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End-to-End Computer Vision Pipeline for Perforation Defect Detection and Classification in Industrial Imaging

Joanne Yun, Hasnaa Ouidadi, Khawlah Alharbi, Pengyu Zhang and Hantang Qin
Department of Industrial and Systems Engineering
University of Wisconsin-Madison, USA
jyun45@wisc.edu, ouidadi@wisc.edu, kaalharbi@wisc.edu, pzhang256@wisc.edu,
hqin52@wisc.edu

Abstract

Quality control is essential for product consistency and reliability in modern manufacturing. This work presents an end-to-end computer-vision pipeline that automatically detects and classifies perforation defects in industrial imagery. A two-stage architecture is proposed: a YOLOv11 detector localizes individual perforation regions, and a multi-label EfficientNetB0 classifier assigns one of four defect classes (DT0 non-defective, DT1 missing, DT2 touching, DT3 out-of-bounds). To address the scarcity of labeled data, we combine active learning and bootstrapping to select representative images for manual annotation, then apply an adaptive-thresholding pseudo-labeling stage to automatically label the selected samples, expanding the training set from a small hand-labeled subset to a substantially larger validated dataset. The final classifier reaches F1-micro 99.08% on held-out test data, demonstrating that the framework can support process monitoring and preventive maintenance.

Keywords
Computer Vision, Perforation Defect, Imaging