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Vision-Based Real-Time Safety Gear Monitoring and Alert System for Construction Sites

Presented by Group 5

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Background

4,764 workers died on the job in 2020 (3.4 per 100,000 full-time equivalent workers).

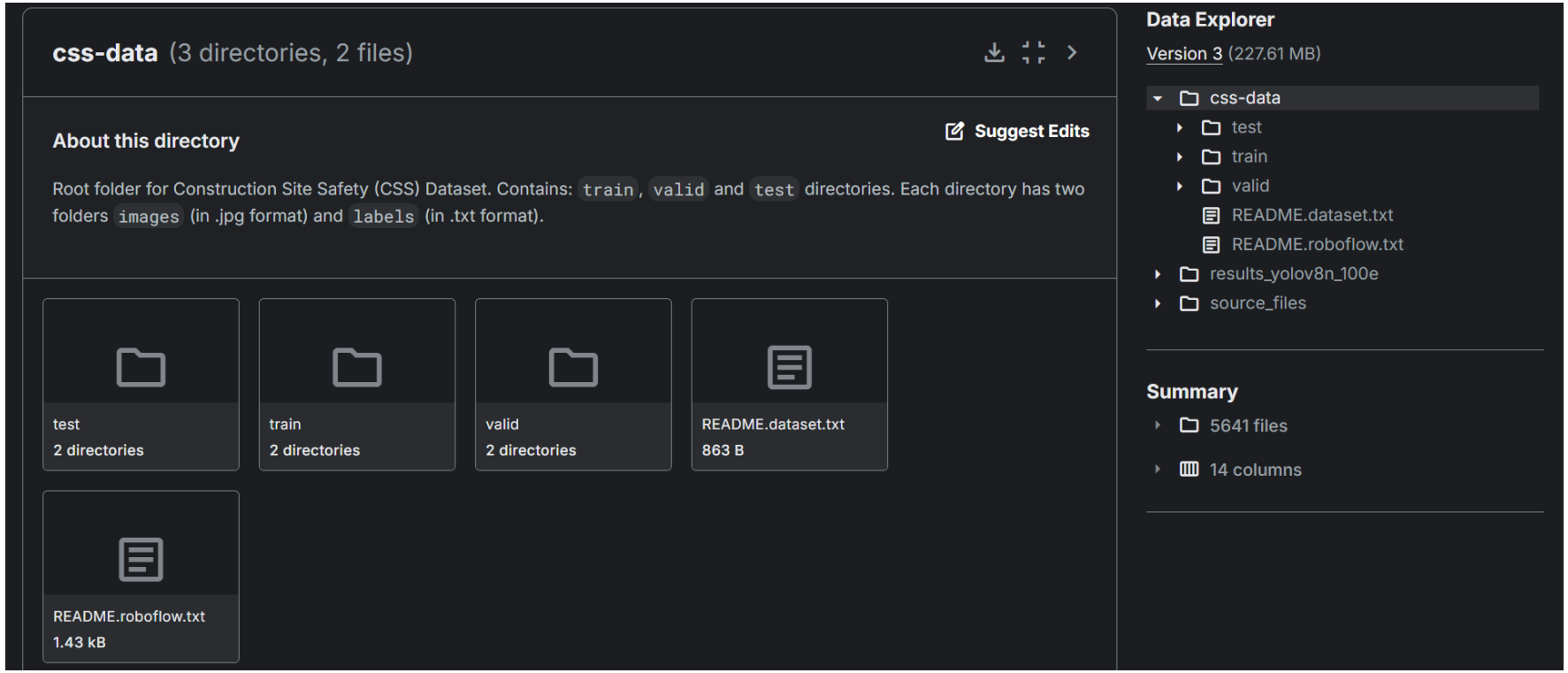
Occupational Safety and Health Administration (US Department of Labour)

From Strongrise Construction

- **Problem:** High accident rates caused by frequent PPE violations.
- **Gap:** Manual inspections are inconsistent; current tech is costly and privacy-invasive.
- **Solution:** An edge-optimized YOLOv8 system on low-power hardware.
- **Goal:** Real-time, scalable, and privacy-secure safety monitoring.

Data

- https://www.kaggle.com/datasets/snehilsanyal/construction-site-safety-image-dataset-roboflow



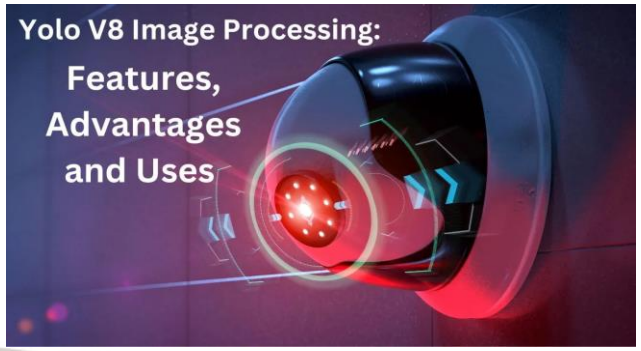
Model and features

- **YOLOv8n (Nano):** The smallest, fastest architecture in the YOLOv8 family.
- **Key Advantages:**

  Ultra-Lightweight: Only 3.2M parameters (vs. 11.2M for v8s).

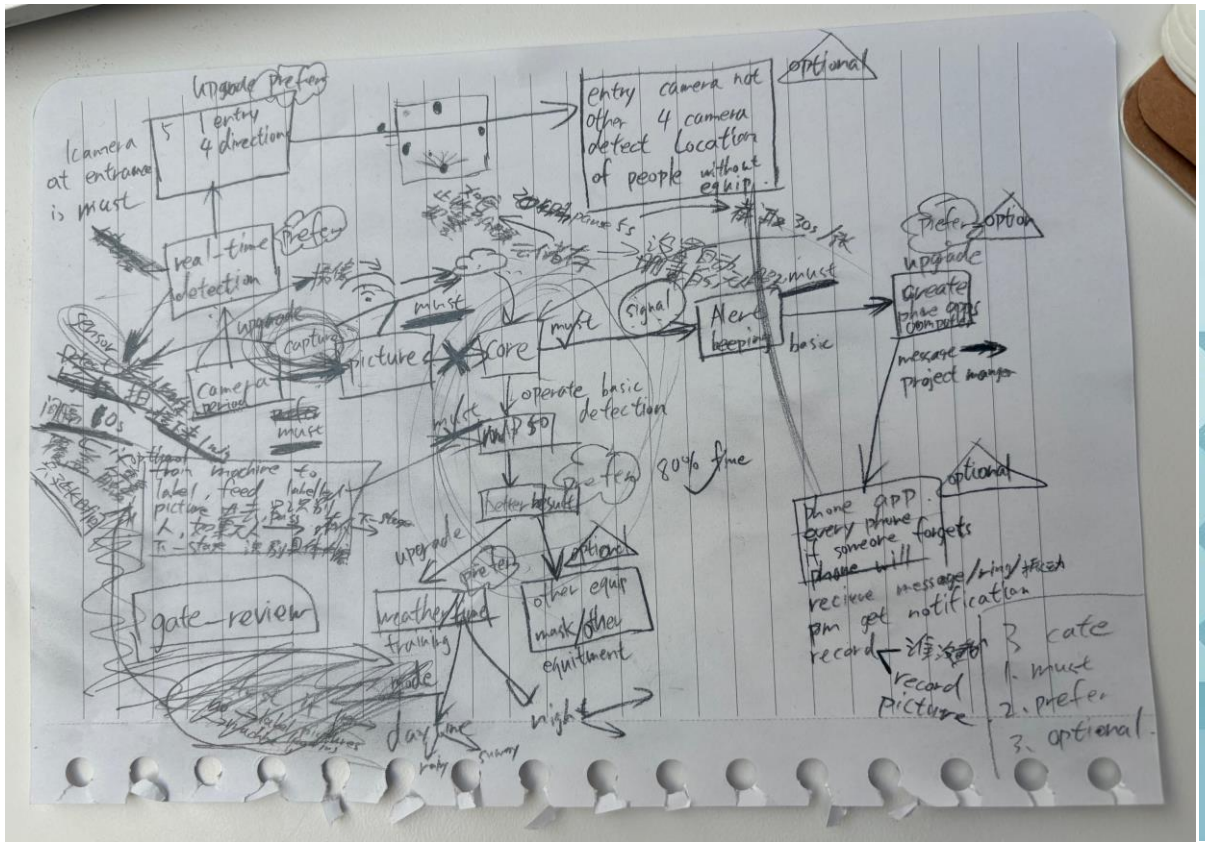
  Edge-Ready: Enables low-latency, real-time inference on resource-constrained hardware.

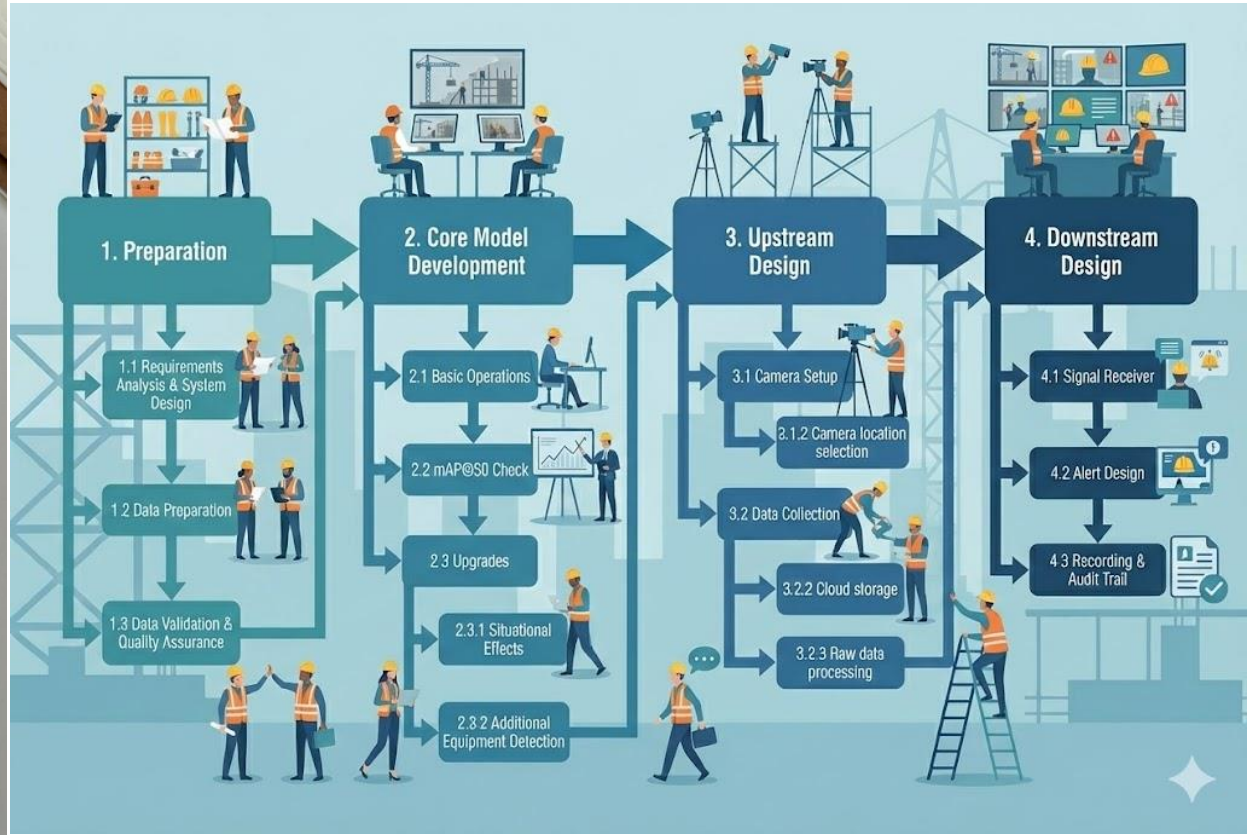
  Efficient: Balances sufficient accuracy with minimal power consumption.



From NVIDIA Jetson AI Lab

Flow chart



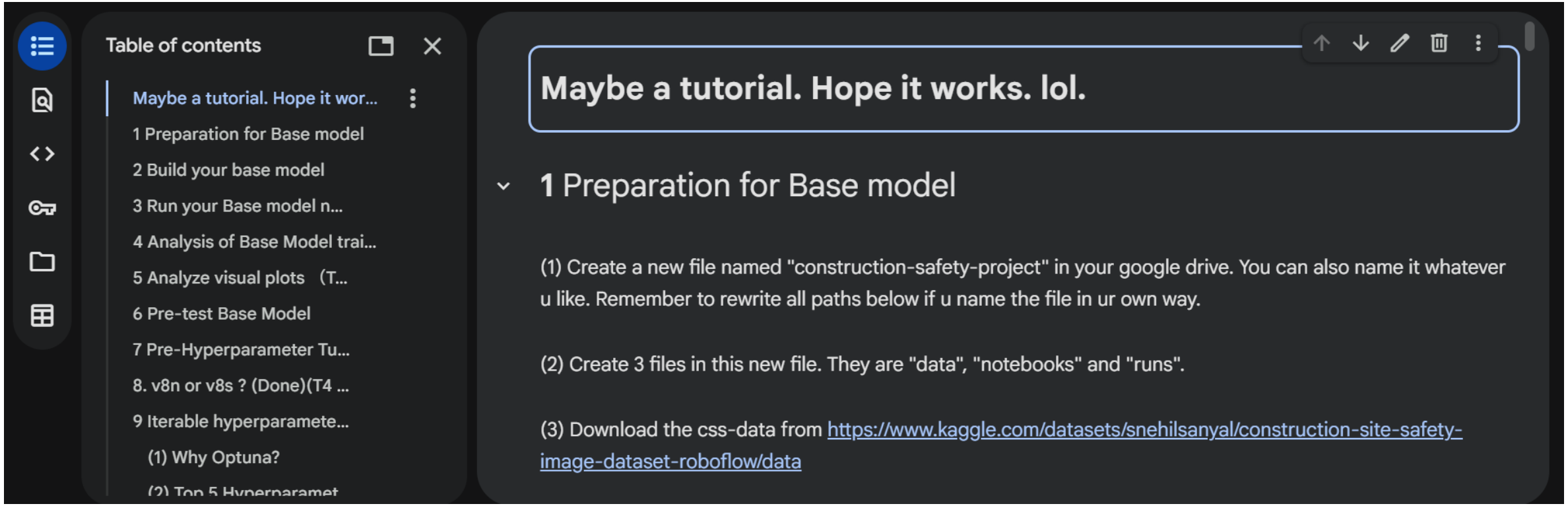


Generated by Gemini based on Sun's design in Proposal

Final results

Hyperparameters tuning failed, base model won

https://colab.research.google.com/drive/11zneNKfsk5LbuhR21XVkxZsmh9bN2YG4?usp=sharing



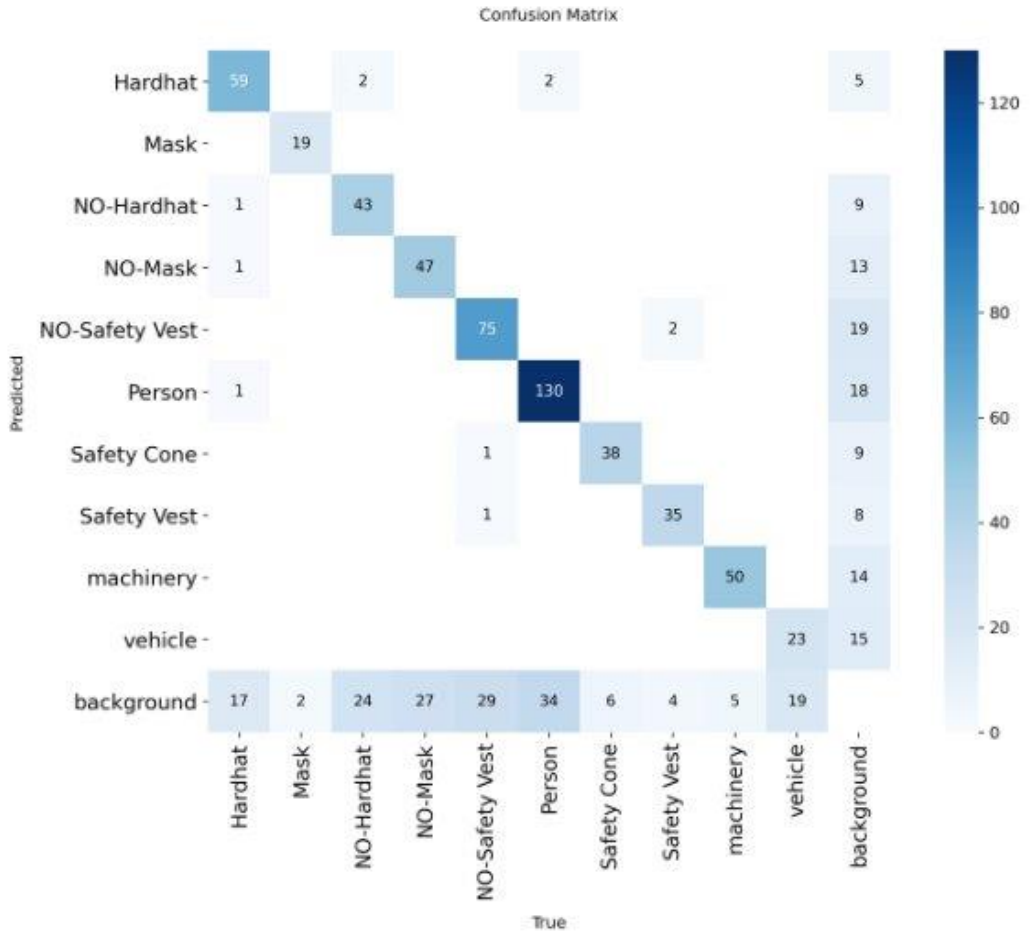
Final results

Class	Images	Instances	Box(P	R	mAP50	mAP50-95): 100%
all	114	697	0.911	0.714	0.801	0.51
Hardhat	42	79	0.968	0.722	0.879	0.554
Mask	19	21	0.979	0.905	0.928	0.697
NO-Hardhat	37	69	0.931	0.551	0.729	0.426
NO-Mask	44	74	0.899	0.527	0.623	0.323
NO-Safety Vest	56	106	0.886	0.661	0.773	0.455
Person	84	166	0.938	0.73	0.827	0.537
Safety Cone	13	44	0.85	0.818	0.845	0.48
Safety Vest	28	41	0.916	0.797	0.924	0.609
machinery	26	55	0.908	0.909	0.944	0.668
vehicle	16	42	0.83	0.524	0.539	0.352

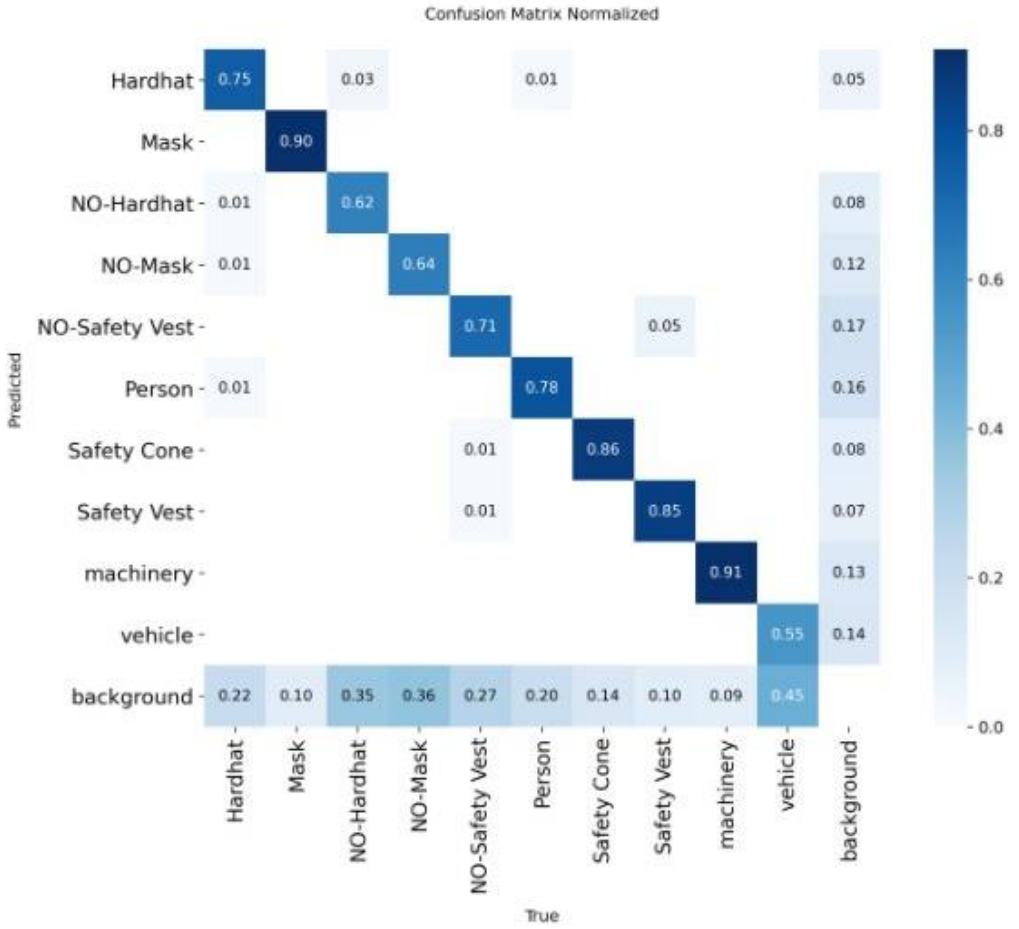
Speed: 0.2ms preprocess, 2.6ms inference, 0.0ms loss, 6.9ms postprocess per image

mAP50: A key metric for detection accuracy. It measures how well the model identifies and locates objects with >50% overlap.

Confusion matrix

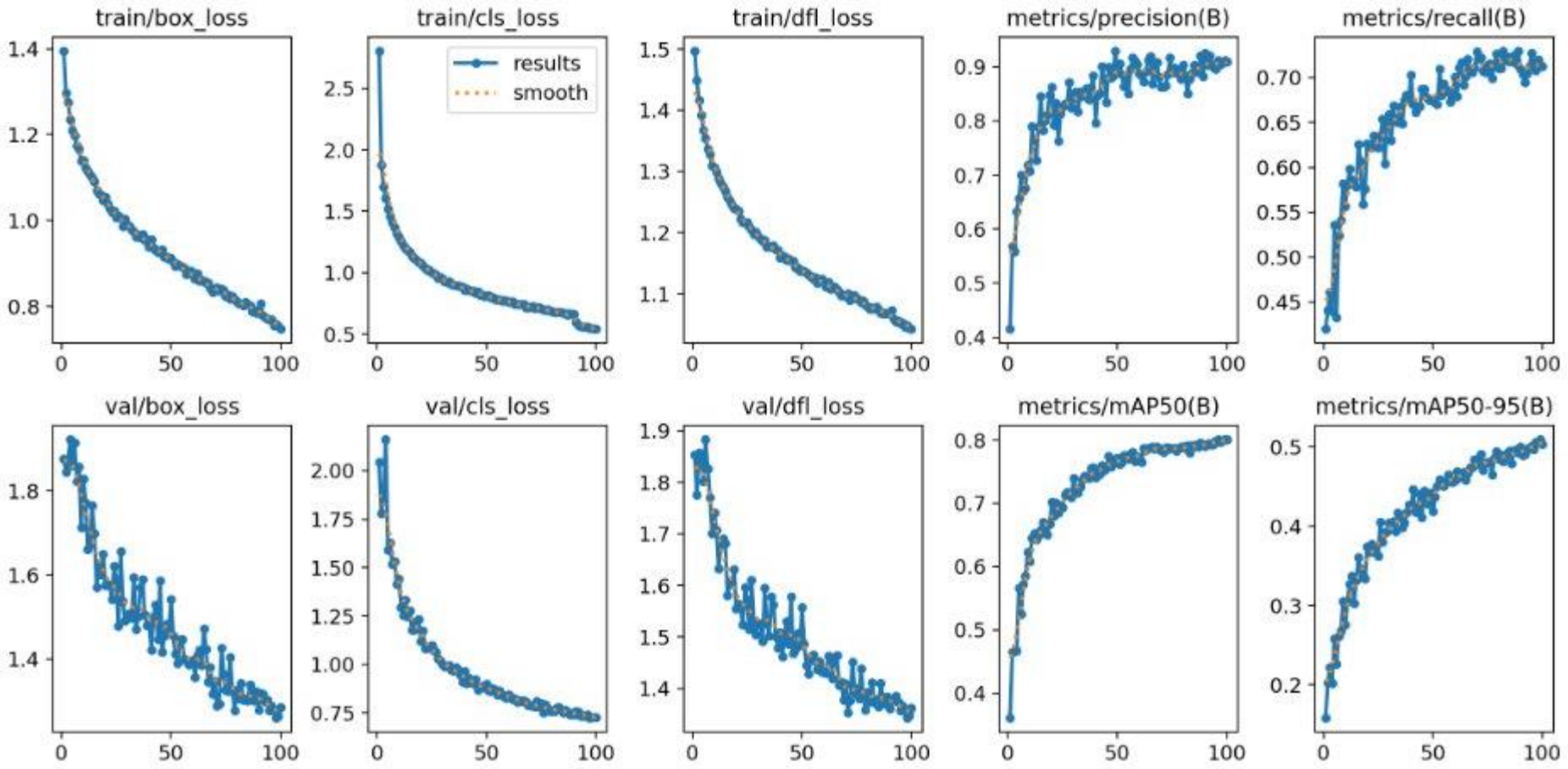


Missed Detections are the Biggest Problem



Inter-Class Confusion is Not Severe

Overall results plot



Healthy Training, No Overfitting

Performance is Nearing Saturation

Validation Batch Predictions

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Ground Truth Labels

Model Predictions

Accurate and Confident on Strong Classes

Weaknesses are Visually Obvious

MAIN MENU

- Live Monitor
- Dashboard
- Violation Logs
- Settings

Live Monitor

Source: Main Gate Camera

Main Gate Camera

Start

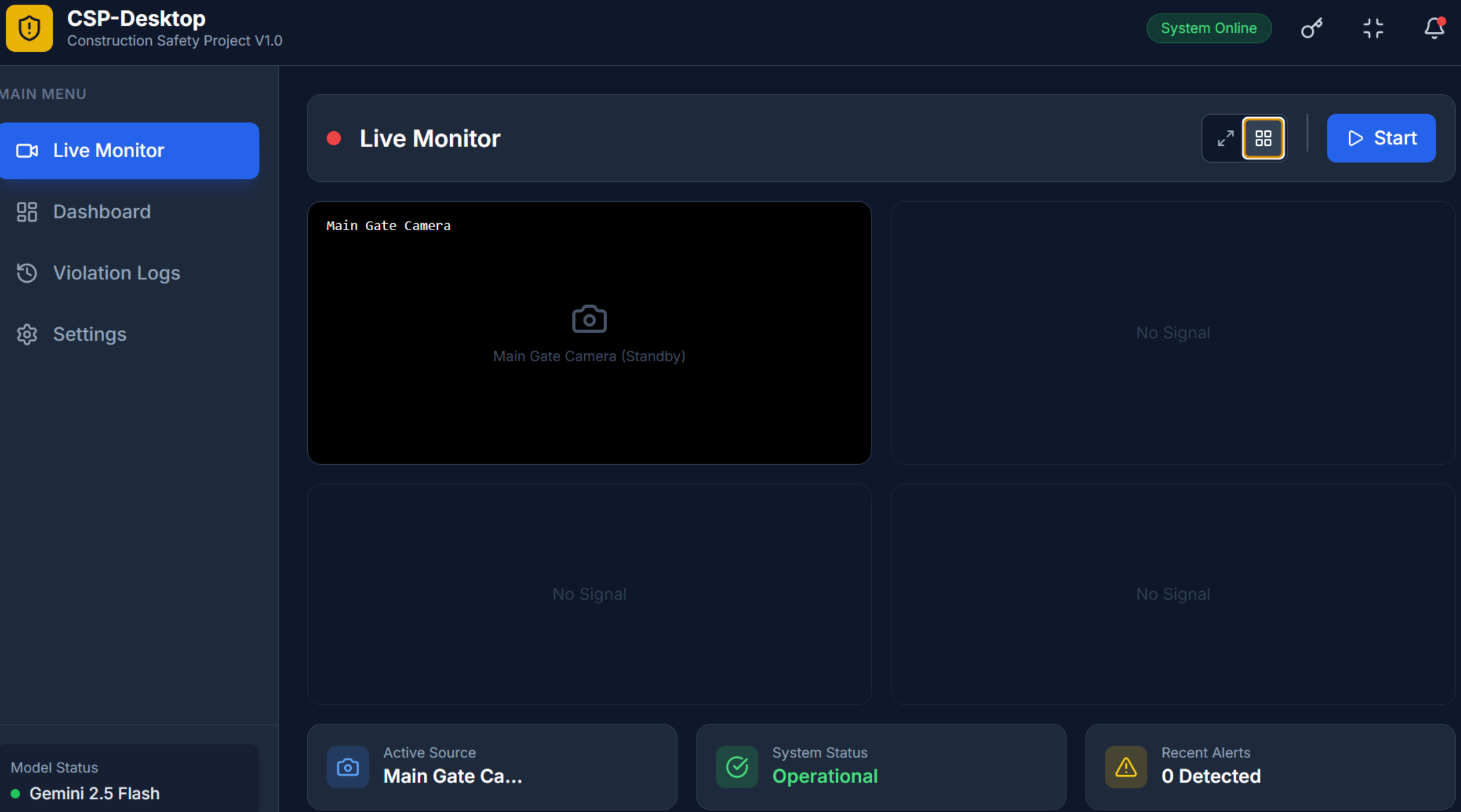
Camera is offline. Click Start to begin.

Active Source
Main Gate Ca...

System Status
Operational

Recent Alerts
0 Detected

Model Status
Gemini 2.5 Flash


CSP-Desktop
Construction Safety Project V1.0
System Online
MAIN MENU
Live Monitor
Dashboard
Violation Logs
Settings
Model Status
Gemini 2.5 Flash
Live Monitor
Start
Main Gate Camera
Main Gate Camera (Standby)
No Signal
No Signal
No Signal
Active Source
Main Gate Ca...
System Status
Operational
Recent Alerts
0 Detected

Construction Safety Guard

CSP-Desktop
Construction Safety Project V1.0

System Online

MAIN MENU

- Live Monitor
- Dashboard
- Violation Logs
- Settings

Model Status
● Gemini 2.5 Flash

Safety Analytics

TODAY | WEEK | MONTH | ALL

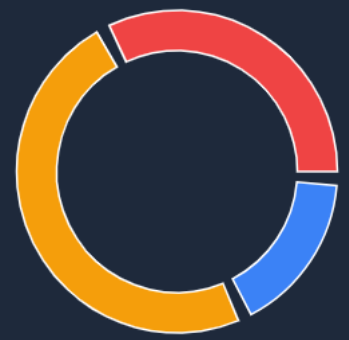
Total Violations
10
In selected period

Compliance Rate
80.0%
Calculated based on detected events

Total Activity
10
Events Logged

Violations Trend

Violation Distribution



No Hardhat No Vest Other

Construction Safety Guard

CSP-Desktop
Construction Safety Project V1.0

System Online

MAIN MENU

- Live Monitor
- Dashboard
- Violation Logs
- Settings

Model Status
Gemini 2.5 Flash

Event Logs

Real-time audit trail with visual evidence

Clear | Export CSV

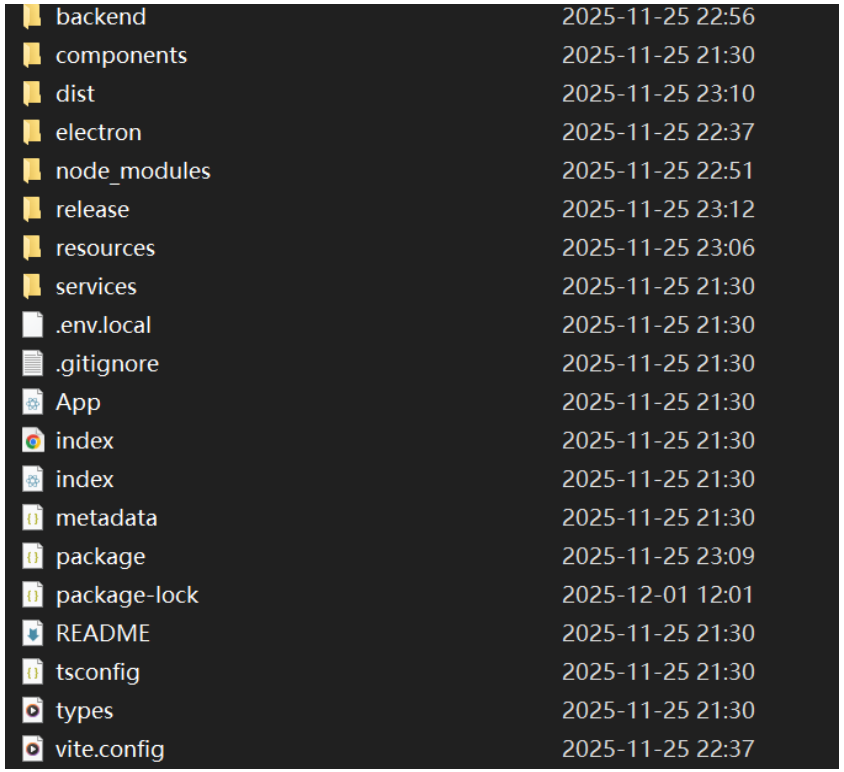
Search by violation type or camera name...

Detected: Detected violation: NO-Mask
14:41:26
2025/12/1 Main Gate Camera
Detected 4 objects

Detected: Detected violation: NO-Mask
14:41:20
2025/12/1 Main Gate Camera
Detected 4 objects

Detected: Detected violation: NO-Hardhat, Detected violation: NO-Mask
14:41:08
2025/12/1 Main Gate Camera
Detected 4 objects

Limitations and Future



- **Model Challenges:** Resource constraints limited tuning; diverse negative features caused lower "No-PPE" accuracy.
- **App Development**
- Built frontend using Gemini App Design.
- Backend: Runs local best.pt directly (no external API calls).

Thank you, questions?