The Future of GeoAI

April 9 2025
Alaska GeoSummit 2025

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- Exploring the Intersection of AI and Geospatial Technologies

AGENDA

AI Definitions
Evolution of GeoAI
Challenges in Geospatial Data Interpretation
Real-World Examples
What am I working on?
Cutting-Edge Research in Vision AI for GeoAI
    -> Changing Daily!
Vertical Specific GeoAI
Future Prospects in GeoAI
Ethical Considerations in GeoAI
Q&A

Defining GeoAI

Key Terms: Computer vision, machine learning, and remote sensing

Machine Learning: enables computers to learn patterns from data and make predictions or decisions without being explicitly programmed. Instead of following a rigid set of instructions, ML models improve their performance over time as they are exposed to more data.

Artificial Intelligence (AI) is the field of computer science that focuses on creating systems capable of performing tasks that typically require human intelligence.

Supervised Learning – The model is trained on labeled data, meaning each input has a known output.

Example: Email spam detection (classifying emails as spam or not spam based on past examples).

Unsupervised Learning – The model analyzes unlabeled data to find hidden patterns.

Example: Customer segmentation (grouping customers based on purchasing behavior).

Reinforcement Learning – The model learns by interacting with an environment and receiving rewards or penalties for actions.

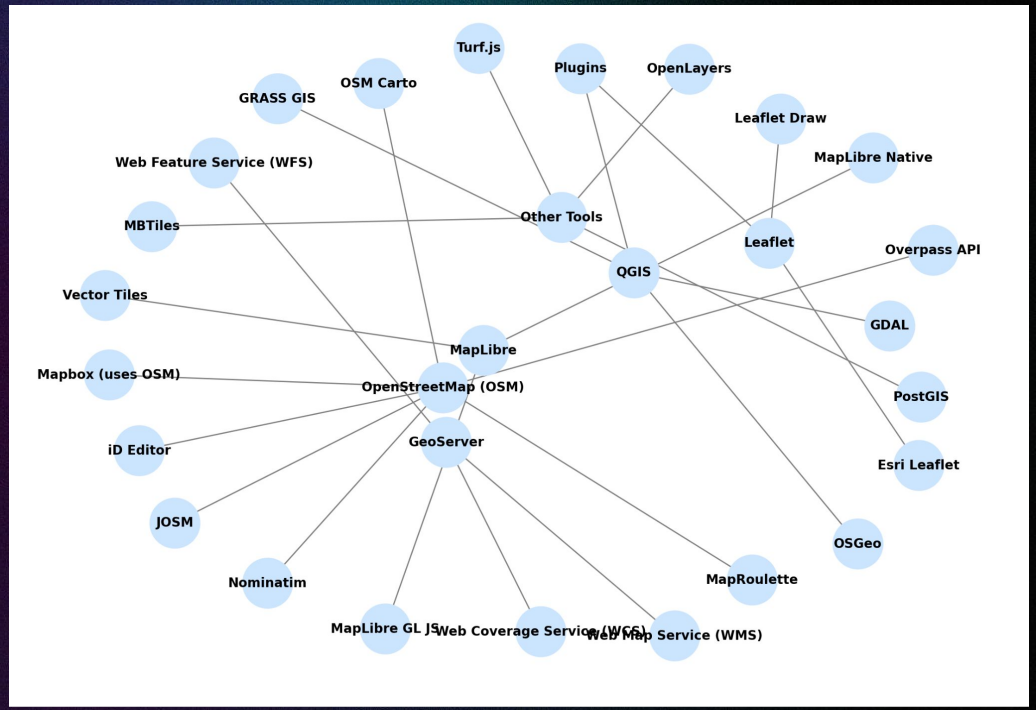
Example: AlphaGo, which learned to play the game Go by playing against itself.

The Role of Open Data and Crowdsourcing in GeoAI

Community-driven mapping initiatives.

Examples: OpenStreetMap, humanitarian mapping efforts.

Challenges in data accuracy and validation.



The Intersection of AI and Remote Sensing Technologies

Combining AI with LIDAR, SAR, and hyperspectral imaging.

Applications in agriculture, forestry, and urban development.

Future developments in AI-enhanced remote sensing.

The Role of Satellite Imagery in GeoAI

How AI processes high-resolution satellite images.

Use cases in land-use classification and environmental monitoring.

Challenges with image resolution and atmospheric interference.

Evolution of GeoAI

Early geospatial analytics vs. modern AI-driven methods.

From traditional GIS to AI-powered spatial analysis.

Advancements in computing power enabling GeoAI.

	Early Geospatial Analytics	Modern AI-Driven Methods
Data Collection	Manual surveys, aerial photography, and satellite imagery with limited resolution	High-resolution satellite, drone, and IoT sensor data with real-time updates
Analysis Techniques	Statistical models, rule-based approaches, and GIS mapping tools	Machine learning, deep learning (CNNs), and neural networks for pattern recognition
Land Use Classification	Human analysts interpret maps and satellite images using predefined criteria	AI models classify land cover types automatically with high precision
Disaster Prediction & Response	Historical trend analysis and basic forecasting models	AI-powered predictive analytics for early disaster warnings and real-time monitoring
Urban Planning	Traditional GIS-based mapping for zoning and development	AI-driven simulations for optimal land use, traffic management, and resource allocation
Climate & Environmental Monitoring	Remote sensing and historical climate models	AI processes satellite and sensor data for real-time climate change monitoring and predictive modeling
Agriculture & Precision Farming	Basic crop monitoring with satellite imagery and farmer reports	AI-driven crop health assessment, yield prediction, and irrigation optimization using hyperspectral imaging

Challenges in Geospatial Data Interpretation

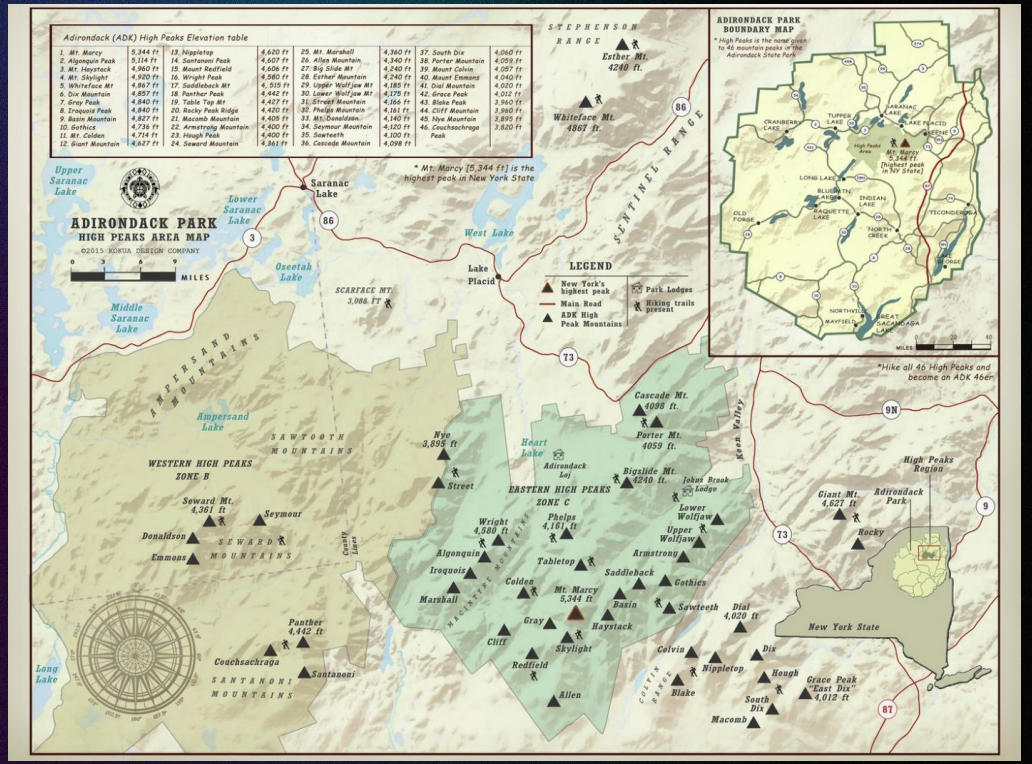
Misclassification Issues: AI mistaking hiking trails for dirt roads.

Data Quality Problems: Limited diverse datasets impact model performance. Lots of data is still not digitized.

Solutions: Enhancing training datasets and refining models.

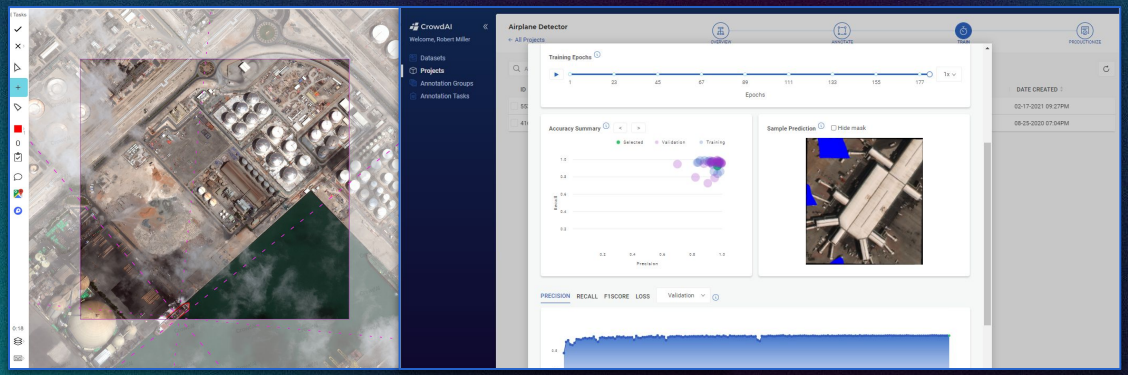
USGS Use Case

Identifying peaks from paper imagery.



CrowdAI


INTEGRATE
TRANSFORM
ANNOTATE
ENRICH
TRAIN
DEPLOY


CrowdAI
Welcome, Robert Miller
Datasets
Projects
Annotation Groups
Annotation Tasks
Airplane Detector
Training Epochs
Epochs
Accuracy Summary
Sample Prediction
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PRECISION
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LOSS
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DATE CREATED
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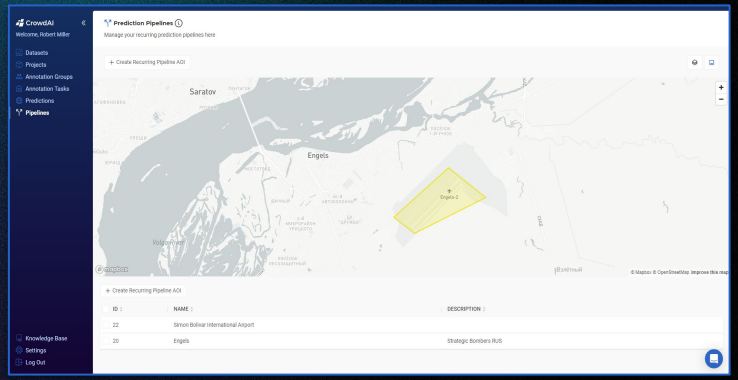
CrowdAI
Welcome, Robert Miller
Datasets
Projects
Annotation Groups
Annotation Tasks
Predictions
Pipelines
Knowledge Base
Settings
Log Out
Prediction Pipelines
Manage your recurring prediction pipelines here
Create Recurring Pipeline AOI
Saratov
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DESCRIPTION
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Simon Bolivar International Airport
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Engels
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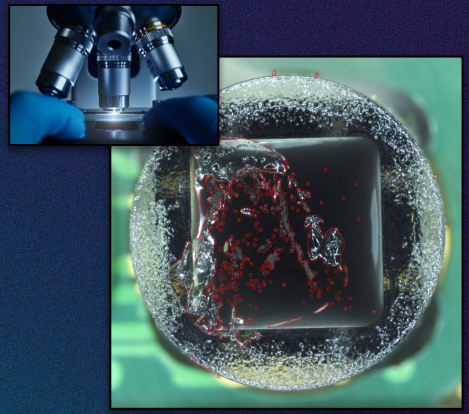
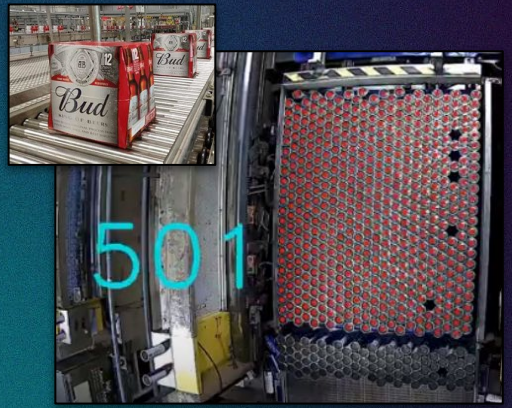



344 Acres
38 Acres
218 Acres
38 Acres
2160 Acres
20 Acres
38 Acres
61 Acres
13 Acres
106 Acres
5 Acres


2. Boeing 737-700
(16.7%)
1. Boeing 737-400
(25.0%)
5. Boeing 737-400
(33.3%)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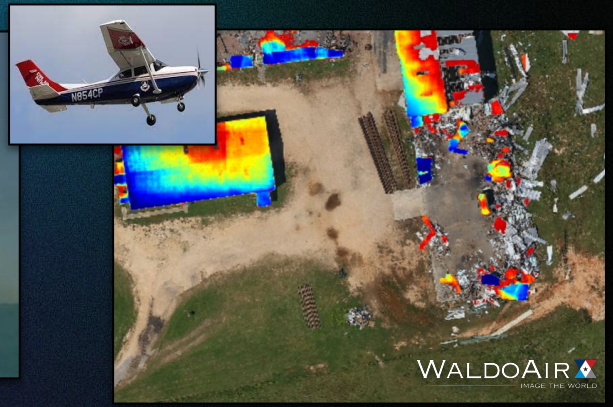
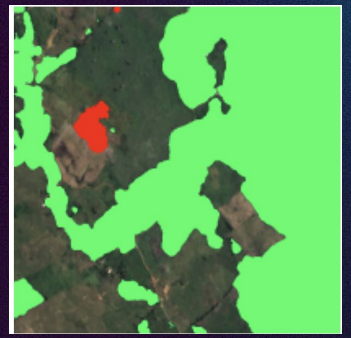
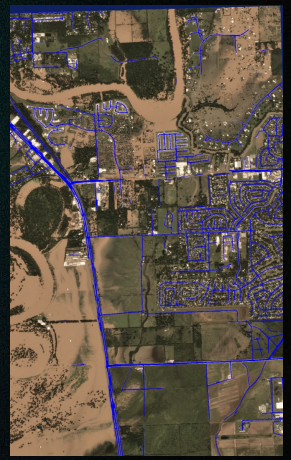
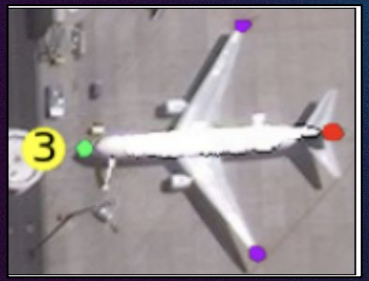
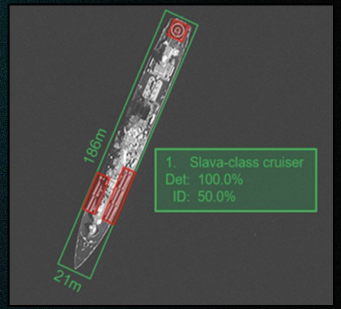
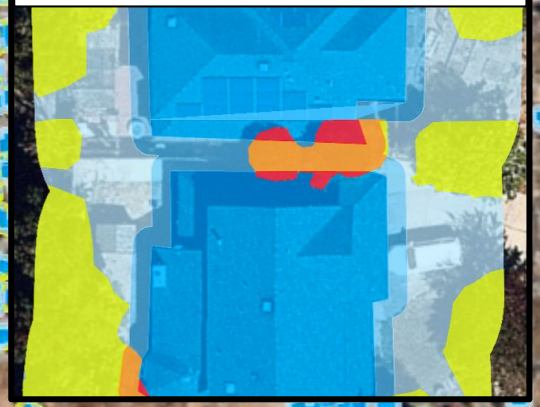

WALDOAIR
IMAGE THE WORLD

Model Type:	Vessel	Forest Detector, Cloud Detector	Well-pad, Waste Water, Fracking Detection	Infrastructure
Use Case:	*Identify vessels and wake*	*Identify forest and clouds*	*Identify Well-pad, Waste Water, Fracking across Permian and PA*	*Identify for roads and building infrastructure*
Media:				

Model Type:	Classification of object type	Key point Model	Segmentation Model	Multi-Class Model
Use Case:	*Identify 6 types of defects on medical device sensors to reduce product malfunction*	*Count the number of cans that move on and off the depalletizer to pinpoint process failures*	*Locate open and closed valves and the label denoting the proper position to confirm valves are in correct state*	*Identify percentage of crunch coating to ensure high-quality product*
Media:				

CrowdAI automated pre- and post-disaster assessment models on nearmap imagery. Left inset shows fire defensible zones and vegetation encroachment. At right, shows neighborhoods after the Santa Rosa wildfire, including healthy and burned trees as well as utility poles.

Automated vulnerability assessment



Buildings
Zone 1 Area
Zone 2 Area
Zone 2 Trees
Zone 1 Trees
Zone 0 Trees

Buildings
Burnt trees
Healthy trees
Utility poles

CrowdAI

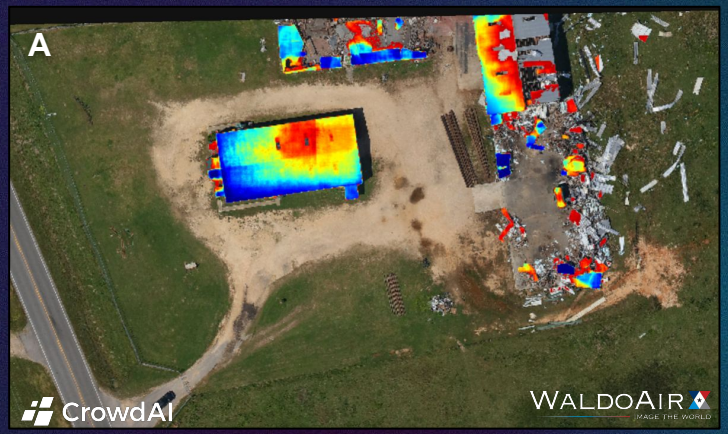
nearmap GIC

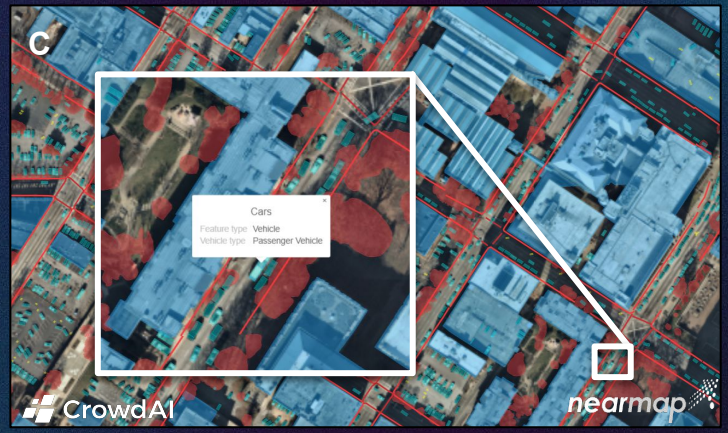
Supported Sensor Data

Examples include:

- **A.** Damage classification on Waldo Air imagery (FEMA)
- **B.** Rooftop deterioration classification on Woolpert imagery (AFIMSC / AFCEC)
- **C.** Object classification on nearmap imagery
- **D.** Object classification on nearmap/GIC imagery

From vehicles to buildings, roads, pavement markers, and utility posts, CrowdAI models can be trained to detect nearly any object or subfeature of an object.

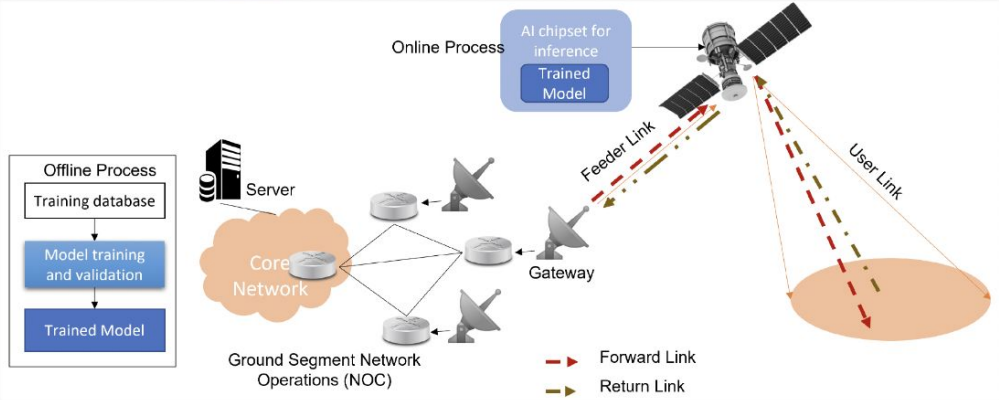




Current Applications of GeoAI: What I work on at Saab

Information Fusion Systems: Real-time decision support.

Figure 1. AI chipset implementation in the space segment for onboard processing. The training of the ML algorithm is performed offline in the ground segment with a training database, thus saving the obtained model, and the AI chipset can go on board the satellite using the model for inference.



Responsible AI: What I work on at Saab

Layer 1: Foundational Principles -

Fairness: Avoid bias and discrimination; Transparency: Be clear about how the system works; Accountability: Assign responsibility for decisions; Privacy: Protect user data and consent; Safety & Robustness: Design systems to prevent harm

Layer 2: Human-Centered Design -

Involve diverse stakeholders early; Build for real human needs, not just technical goals'; Keep a "human in the loop" for critical decisions

Layer 3: Technical Practices -

Bias detection & mitigation tools; Explainability algorithms (e.g., SHAP, LIME); Secure data handling and encryption; Red-teaming & adversarial testing; Continuous performance monitoring

Layer 4: Governance & Policy -

Internal ethics review boards; Regulatory compliance (e.g., GDPR, AI Act); Documentation and audit trails; Public disclosures when AI is used

What I am passionate about

Senate Testimony on AI: Challenges in AI procurement

Senator Schumer’s AI Executive Forum

NGAC Board Membership!

Cutting-Edge Research in Vision AI for GeoAI

Advances in Computer Vision: AI models improving satellite imagery analysis.

Remote Sensing Integration: AI for environmental change detection.

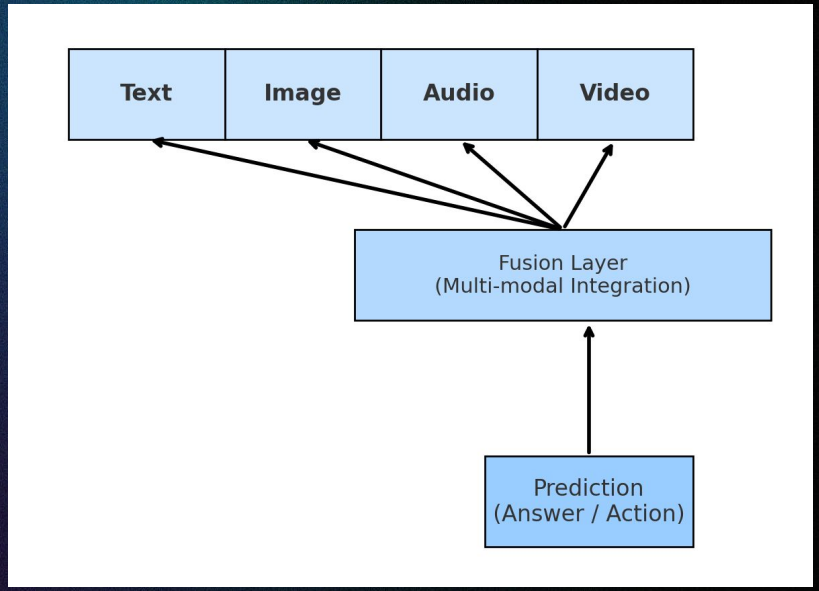
Notable Research Papers: Recent breakthroughs in vision AI for geospatial intelligence.

The Role of Multimodal AI in Transforming GeoAI

What is Multimodal AI? AI integrating text, images, and sensor data.

Impact on GeoAI: More accurate and comprehensive geospatial analysis.

Future Potential: Autonomous mapping, advanced urban planning, disaster preparedness.

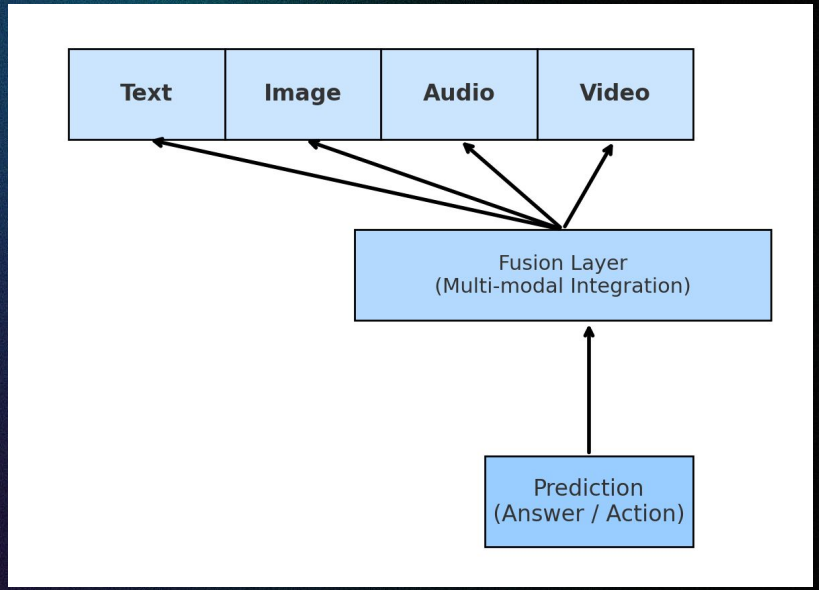


Just Yesterday, April 8th!

Google Cloud released multi-modal models: SigLIP, MaMMUT, OWL-ViT

Maps + Satellite/ Aerial Imagery + Waze = Real-time change detection

Models trained on high-resolution satellite and aerial images with accompanying text descriptions and bounding box annotations.



Real-Time Data Processing and Edge AI for GeoAI

Edge computing reducing latency in GeoAI applications.

Examples: Autonomous vehicles, emergency response, and surveillance.

Challenges in integrating real-time data streams.

Enhancing Mapping Services with GeoAI

Real-time map updates and traffic prediction.

AI-enhanced navigation and route optimization.

Digital Twin

User-Generated Data: Crowd-sourced inputs for improved AI training.

New Research in Remote Sensing

Advancements in Remote Sensing Foundation Models: The development of foundation models tailored for remote sensing has been a focus in recent research. These models, trained on extensive datasets, have demonstrated significant improvements in tasks such as scene classification and object detection.

> **Foundation Geospatial Models: SigLIP, MaMMUT, OWL- ViT,** all models trained on high-resolution satellite and aerial images with accompanying text descriptions and bounding box annotations.

AI-Powered Weather Forecasting: The Aardvark project, led by the UK's Alan Turing Institute in collaboration with institutions like Cambridge University and Microsoft, has introduced an AI-driven weather prediction model. Google’s Weather Next AI weather forecast.

Applications of AI in Remote Sensing Workshops: The 3rd Machine Learning for Remote Sensing (ML4RS) Workshop, associated with ICLR 2025, has called for research papers addressing advancements in key topics such as domain adaptation, concept drift, out-of-distribution detection, and evaluation using unlabeled data.

AI-Based Object Detection in Remote Sensing: Advancements in AI have improved object detection in remote sensing applications. Research has introduced standard datasets and critical performance evaluation parameters, along with network structures and implementation methods for two-stage, single-stage, and other improved algorithms.

Vertical Specific Examples

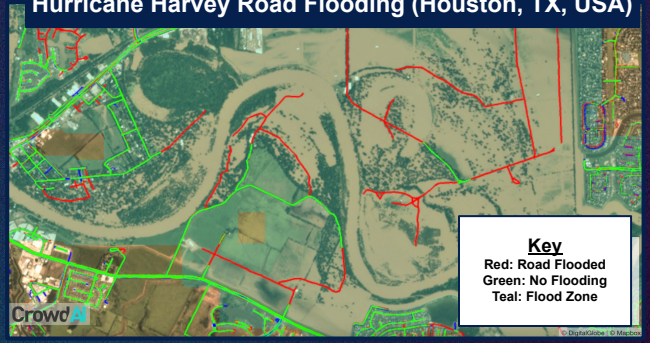
GeoAI in Disaster Response, Land Use Changes, Climate Monitoring

AI for flood prediction and wildfire detection.

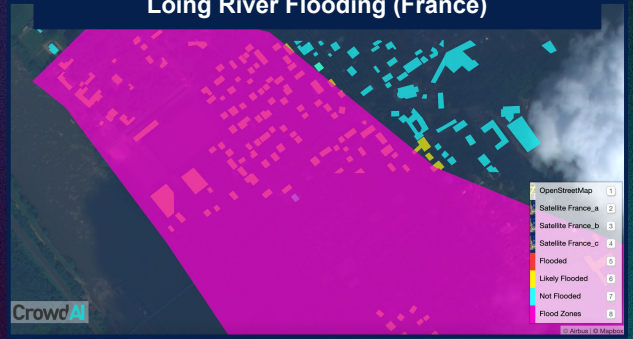
Tracking deforestation and environmental changes.

Improving disaster response coordination.

Hurricane Harvey Road Flooding (Houston, TX, USA)

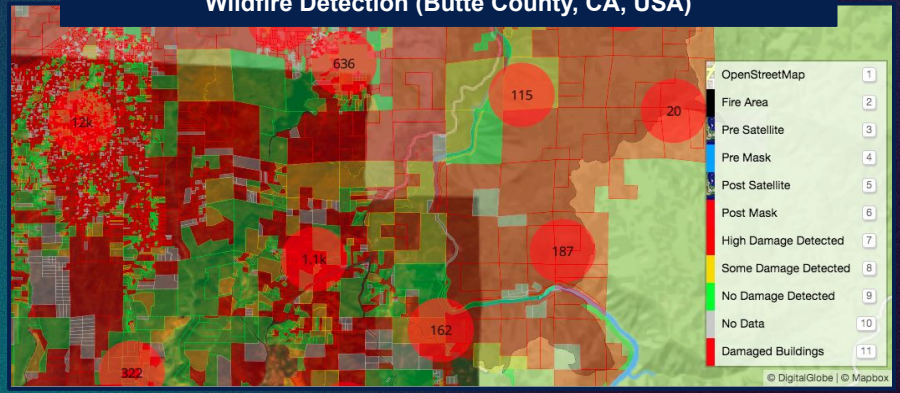


Loing River Flooding (France)



Drought Detection in River (Victoria, Australia)

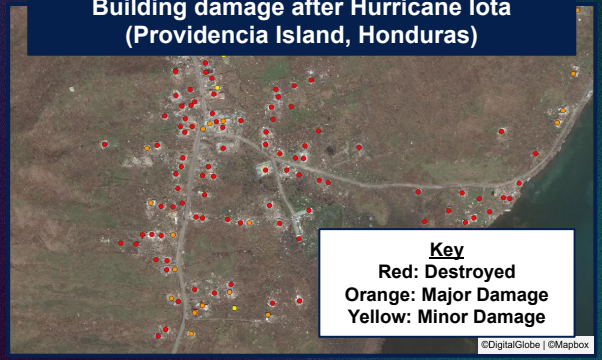
Wildfire Detection (Butte County, CA, USA)



Hurricane Damage (San Juan, Puerto Rico)

Destruction (Syria)

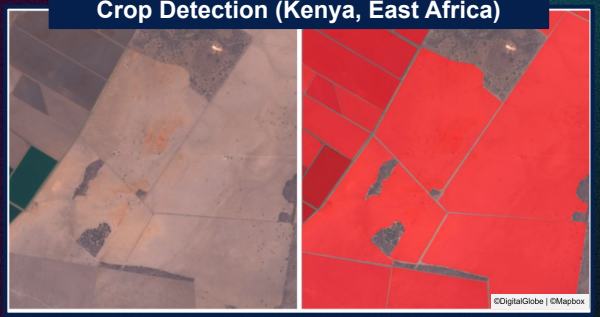
Building damage after Hurricane Iota (Providencia Island, Honduras)



Land-Use Change (Jakarta, Indonesia)

Volcano Eruption Damage (Guatemala)

Crop Detection (Kenya, East Africa)



Tsunami Damage (Palu, Indonesia)

GeoAI in Smart Cities and Infrastructure

AI-powered urban planning and traffic management.

Predictive analytics for infrastructure maintenance.

Improving public transportation systems.

GeoAI in Defense and National Security

Surveillance and reconnaissance applications.

Monitoring geopolitical risks and conflicts.

Ethical implications of AI-powered military operations.

GeoAI in Space Exploration and Astronomy

Using AI for planetary mapping and extraterrestrial research.

Geospatial intelligence for interplanetary navigation.

Case studies from NASA and private space enterprises.

New examples of data processing and ground data collection stations

Future Prospects in GeoAI

Emerging Trends: Real-time 3D mapping, AI-driven geospatial predictions.

The role of quantum computing in geospatial analysis.

Potential breakthroughs in geospatial AI modeling.

Ethical Considerations in GeoAI

Privacy concerns with geospatial data collection.

Bias in AI models and its implications.

Transparency and accountability in AI-driven geospatial decision-making.

Q&A

Key Takeaways:

GeoAI is revolutionizing industries with AI-driven geospatial insights.

Challenges remain in data accuracy, ethics, and model refinement.

Future trends indicate deeper integration of AI in geospatial technologies.

Q&A Session: Open discussion on applications and challenges. Job opportunities? How can I learn about this technology?

THANK YOU