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SECTION 3. Emerging Trends and Technologies in IT Application (5 MAY 2023)

**Recycling for Recycling: RoI Cropping by
Recycling a Pre-trained Attention Mechanism for
Accurate Classification of Recyclables**

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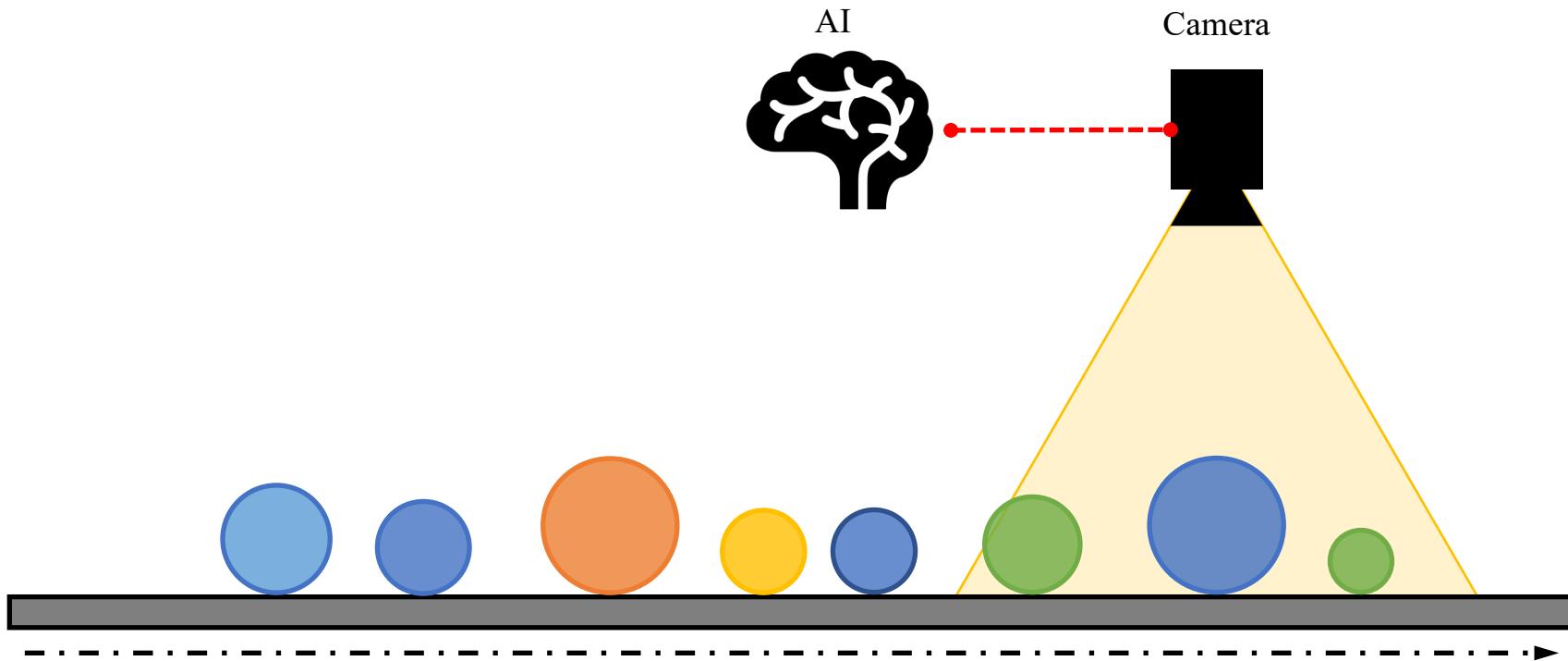
²IoT Solution Business Group SK Planet Co., Ltd., Korea



Background



Ideal System



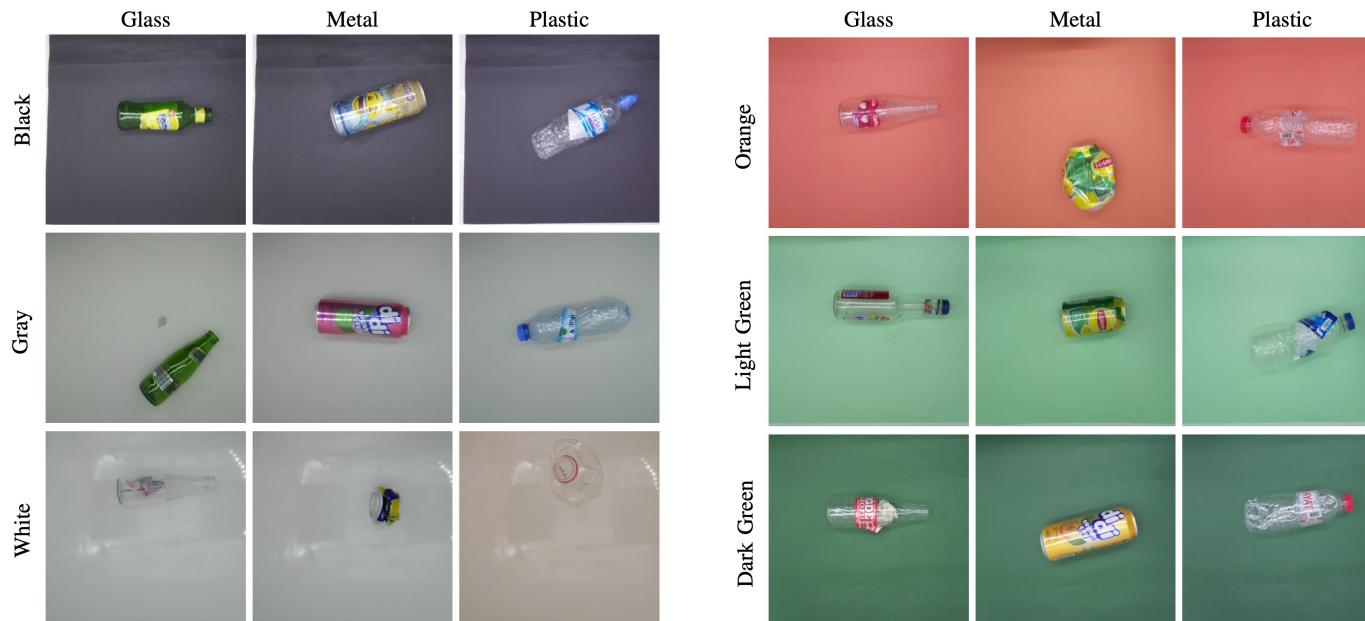
- Move recyclables **one by one** on a conveyor belt
- Classify each object via machine vision system
- Consider **end-to-end** object detection and recognition model
 - i. e. R-CNN * or YOLO **

* S. Ren, K. He, R. Girshick, and J Sun. "Faster R-CNN: Towards real-time object detection with region proposal networks." Advances in neural information processing systems. 2015.

** J. Redmon, S. Divvala, R. Girshick, and A. Farhadi. "You only look once: Unified, real-time object detection." IEEE conference on computer vision and pattern recognition. 2016.

Real-world Problem

Recyclable Solid Waste Dataset (RSWD) dataset *



Limitations of an end-to-end model

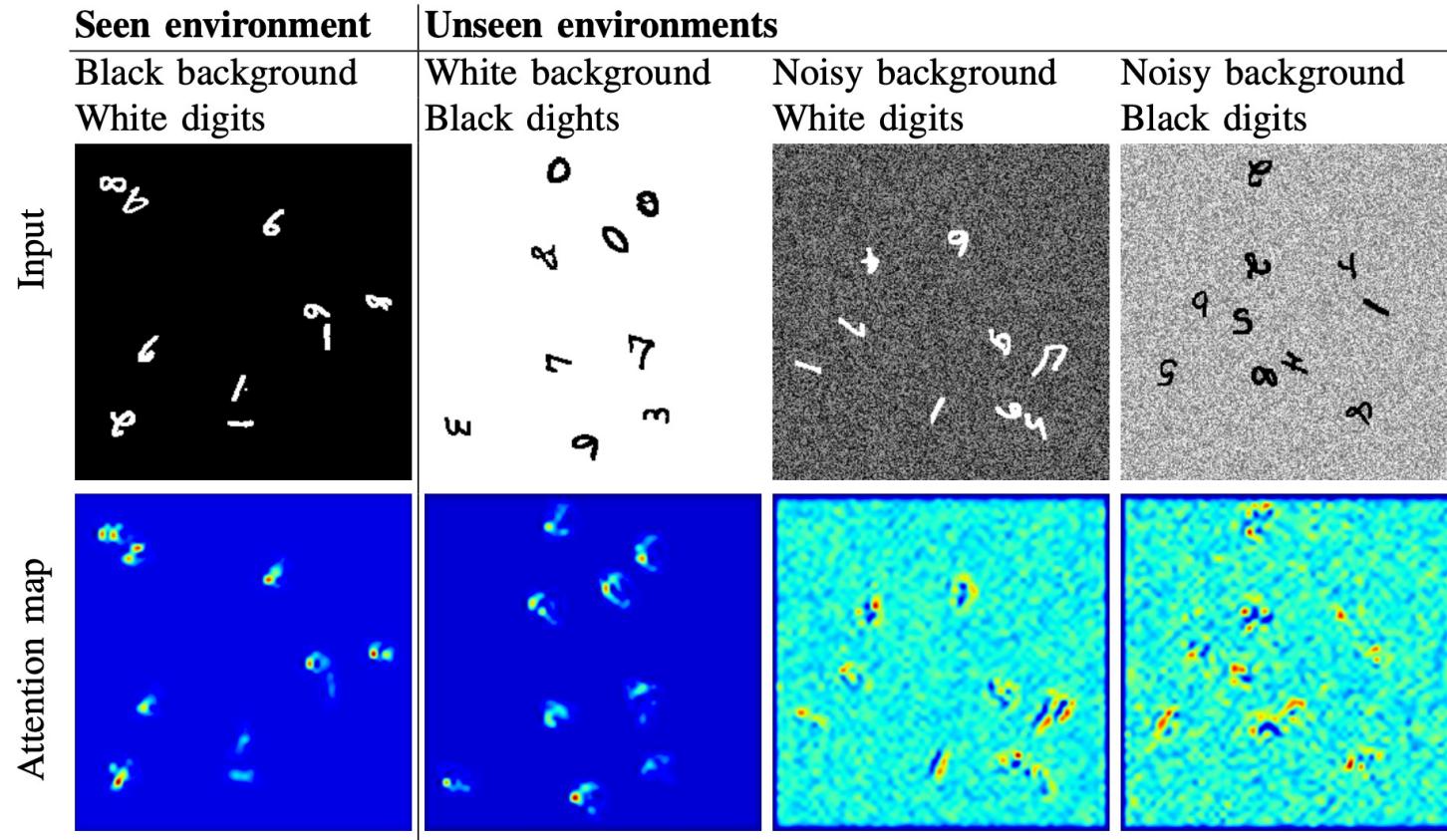
- Infinite kind of recyclable data type
 - i. e. colors, transparency, pose of recyclables, and various data collection environments.
- Practically impossible to construct dataset to train end-to-end models

Build an object detection while minimizing the above

- Should work universally in a variety of environments

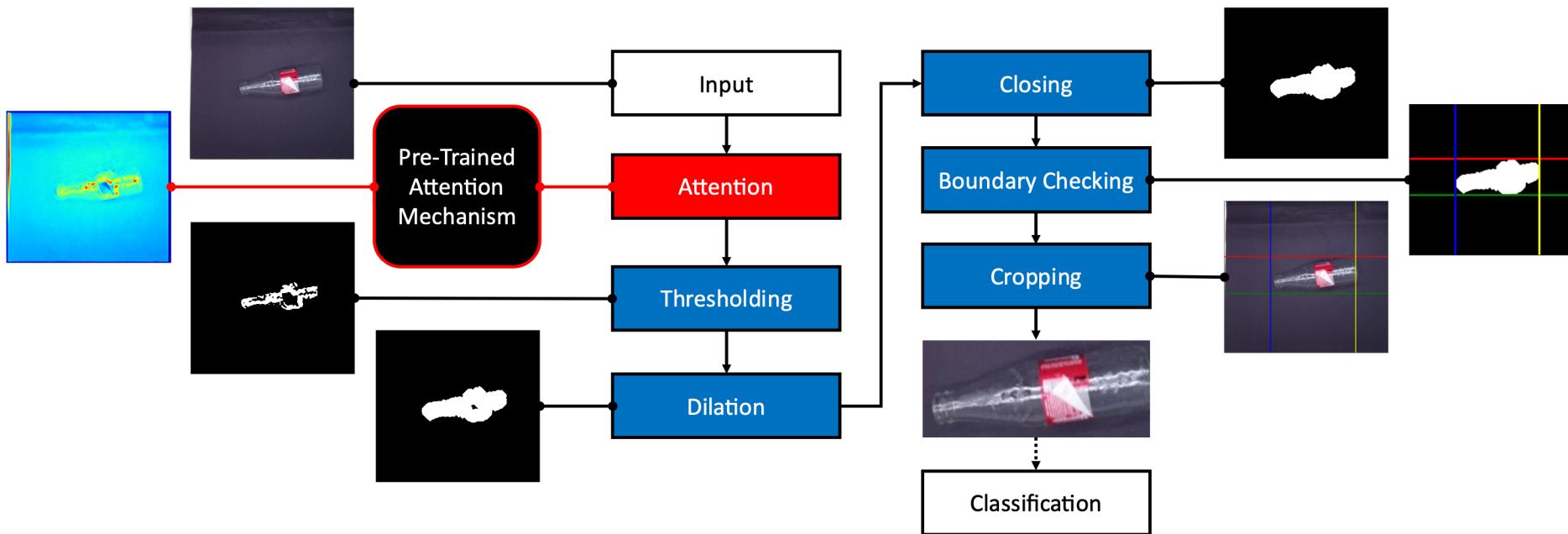
*Recyclable Solid Waste Dataset, Kaggle, 2021. [Online]. Available: <https://www.kaggle.com/datasets/hseyinsaidkoca/recyclable-solid-waste-dataset-on-5-background-colors>

Approach



- MNIST pre-trained attention properly emphasizes even for unseen environments
 - i. e. digit rotation or background color change
- Pre-trained attention can be utilized to detect recyclables

Attention-based RoI Cropping



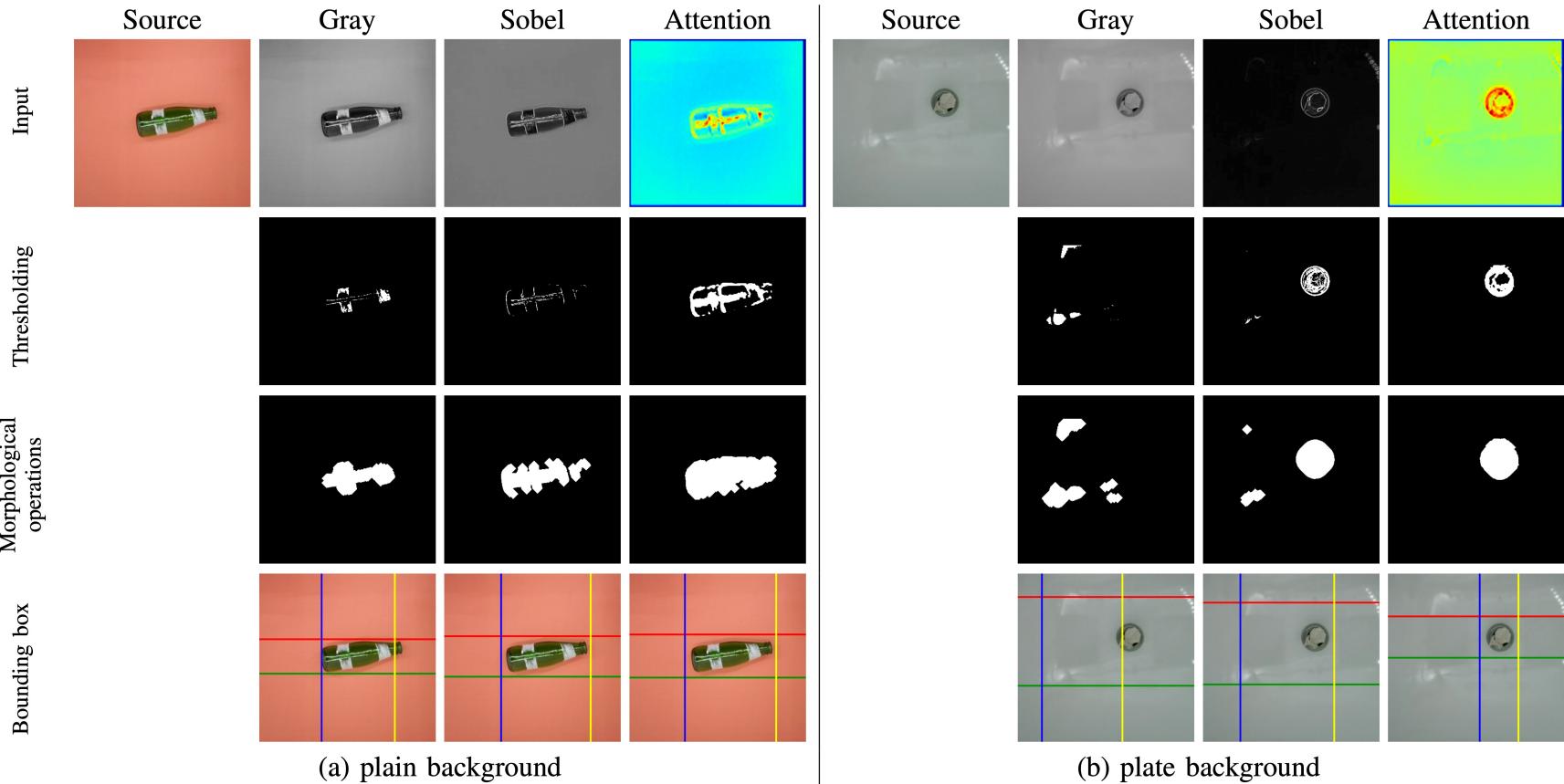
Proposal

- ROI cropping method based on pre-trained attention

Strength

- Minimize the hindrance surrounding information for recyclables recognition
- No longer need an end-to-end object detection model

RoI Cropping Results



- Comparison of RoI detection based on grayscaling, Sobel filtering, and attention mechanism
- For easy case (a), all three methods perform well
- In difficult case (b), an object on a transparent plate, only the attention method performs well

Dataset

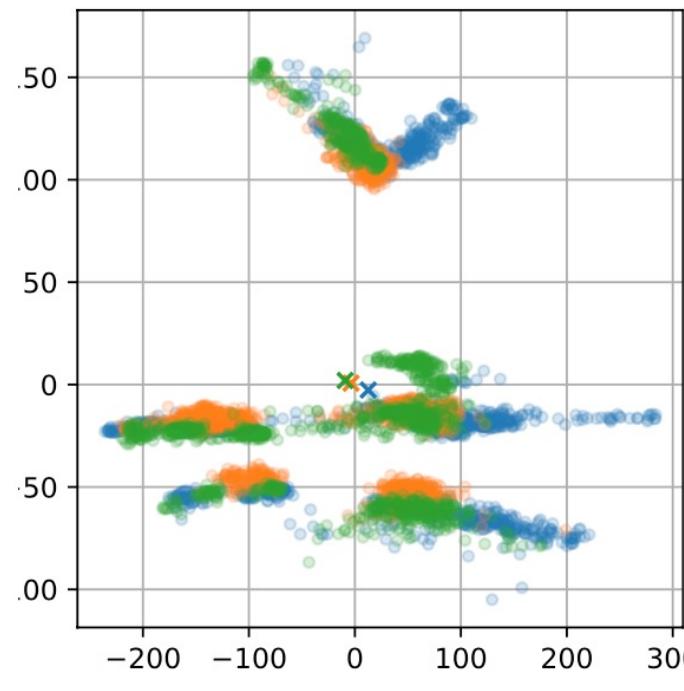
Recyclable Solid Waste Dataset (RSWD) dataset *

Class	Black	Gray	White	Orange	Light Green	Dark Green	Total
Glass	364	351	92	348	345	161	1661
Metal	332	353	169	343	342	116	1655
Plastic	330	353	175	340	337	95	1630

*Recyclable Solid Waste Dataset, Kaggle, 2021. [Online]. Available: <https://www.kaggle.com/datasets/hseyinsaidkoca/recyclable-solid-waste-dataset-on-5-background-colors>

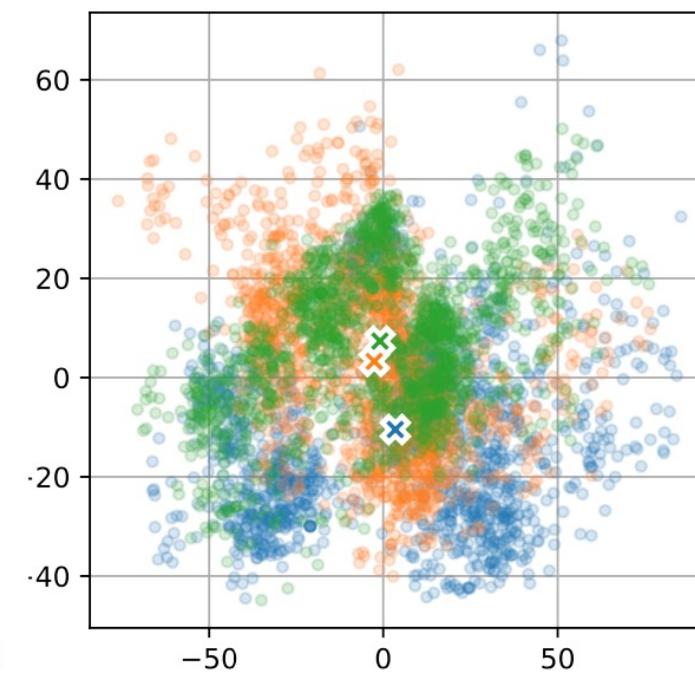


Effect of RoI Cropping



F-ratio: 0.008

- Before RoI cropping, 5 clusters according to the background color
- After RoI cropping, 3 clusters by each class, glass, metal, and plastic



F-ratio: 0.220



Model	ResNet50 *		EffNetB0 **	
RoI Crop.	X	✓	X	✓
Accuracy	0.839	0.898	0.885	0.927
Precision	0.886	0.919	0.902	0.932
Recall	0.839	0.897	0.885	0.927
F1-score	0.828	0.893	0.869	0.927

- Widely adopted classifiers, ResNet50* and EfficientNet-B0**
- Performance improvement in all metrics on both classifiers

* He, Kaiming, et al. “Deep residual learning for image recognition.” IEEE conference on computer vision and pattern recognition. 2016.

** M. Tan and Q. Le “EfficientNet: Rethinking model scaling for convolutional neural networks.” International Conference on Machine Learning, vol. 97, 2019, pp. 6105–6114.

Conclusions

Reduce Hindrance

- Pre-trained attention detects RoI accurately
- RoI cropping reduces interference by surrounding information

Improve Efficiency/Performance

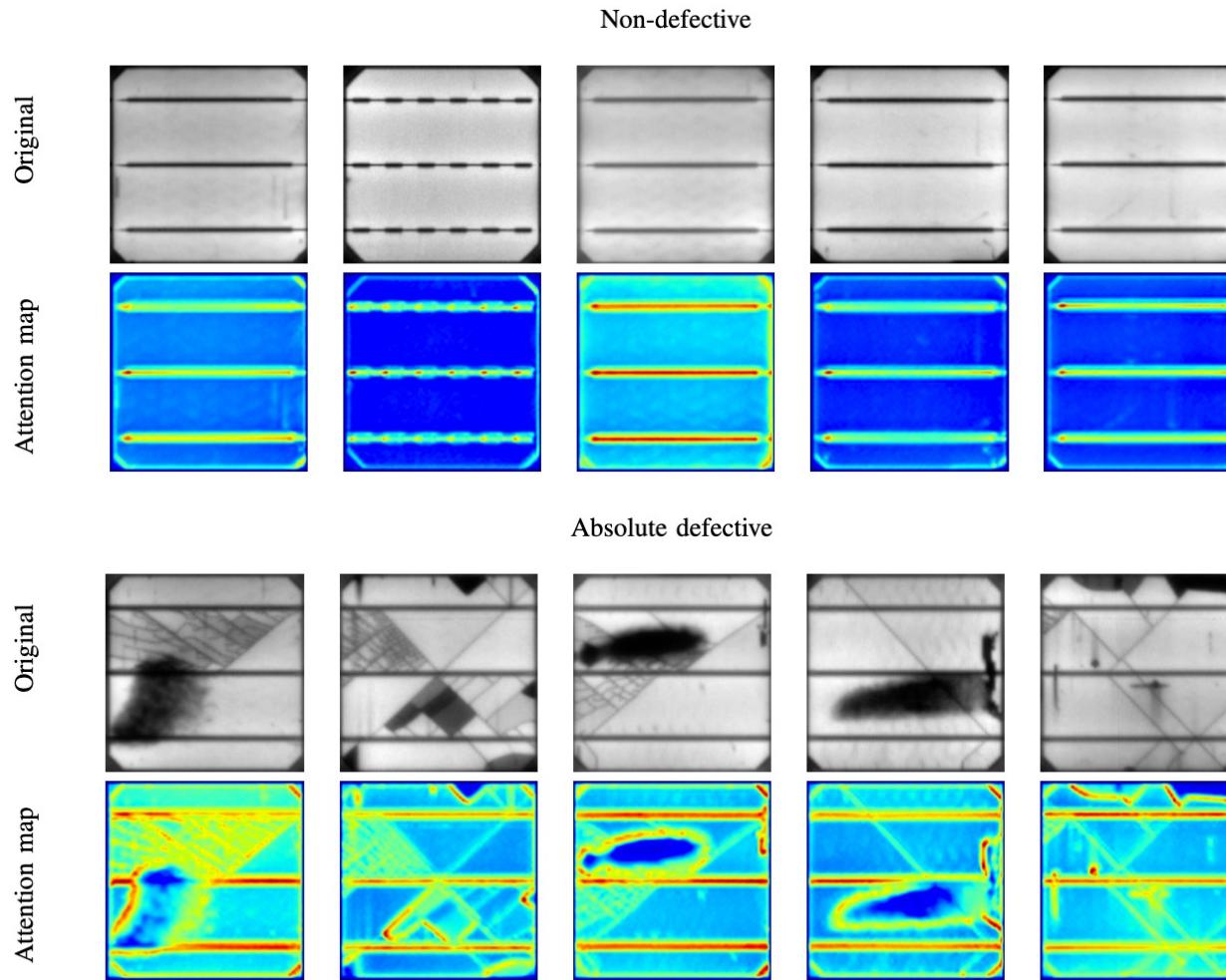
- RoI cropping reduces the image size and the computational burden of classifiers
- Classification performance is increased by focusing on object information

Recycling for Recycling

- Repurposing pre-trained attention contributes directly to resource recycling
- Data annotation and training end-to-end model is no longer needed



Related Research



* Y.H. Park, M.J. Kim, U. Gim, and J. Yi. "Boost-up Efficiency of Defective Solar Panel Detection with Pre-trained Attention Recycling." *IEEE Transactions on Industry Applications*, 2023.



Thank you

