ICPR 2020

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

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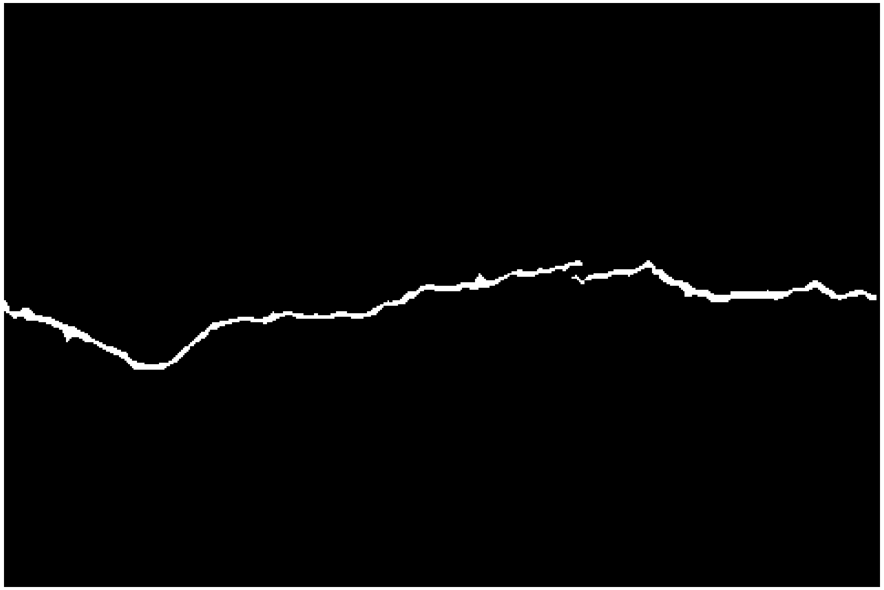
Crack Detection

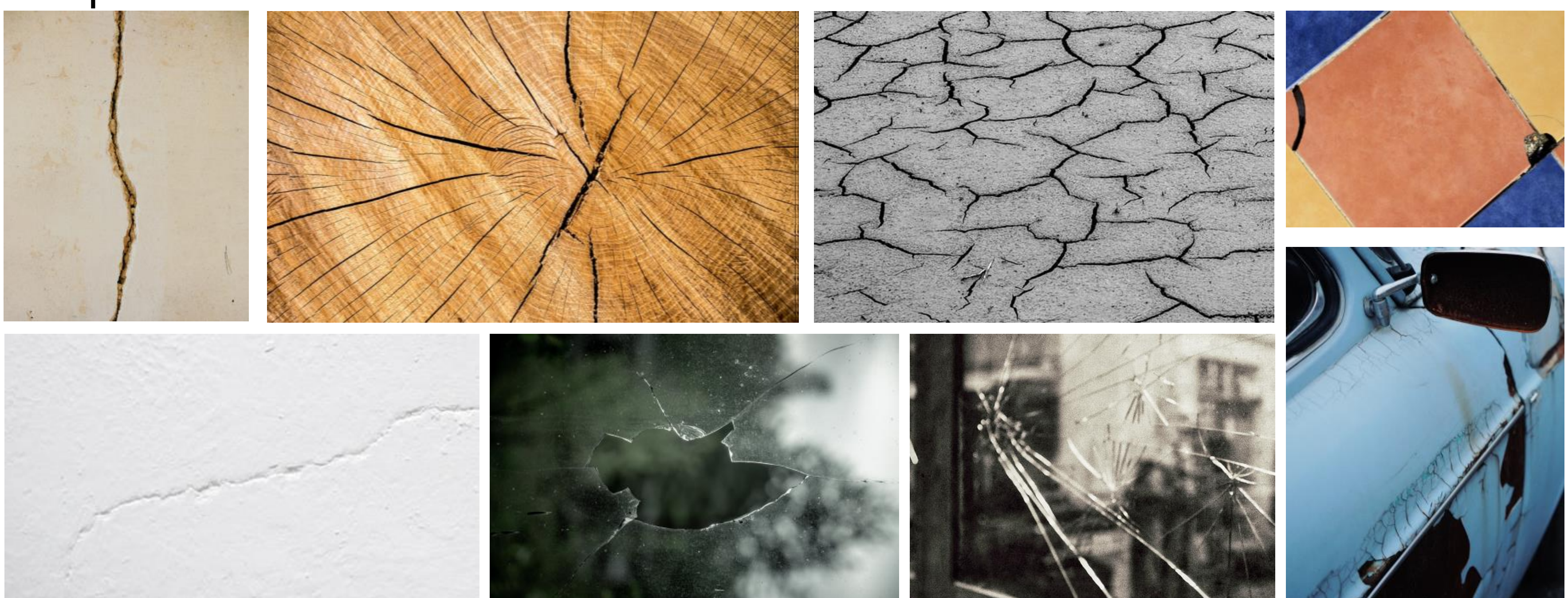
- There are many roads and buildings desperately in need of **maintenance**
- Can we **automate the inspection process** to cut cost?
- Crack detection problem is formulated as a **semantic segmentation** problem
  - ✓ Pixel-level output provides other information necessary for inspection, such as **crack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

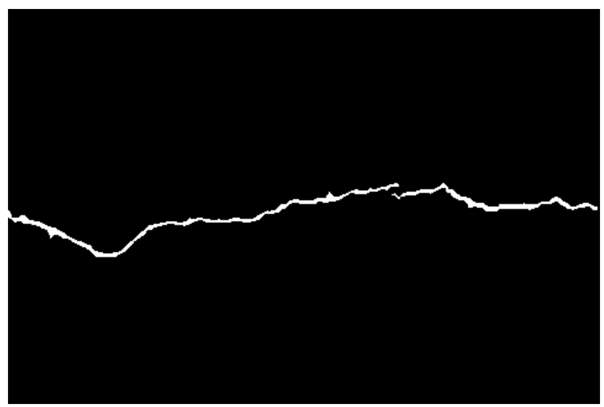
…quick search for "crack" on the internet



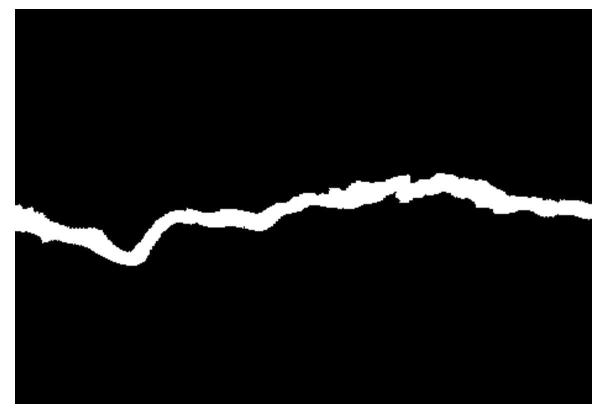
Crack Detection as Weakly-Supervised Problem

- 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

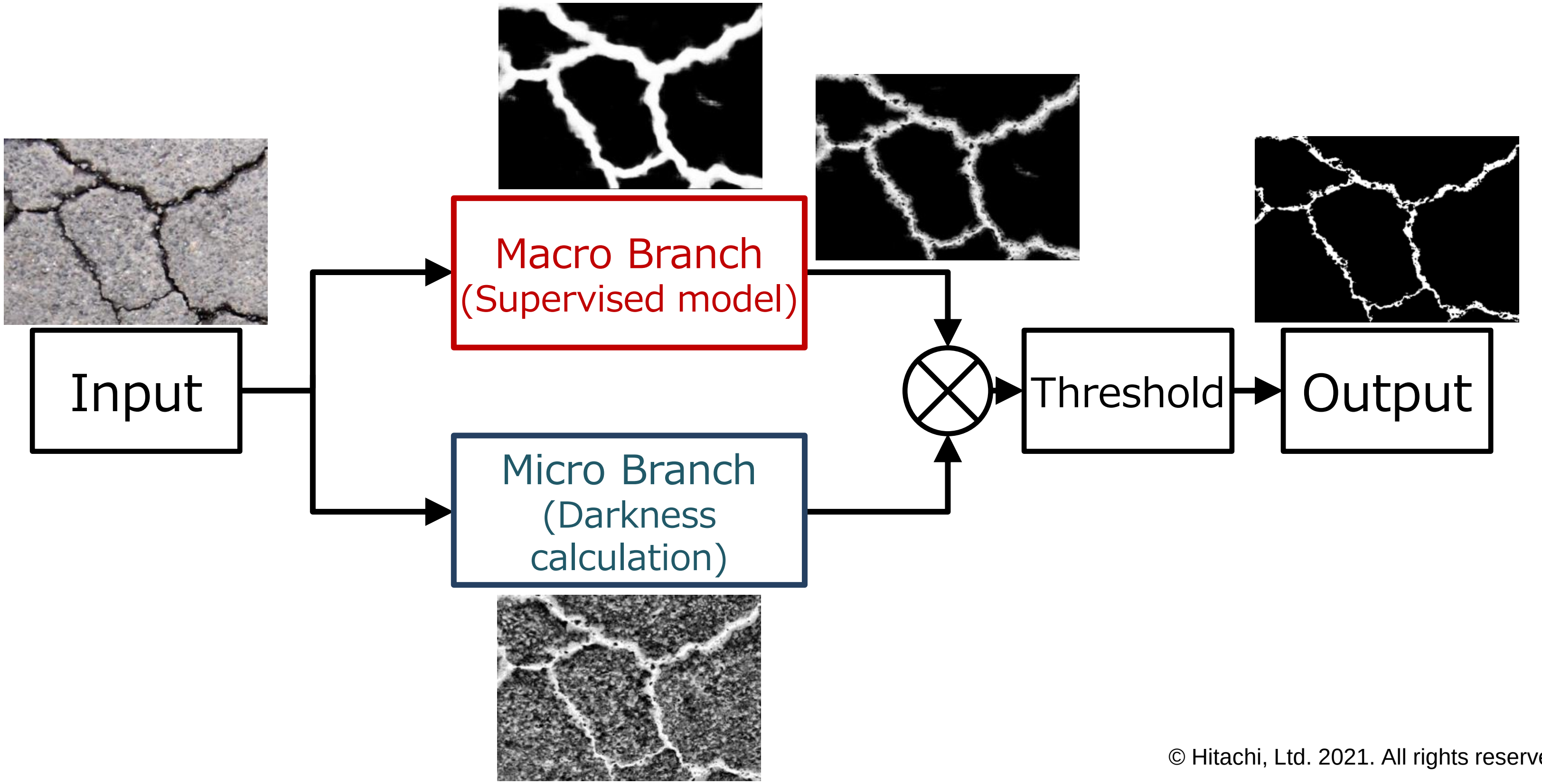


Rough annotation

Method

Proposed Framework

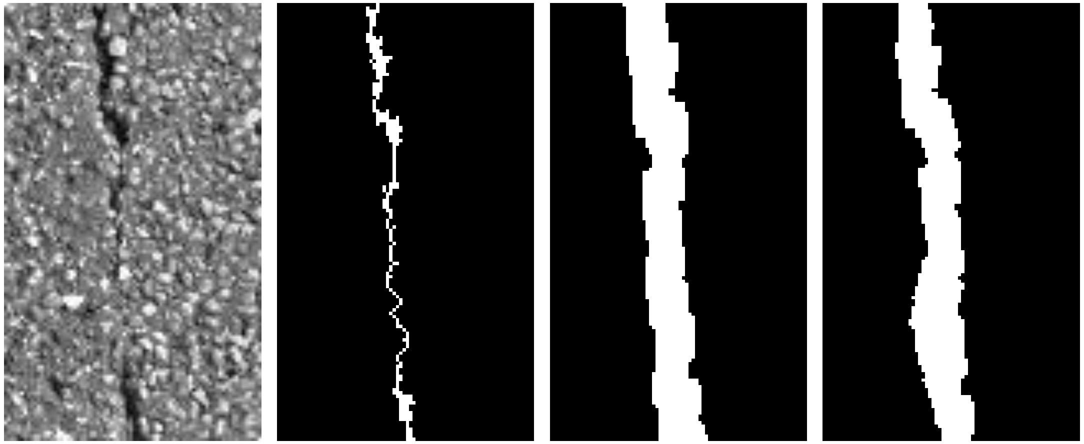
- **Macro Branch**
  - ✓ Regular supervised crack detector, predicts using global information
- **Micro Branch**
  - ✓ Rule-based detector, predicts using localized information



Experiments

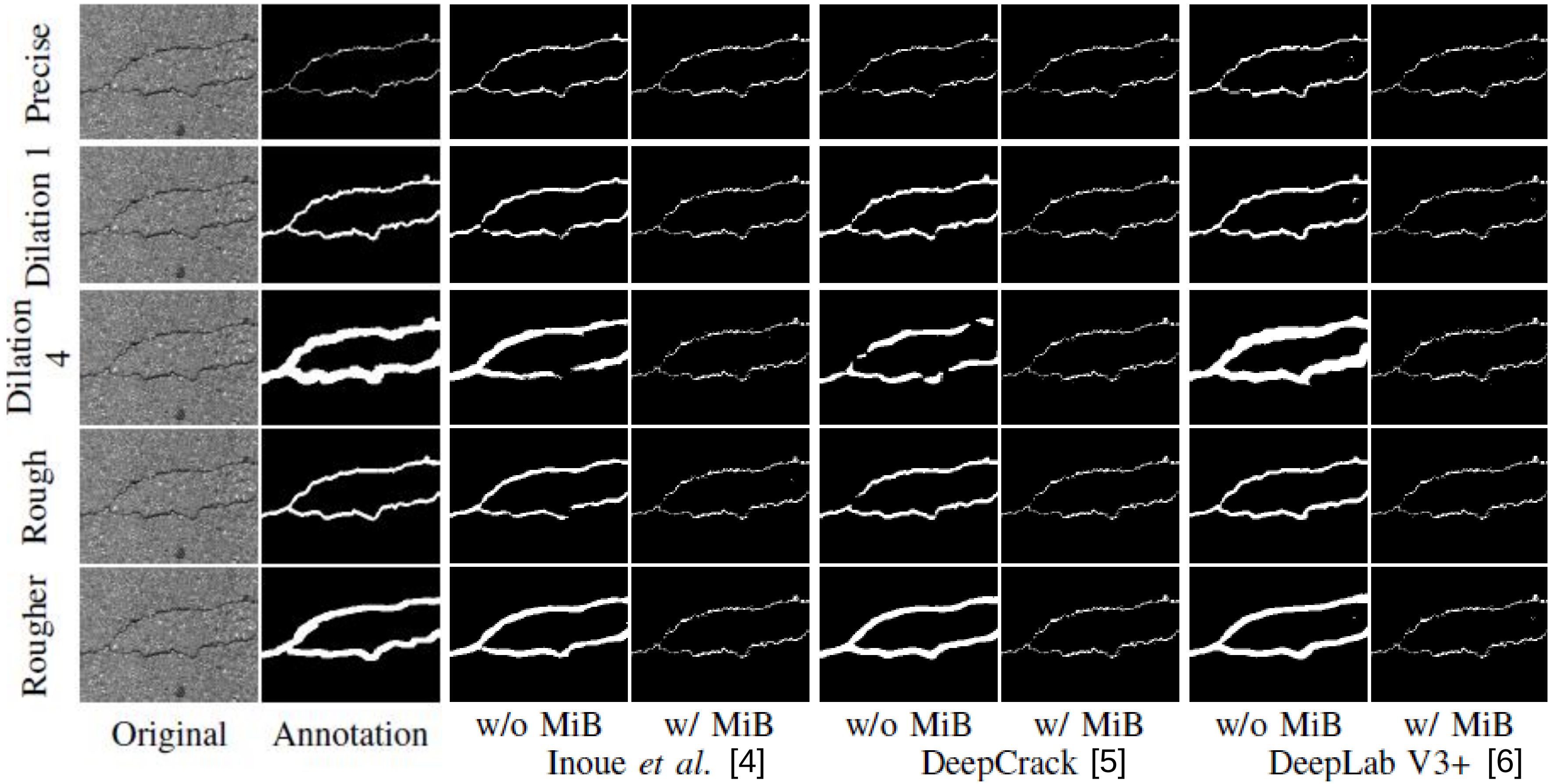
Low Quality Annotations

- **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



Input GT Dilated Distorted

Sample Outputs



[4] Yuki Inoue and Hiroto Nagayoshi. Deployment conscious automatic surface crack detection. In WACV, pages 686–694. IEEE, 2019.
[5] Yahui Liu, Jian Yao, Xiaohu Lu, Renping Xie, and Li Li. Deepcrack: A deep hierarchical feature learning architecture for crack segmentation. Neurocomputing, 338:139–153, 2019.
[6] Liang-Chieh Chen, Yukun Zhu, George Papandreou, Florian Schroff, and Hartwig Adam. Encoder-decoder with atrous separable convolution for semantic image segmentation. In ECCV, 2018.

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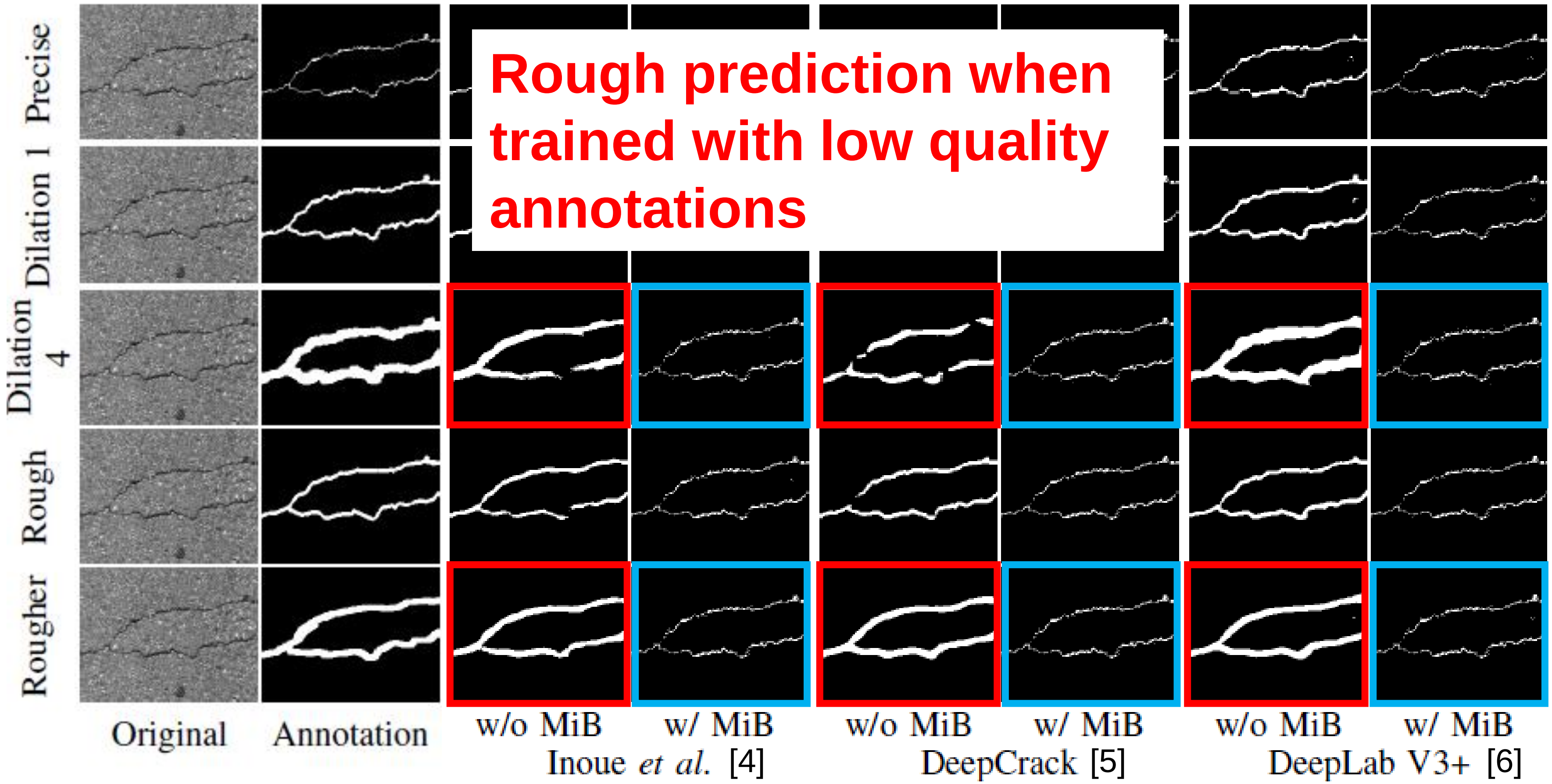
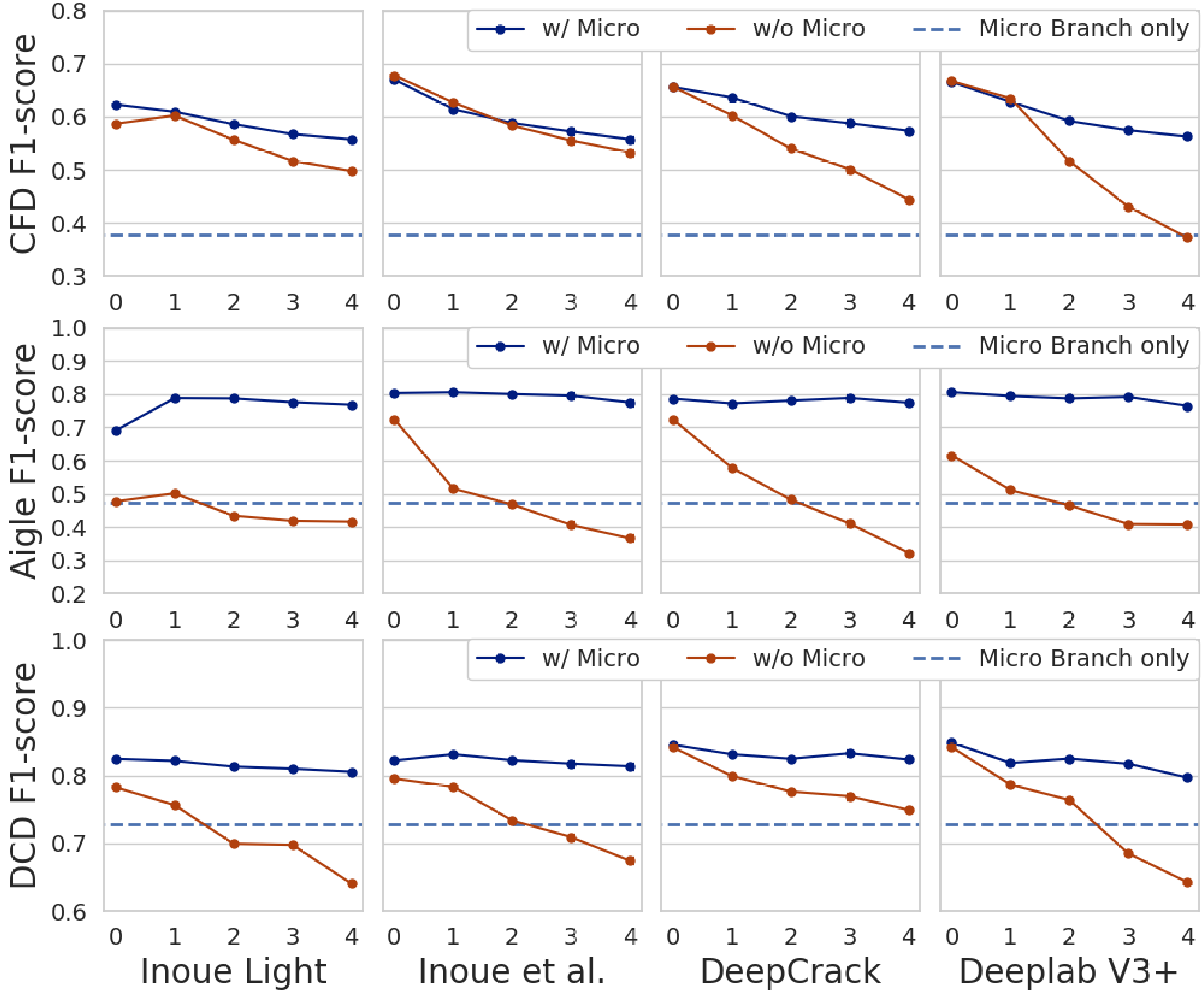


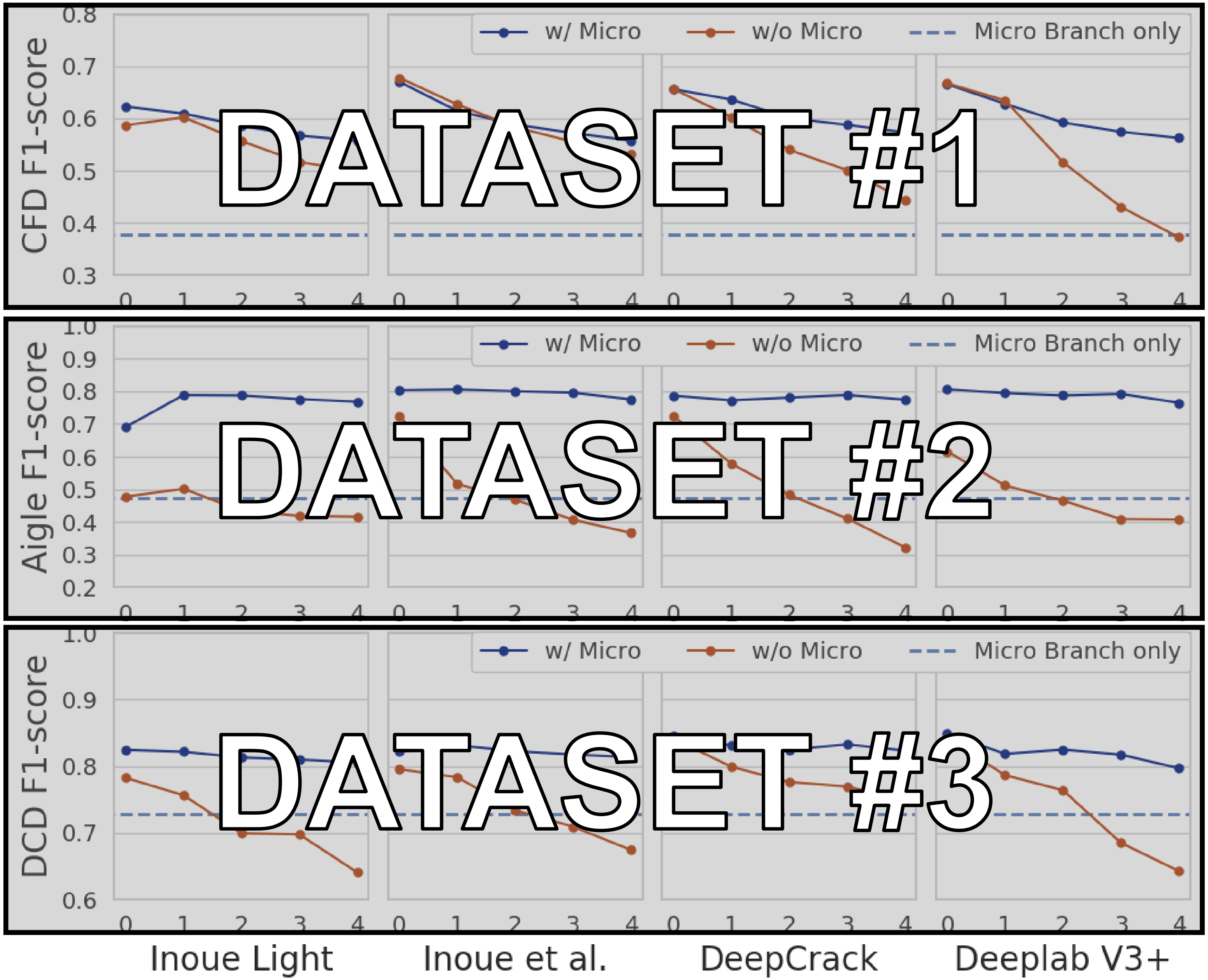
Micro Branch cleans the rough output

[4] Yuki Inoue and Hiroto Nagayoshi. Deployn … ges 686–694. IEEE, 2019.
[5] Yahui Liu, Jian Yao, Xiaohu Lu, Renping X … chitecture for crack segmentation. Neurocomputing, 338:139–153, 2019.
[6] Liang-Chieh Chen, Yukun Zhu, George Papandreou, Florian Schroff, and Hartwig Adam. Encoder-decoder with atrous separable convolution for semantic image segmentation. In ECCV, 2018.

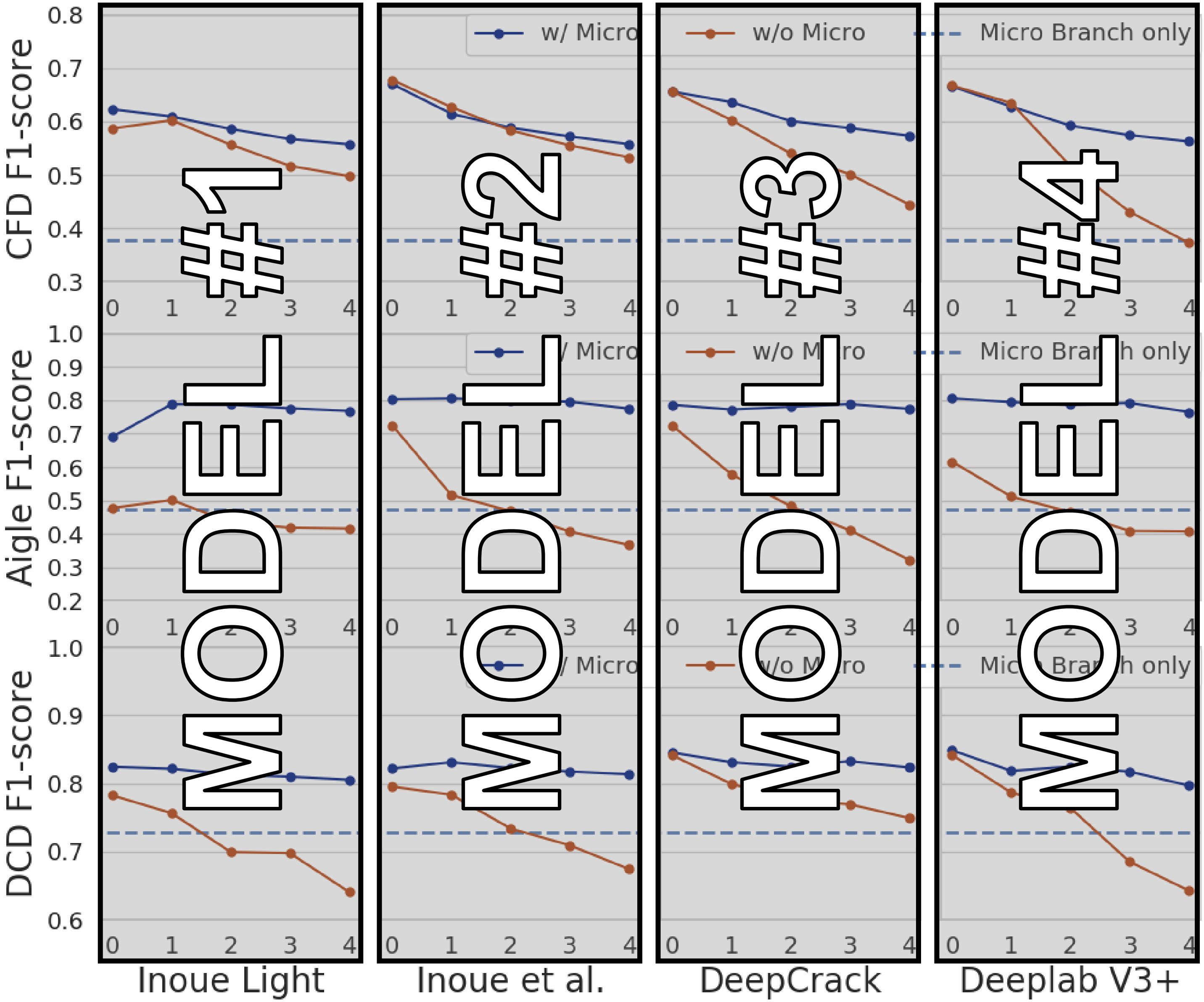
Results on Synthetic Dataset



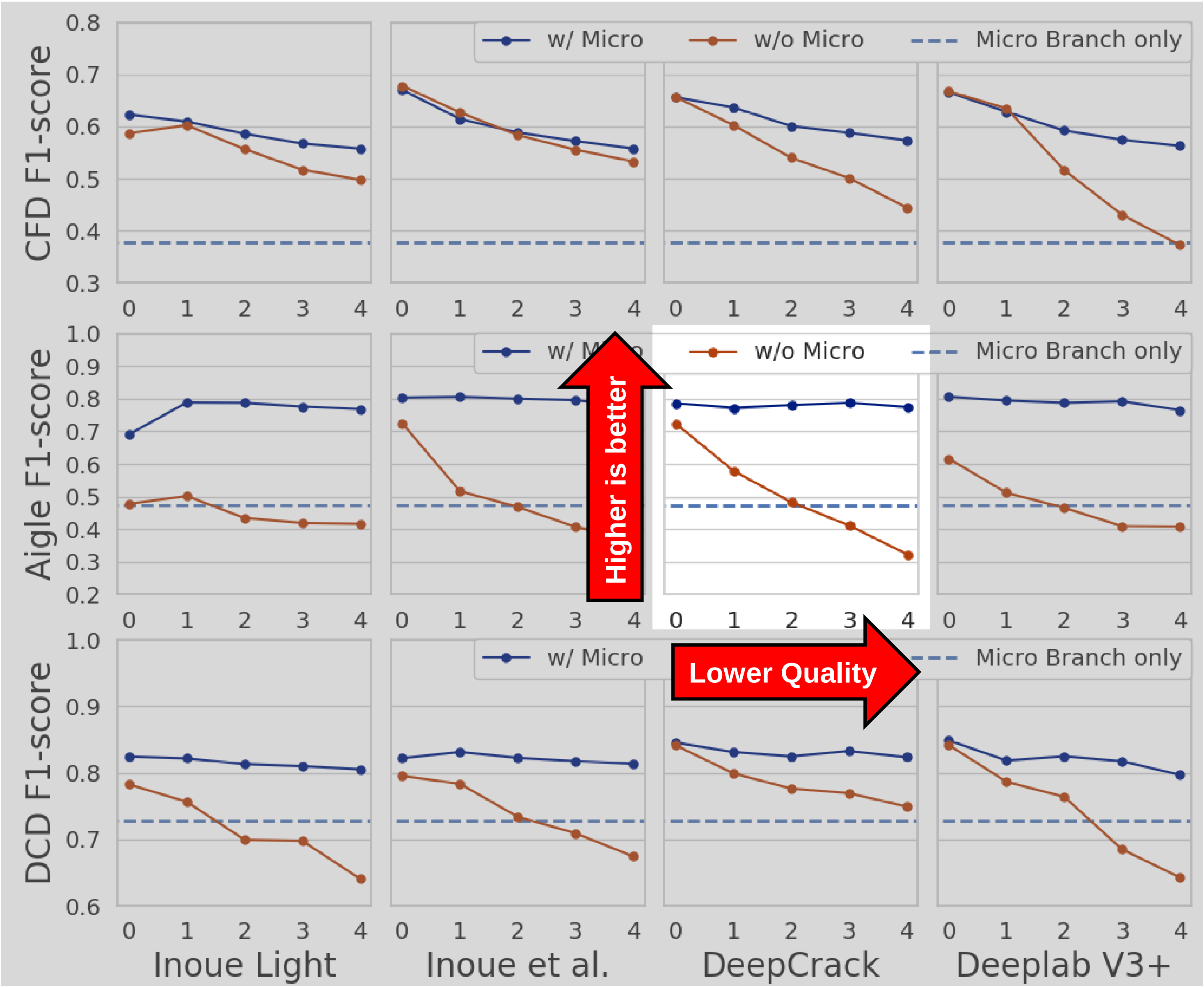
Results on Synthetic Dataset



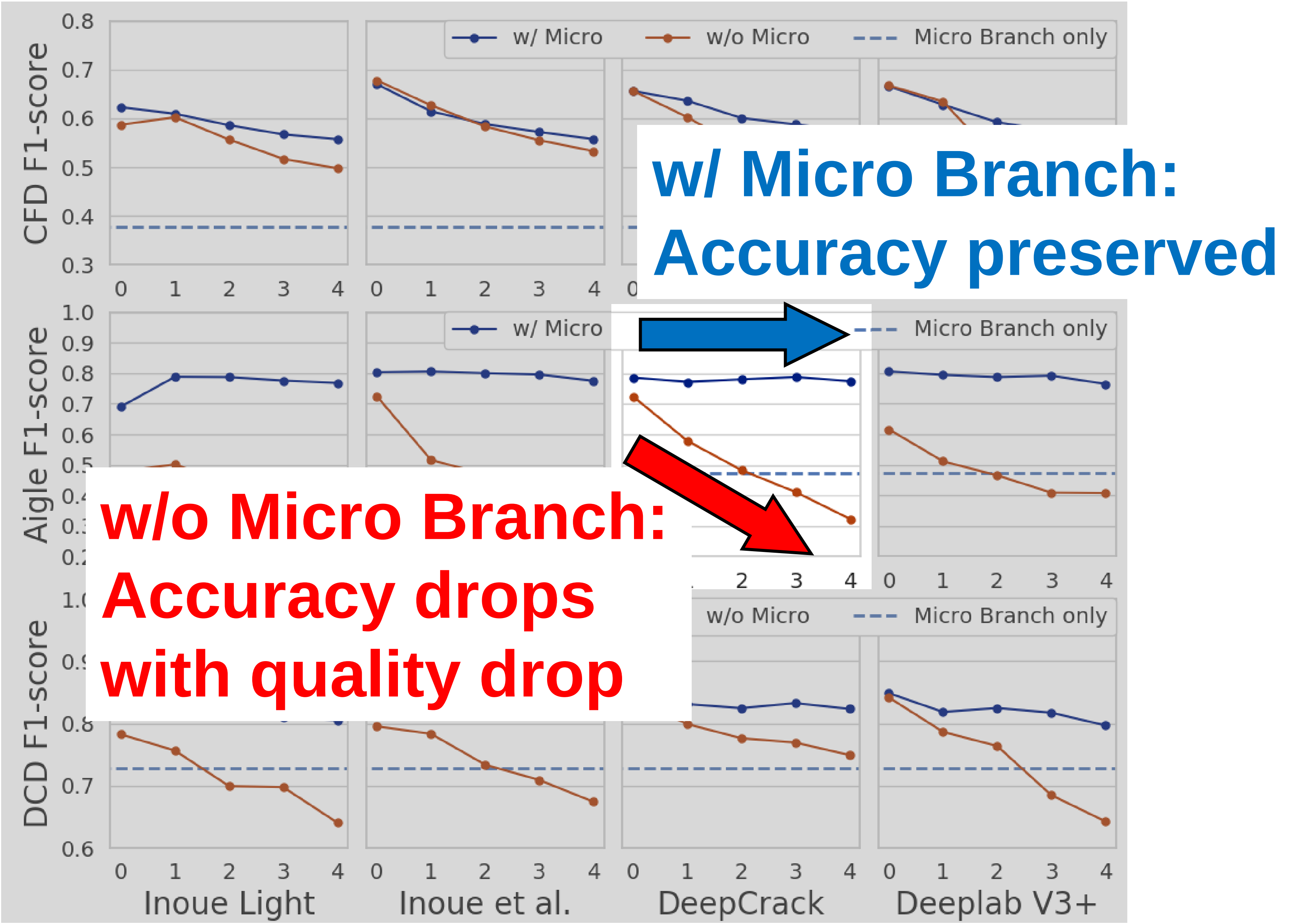
Results on Synthetic Dataset



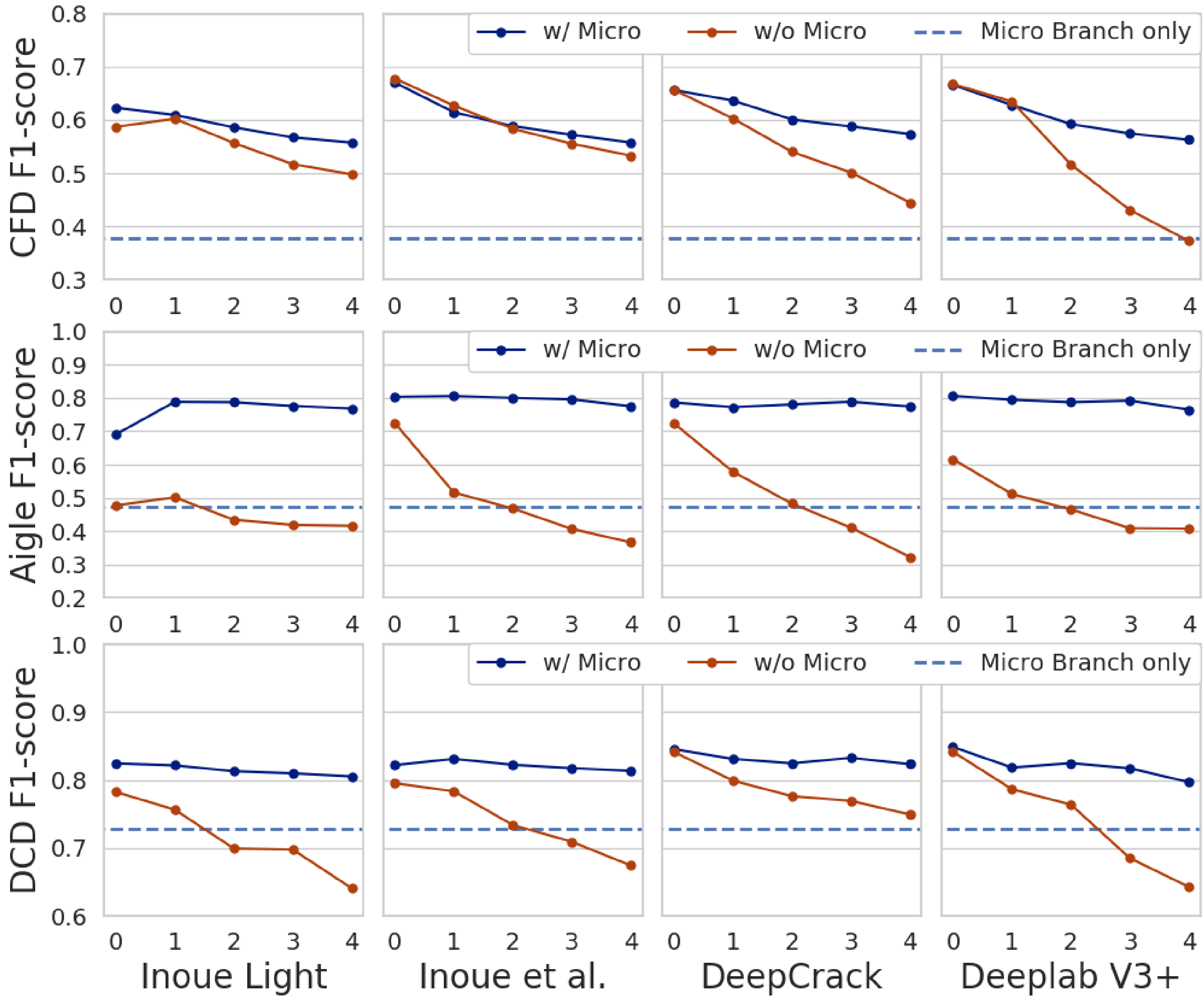
Results on Synthetic Dataset



Results on Synthetic Dataset

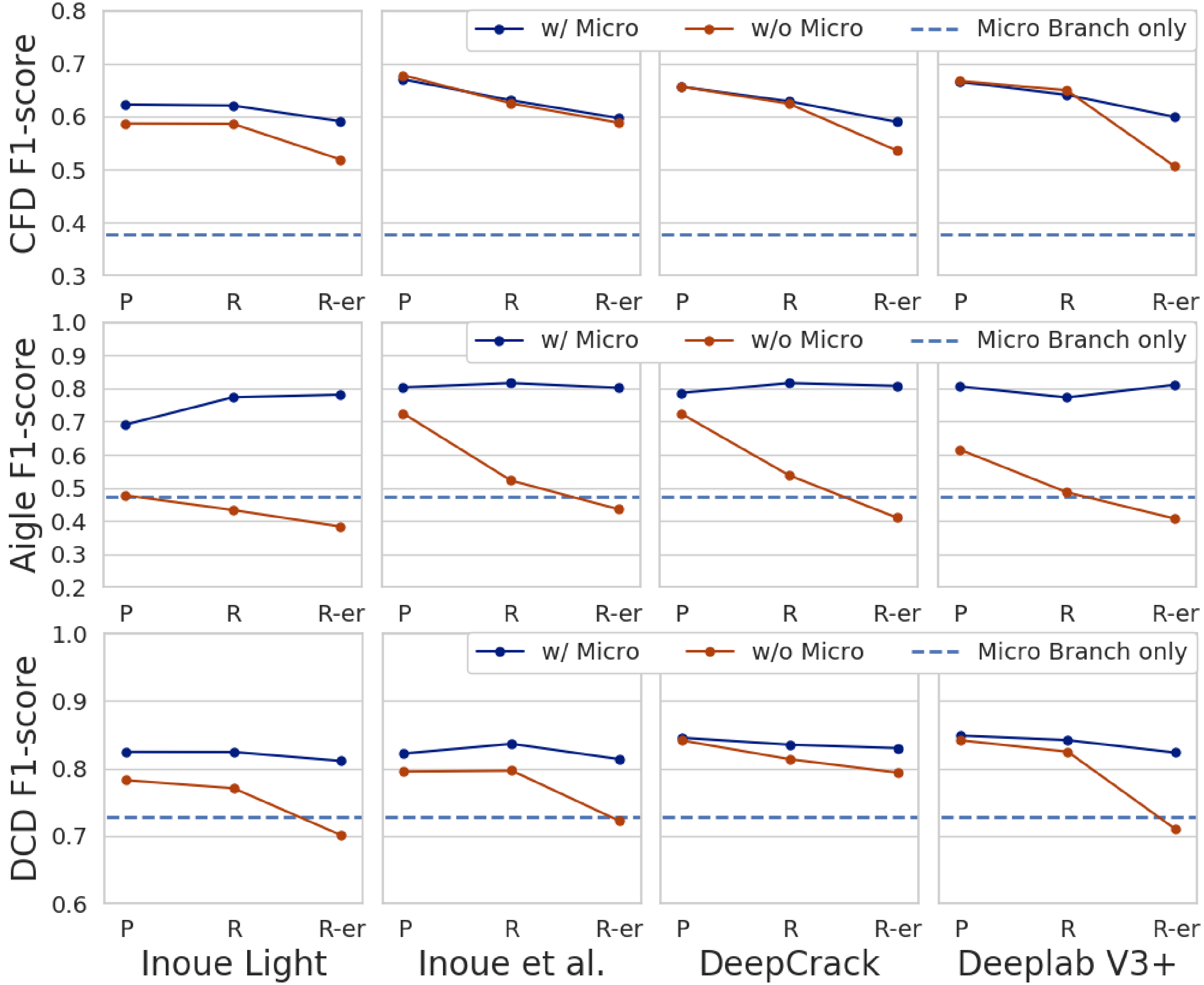


Results on Synthetic Dataset



Results on Manual Dataset

HITACHI
Inspire the Next



End

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Prediction across different datasets

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

	Inoue Light					Inoue				
	Aigle	CFD	DCD	R	R-er	Aigle	CFD	DCD	R	R-er
Aigle	-	0.645	0.475	0.773	**0.781**	-	0.669	0.654	**0.816**	0.802
CFD	0.607	-	0.542	**0.621**	0.591	**0.647**	-	0.625	0.631	0.597
DCD	0.721	0.760	-	**0.824**	0.811	0.795	0.785	-	**0.836**	0.813

	DeepCrack					DeepLab V3+				
	Aigle	CFD	DCD	R	R-er	Aigle	CFD	DCD	R	R-er
Aigle	-	0.748	0.694	**0.816**	0.808	-	0.278	0.498	0.773	**0.811**
CFD	**0.635**	-	0.548	0.629	0.590	0.590	-	0.573	**0.641**	0.599
DCD	0.565	0.382	-	**0.835**	0.830	0.829	0.686	-	**0.842**	0.823