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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>

css-data (3 directories, 2 files)

About this directory

Root folder for Construction Site Safety (CSS) Dataset. Contains: `train`, `valid` and `test` directories. Each directory has two folders `images` (in .jpg format) and `labels` (in .txt format).

Suggest Edits

test 2 directories	train 2 directories	valid 2 directories	README.dataset.txt 863 B
README.roboflow.txt 1.43 kB			

Data Explorer

Version 3 (227.61 MB)

- css-data
 - test
 - train
 - valid
 - README.dataset.txt
 - README.roboflow.txt
- results_yolov8n_100e
- source_files

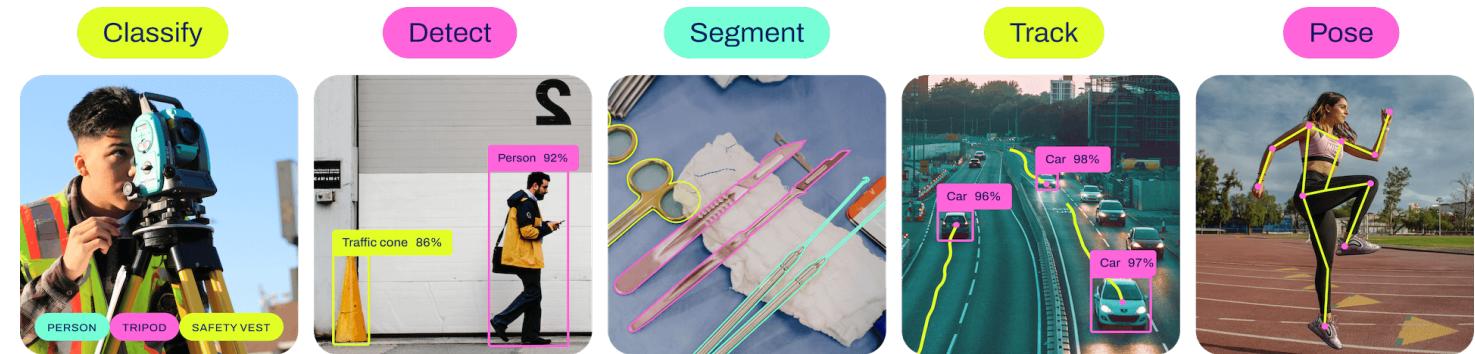
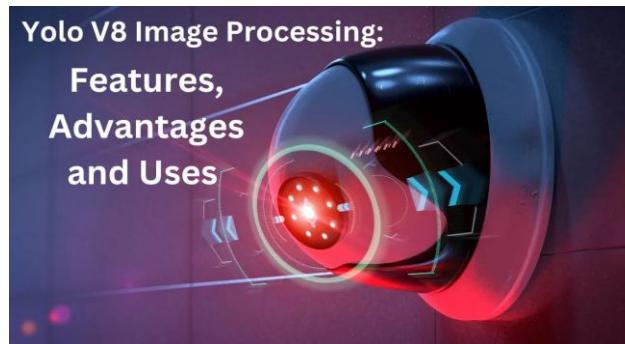
Summary

- 5641 files
- 14 columns



Model and features

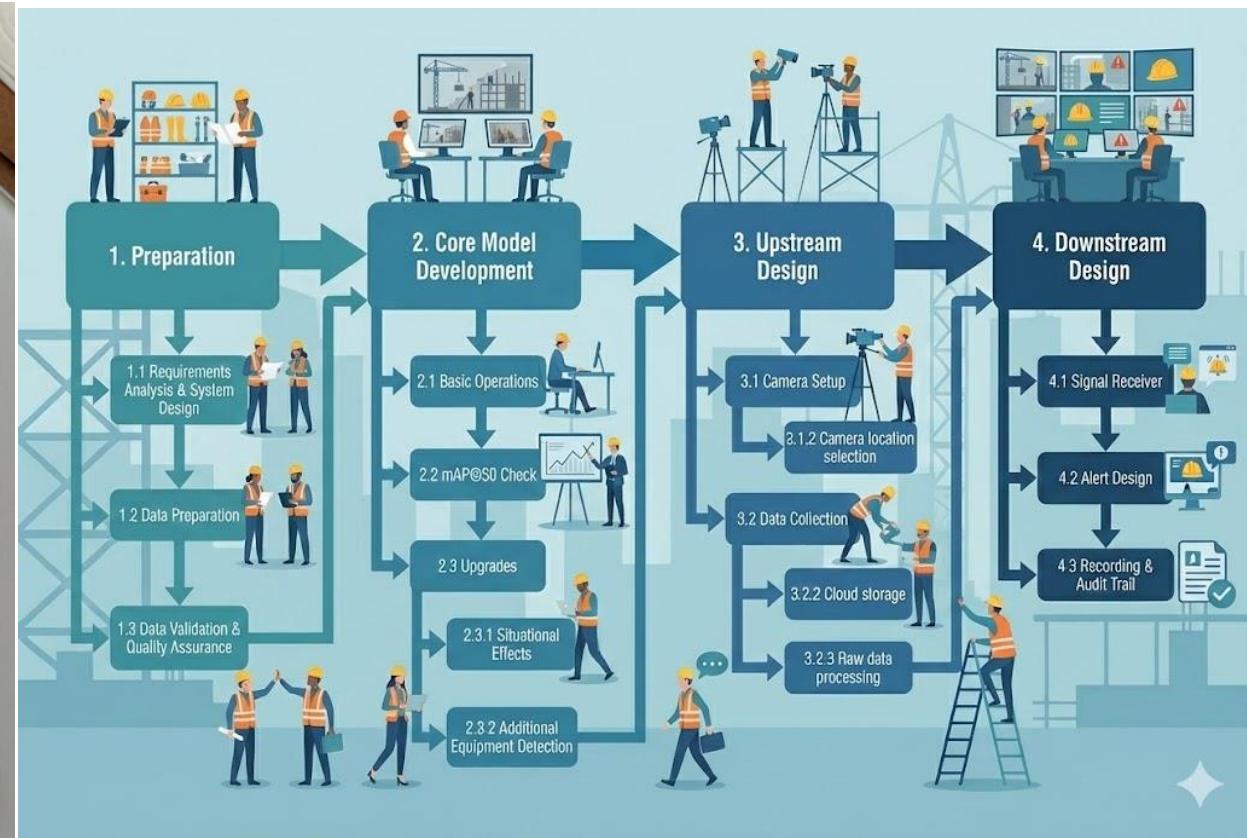
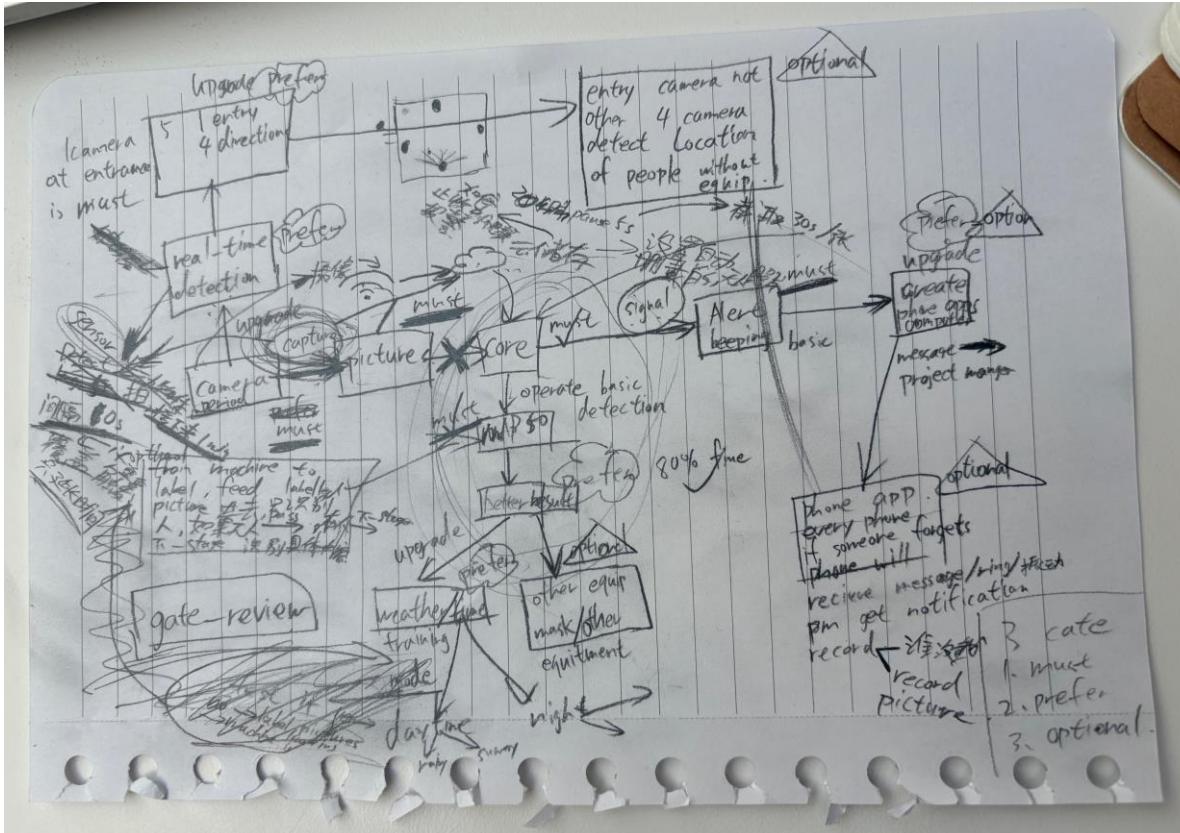
- **YOLOv8n (Nano):** The smallest, fastest architecture in the YOLOv8 family.
- **Key Advantages:**
 - Ultra-Lightweight:** Only 3.2M parameters (vs. 11.2M for v8s).
 - Edge-Ready:** Enables low-latency, real-time inference on resource-constrained hardware.
 - Efficient:** Balances sufficient accuracy 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>

The screenshot shows a Google Colab notebook interface. On the left, there's a sidebar with various icons (Table of contents, search, refresh, etc.) and a table of contents list:

- Maybe a tutorial. Hope it wor...
- 1 Preparation for Base model
- 2 Build your base model
- 3 Run your Base model n...
- 4 Analysis of Base Model trai...
- 5 Analyze visual plots (T...
- 6 Pre-test Base Model
- 7 Pre-Hyperparameter Tu...
- 8. v8n or v8s ? (Done)(T4 ...
- 9 Iterable hyperparamete...
- (1) Why Optuna?
- (2) Top 5 Hyperparamet...

The main content area has a title "Maybe a tutorial. Hope it works. lol." and a section "1 Preparation for Base model" with three numbered steps:

- (1) Create a new file named "construction-safety-project" in your google drive. You can also name it whatever u like. Remember to rewrite all paths below if u name the file in ur own way.
- (2) Create 3 files in this new file. They are "data", "notebooks" and "runs".
- (3) Download the css-data from <https://www.kaggle.com/datasets/snehilsanyal/construction-site-safety-image-dataset-roboflow/data>



Final results

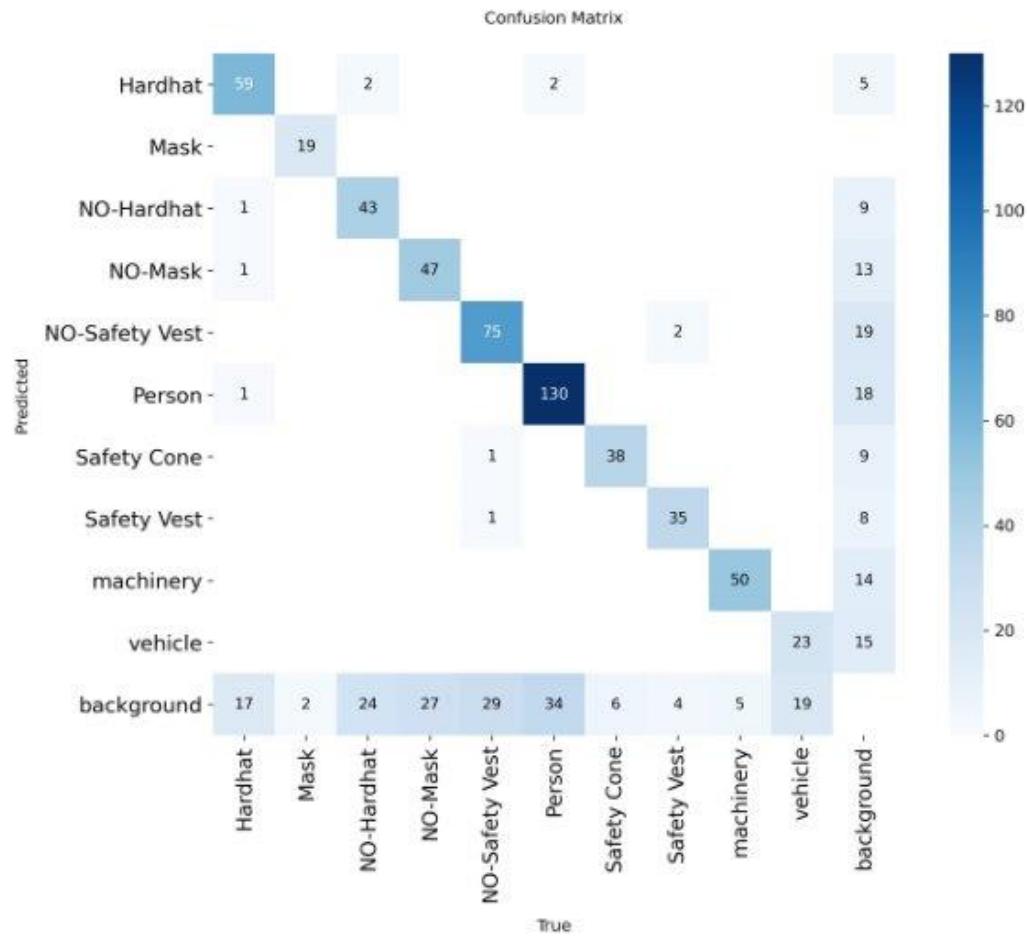
Class	Images	Instances	Box (P)	R	mAP50	mAP50–95) : 100% —
all	114	697	0.911	0.714	0.801	0.51
Hardhat	42	79	0.968	0.722	0.879	0.554
Mask	19	21	0.979	0.905	0.928	0.697
NO-Hardhat	37	69	0.931	0.551	0.729	0.426
NO-Mask	44	74	0.899	0.527	0.623	0.323
NO-Safety Vest	56	106	0.886	0.661	0.773	0.455
Person	84	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

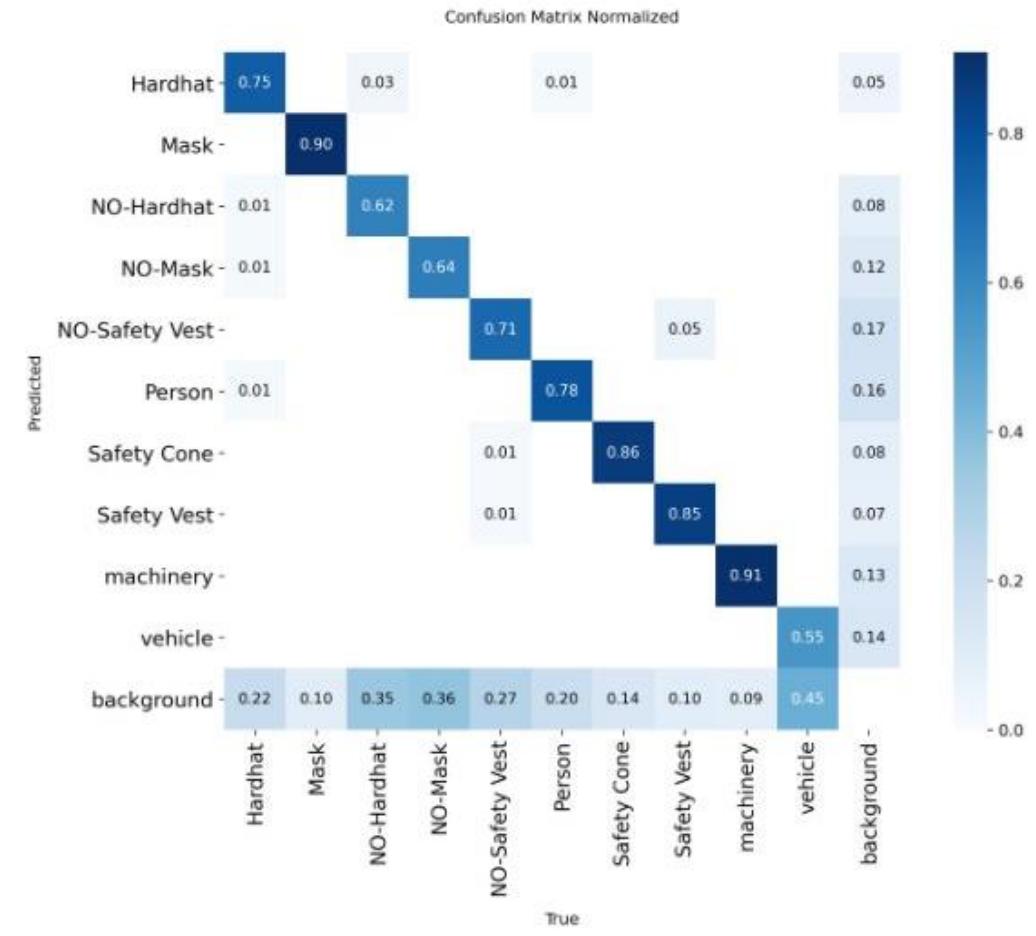
mAP50: A key metric for detection accuracy. It measures how well the model identifies and locates objects with >50% overlap.



Confusion matrix

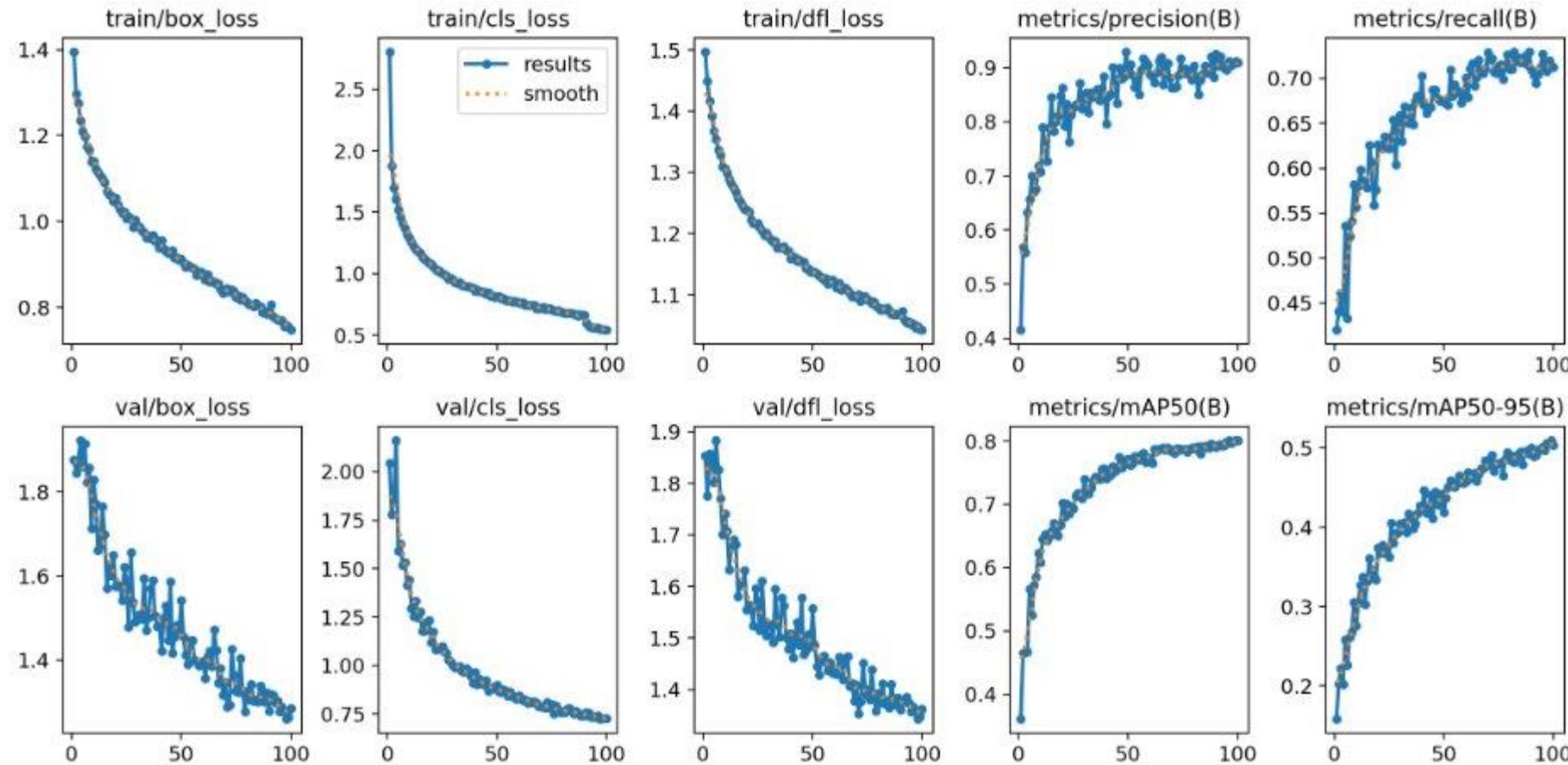


Missed Detections are the Biggest Problem



Inter-Class Confusion is Not Severe

Overall results plot



Healthy Training, No Overfitting

Performance is Nearing Saturation



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Validation Batch Predictions

Ground Truth Labels



Accurate and Confident on Strong Classes

Model Predictions



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.

Model Status

● Gemini 2.5 Flash



Active Source

Main Gate Ca...



System Status

Operational



Recent Alerts

0 Detected



MAIN MENU

Live Monitor

Dashboard

Violation Logs

Settings

Model Status

● Gemini 2.5 Flash

Live Monitor

Main Gate Camera



Main Gate Camera (Standby)



Start

No Signal

No Signal

No Signal

Active Source
Main Gate Ca...System Status
OperationalRecent Alerts
0 Detected



MAIN MENU

Live Monitor

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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

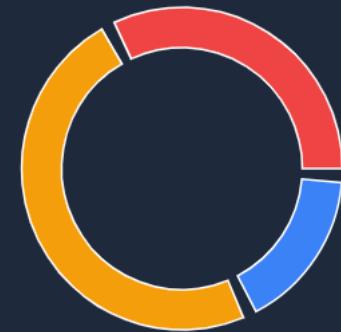
10

Events Logged

Violations Trend



Violation Distribution



No Hardhat No Vest Other



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

Q Search by violation type or camera name...

**Detected: Detected violation: NO-Mask**

© 2025/12/1 @ Main Gate Camera

Detected 4 objects

14:41:26

**Detected: Detected violation: NO-Mask**

© 2025/12/1 @ Main Gate Camera

Detected 4 objects

14:41:20

**Detected: Detected violation: NO-Hardhat, Detected violation: NO-Mask**

© 2025/12/1 @ Main Gate Camera

Detected 4 objects

14:41:08



Limitations and Future

backend	2025-11-25 22:56
components	2025-11-25 21:30
dist	2025-11-25 23:10
electron	2025-11-25 22:37
node_modules	2025-11-25 22:51
release	2025-11-25 23:12
resources	2025-11-25 23:06
services	2025-11-25 21:30
.env.local	2025-11-25 21:30
.gitignore	2025-11-25 21:30
App	2025-11-25 21:30
index	2025-11-25 21:30
index	2025-11-25 21:30
metadata	2025-11-25 21:30
package	2025-11-25 23:09
package-lock	2025-12-01 12:01
README	2025-11-25 21:30
tsconfig	2025-11-25 21:30
types	2025-11-25 21:30
vite.config	2025-11-25 22:37

- **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?