Project HORIZN: Multi-Modal Hazard Intelligence for Urban Response Criminal Computer Vision, Weather Prediction, and Frontend Decision Support

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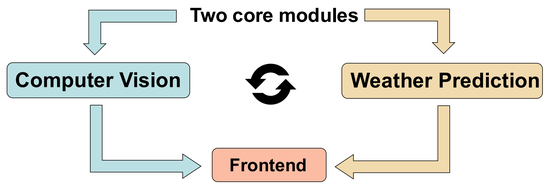
Background

AI-powered city response platform for real-time hazard awareness
Combines:
- Environmental sensing (weather, NOAA, forecasts)
- Predictive analytics
- Computer vision (CCTV/video)

Transforms **raw** data → **actionable** alerts via dashboard
Move from passive monitoring → intelligent, real-time decision support



Aims

1. Develop a **multi-modal hazard intelligence platform** that combines weather prediction and computer vision into one architecture.
2. Forecast city-relevant **environmental threats** such as severe storms, flooding conditions, or outage-related risks using structured hazard data and real weather inputs.
3. Detect **suspicious** or **dangerous activity** in video by combining person-level anomaly detection with scene-level classification.
4. Integrate all outputs into a **frontend dashboard** that allows hazard review, prioritization, and communication through a unified interface.
5. Build a modular prototype that can **later expand** to live city feeds, broader APIs, and additional hazard sources.

Challenges

1. Multi-modal system
- Structured data (weather) vs unstructured data (video)
- Different pipelines → must produce one unified output

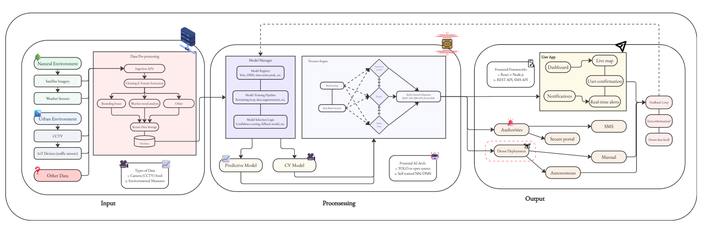
2. Weather / Prediction
- Turning historical events → real-time forecasts
- Making predictions interpretable for alerts + maps
- Heavy preprocessing + dataset engineering (NOAA)

3. Computer Vision
- Real-world variability (lighting, angles, crowds)
- Noisy frame-level predictions → unstable alerts
- Avoiding data leakage in video-based training

4. System Integration
- Combine both branches into one frontend
- Align outputs for real operator use
- API + real-data testing still in progress

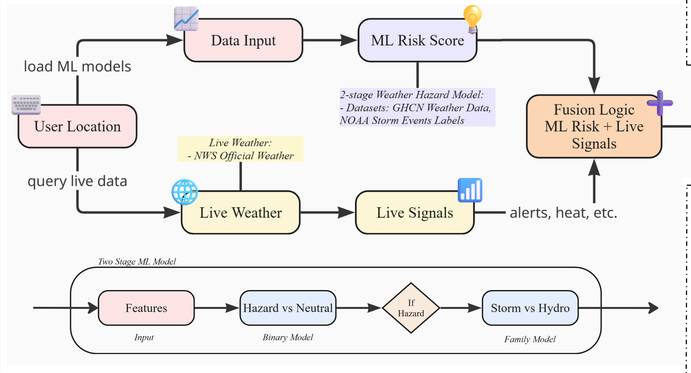
Methods

1. Multi-input, multi-model, single-dashboard
2. Natural-environment data, urban-environment data, CCTV/video feeds



3. **Predictive model branch** and a **computer vision branch**
4. Interfaces such as a user application, authority-facing alerts

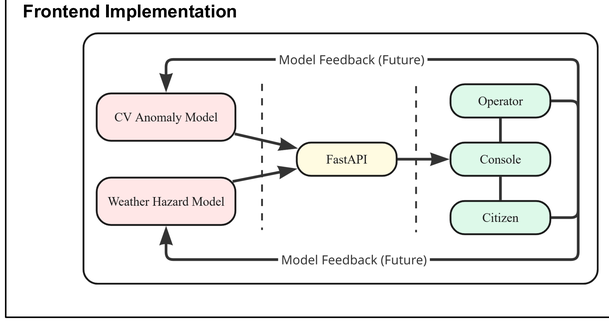
Methods

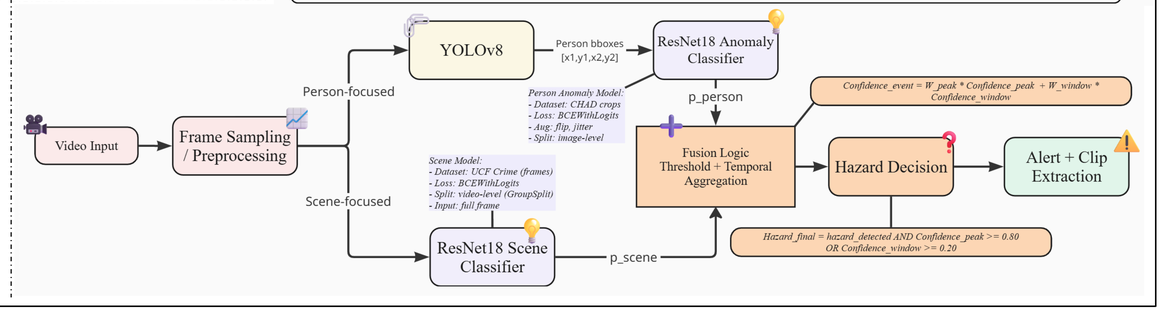


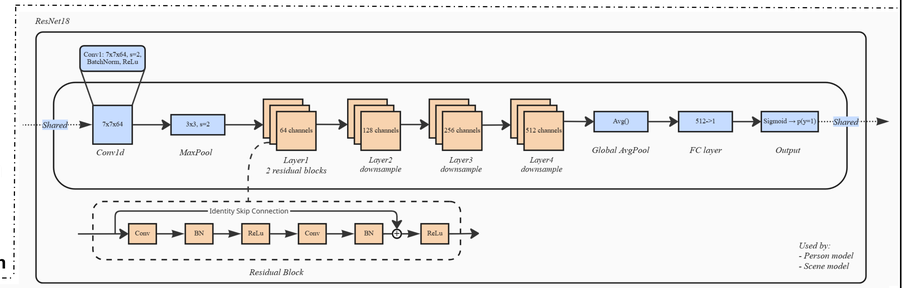
Weather Hazard Detection

Multi-Modal System

CV Anomaly Detection







References

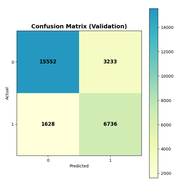
- **YOLOv8**, Ultralytics object detection framework
- **CHAD dataset** for anomaly-related human activity analysis
- **UCF Crime dataset** for scene-level crime classification
- **TorchVision ResNet18** pretrained ImageNet backbone
- **OpenCV / PyTorch** for inference and deployment pipeline
- **NOAA GHCN Daily Dataset** for historical weather features
- **NOAA Storm Events Database** for supervised hazard labeling
- **National Weather Service (NWS) API for** live alert ingestion
- **Scikit-learn tree models** for tabular risk prediction
- **FastAPI** for backend inference, fusion, and API delivery

Results

Computer Vision Results

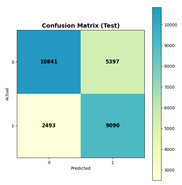
Person-level Detection

Metric	Frame (Old)	Temporal (Ours)	Change
Accuracy	0.882	0.817	↓
Balanced Accuracy	0.618	**0.724**	↑↑
Precision	0.647	0.380	↓
Recall	0.257	**0.597**	↑↑
F1 Score	0.368	**0.465**	↑↑
AUROC	0.783	**0.836**	↑



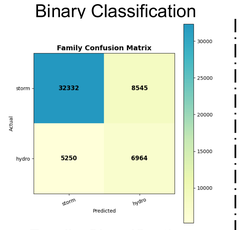
Scene-level Detection

Metric	Value
Accuracy	0.890
Balanced Accuracy	0.871
Precision	0.821
Recall	0.822
F1 Score	0.822
AUROC	0.941

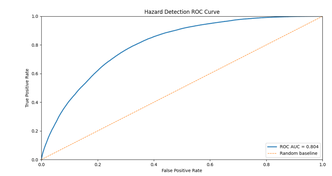


Weather Results

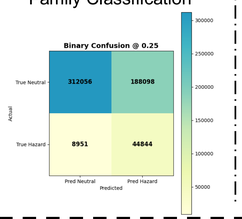
Binary Classification

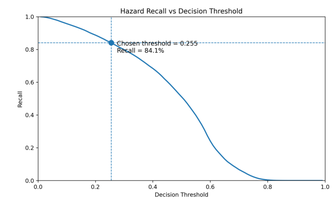


Overall Hazard Detection

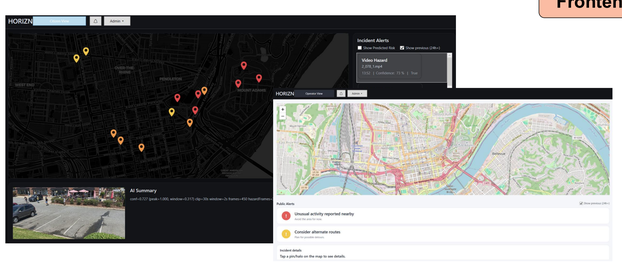


Family Classification

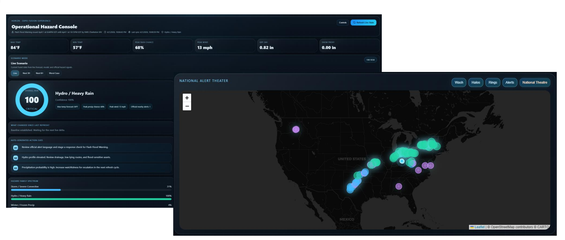




Frontend



CV Dashboard



Weather Hazard Dashboard

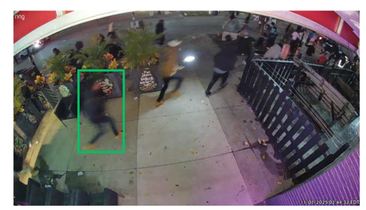
Conclusions

HORIZN is a real-time hazard intelligence platform that fuses computer vision with weather-driven risk modeling to provide unified situational awareness.

Computer Vision Pipeline:
Person detection + anomaly classification + scene-level risk estimation
Weather Prediction Pipeline:
Historical ML models (hazard vs. neutral, storm vs. hydro) combined with live official weather signals
System Integration:
Backend fusion layer merges CV outputs and environmental risk with real-time alerts into a single operational view
Outcome:
Supports real-time decision-making for emergency response, infrastructure monitoring, and public safety

Next Steps

1. Improve CV robustness (temporal + noise reduction)
2. Advance weather forecasting + validation
3. Finalize API integration
4. Enhance frontend (citizen + operator views)
5. Test real-world deployment scenarios
6. Drone implementation



CV Detection Example