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THE OHIO STATE UNIVERSITY

End-to-end Deep Learning Methods for Automated Damage Detection in Extreme Events at Various Scales

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- Scene level (scale) problem in cracking detection:

(a) pixel level

(b) object level

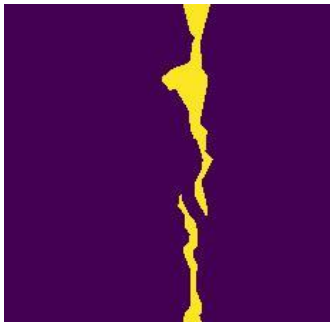
(c) structural level

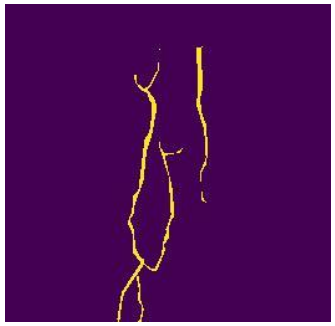
Three scene levels (scales)

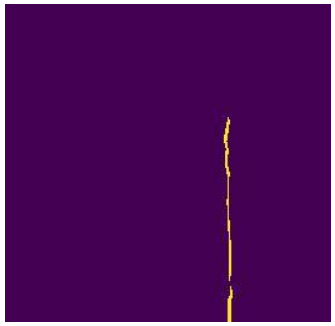
Can we find a deep learning method to detect cracks automatically and successfully on 2D images at various scene levels or scales ?

- Data preparation for training:

2,021 images with the size from 168×300 to 4600×3070 and with three scales are lablled.



Pixel level



Object level



Structural level

original label

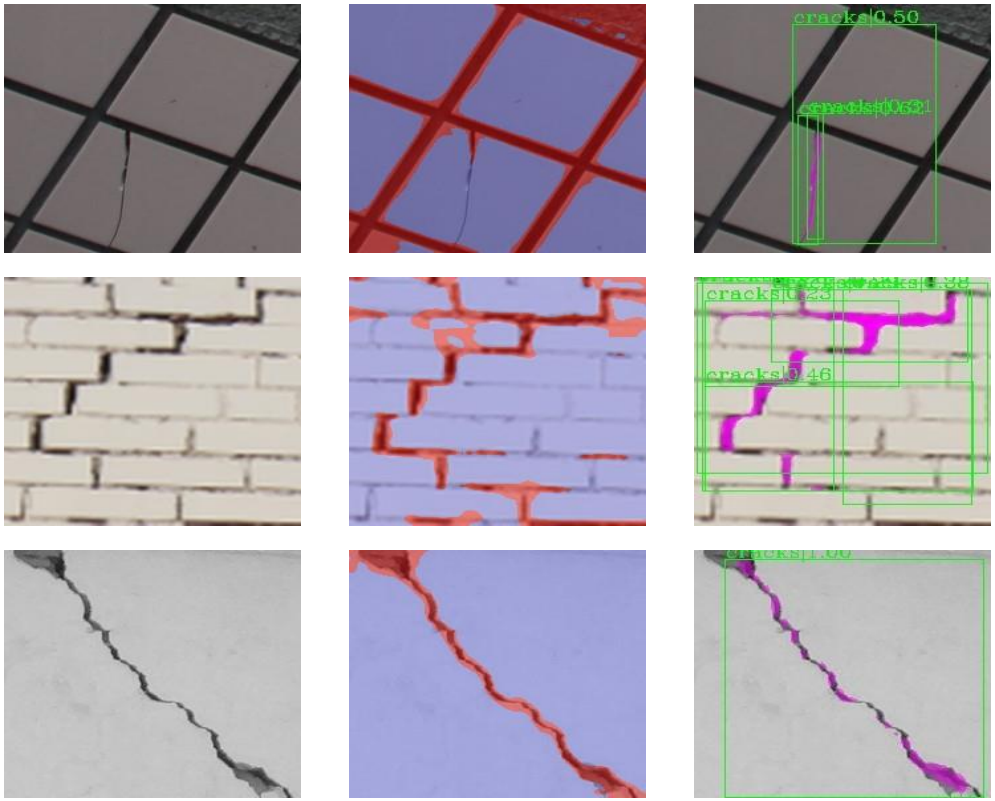
Some examples of training data at different scales

Frameworks of proposed networks:

1. Basic network: Mask R-CNN
2. Mask R-CNN with Path Aggregation Network (PANet) and Spatial Attention Mechanisms (Mask R-CNN + A-PANet)
3. Mask R-CNN with High-resolution Network (Mask R-CNN + HRNet)

➢ Implementation:

2.1) Pixel scene level (scale) Task in Phi-Net:



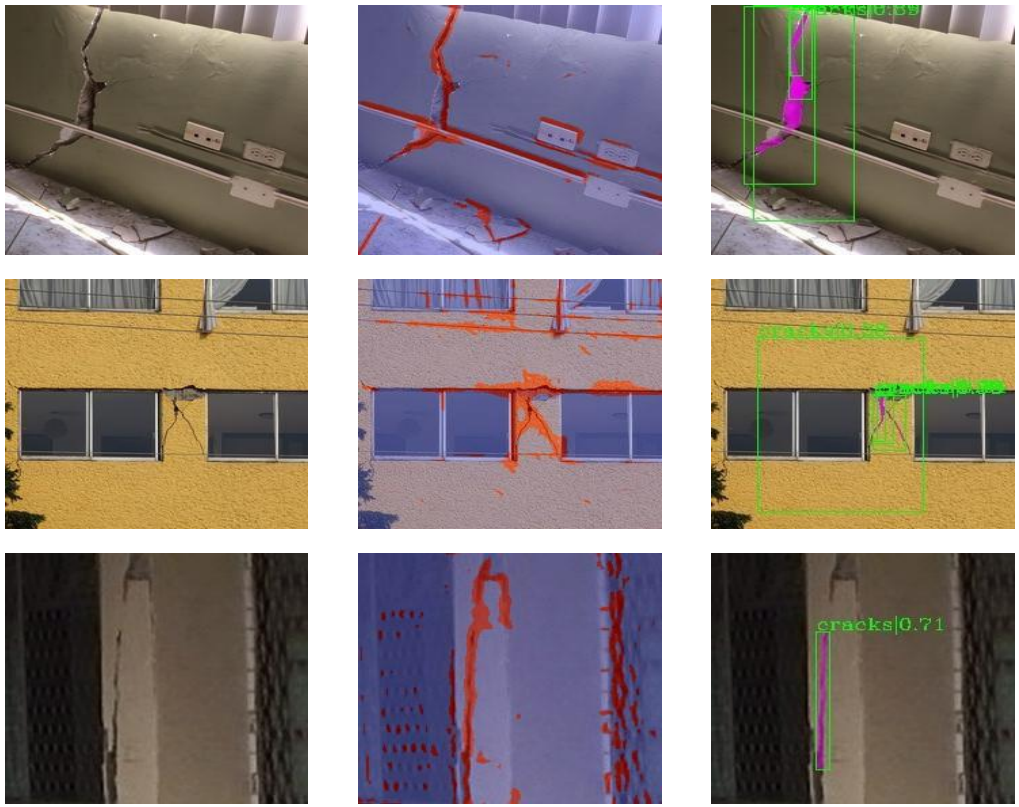
original U-Net Mask R-CNN + A-PANet

N = 4,663 images
Accuracy = 60.5% ; (U-Net)
Accuracy = **84.7%** (Mask R-CNN + A-PANet)

Some correct predictions of U-Net and Mask R-CNN + A-PANet at pixel level

➢ Implementation:

2.2) Object scene level (scale) Task in Phi-Net:



N = 5,713 images
Accuracy = 26,2% ; (U-Net)
Accuracy = **77.1%** (Mask R-CNN + A-PANet)

original U-Net Mask R-CNN + A-PANet

Some correct predictions of U-Net and Mask R-CNN + A-PANet at object level

➢ Implementation:

2.3) Structural scene level (scale) Task in Phi-Net:

original U-Net Mask R-CNN + A-PANet

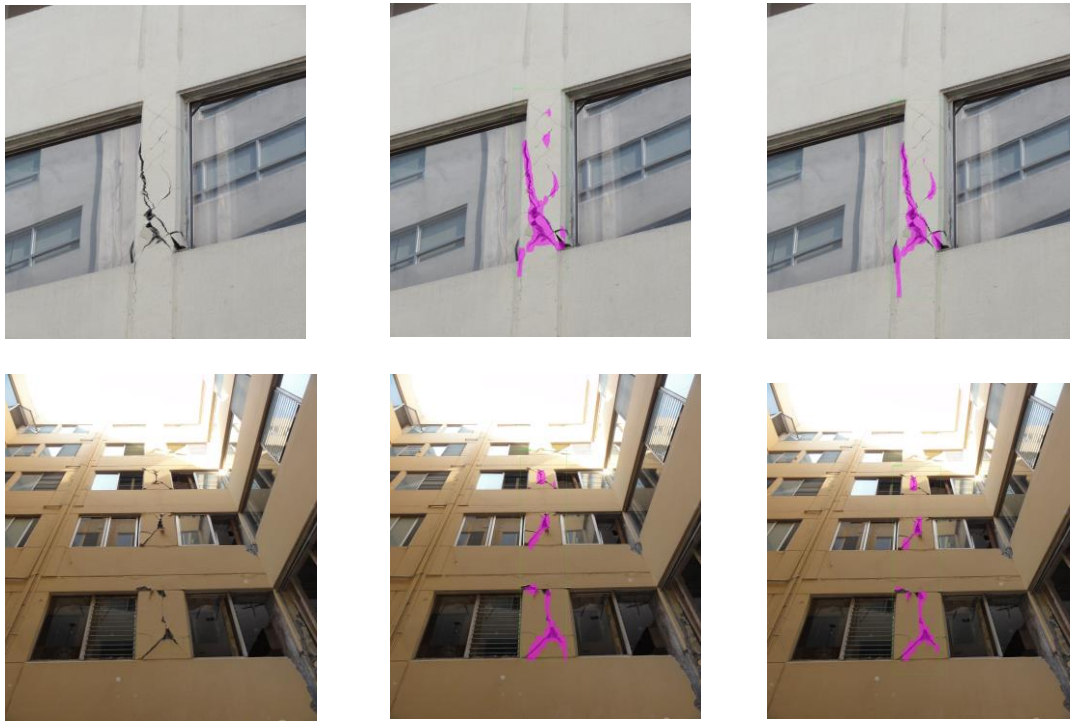
N = 5,832 images
Accuracy = 8.9% ; (U-Net)
Accuracy = **81.9%** (Mask R-CNN + A-PANet)

Some correct predictions of U-Net and Mask R-CNN + A-PANet at structural level

3. *Testing on the Other Two Datasets*:

3.1) Testing on 2017 Mexico City earthquake images (4,136):

Methods	Accuracy	Recall	Precision
Mask R-CNN + A-PANet	70.6%	53.6%	**92.9%**
Mask R-CNN + HRNet	**73.0%**	**62.7%**	90.5%



original Mask R-CNN + HRNet Mask R-CNN + A-PANet

Prediction of Mask R-CNN with Attention PANet and HRNet for 2017 Mexico City earthquake images

3.2) Testing on 2017 Pohang earthquake images (4,109):

Methods	Accuracy	Recall	Precision
Mask R-CNN + A-PANet	**74.1%**	56.9%	**94.7%**
Mask R-CNN + HRNet	74.0%	**63.6%**	88.3%

original | Mask R-CNN + HRNet | Mask R-CNN + A-PANet

Prediction of Mask R-CNN with Attention PANet and HRNet for 2017 Pohang earthquake images

Discussion and conclusion

1. With appropriate training data, end-to-end deep learning methods like the latest Mask R-CNN which can detect cracks at various scale precisely are possible.
2. We still need to collect more data for counteracting the imbalance among training data and finding a way to speed up the prediction for high-resolution images.
3. We plan to try other networks in future.

Thank you!