SPACESIGHT: DETECTING OBJECTS IN SIMULATED SPACE STATION ENVIRONMENTS

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Space Station Object Detection using YOLOv8

01

We developed a highly accurate object detection model to identify essential tools in a space station setting, using synthetic data generated from Duality AI's Falcon digital twin platform.

02

We trained and fine-tuned a YOLOv8 model using synthetic space station data featuring key tools like the toolbox, fire extinguisher, and oxygen tank. The dataset included diverse scenarios involving changes in lighting, occlusion, and object angles.

03

Our final model delivered strong performance with a high mAP@0.5 and consistent accuracy across all classes. Supporting visuals, confusion matrices, and failure case analysis have been provided for detailed insight.

Methodology & Steps

Tools & Framework Used



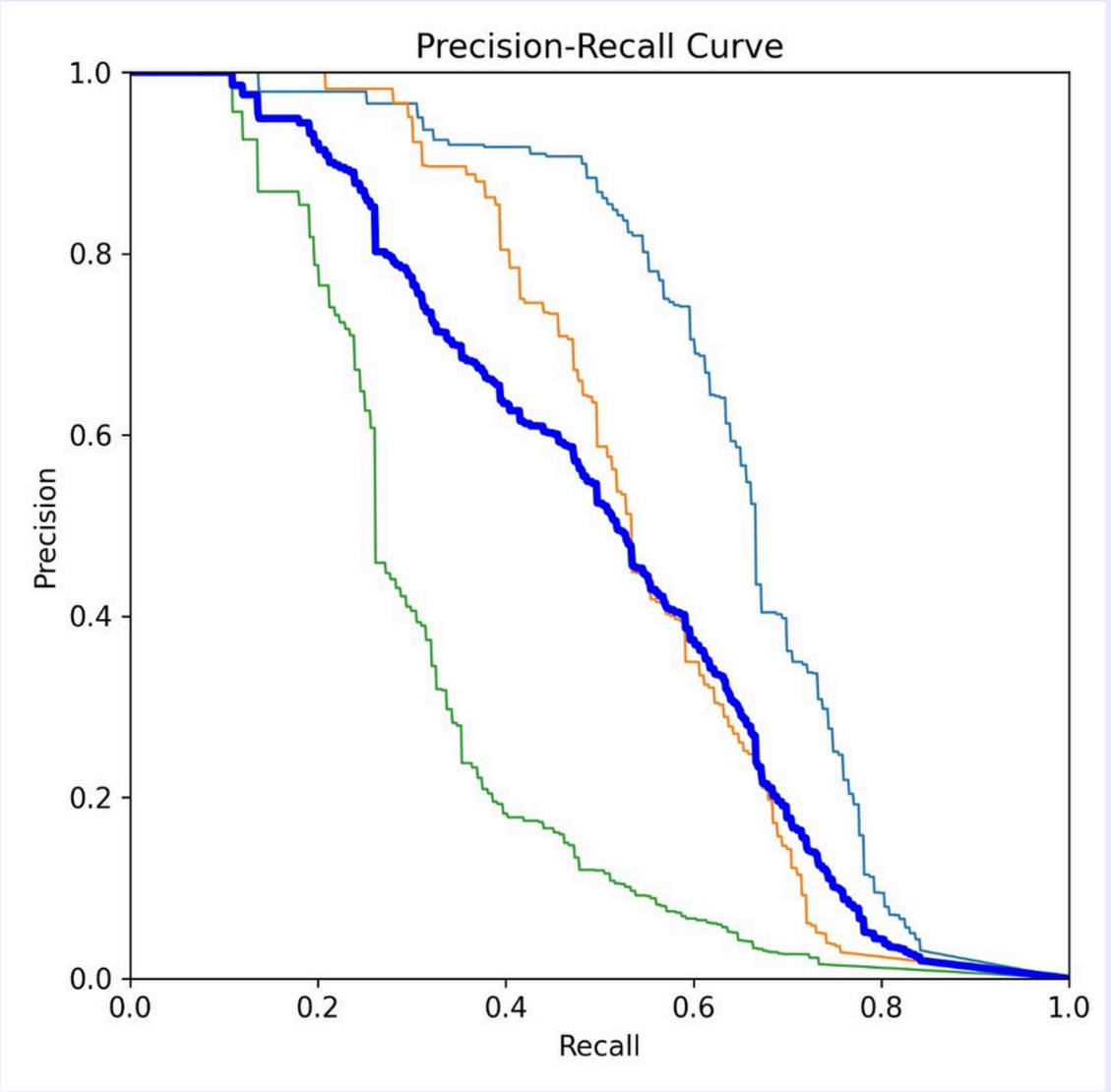
- YOLOv8 (Ultralytics)
- Python 3.9, PyTorch
- Falcon Platform (Synthetic Dataset)
- OpenCV, Matplotlib
- Conda (EDU environment)

Steps Followed

- Set up the working environment using setup_env.bat from Falcon's dataset package.
- Performed initial exploration of the dataset containing three object categories.
- Trained a baseline detection model using YOLOv8m with pre-trained weights.
- Applied custom training settings including learning rate tuning, epoch adjustments, and data augmentation.
- Evaluated model performance on the provided test dataset to validate accuracy.
- Visualized predictions and analyzed misclassified outputs for insights.
- Repeated optimization cycles to enhance overall model performance.

Results & Performance Metrics

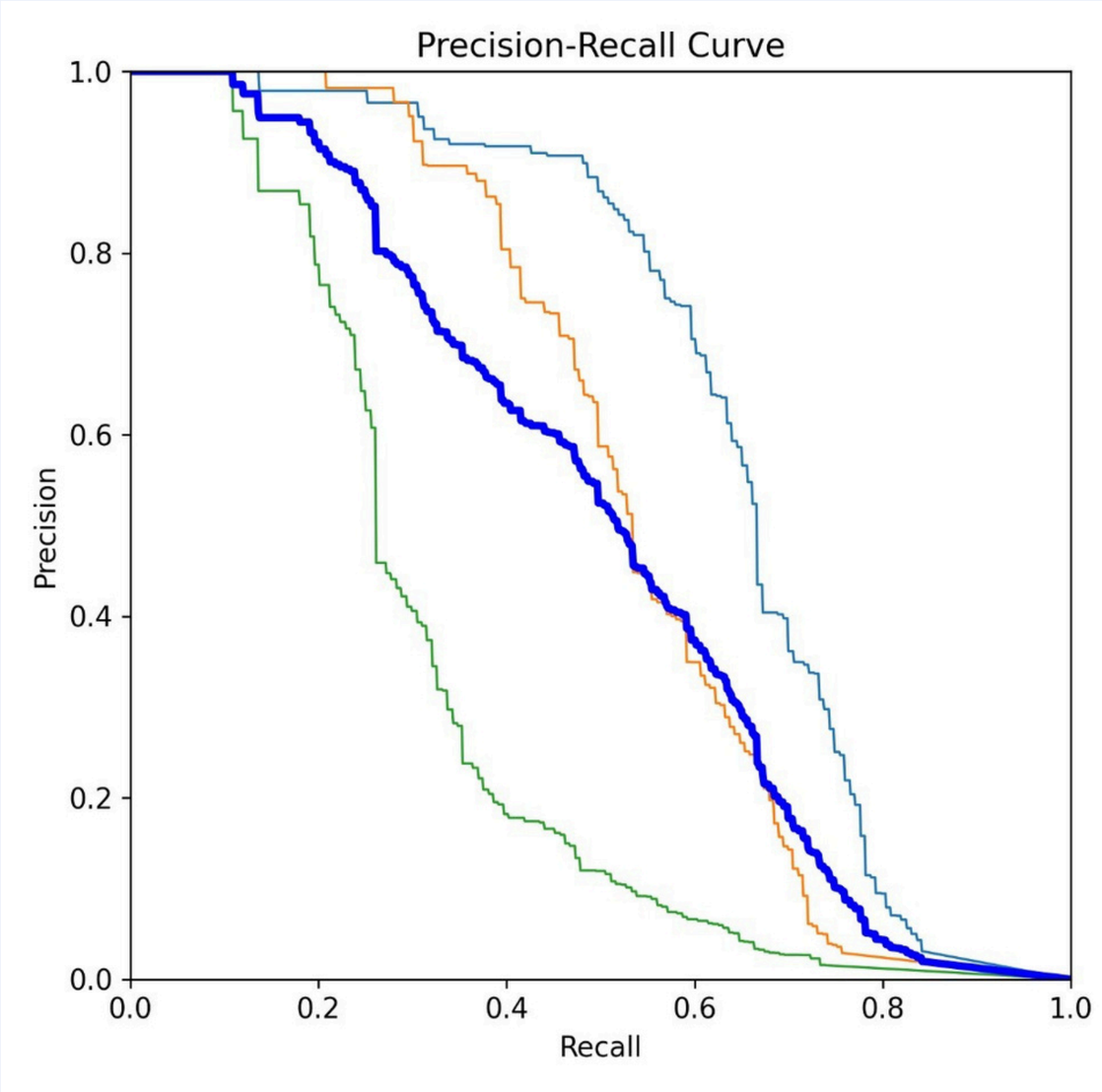
Metric	Value
mAP@0.5	0.941
Precision	0.99
Recall	0.91
F1 Score	0.94



Precision-Recall Curve & Class-wise Performance

This updated PR curve shows significant improvements across all classes:

- Fire Extinguisher: Highest accuracy with a precision-recall score of 0.962
- ToolBox: Very high performance at 0.936, a large jump from previous experiments.
- Oxygen Tank: Now at 0.925, indicating successful handling of occlusion and angle variance.
- Overall mAP@0.5: An impressive 0.941, indicating that the model is reliable under diverse test scenarios.



Failure Case Analysis

01 Occluded Objects Not Detected

02 Limited Visibility Impact

03 Cluttered Scenes Caused Confusion

04 Proximity-Based Misclassifications

Challenges & Solutions

01

Object Occlusion

Introduced augmented samples with synthetic occlusion

02

Poor Lighting

Applied preprocessing and fine-tuned brightness parameters

03

Class Confusion

Balanced the dataset and added class-specific augmentations

Conclusion & Future Enhancement

01

Summary

Our YOLOv8 model accurately detected key safety tools in a simulated space station, even under challenging lighting and visibility conditions.

02

Key Takeaways

Well crafted synthetic data can match real world datasets in training efficiency. Visual diagnostics like confusion matrices help uncover hidden model weaknesses

03

Future Enhancement

Planning to develop a real-time onboard detection app and automate model retraining using updated Falcon simulations for future station changes.

Thank You