Innovative Applications of Computer Vision for Power Utility Infrastructure Inspection

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Utilities are facing a host of critical infrastructure challenges

Aging infrastructure

Storms & grid-sparked wildfires

Substation vandalism

Labor shortages

Supply chain issues

Grid modernization & digitization

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The Solutions: PowerAI & PowerGUARD

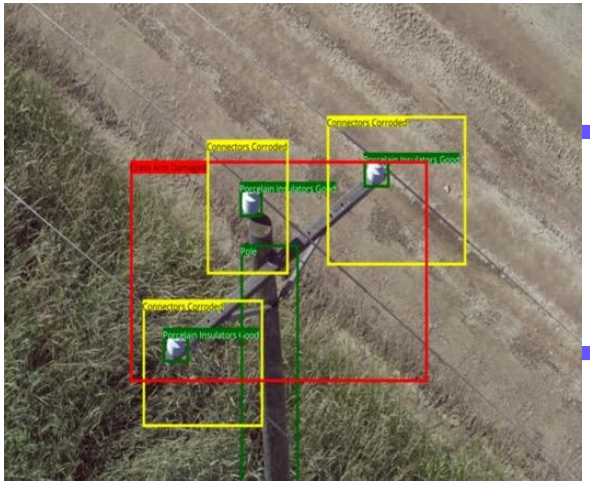
PowerAI platform

Image Capture

Source Data
- Asset ID
- Asset Type

Aerial visual data collection

APIs



Cloud based software platform PowerAI – Data Management, Image Processing, Analytics

Visual inspection data management

AI-based fault and anomaly detection

Infrastructure mapping

Images

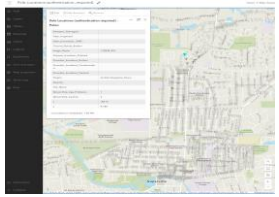
Data
- Asset ID
- Asset Type
- Condition
- Faults

APIs

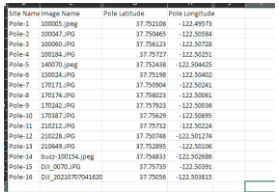
Image Storage

Database

Data analytics & reporting



GIS Integrations (ESRI, Maximo, etc.)



Work Order

Workflow integrations

Work & maintenance prioritization

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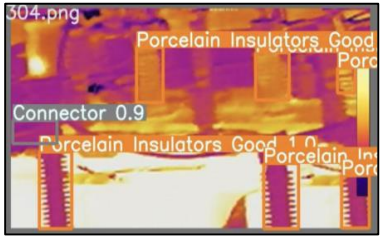
PowerGUARD – 24/7 substation alerting solution

Security	Safety	Equipment Monitoring	Thermal
⓾ Facility entry security ⓾ Unauthorized vehicle ⓾ Unauthorized person ⓾ Animal entry	⓾ Personnel safety ⓾ PPE gear and hard hat identification ⓾ Substation personnel injury	⓾ High energy release event ⓾ Smoke ⓾ Fire ⓾ Arc flashing ⓾ Oil leakage ⓾ Reactor ⓾ Transformer	⓾ High temperature and overheating events ⓾ Fans ⓾ Radiators ⓾ Bushings ⓾ Insulators ⓾ Reactors ⓾ Transformers

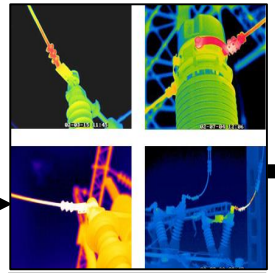
PowerGUARD platform

24/7 video feed from fixed camera systems



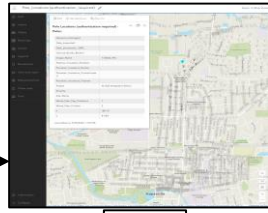
24/7 near-real time edge AI platform for infrastructure security, safety and condition monitoring

Alerts

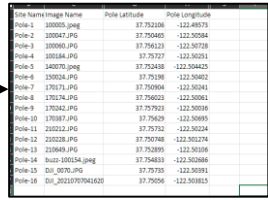


Video Feed, AI Alerts and Actions

VPN/Secure on-prem utility servers



GIS



Work Order

Camera system for 24/7 visual data collection

Intrusion monitoring

Worker safety monitoring

Equipment thermal analysis

Equipment condition and damage monitoring

Fire, smoke, arcing detection

Alerting and reporting system

Maintenance & work prioritization

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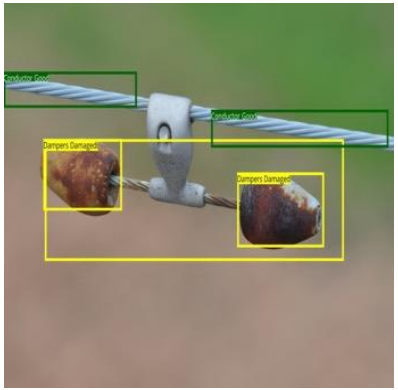
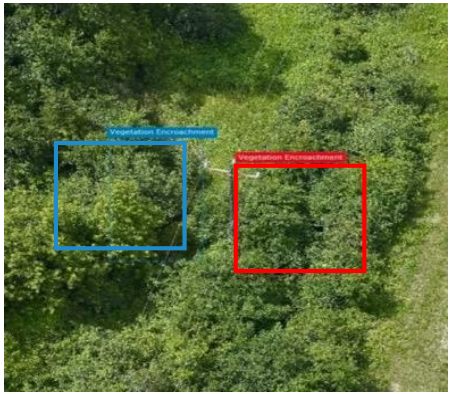
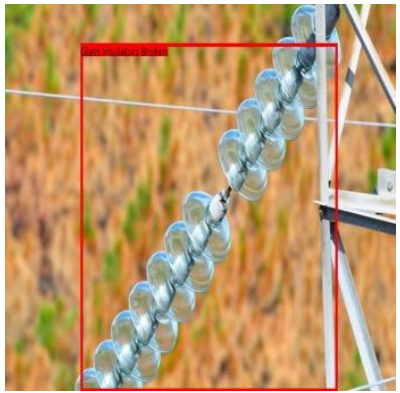
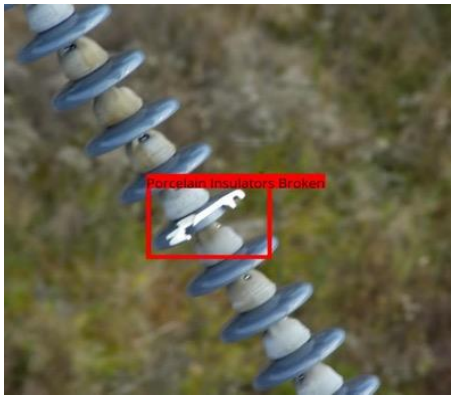
PowerAI – The datasets

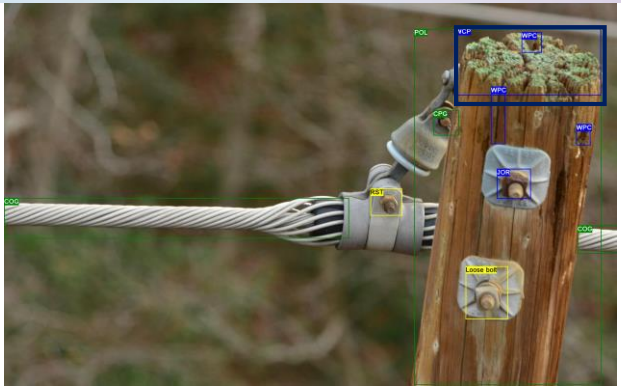




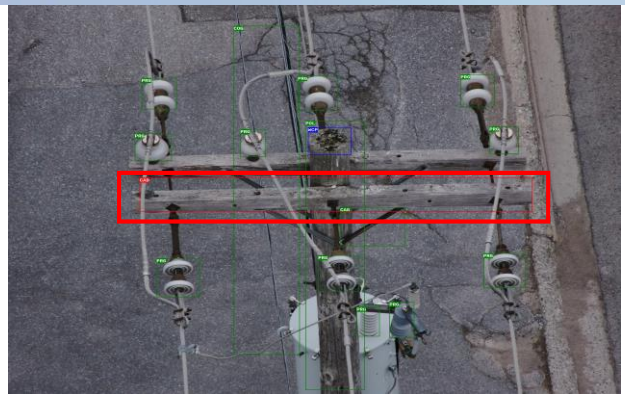




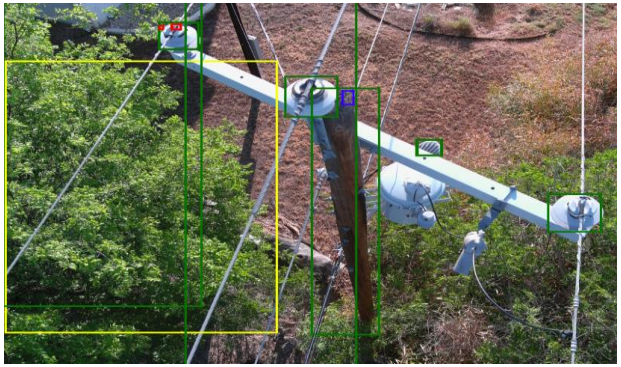
PowerAI – The datasets



Pole Cap Damage



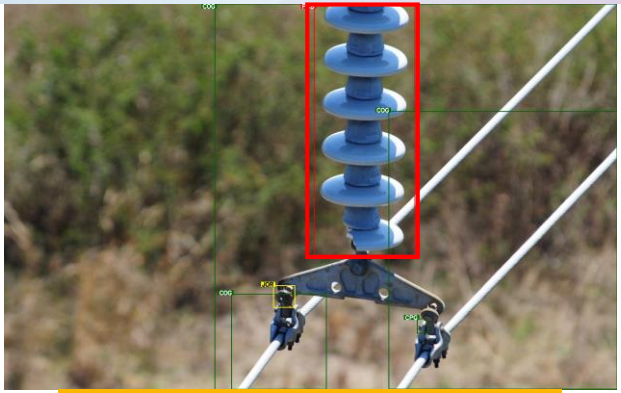
Cross Arm Damage



Vegetation Encroachment

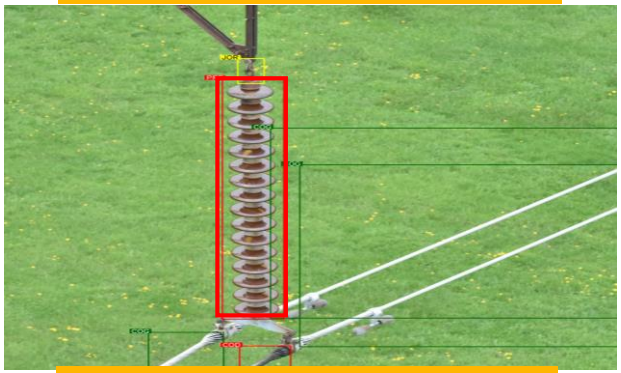
Pole Cavities and Cracks

PowerAI – The datasets



Insulator Damage

Insulator Damage



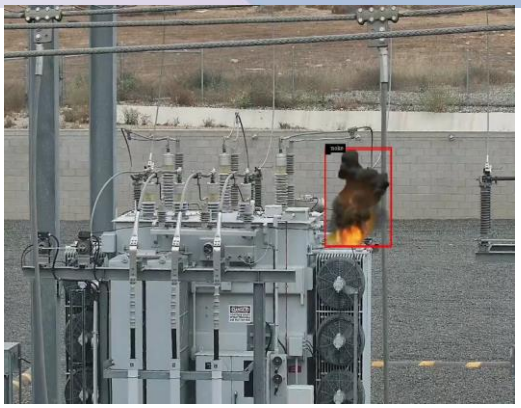
Insulator Flashing, Conductor Damaged, Rusted C-Hook

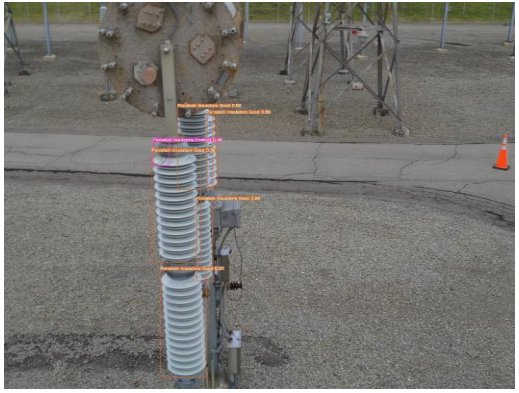
Insulator Flashing, Rusted C-Hook, Structure Rusting

Challenges

- ❖Lack of publicly available critical infrastructure image data
- Lack of data capture standardization: Data being captured in different formats, camera resolutions, angles and other variabilities
- Dataset imbalance: Lack of enough “faulty” data
- •Lack of analysis standardization: Manual inspection analysis is subjective

Generative AI and synthetic data solutions





Generative AI for substations

- Creating edge cases training sets (fire, smoke, animals, etc.) using Gen AI
- Training models based on simulated substation scenarios
- Transfer learning
- Rigorous testing and active learning

Synthetic data generation

- Balancing data set classes using synthetic data generation models
- Data is captured through various modes (drones, helicopters, ground vehicles, etc.)
- Synthetic data generation and augmentation used to standardize data

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Generative AI and synthetic data solutions

Generative AI for powerlines

- Generated differing backgrounds for less frequent classes
- Generated defects and anomalies for less frequent classes (such as rust, wooden cracks, etc.)
- Transfer learning
- Rigorous testing and active learning

Synthetic data generation

- Synthetically generated less frequent classes to enrich and balance training data
- Synthetically augmented the data to filter out noise, provide standardization in the imagery and create better training data points for images lacking quality

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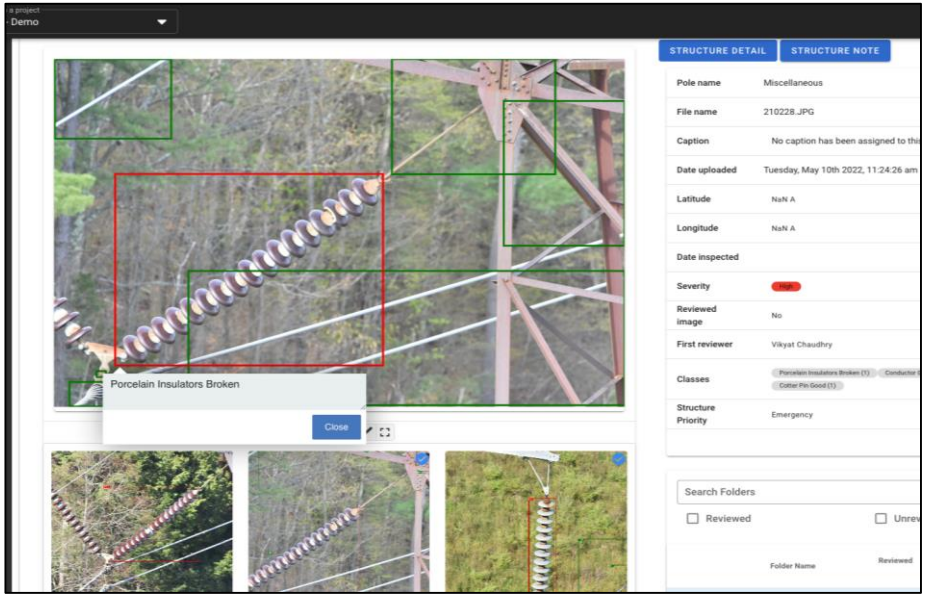
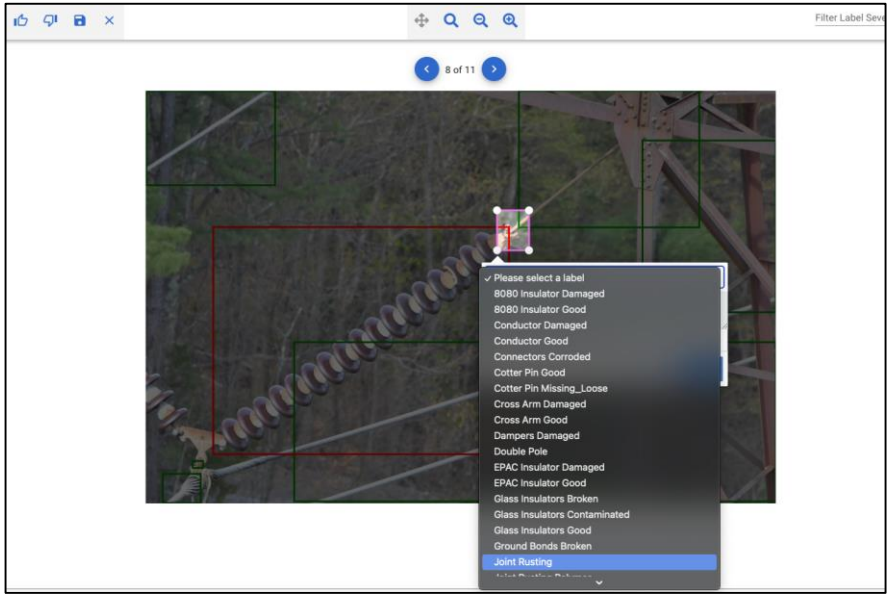
Lack of analysis standardization: Human-in-the-loop

AI predictions and recommendations → Subject matter expert review, edits, additions and feedback on predictions → Feedback saved/recorded and continuous AI retraining (Active learning) → AI personalization





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Advantages

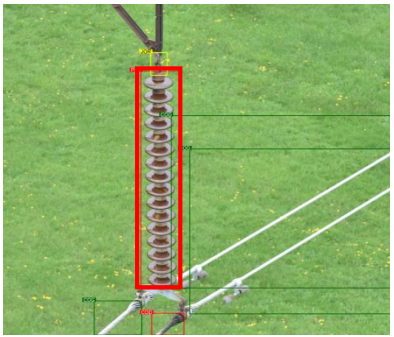
- Generative AI solutions for substations helped us curate training data for classes that we had no examples for
- Generative AI and synthetic data models helped us increase our accuracy metrics (mAP) for less frequent classes for both powerline and substation models
- Synthetic data generation models helped us augment low quality imagery and use that as training data
- Synthetic data models helped us standardize imagery collected in the field with variabilities (resolutions, angles, mode of capture, etc.)
- Human-in-the-loop workflow helped us with standardizing manual inspection workflow of inspectors and making it less subjective

Successful Use Cases

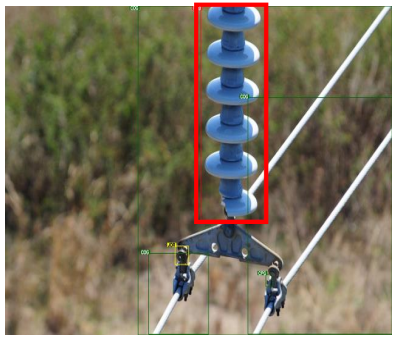
New York Power Authority (NYPA) use case

Problem:

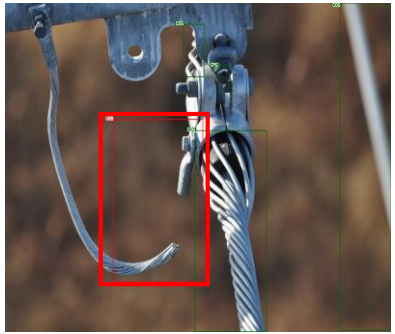
- NYPA building an in-house drone program to inspect 1,400 miles of power lines annually
- NYPA needs to use automation to manage and analyze millions of visual data points captured annually
- NYPA wants to improve cost and time efficiency



Porcelain Insulator Flashing, Conductor Damaged, Rusted C-Hook



Porcelain Insulator Broken



Ground Bonds Broken

The Value

- ❖**Saved significant analysis time** by delivering highly accurate algorithms
- **Faster decision-making** as results integrated into Media Hub and Work Order Management System
- **Tracked assets** (both healthy and anomalous) for optimized time-to-maintenance
- •**Reduced risk of outages** and critical component failures with quick analysis

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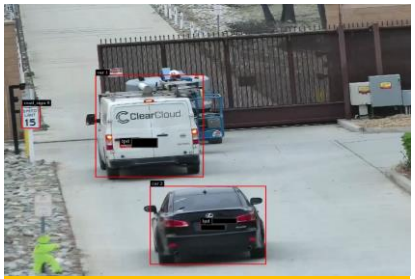
Southern California Edison (SCE) use case

Problem:

- SCE needs a 24/7 automated monitoring solution for substations
- SCE needs to prevent theft, break-ins and equipment damage

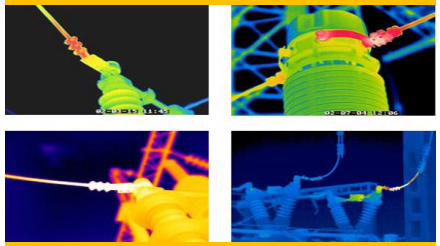


Security + intrusion

Equipment condition

Personnel safety

Equipment fire and smoke



High energy events

Equipment thermal condition

The Value

- ❖Reduced O&M costs with immediate ROI for workforce
- Improved maintenance productivity with informed decision-making
- Reduced unnecessary truck rolls and improved safety on site
- •Mitigated risks of vandalism and physical security threats

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Conclusions

- Computer vision modeling can be applied to power utility use cases and inspection imagery with high degree of precision
- Synthetic data modeling can be used to augment imagery that is lacking standardization during data collection
- Generative AI modeling can be used to enhance your training data for classes that are edge cases and don’t frequently occur
- Synthetic data generation can be effectively used to help with class imbalance within your training data and hence improve your accuracy metrics
- The key to building an effective and value driven computer vision AI solution is to understand the industry use case, work with subject matter experts and leverage data.
- Remember that the solutions are out there, **you just have to apply them effectively!**

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Resources

- Buzz Solutions website: https://buzzsolutions.co/
- Learn how power utilities are looking to leverage and evaluate AI solutions: https://www.unite.ai/finding-real-partnerships-how-utility-companies-are-evaluating-artificial-intelligence-vendors/
- Learn how “real” and “synthetic” data is being used for power line inspections: https://energycentral.com/c/pip/keeping-it-real-data%E2%80%99s-critical-role-optimizing-power-utility-infrastructure
- Learn how power utilities are adopting and scaling AI solutions: https://www.tdworld.com/smart-utility/grid-security/article/21284605/adopting-ai-is-just-the-beginning-for-utility-companies
- Learn a bit more about the speaker: https://medium.com/authority-magazine/green-tech-vikhyat-chaudhry-of-buzz-solutions-on-how-their-technology-will-make-an-important-51ca3863e023

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Thank you!

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