Integration and Comparison of Vision Models for Smart Inspection Cell

Case Study

Intelligent Systems in Production

Technische Hochschule Deggendorf

Campus Cham

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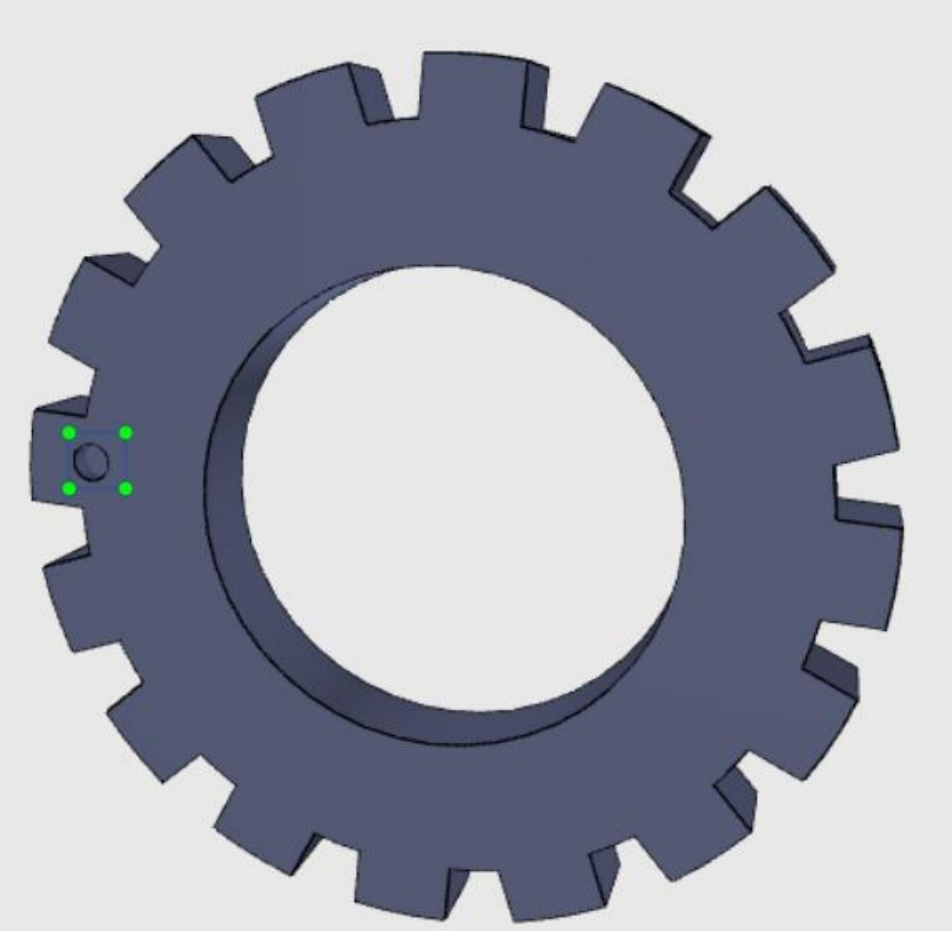
Contents

Dataset Preparation

Completed since last presentation:-

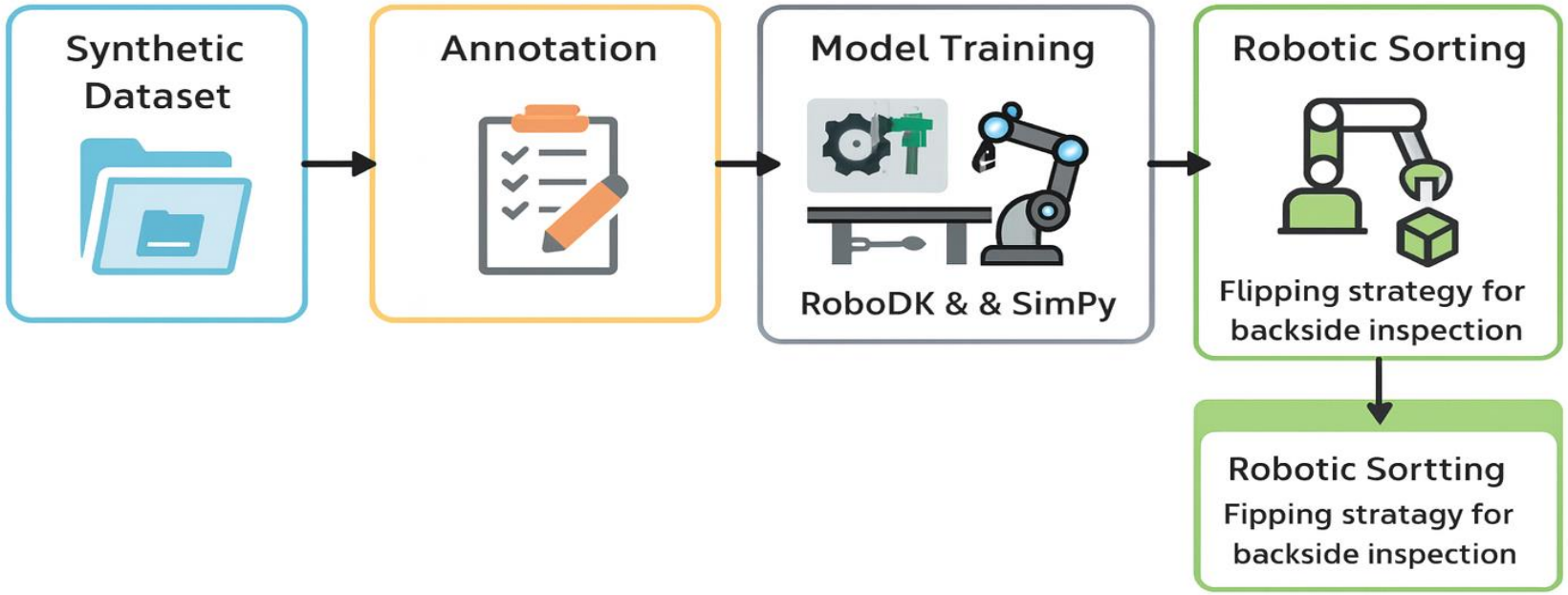
Created synthetic dataset using **Onshape defect modelling**

- Included **scratch, dent, void.**
- Rendered multiple variations (pose, lighting, angles)
- Annotated entire dataset using LabelImg
- Structured dataset for YOLOv8 training



Labelling for YOLO

Methodology Overview



Defect Identification Strategy

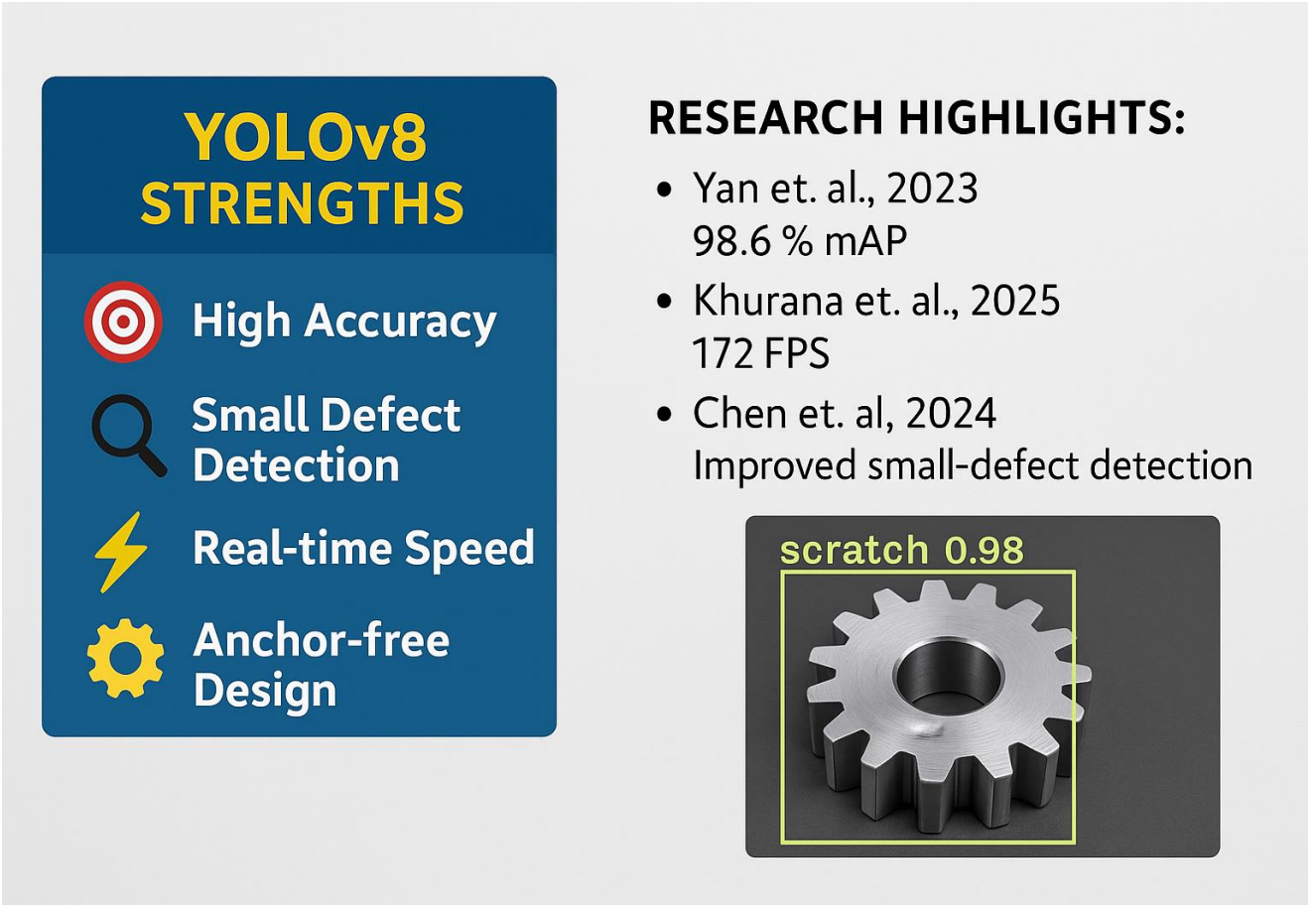
- **Challenge:** Initial design only inspected one side of surface.

  Solution Option Considered:
- **Robot flipping method**: robot rotates gear for opposite-side inspection
- Integrated additional camera frame into RoboDK cell

Why YOLOv8?

Backed by strong research evidence:

- **Chen et al., 2024 (IEEE Access):**
  YOLOv8's **anchor-free** design significantly improves **small defect detection**.
- **Khurana et al., 2025 (Springer):**
  YOLOv8 achieved **up to 172 FPS** after optimization → ideal for real-time inspection.
- **Yan et al., 2023 (MDPI Sensors):**
  YOLO-based models achieved **98.6% mAP** on gear defect datasets.



Why MobileNetV2?

Supported by multiple references:

- **Nguyen, 2020 (JTAIT):**
  MobileNetV2 delivers **very high FPS** using depthwise separable convolutions.
- **Sandler et al., 2018 (CVPR):**
  Lightweight architecture ideal for **edge devices**.
- **Khurana et al., 2025 (Springer):**
  Hybrid MobileNetV2 + YOLOv8 system **reduces parameters by 45%** while retaining **98% accuracy**.

Research Highlights

- ✓ Very high FPS (**Nguyen, 2020**)
- ✓ Lightweight for edge (**Sandler et al., 2018**)
- ✓ Hybrid model cuts 45% params (**Khurana et al., 2025**)

Why These Two Models Only?

1. Strong literature support

2. Representing two extremes in model design

3. Fits our simulation requirements

4. Fills a research gap

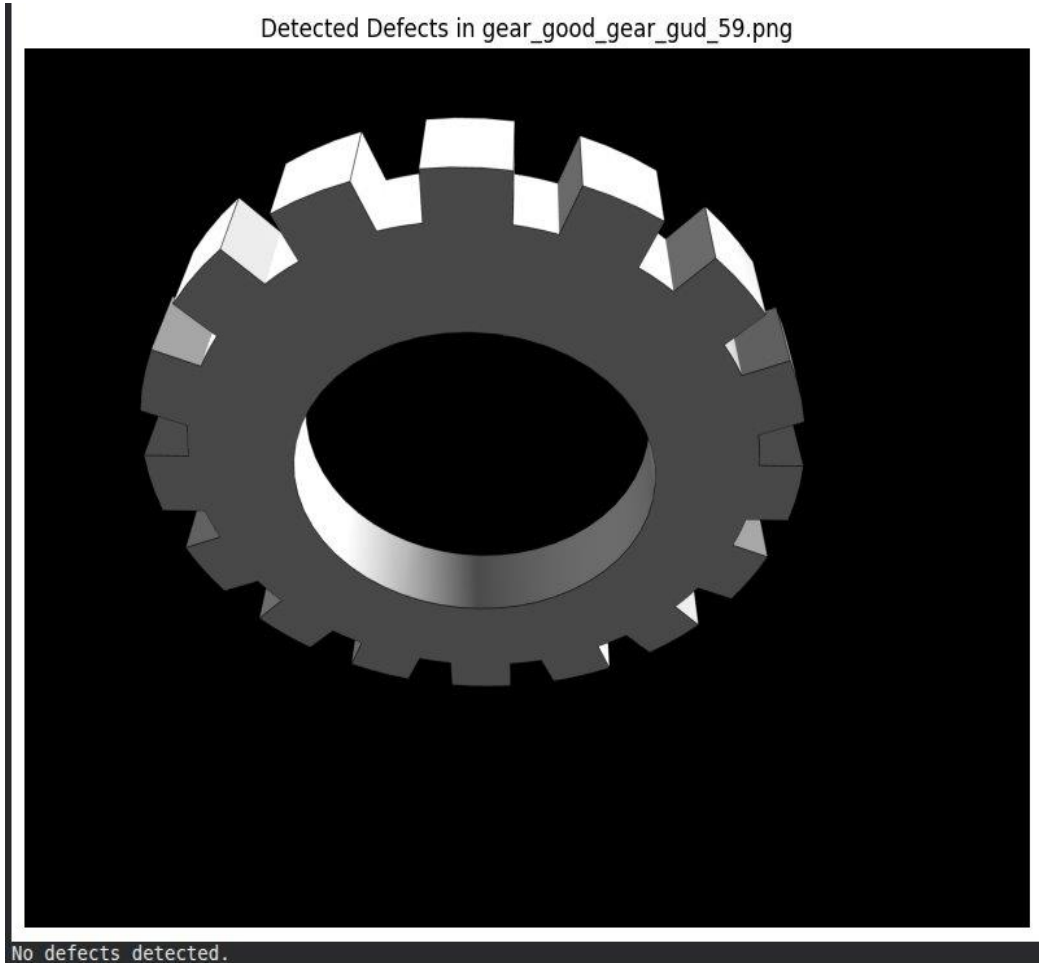
Bibliography Section 2.5.1 identifies:

"Lack of comparative evaluation of modern models in a robotic inspection environment."

→ Our project directly addresses this.

Model Training Progress

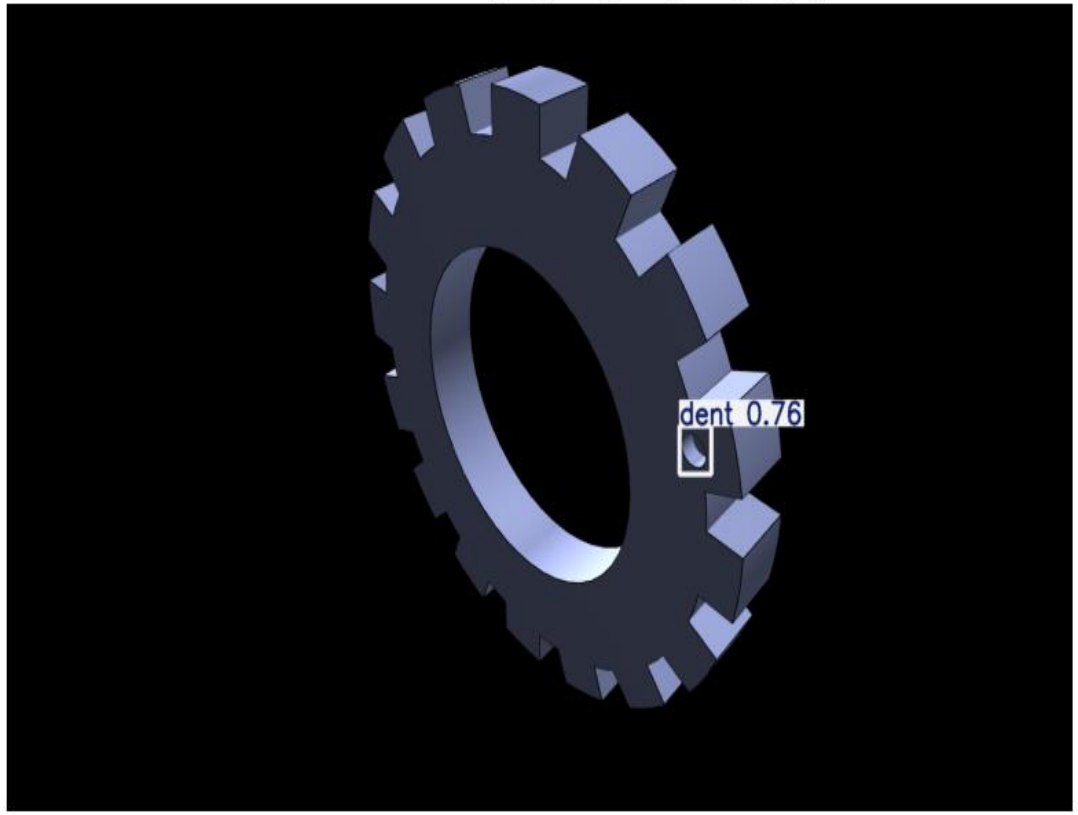
- Dataset structured into YOLO format
- Annotations completed
- Training pipeline prepared
- Fully trained Yolov8 model ready for RoboDK integration
- Initial runs for MobileNetV2 classification underway



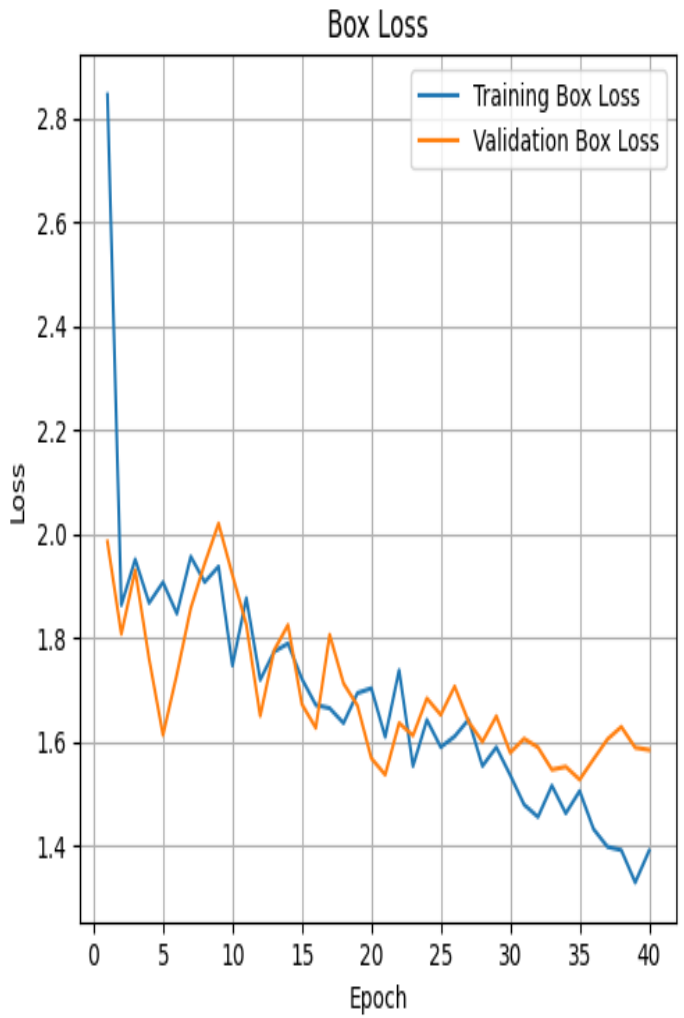
Model Predictions and Confidence scores

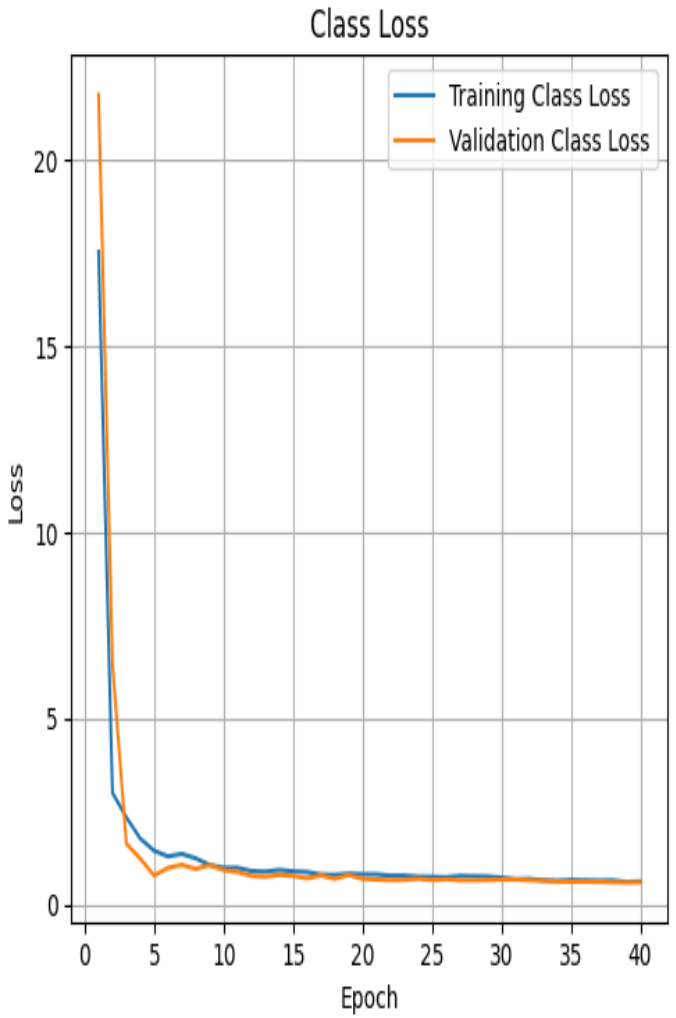
Detected Defects in gear_scratch_Gear_scratch_29.png

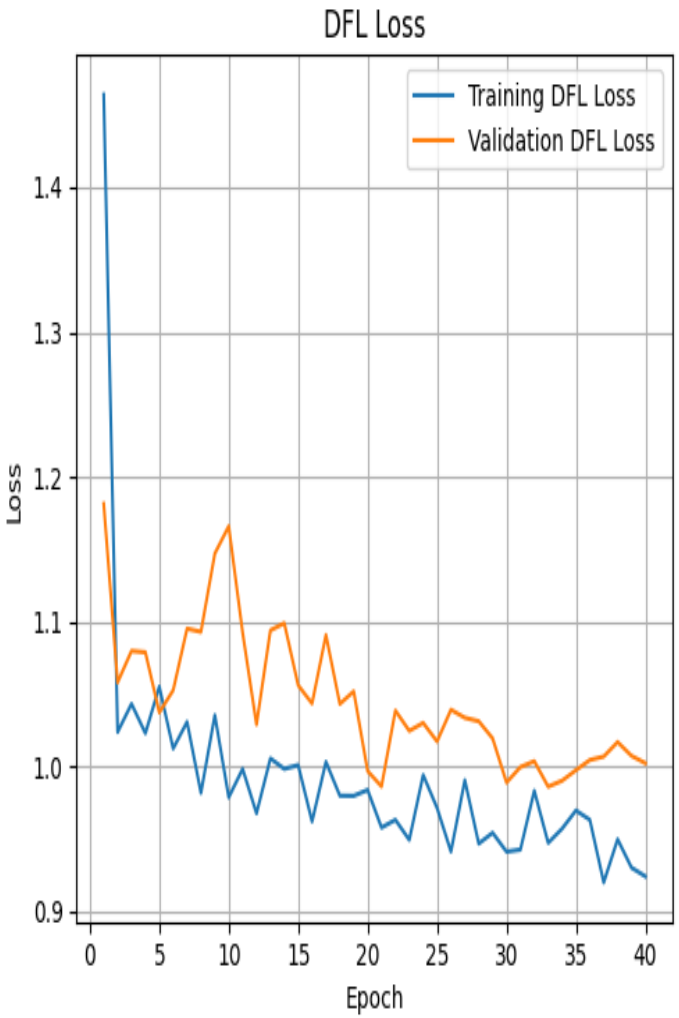
Detected Defects in gear_dent_Gear_dent_96.png



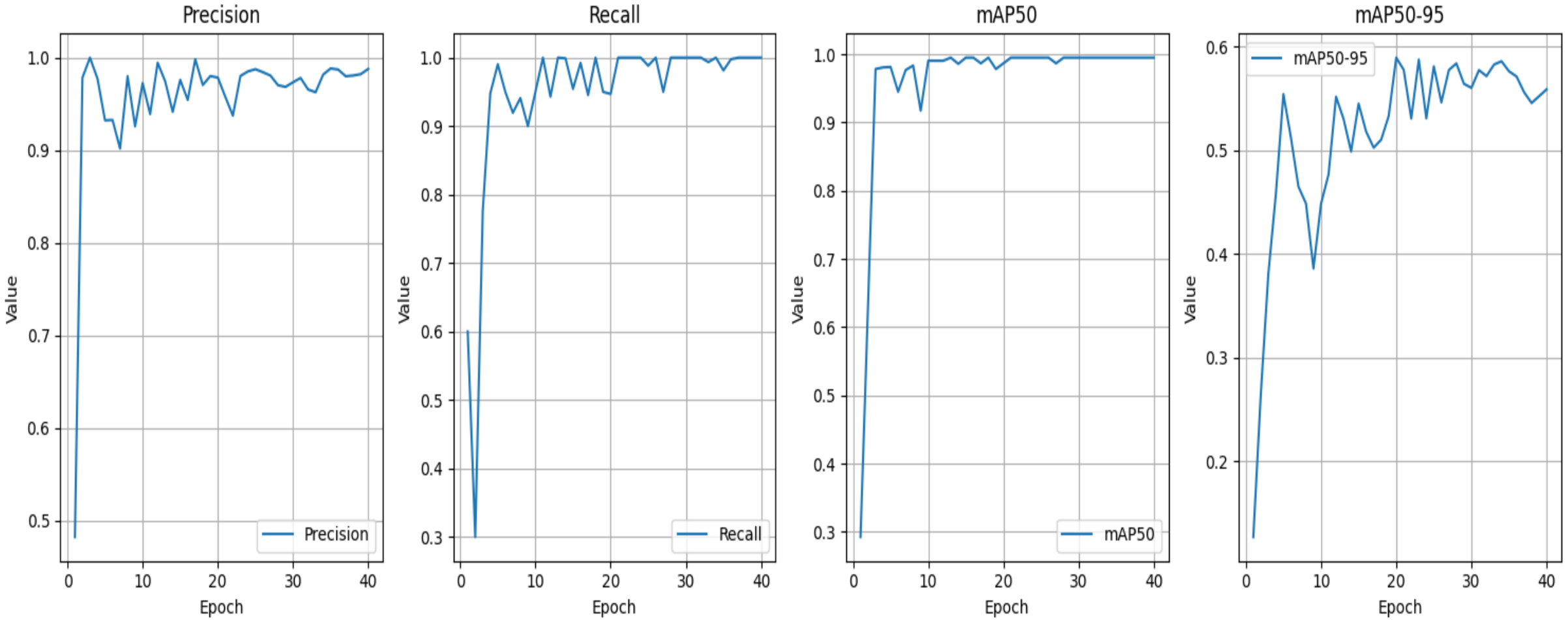
Training vs Validation Loss







Precision-Recall-mAP Curves



Simulation Workflow

Workflow inside the RoboDK inspection cell:

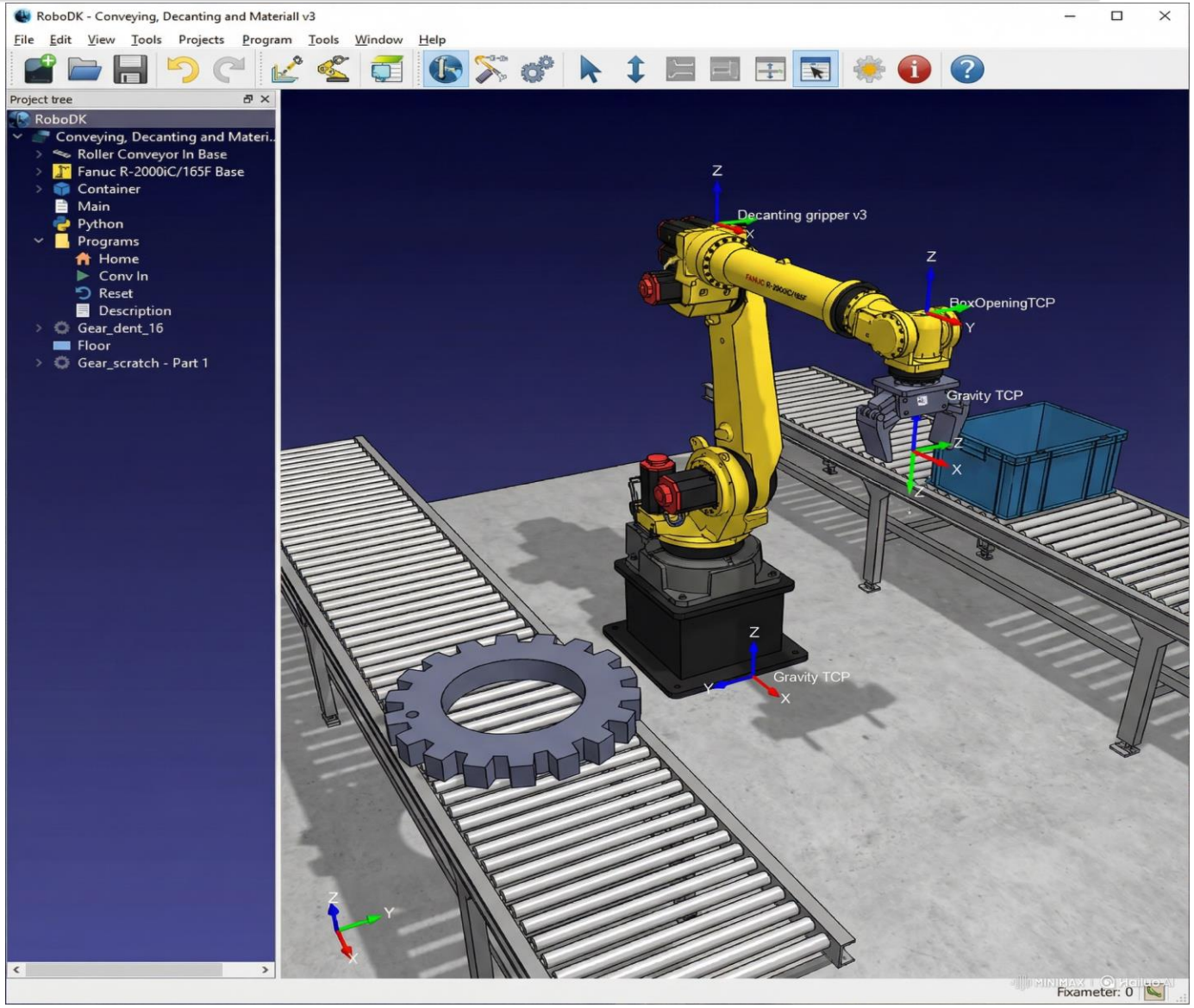
1.Gear enters inspection zone

2.Camera capture image

3.AI model sends prediction

4.Robot sorts good/defective part

5.Loop repeats for next gear



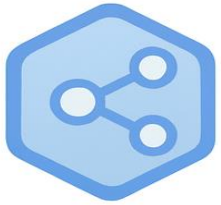
Tools & Integration

Onshape:
Defect modeldling

LabelImg:
Annotation

YOLOv8 / MobileNetV2:
AI models

RoboDK:
Robotic simulation



SimPy:
Process timing

Python:
Complete integratic

Milestone

Work	(Oct)Week42	Week43	Week44	(Nov)Week45	Week46	Week47	Week48	(Dec)Week49	Week50	Week51	Week 52	(Jan)Week 01	Week 02
Dataset preparation & annotation													
Sim Setup & Model training													
Model deployment & evaluation													
Final presentation & report													

Next Steps and GitHub Upload

- Training MobileNetV2 model and comparing performance metrics.
- Inference Scripting between trained models and RoboDK for component loading and robotic sorting integration.
- Upload the sim demonstrations, latest report, refined datasets, and code to the team GitHub repository.

Key References

•Chen et al., 2024 – YOLOv8 for small defect detection

•Khurana et al., 2025 – YOLOv8 + MobileNetV2 hybrid

•Yan et al., 2023 – YOLOv5 gear defect detection

•Nguyen, 2020 – Fast MobileNetV2 detection

•Sandler et al., 2018 – MobileNetV2 architecture

Thank You

https://github.com/Pallelayaswitha1/Integration-and-Comparison-of-vision-models-for-smart-inspection-cell/tree/main

Any Questions?