Crack Detection as a Weakly-Supervised Problem: Towards Achieving Less Annotation-Intensive Crack Detectors

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Crack Detection

- There are many roads and buildings desperately in need of maintenance
- Can we automate the inspection process to cut cost?
- Crack detection problem is formulated as a semantic segmentation problem
  - Pixel-level output provides other information necessary for inspection, such as crack width and orientation
Annotation is a Bottleneck

- For real life deployment, prediction accuracy is not enough
- **Annotation** process is a huge **bottleneck**
  1. Pixel-level annotation
  2. **Difficult to make robust crack detectors**, because cracks can form on any surface in many different shapes

...quick search for “crack” on the internet
Crack Detection as Weakly-Supervised Problem

- We propose a weakly-supervised approach to crack detection problem
- It is much easier to approximately annotate cracks
  - ✓ 9-30 times faster!
- Rough annotation = rough prediction…

Input

Precise annotation

Rough annotation
Method
Proposed Framework

- **Macro Branch**
  - ✓ Regular supervised crack detector, predicts using global information

- **Micro Branch**
  - ✓ Rule-based detector, predicts using localized information
Experiments
Low Quality Annotations

- Need low quality annotations to evaluate under weakly-supervised settings
- Prepared **synthetic** and **manual** annotations for evaluation
- Synthetic annotation pipeline
  1. Apply **dilation** operation to the precise GT
  2. Distort the result using **Elastic Transform**
     - Distortion is applied until the generated annotation achieves recall value between 0.925 and 0.975
Sample Outputs

Rough prediction when trained with low quality annotations

Micro Branch cleans the rough output


Results on Synthetic Dataset

Inoue Light  Inoue et al.  DeepCrack  Deeplab V3+

CFD F1-score

Aigle F1-score

DCD F1-score

w/ Micro  w/o Micro  Micro Branch only

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Results on Synthetic Dataset

**DATASET #1**

**DATASET #2**

**DATASET #3**
Results on Synthetic Dataset

- **MODEL #1**: Inoue Light
- **MODEL #2**: Inoue et al.
- **MODEL #3**: DeepCrack
- **MODEL #4**: Deeplab V3+
Results on Synthetic Dataset

Higher is better

Lower Quality
Results on Synthetic Dataset

w/o Micro Branch: Accuracy drops with quality drop

w/ Micro Branch: Accuracy preserved
Results on Synthetic Dataset

Graphs showing the performance of different models on synthetic dataset metrics.
Results on Manual Dataset
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Prediction across different datasets

- **Out-of-domain** vs. **weakly-supervised** results.
- **Bold** indicates the best results for the setting.

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