SYNDETECT – Hackathon Report

Team Name: TECH TITANS

Project Name: SYNDETECT – Synthetic Space Object Detection Web App

Tagline: “Detecting the Undetectable — Synthetic Vision for Safer Space Missions”

# 1. Methodology

Our object detection system was built using YOLOv8 with a focus on detecting synthetic space objects and anomalies.   
The dataset consisted of synthetic space imagery generated using Blender and sourced from publicly available synthetic datasets.  
  
- Model: YOLOv8n (Nano version for efficiency)  
- Framework: Ultralytics YOLOv8 (PyTorch backend)  
- Image Size: 640x640  
- Epochs: 50  
- Batch Size: 16  
- Loss Function: Composite of objectness, classification, and localization loss  
- Augmentations: Mosaic, HSV, horizontal flip  
- Environment: Google Colab Pro and local VS Code setup with CUDA GPU support

# 2. Challenges & Solutions

- Lack of real-world data: Resolved using synthetic image generation and domain randomization techniques.  
- GPU memory crashes during training: Switched to YOLOv8n and reduced image size.  
- Labeling inconsistencies: Manually reviewed data with Roboflow Annotate.  
- Integration issues with YOLO and web interface: FastAPI used to build robust API for model inference.

# 3. Optimizations

To improve model performance and efficiency:  
- Applied data augmentations like mosaic, HSV, flipping to improve robustness.  
- Reduced image size to 416x416 for faster web inference.  
- Converted model to ONNX for potential future edge deployment.  
- Tuned confidence threshold in frontend to suppress false positives.

# 4. Performance Evaluation

The final model evaluation was performed on a test set of 400 images across 3 object classes: **FireExtinguisher**, **ToolBox**, and **OxygenTank**. Below are the detailed metrics:

| **Class** | **Instances** | **Precision (P)** | **Recall (R)** | **mAP@0.5** | **mAP@0.5:0.95** |
| --- | --- | --- | --- | --- | --- |
| FireExtinguisher | 183 | 0.240 | 0.107 | 0.107 | 0.0634 |
| ToolBox | 193 | 0.135 | 0.074 | 0.074 | 0.0501 |
| OxygenTank | 184 | 0.201 | 0.164 | 0.164 | 0.113 |
| **All** | **560** | **0.274** | **0.145** | **0.114** | **0.0754** |

* **Speed**: ~0.3ms preprocessing, 6.3ms inference, 5.6ms postprocess per image
* **Hardware**: NVIDIA GeForce RTX 4050 (Laptop GPU), 6140 MiB VRAM

`Failure Case Analysis:  
- False Positives due to reflection noise — plan to enhance dataset diversity.  
- Missed small object detections — consider tiled input or higher resolution.  
- Misclassification of similar-looking objects — class-specific image context enhancement required.

# 5. Conclusion & Future Work

SYNDETECT offers an efficient, scalable approach to synthetic space object detection. It combines YOLOv8 with a full-stack web interface, including voice command capabilities and detection history.  
  
Future enhancements:  
- Real-time video stream inference from satellite feeds.  
- Multi-class object support including tools, debris, and damage.  
- 3D spatial visualization for spatial orientation.  
- Onboard edge deployment with TensorRT optimization.