Improving YOLOv8 Transferability via Model Fine-Tuning with Domain-Specific Manufacturing Data

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Problem

Deep learning models like YOLOv8 often struggle with manufacturing-specific applications due to:

- Limited domain knowledge in pretrained models
- Complex surface variations in industrial materials
- High precision requirements for defect detection
- Need for consistent performance across different manufacturing environments

Objectives

- Enhance YOLOv8's performance through domain-specific fine-tuning for manufacturing applications
- Develop a robust transfer learning methodology for cross-domain application, e.g., from generic object recognition to metal crack detection
- Create an automated framework for weld surface inspection
- Establish quantitative metrics for model transferability assessment

Future works

- Implementation of multi-angle fusion techniques
- Development of automated alert systems for quality control
- Test and enhance model robustness of domain-adapted YOLOv8 in specific manufacturing scenarios like 3D printing.

Method

Domain Adaptation Framework

1. Feature Extraction[2]:

$$X = \{x_i\}_{i=1}^{N} \; where \; x_i \in R^{H*W*C}$$

- X: Input crack images
- H,W: Height and width
- C: Number of channels

2. Loss Function[2]:

$$L_{total}=\alpha L_{det}+\beta L_{domain}$$

Where:

$$L_{det}=L_{cls}+L_{box}+L_{obj}$$

$$L_{domain}=MMD(F_s,F_t)$$

- L_{cls}: Classification loss
- L_{box}: Bounding box regression loss
- L_{obj}: Objectness loss

Fine Tuning Algorithm[1]

Algorithm: Domain-Adaptive YOLOv8

Input: Source domain S, Target domain T

Output: Fine-tuned model M

1. Initialize YOLOv8 with pretrained weights
2. For each epoch:
   a. Extract features from S and T
   b. Compute domain discrepancy
   c. Update model parameters via backpropagation
   d. Adjust learning rate $\alpha = \alpha_0/(1 + \gamma p)^{\beta}$
3. Validate on target domain

Results/Conclusion

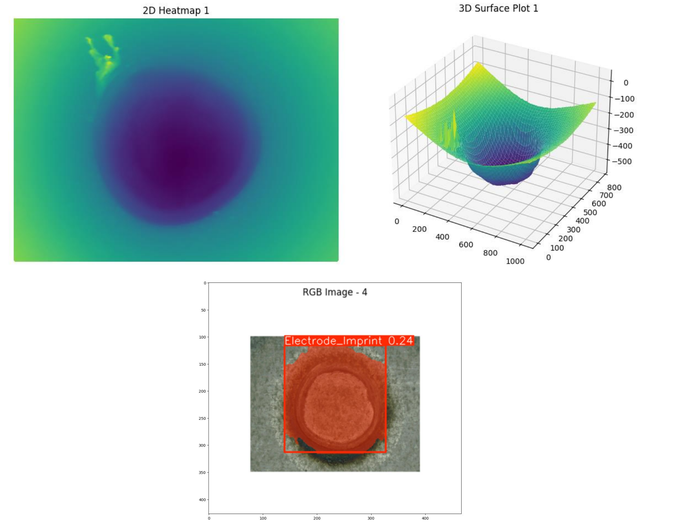

Fig 1. Fine tuned YOLOv8 model identifying no cracks and other parts of the image successfully.

Conclusion: The fine-tuned YOLOv8 model successfully demonstrates transferability to specialized manufacturing applications, achieving accurate segmentation of concentric regions across multiple samples.

Acknowledgement/References

We thank the team of Drs. Dali Wang and Zhili Feng from ORNL for sharing the case study data.

References:

1. https://www.youtube.com/watch?v=ytlhMAF6ok0
2. Yan & Hu, Miao & Wang, Taiyong. (2019). Weld Image Recognition Algorithm Based on Deep Learning.

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