Protection of Detector System: Using YOLOv8 for Real-Time Crystal Detection
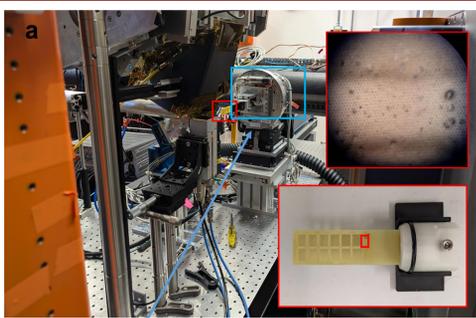
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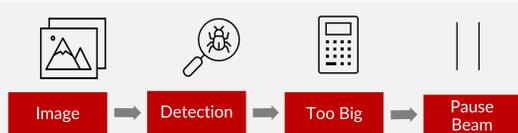[1]College of Engineering and Architecture, Howard University, Washington, DC, USA
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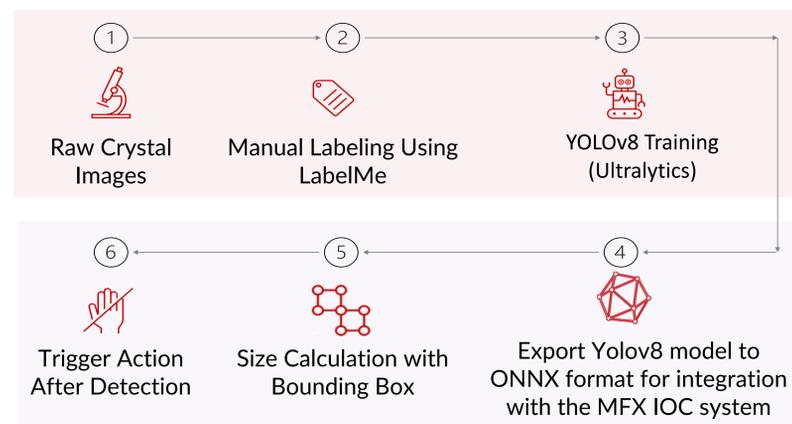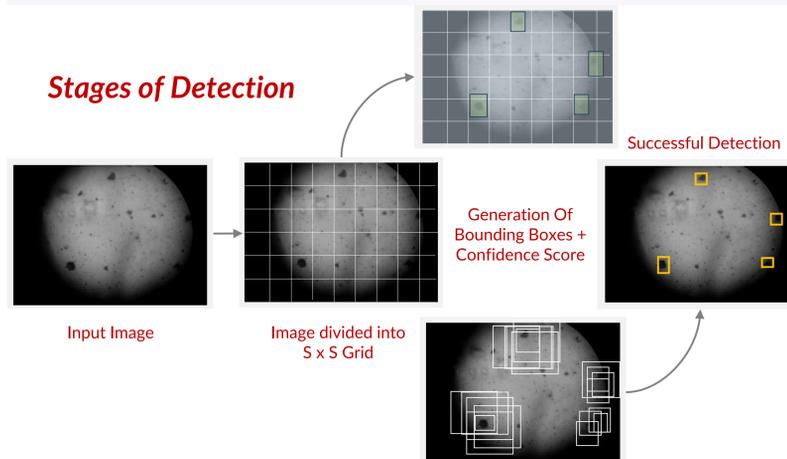
INTRODUCTION

- Protein crystallography uses X-ray imaging to study molecular structures.
- Large crystals can scatter excessive energy and damage detectors.
- The goal of this project is to develop a real-time AI system that detects large crystals and automatically stops the X-ray beam to protect the detector.
- Requirements: Detection speed < 20ms, Crystal size threshold > 100μm.

METHODOLOGY

1. Raw Crystal Images
2. Manual Labeling Using LabelMe
3. YOLOv8 Training (Ultralytics)
4. Export Yolov8 model to ONNX format for integration with the MFX IOC system
5. Size Calculation with Bounding Box
6. Trigger Action After Detection

Stages of Detection

Input Image → Image divided into S x S Grid → Generation Of Bounding Boxes + Confidence Score → Successful Detection

FUTURE WORK

- Collect and label more crystal images using semi-automated tools to improve detection accuracy and speed up annotation.
- Adapt the system to work with different lighting conditions, crystal types, or detector setups.
- Integrate the ONNX model with the IOC (Input Output Control) system for real-time communication with beamline hardware.

CHALLENGES FACED

- Limited training data reduced overall model accuracy and increased the risk of overfitting.
- Changes in lighting, along with presence of grease and bubbles, made instance segmentation less accurate, so we had to do more manual labeling, which took a lot of time.
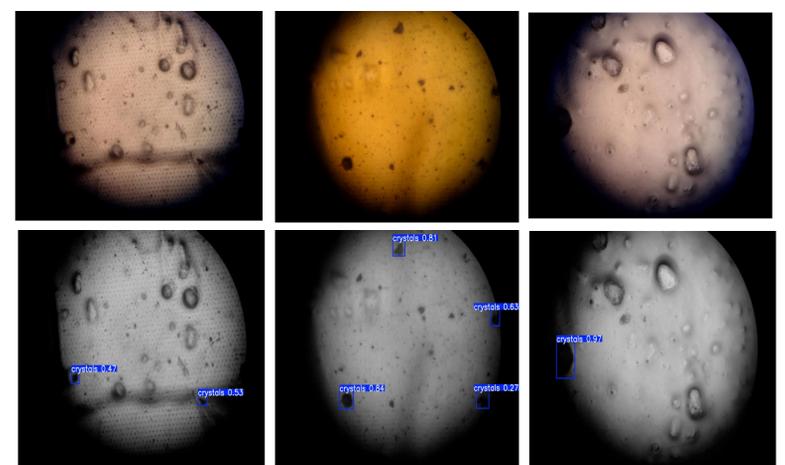
RESULTS
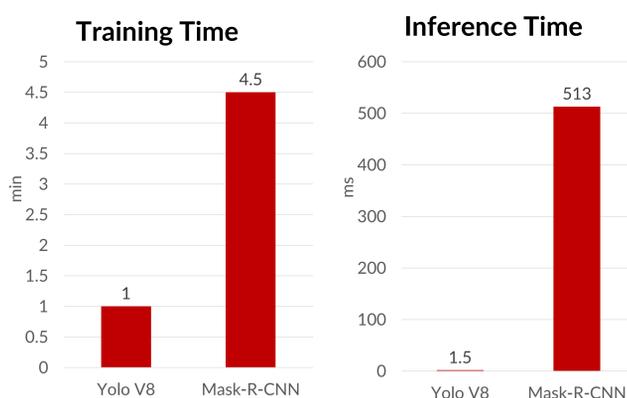
YOLOv8 significantly outperforms Mask R-CNN in training speed (1 min vs. 4.5 min).

YOLOv8 achieves significantly faster inference (1.5 ms vs 513 ms).
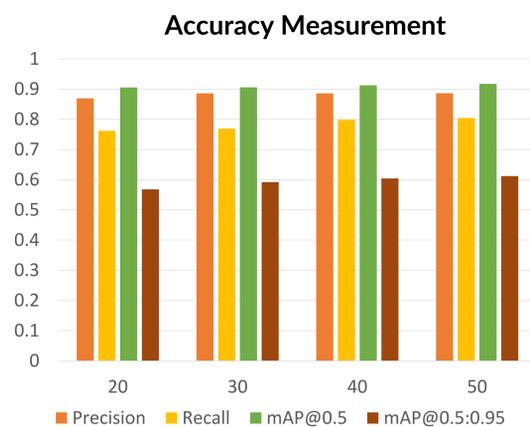
Precision: % of predicted crystals actually correct
Recall: % of actual crystals detected
mAP: Mean Average Precision, a combined measure of precision and recall

Original Crystal Samples (Top) And Yolov8 Detection Results (Bottom)

REFERENCES

- Z. J. Khow, Y.-F. Tan, H. A. Karim, and H. A. A. Rashid, "Improved YOLOv8 Model for a Comprehensive Approach to Object Detection and Distance Estimation," *IEEE Access*, May 2024.
- Github Repository: https://github.com/prakritisubedii/coyote_protector