Duality AI – Space Station Hackathon Report

Team Name: Code Masters
Project Title: Space Station Object Detection using YOLOv8
Hackathon: Duality AI x SunHacks 2025
Tagline: Keeping Space Stations Safer, Smarter, and AI-ready

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1. Overview

This project presents an object detection system trained on synthetic space station data using the YOLOv8 deep learning architecture.
The primary goal was to detect and classify mission-critical objects—specifically, **toolboxes, oxygen cylinders, and first aid kits**—within a simulated space environment.
The dataset was provided by Duality AI's Falcon platform, which generates high-quality synthetic data through digital twin simulation.
Our approach leverages the power of transfer learning and modern data augmentation techniques to develop a model that is both accurate and efficient for real-time inference in space-like scenarios.

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2. Methodology

The dataset consisted of Falcon-generated synthetic images simulating a space station interior with varied lighting, angles, and occlusion conditions.
The object categories were limited to three classes: **toolbox, oxygen cylinder, and first aid kit**.
The dataset was formatted in YOLOv8-compatible structure, including separate folders for training, validation, and test images, each with corresponding label files in YOLO format.

The model used was YOLOv8s (small version), implemented with the Ultralytics framework. We trained the model for 100 epochs.
Training was performed on Google Colab with a T4 GPU. The config.yaml file defined dataset paths and class names.

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3. Results & Performance

After training, the model achieved the following evaluation metrics on the test dataset:

Metric	Value
mAP@0.5	90.00%
mAP@0.5:0.95	78.01%
Precision	93.13%
Recall	83.40%
Inference Time	~36.34 ms per image

Visual performance evaluations, including confusion matrices and training curves, are available in the runs/train/space_model/ folder.
The model effectively localized all three object classes even under challenging lighting and occlusion conditions.

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4. Challenges & Learnings

Challenges:

- Reducing false positives, especially for small objects.
- Balancing model size with high detection performance.
- Managing GPU memory constraints during training.

Learnings:
✅ Practical experience with YOLOv8
✅ Importance of high-fidelity synthetic data for safety-critical applications
✅ Potential of Edge AI for real-time space monitoring

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5. Conclusion & Future Work

Our YOLOv8-based object detection system demonstrated high performance in a fully synthetic space station environment, proving the viability of synthetic data in training real-world models. Moving forward, we aim to:

- Export the trained model to ONNX or TFLite for deployment on edge devices.
- Develop a lightweight dashboard (using Streamlit or Gradio) for real-time equipment monitoring.
- Continuously refine and expand the dataset with Falcon to simulate evolving mission scenarios.

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6. Project Structure

The GitHub repository contains the following:

- SpaceStation_YOLOv8.ipynb: Google Colab notebook with the full training workflow.
- config.yaml: YOLOv8 dataset config file.
- runs/train/space_model/: Training outputs (weights, confusion matrix, performance graphs).
- Hackathon_Report.md: This report.
- dataset/: Structured synthetic image dataset (not included in the repo due to size).

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7. Submission Checklist

✅ Trained YOLOv8 model weights (best.pt)
✅ Evaluation results and visualizations
✅ Clean and reproducible code (.ipynb)
✅ Final structured report (Hackathon_Report.md)
✅ GitHub repository with complete project

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8. Acknowledgements

We sincerely thank Duality AI for providing access to Falcon and the high-fidelity synthetic dataset, and SunHacks for hosting a well-organized and meaningful AI challenge.

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9. Team Members

- **Tushar Nigam** – Model training, performance evaluation, code implementation
- **Sambhavi Katiyar** – Dataset preparation and application integration
- **Yash Vaibhav** – Documentation and presentation materials