Algorithm Pipeline

Railway Boundary Detection

The CNN model detects the boundaries of the rails in camera images.

Line detection

Key points along the railway line are extracted, allowing for homography computation and segment endpoints.

Homography-Based Measurement

Use identified key points to compute homography matrix and measure track geometry.

Algorithm Pipeline

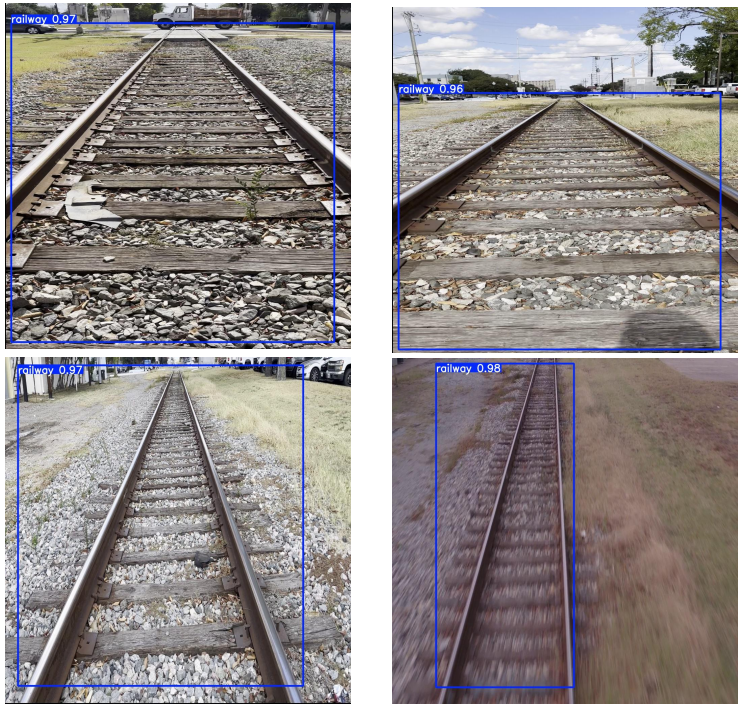
- Dataset
  - Standard
    - Train Set: 3069 images
    - Valid Set: 265 images
    - Test Set: 40 images
    - Augmentations Applied: 90° Rotate (Clockwise, Counter-Clockwise), Rotation (-15° and +15°), Shear (±18° Horizontal, ±14° Vertical), Saturation (Between -91% and +91%)
  - Low-light
    - Train Set: 654 images
    - Valid Set: 93 images
    - Test Set: 48 images
    - Augmentations Applied: Flip (Horizontal, Vertical), Rotation (-15° and +15°), Crop (0% Minimum Zoom, 30% Maximum Zoom), Noise (Up to 1.01% of pixels)

YOLOv8 Training Parameters

- **Pretrained weights:** yolov8n.pt from Ultralytics
- **Epochs:** 50
- **Image size:** 1024 × 1024
- **Batch size:** 8 (GPU) / 2 (CPU fallback)
- **Optimizer:** SGD
  - Initial LR (lr0): 1×10^{-4}
  - Weight decay: 5×10^{-4}
  - Momentum scheduler:
    - warmup_epochs: 5
    - warmup_momentum: 0.5
    - warmup_bias_lr: 0.05
- **Loss gains:** box=7.5, cls=0.5, dfl=1.5
- **Early stopping:** patience = 50

Performance?

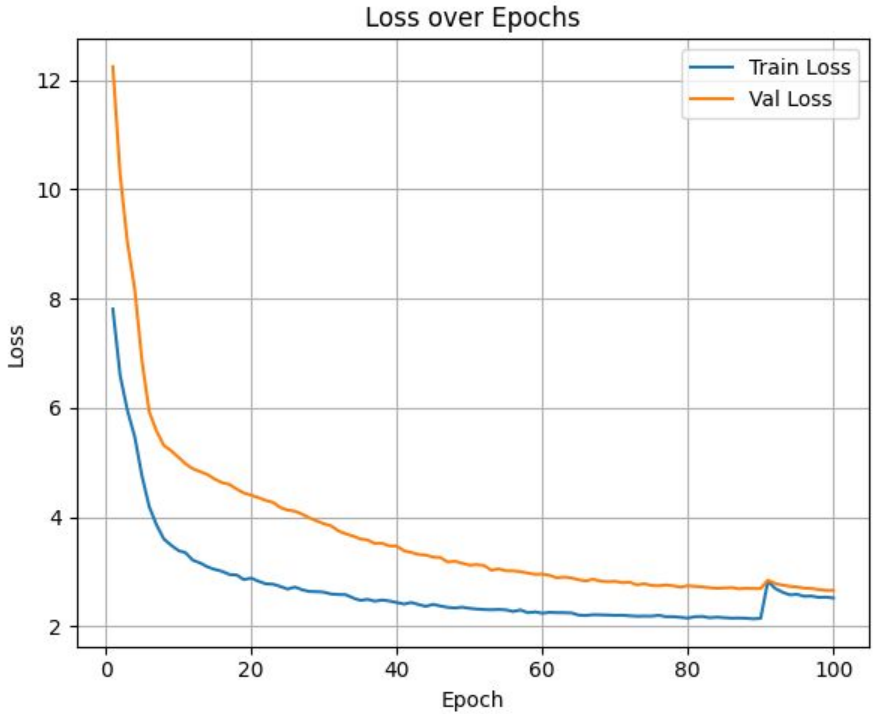
Metric	Values (Standard)
Images evaluated	3069
Ground-truth instances	40 (41 predicted)
Precision	0.9706
Recall	0.9965
mAP @ IoU=0.50	0.9922
mAP @ IoU=0.50:0.95	0.6715
Fitness	0.7035

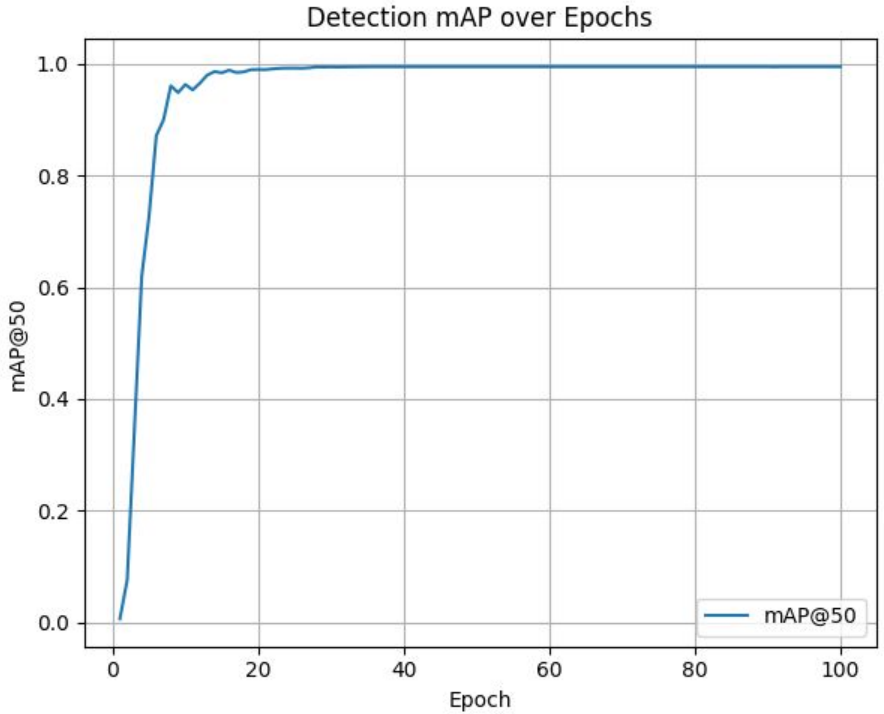


Performance?

Metric	Values (Low-light)
Images evaluated	654
Ground-truth instances	48 (53 predicted)
Precision	0.9974
Recall	1.0000
mAP @ IoU=0.50	0.9950
mAP @ IoU=0.50:0.95	0.9053
Fitness	0.9143

Final Result - Standard Dataset





Final Result - Low-light Dataset