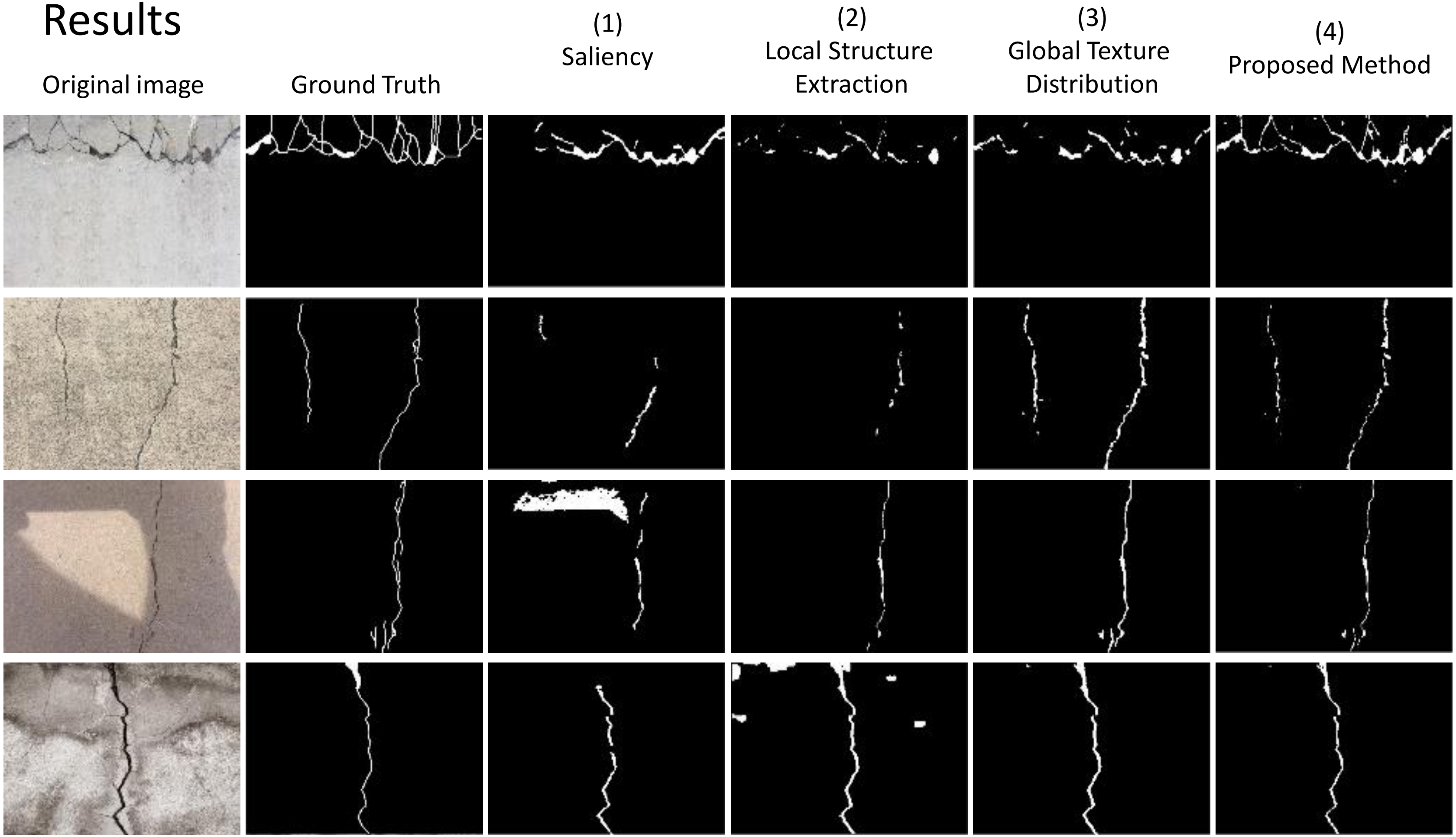
Summary of findings

	Precision	Recall	F-measure
Saliency detection	0.814	0.663	0.697
Local structure	0.823	0.536	0.596
Global texture	0.855	0.751	0.790
Proposed method	**0.859**	**0.817**	**0.815**

Results


Original image
Ground Truth
(1)
Saliency
(2)
Local Structure
Extraction
(3)
Global Texture
Distribution
(4)
Proposed Method

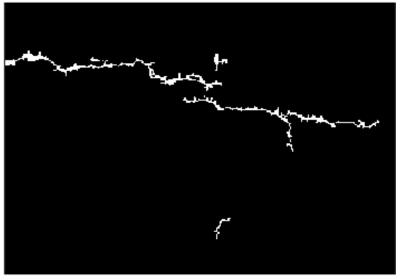
Results

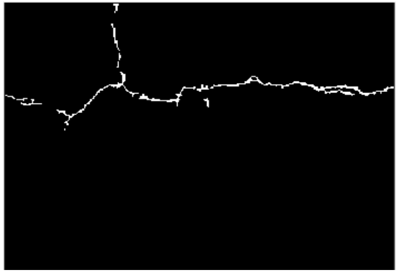

Original image
Ground Truth
(1) Saliency
(2) Local Structure Extraction
(3) Global Texture Distribution
(4) Proposed Method

Some limitations and future works

Original image

Texture Extraction





References

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- Xu, W., Tang, Z., Zhou, J., & Ding, J. (2013). *Pavement crack detection based on saliency and statistical features.* The 2013 IEEE International Conference on Image Processing (ICIP), 4093–4097.
- Xie, J., Xu, L., & Chen, E. (2012). *Image denoising and inpainting with deep neural networks*. Advances in Neural Information Processing Systems, 26:1–8.