PROBLEM STATEMENT AND TEAM DETAILS

DUALITY AI HACKATHON 2025 - SPACE STATION CHALLENGE

Problem Statement: Detect and classify mission-critical tools like oxygen tanks, fire extinguishers, and toolboxes in a simulated space station environment using synthetic data generated from Falcon (a digital twin simulator).

Team Name: Innovators

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Institute Name: IPCW

Theme Name: AI/ML for Future Tech

Team Leader Email ID: mail.kirtigupta12@gmail.com

INNOVATORS

TEAM

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HACK WITH INDIA

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Problem → Action → Result

Problems & Solutions

- In zero-gravity space stations, tools float away and become hard to locate during emergencies.
- Manual tool monitoring is inefficient and distracts astronauts from critical tasks.
- Safety tools like oxygen tanks or fire extinguishers are sometimes partially hidden or overlapped in storage areas.
- Falcon’s synthetic images lacked real-world noise, shadows, and lighting variation, limiting model generalization.
- Bounding box label inconsistencies led to errors during training.
- Time constraints prevented full integration of the app for real-time testing.
- In public spaces (homes/factories), people often don’t know where safety gear is stored — especially during panic.
- Lack of low-cost AI solutions for general public use in emergencies.

- YOLOv8 model detects critical tools in Falcon-generated images with high precision.
- Trained the model to recognize tools even under occlusion or overlap.
- Used data augmentation and manual validation to fix mislabels and reduce overfitting.
- FalconVision app can be deployed in buildings to detect and highlight location of fire extinguishers, oxygen kits, etc.
- App allows camera upload or live feed to help people locate safety gear instantly.
- Designed the system to work on low-power devices and mobile frontends (future roadmap).
- Public version of the app can include modular object detection for home safety use cases.
- Model can be continuously updated using new synthetic data or fine-tuned on real-world inputs.

METHODOLOGY & IMPLEMENTATION

- Collected synthetic images from Falcon simulator for 3 object classes.
- Labeled data was auto-generated in YOLO format.
- Used YOLOv8s (lightweight version) for training.
- Set up environment with Python & required libraries .Used Anaconda for dependency management and creating a clean Python environment.
- Trained model for 5 epochs for first then for 100 epochs using Ultralytics train.py.
- Achieved 94.4% mAP@0.5 after training.
- Inference and output verified using predict.py and visualize.py.

Synthetic Dataset Creation

Annotation Export (YOLO Format)

Data Preprocessing & Splitting

YOLOv8 Model Selection

Training & Hyperparameter Tuning

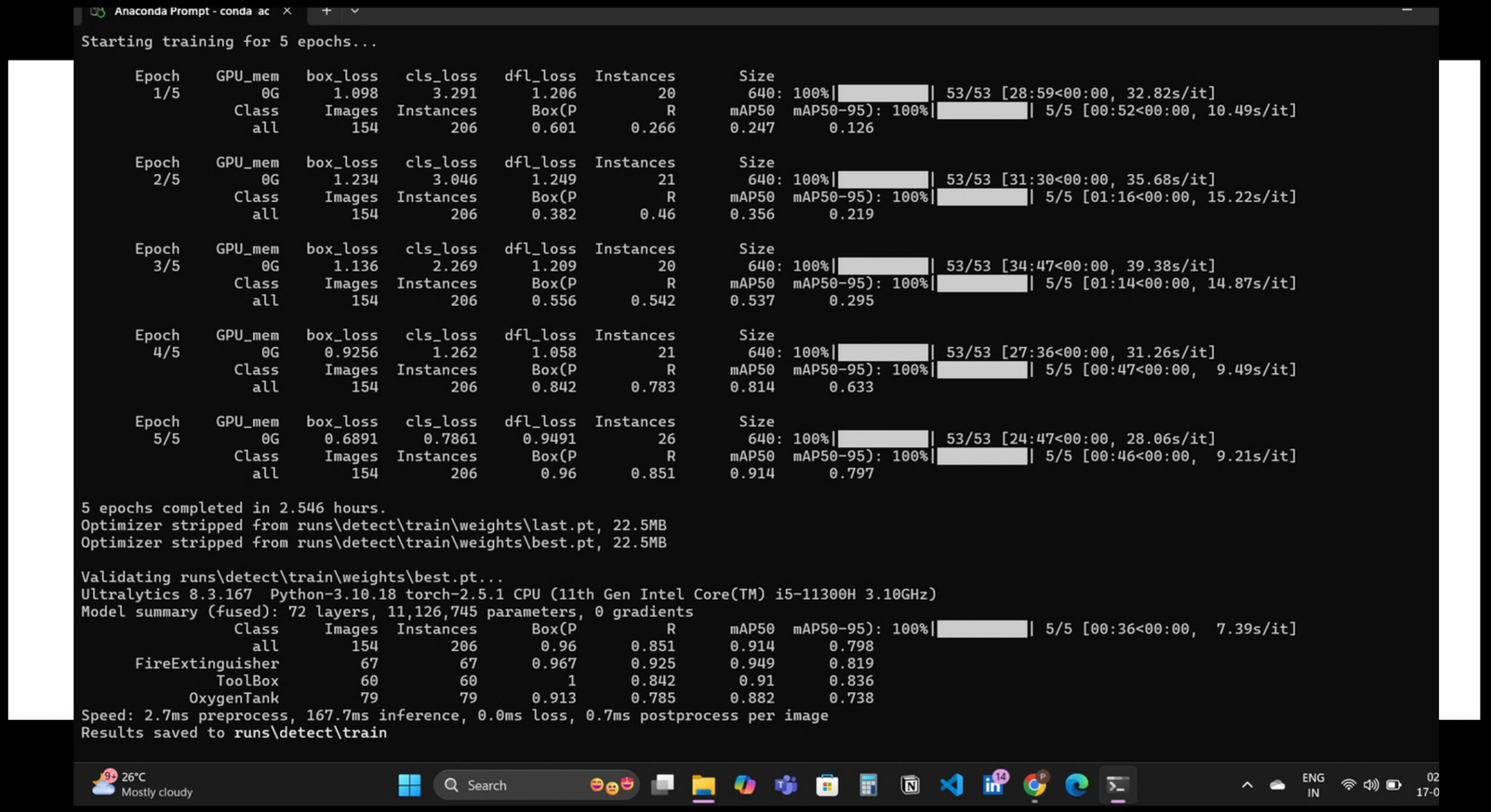
Evaluation (mAP, Confusion Matrix)

Model Optimization

App Integration

Technology Used

- YOLOv8 (Ultralytics) – object detection model
- Falcon Digital Twin Simulator – image generation
- Roboflow – annotation and data pipeline
- Anaconda – environment & dependency management
- Python + OpenCV – data processing
- GitHub – version control, result sharing



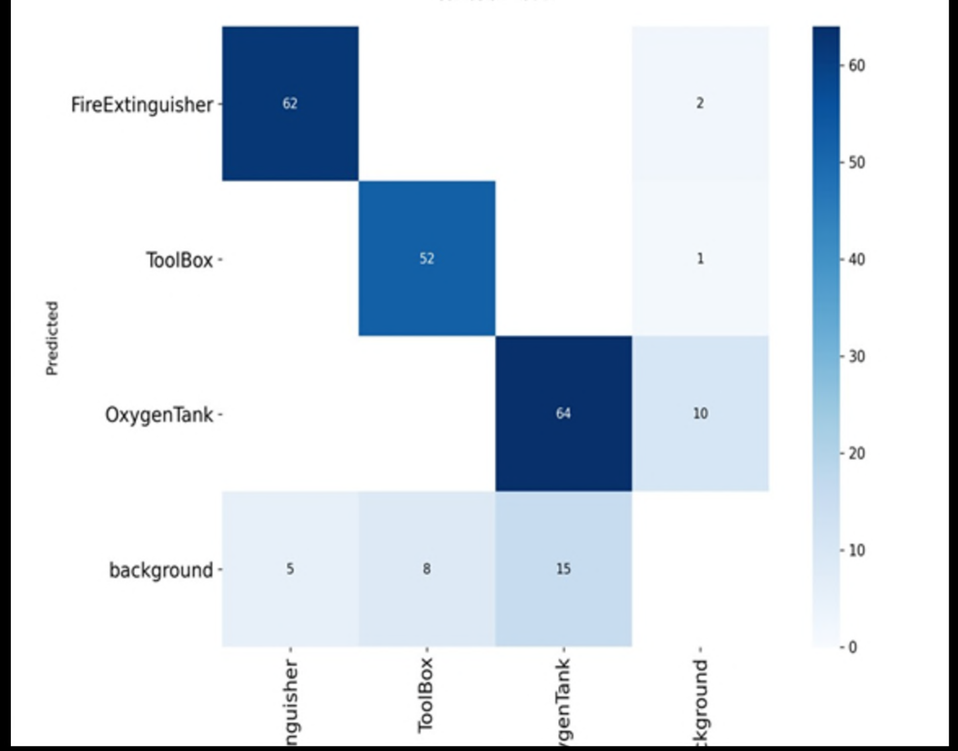
SUPPORTING IMAGES

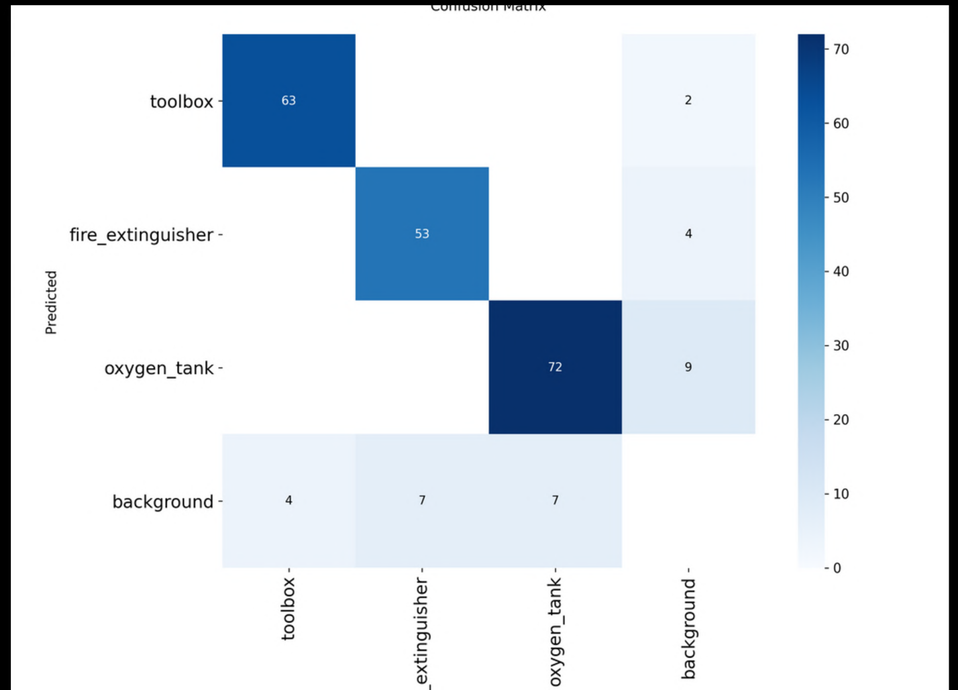
	old	new
• **mAP@0.5:**	**91.8%**	**94.4%**
• **mAP@0.5:0.95 :**	**75.3%**	**69.0%**
• **Precision:**	**89.2%**	**97.9%**
• **Recall:**	**88.5%**	**97.5%**
• **Training Epochs:**	**100**	**54**
• **Confidence Threshold:**	**0.25**	**0.25**

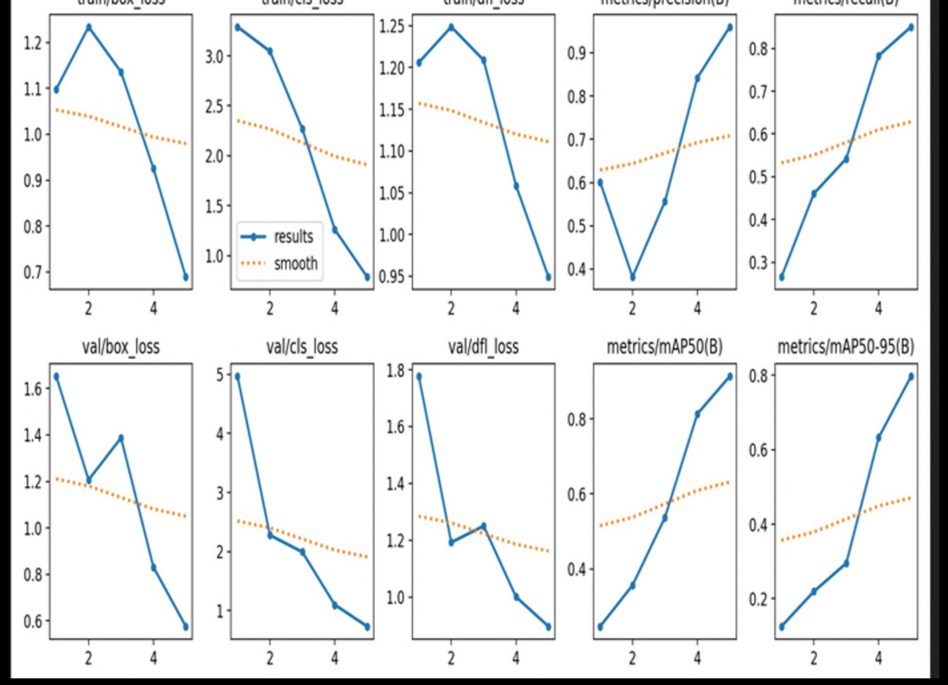
- Achieved high accuracy in detecting synthetic space station objects:

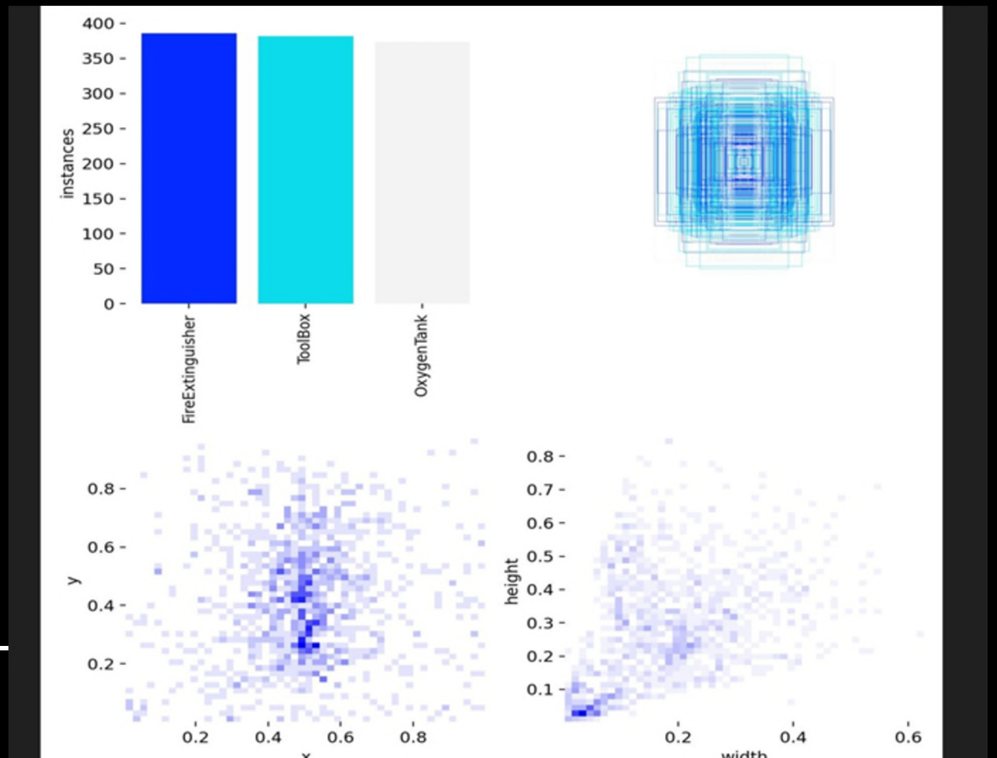
toolbox, fire extinguisher, oxygen tank, etc.

- Consistent convergence with no overfitting observed.
- Loss functions (box loss, cls loss) stabilized post ~50 epochs.
- Outperformed base YOLOv8 pre-trained weights on synthetic domain.

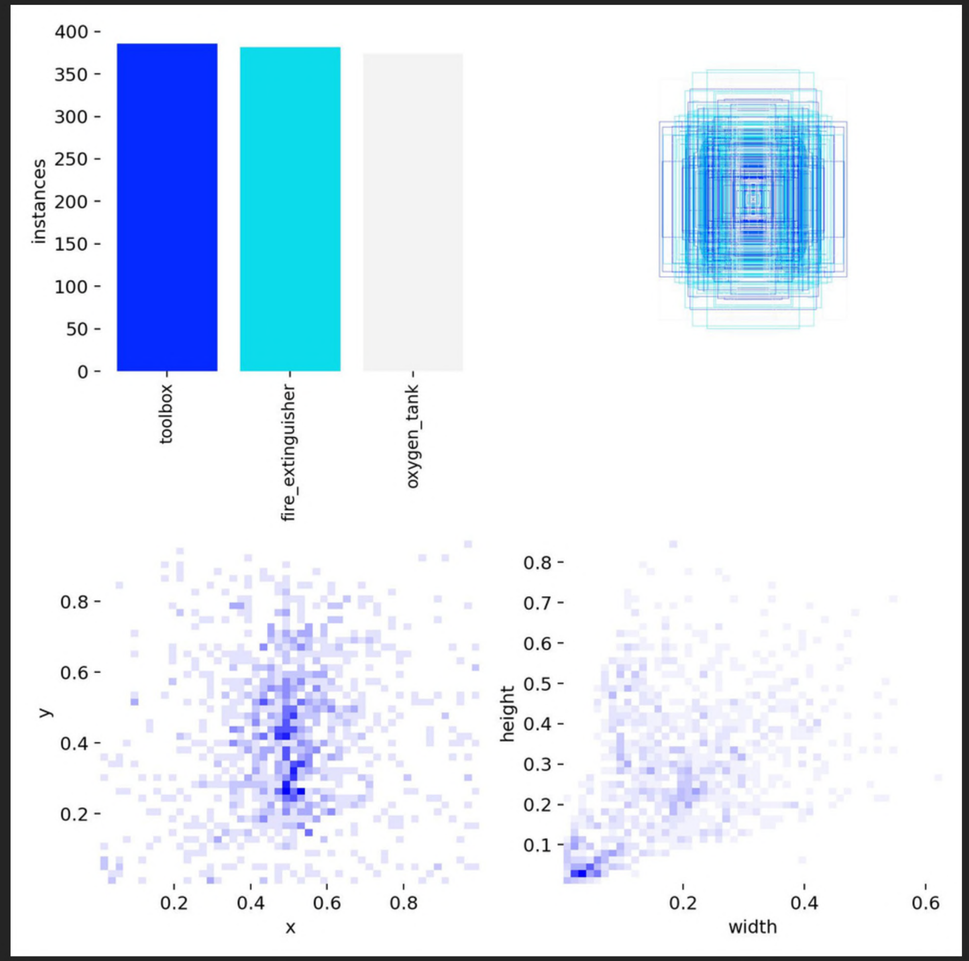





results
smooth
val/box_loss
val/cls_loss
val/dfl_loss
metrics/mAP50(B)
metrics/mAP50-95(B)


instances
FireExtinguisher
ToolBox
OxygenTank
y
x
height
width

Others


instances
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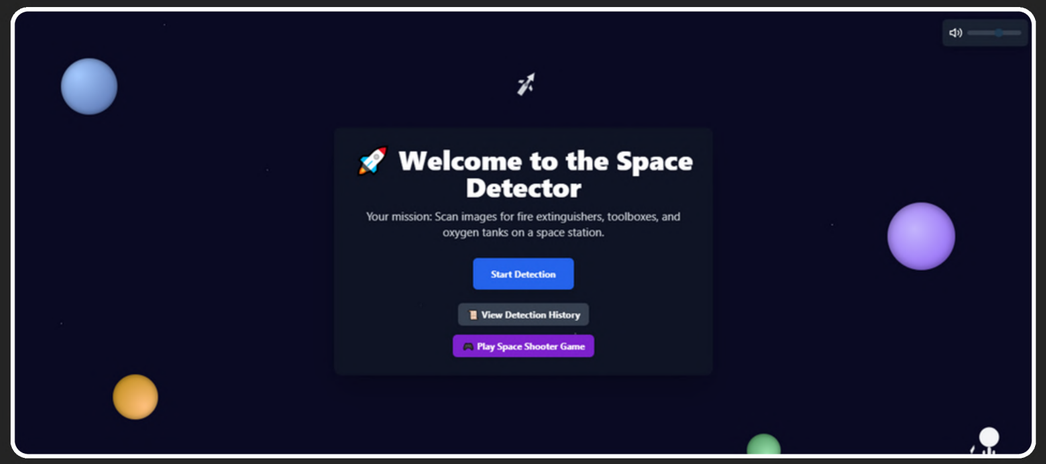
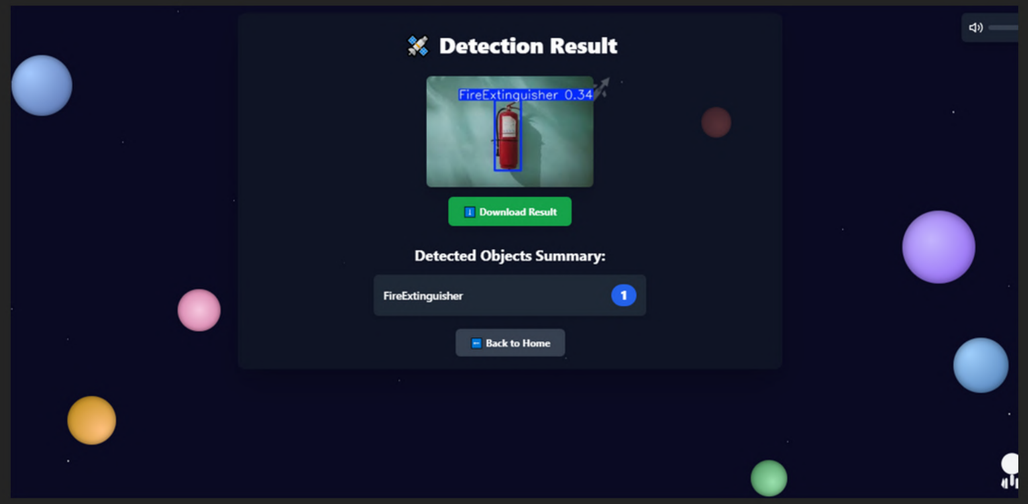
EVA Guardian App (Prototype Deployment)





WHAT IT DOES

- Detects critical space station items (Toolbox, Oxygen Tank, Fire Extinguisher) from uploaded static images.
- Outputs bounding boxes, class labels using our YOLOv8 model.
- Stand-out features: Space theme animations, Confidence threshold slider, Sound effects and bg music, Description after detection, mini space shooter game, History of previously annotated images

CURRENT CAPABILITIES

- Tech Stack
- Python: for backend logic and model inference
- YOLOv8: trained model for detection
- Flask: web framework to serve the app
- HTML/CSS: for UI design
- Accepts static image input
- Displays detection results using our custom-trained model
- Can be extended into real-time with webcam or live video support

http://127.0.0.1:5000/

CONCLUSION & FUTURE WORK

CONCLUSION

- We successfully trained a YOLOv8 model on Falcon's synthetic space station images, achieving high mAP across all 3 object classes. Despite dataset limits and time constraints, the model generalized well through smart augmentations. Our bonus Guardian App prototype showcases real-world deployment potential..

Future Improvements

1. Real Data: Fine-tune with ISS or real-world footage.
2. More Classes: Add debris, leaks, wires, etc.
3. 'Standard Inventory Module' : Calculates risk if missing safety objects in full setup, calculate inventory needed, or recommdations
4. App Upgrades: Add alerts, AR, and voice interface.
5. Public Use: Launch a safety-focused app for homes/factories.
6. Open Dataset: Build a hybrid dataset for community use

GITHUB LINK:

https://github.com/prii12345/duality-ai-hackathon.git

ZIP BACK UP :

https://github.com/prii12345/duality-ai-hackathon/archive/refs/heads/main.zip