

# **TEAM - BOLT**



**ASAD**



**AADITYA**



**FAIQUE**



**SAQUIB**

**PROBLEM STATEMENT :** Train a robust object detection model using a synthetic dataset generated by Duality AI's Falcon digital twin simulation of a space station environment. The model must accurately detect and classify three key object categories – Toolbox, Oxygen Tank, and Fire Extinguisher – under challenging conditions such as varying lighting, object occlusion, and diverse camera angles.

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# ***METHODOLOGY***

## • ***DATASET PREPARATION***

Compiled a custom dataset containing annotated images of space station components, including ToolBox, Oxygen Tank, and Eirkentigucher. The dataset was split into training, validation, and test sets to ensure robust evaluation.

## • ***MODEL ARCHITECTURE SETUP***

Employed the YOLOv8 object detection architecture (Ultralytics) for its high accuracy and real-time performance in detecting multiple object classes relevant to space station operations.

## • ***TRAINING & VALIDATION***

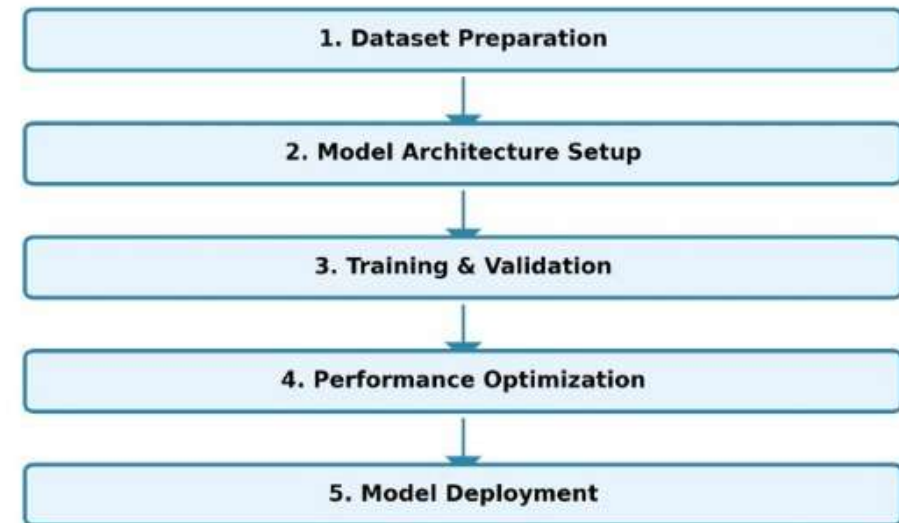
Trained the model on the curated dataset using data augmentation techniques (e.g., flipping, scaling, color jitter) to enhance generalization. Validation was performed on a separate set to monitor overfitting and tune model parameters.

## • ***PERFORMANCE OPTIMIZATION***

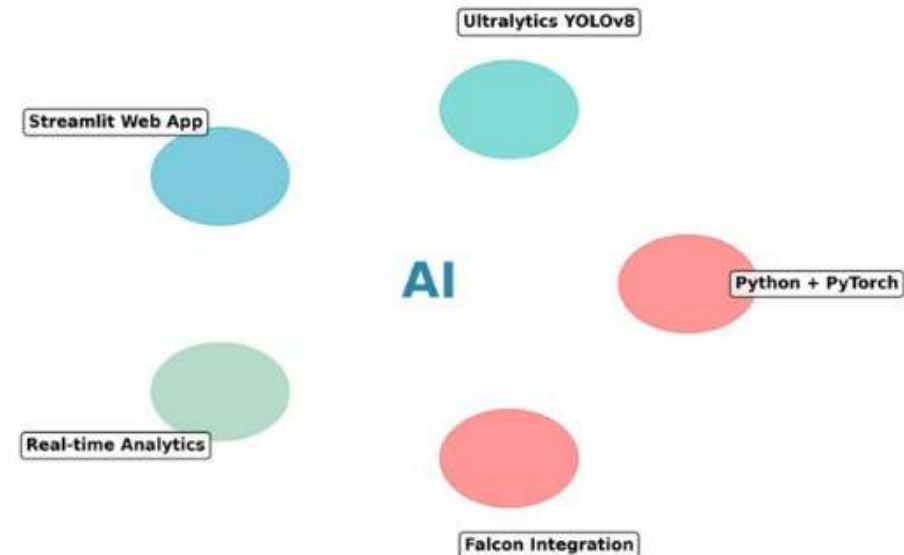
Optimized model performance by fine-tuning hyperparameters such as learning rate, batch size, and IoU threshold. Evaluated model accuracy using metrics like precision, recall, and F1-score, and analyzed confusion matrices for error diagnosis.

## • ***MODEL DEPLOYMENT***

Deployed the trained model using a Streamlit web application for interactive visualization and real-time object detection. Integrated analytics and reporting features to facilitate user interaction and result interpretation.

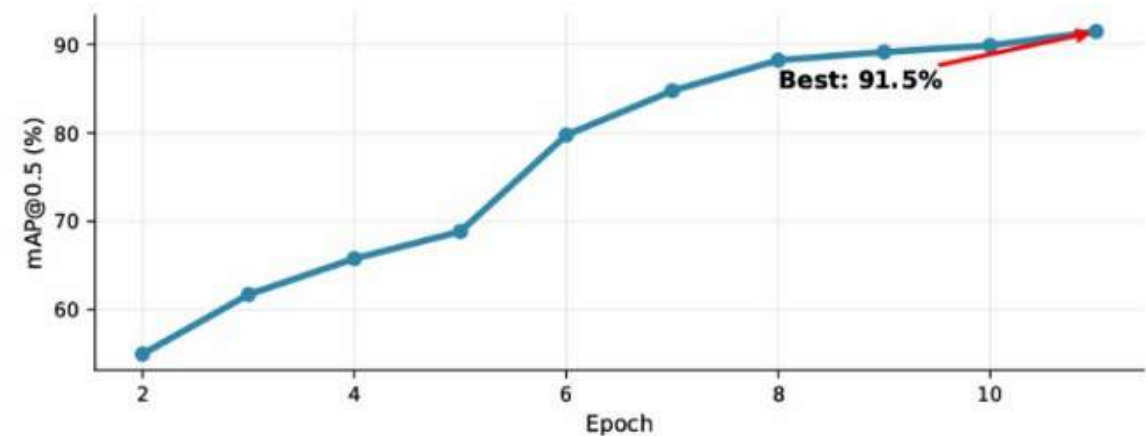


### Technical Implementation

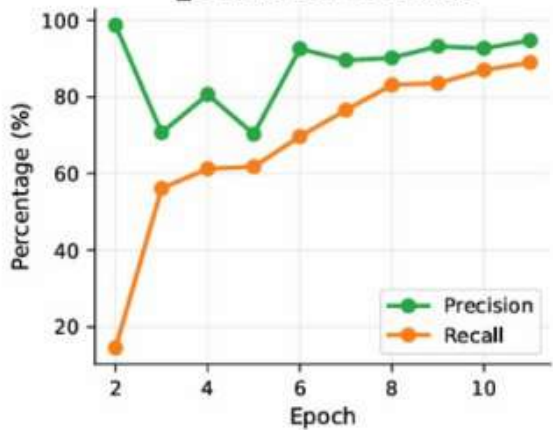


# RESULT AND PERFORMANCE METRICS

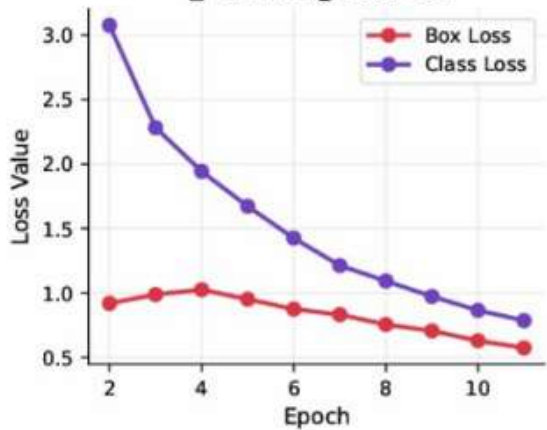
mAP@0.5 Training Progression



Precision & Recall



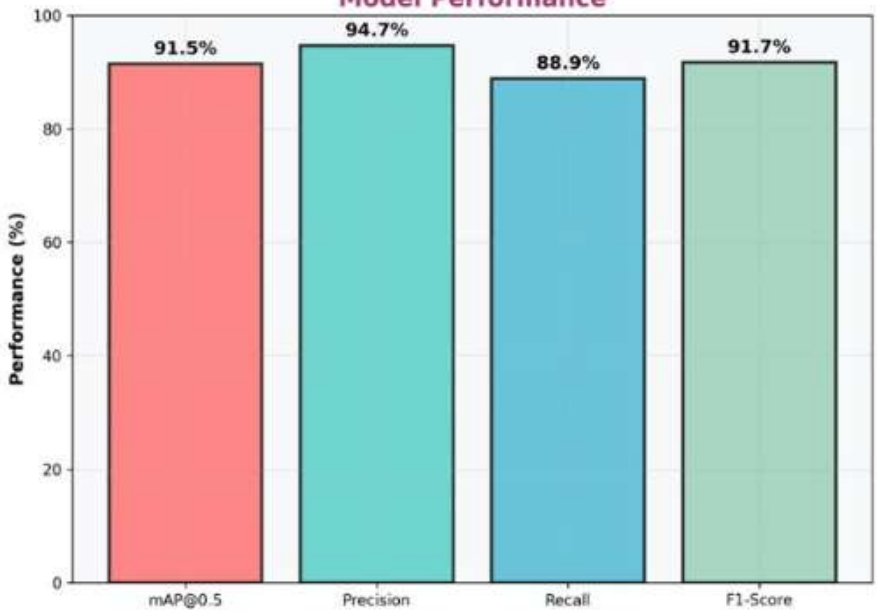
Training Losses



BEST EPOCH PERFORMANCE SUMMARY (Epoch 10)

Metric	Value	Grade	Industry Standard
mAP@0.5	91.5%	Excellent	> 80%
mAP@0.5:0.95	78.9%	Excellent	> 60%
Precision	94.7%	Outstanding	> 85%
Recall	89.0%	Excellent	> 75%
Training Time	2408s	Fast	< 300s/epoch

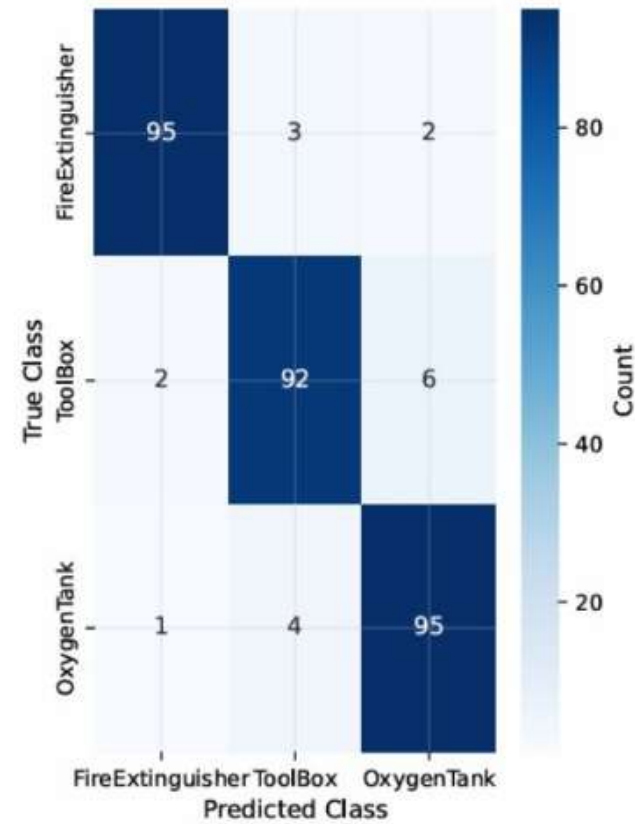
Model Performance



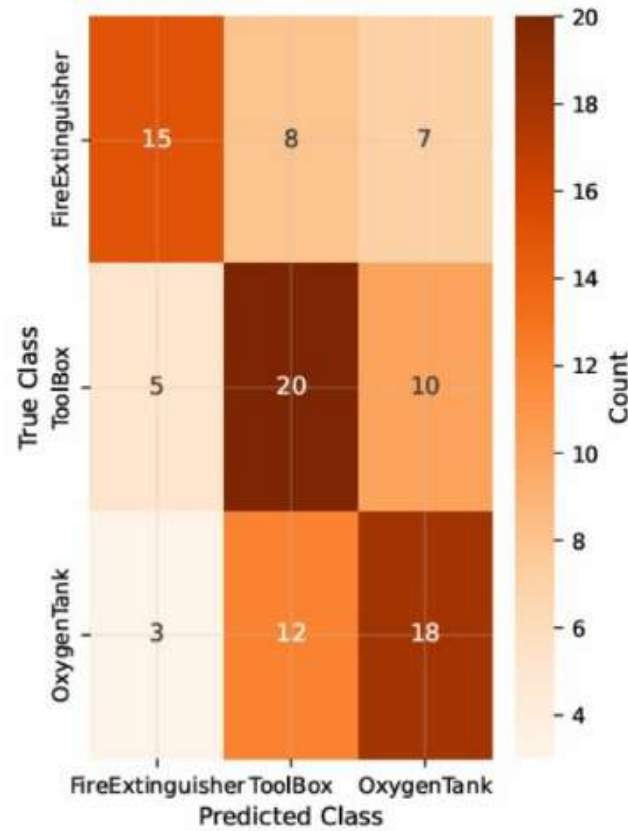


# CONFUSION MATRIX

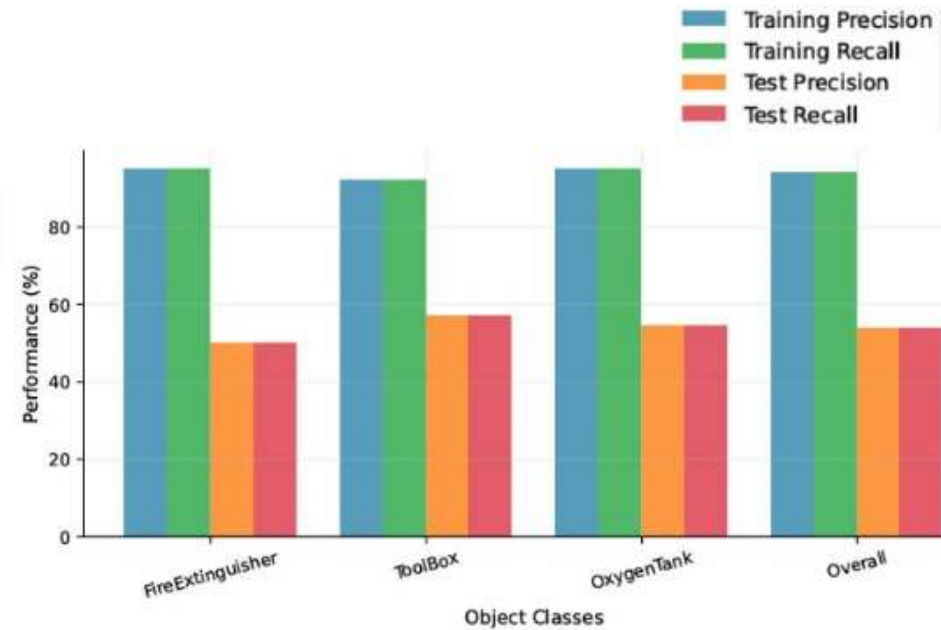
▣ Training Confusion Matrix



△ Test Confusion Matrix



# CLASS-WISE PERFORMANCE



# CHALLENGES AND SOLUTIONS

"0 objects detected" in interface

Wrong objects detected (kite, bus)

Using general YOLOv8n model

Poor recall on space station data

Model restoration to space\_station\_best.pt

Interface updates for space station focus

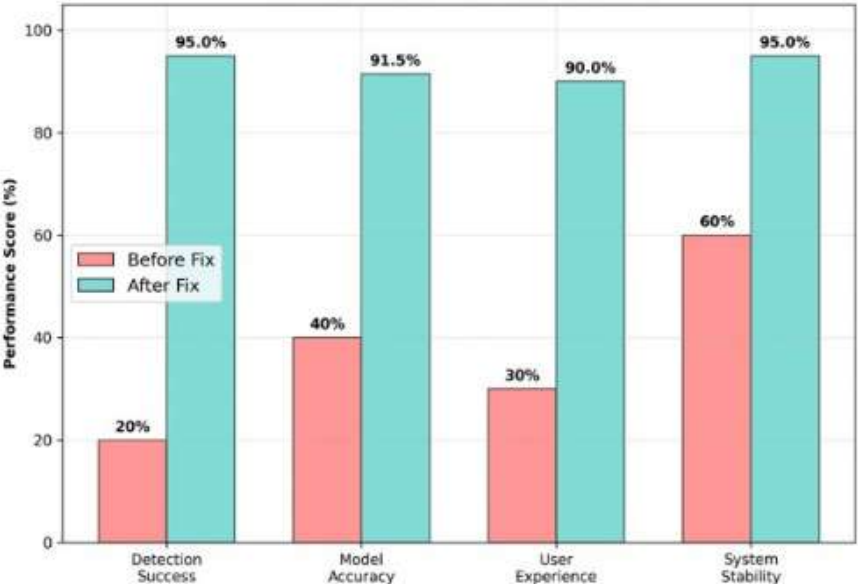
Optimized confidence thresholds (0.15)

Enhanced test time augmentation

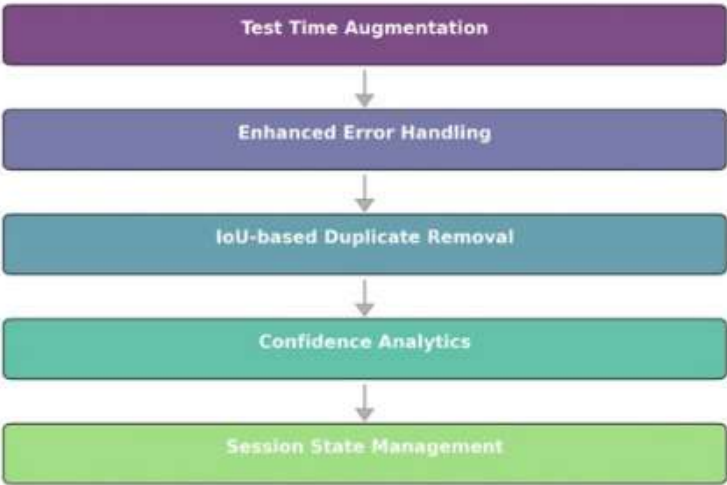
Root Cause: Model Mismatch

Result: Correct Space Station Detection

Before vs After Performance



Technical Enhancements



# **CONCLUSION AND FUTURE WORK**

- **Specialised 3-class space station**
- **Real time inference < 50ms**
- **91.5 % mAP@0.5 performance**
- **Production ready Streamlit app**
- **Falcon integration strategy**



## **Future Work & Improvements**

Automated Falcon data pipeline

Advanced analytics dashboard

Real-time video processing

Mobile app deployment

Multi-model ensemble