CIGRE-US National Committee

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Enhancing Power Distribution Defect Identification with Video-based Computer Vision

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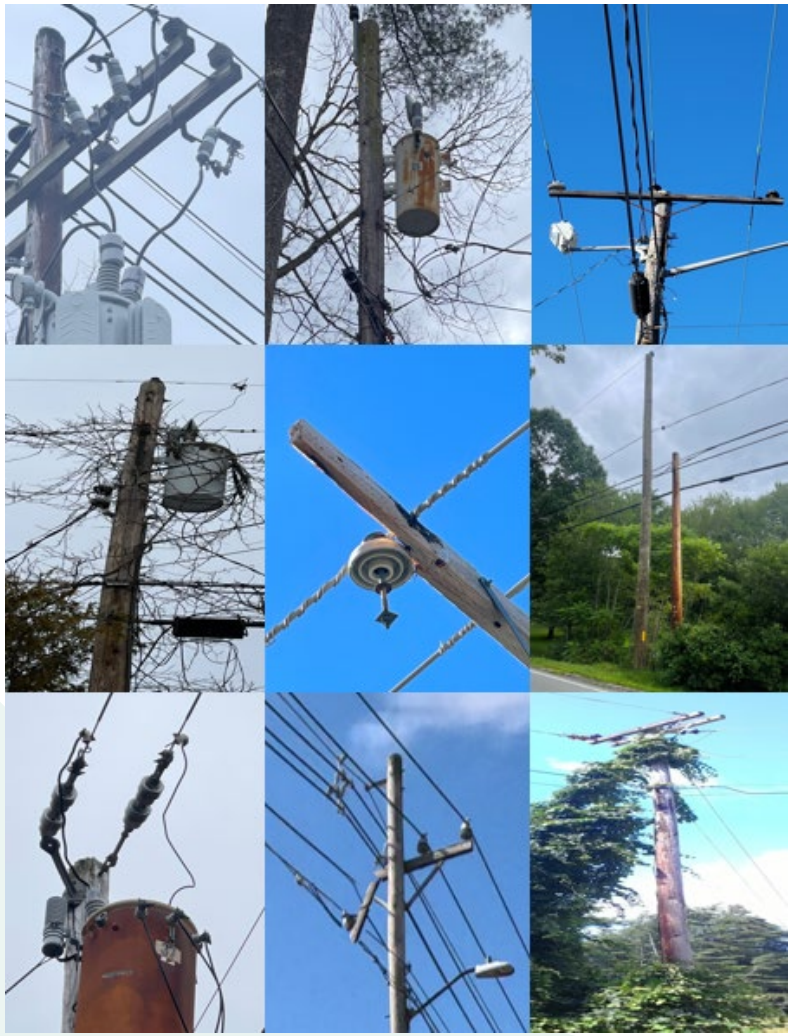
EVERSOURCE

Why Video and AI-based Inspection?

- Distribution Inspections
  - Asset verification, damage assessment, vegetation inspection, post-storm inspection, etc.
- Traditional Methods
  - 2 labors - 1 driver and 1 inspector
- Difficulties
  - Limited resources
  - Majority of the time spent behind the wheels
  - Large geographical area
  - Lack of a master database to track work and perform post analytics

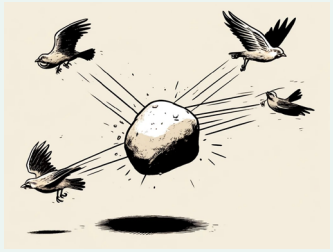


Defects in the distribution system

What is Video and AI-based Inspection?

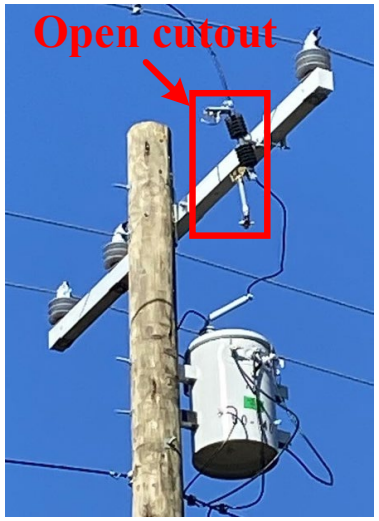
- Truck mounted dash cameras
  - 4k@30fps inspection videos
  - 10Hz GPS location
- Advantages
  - Safe: Drivers only focus on driving
  - Huge cost savings
    - Up to 75% labor hours saved
    - One driver, no stop for recording defects
  - Faster assessment and recovery
  - Multiple purpose benefits with same efforts, such as
    - Asset verification
    - Defect detection
    - Vegetation inspection
    - Post-storm inspection, etc.

AI generates results automatically



Challenges

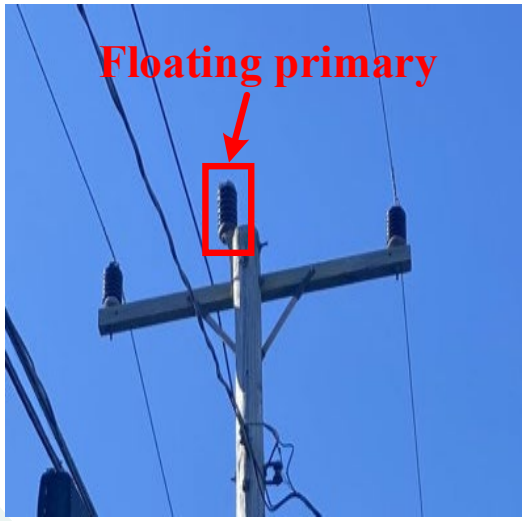
- Distribution defects:



Open cutout

Rusted transformer

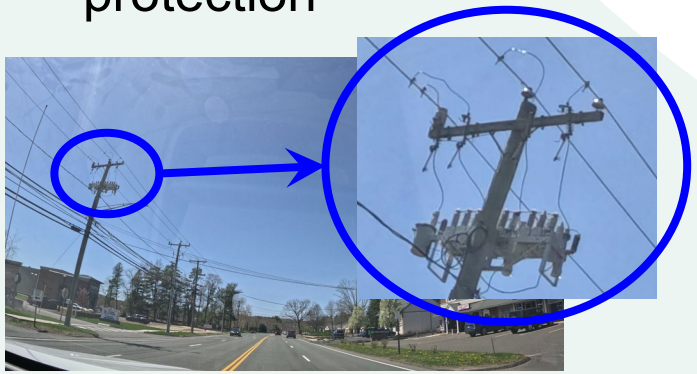
Missing animal protection



Floating primary

Vined pole

- Detection challenges:
  - 1) Small defects
  - 2) Limited training data



Small/Tiny defects in the video frame

Available Datasets

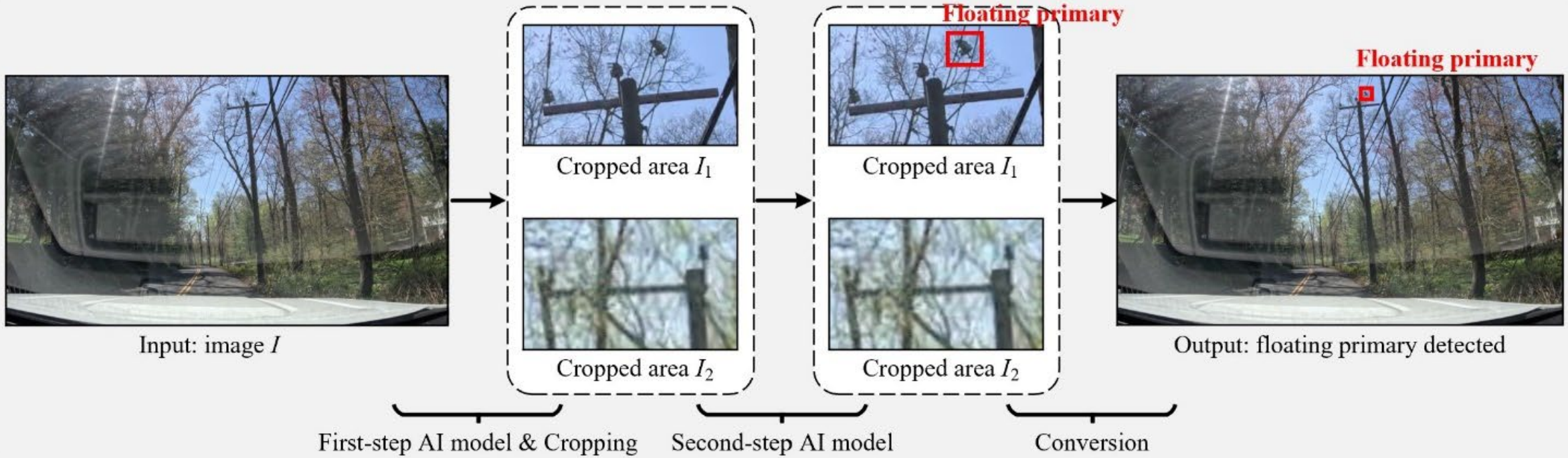
1. Video frames:
   - Defects are small
   - Most frames do not contain defects

2. Photos taken by hand-held devices:
   - Many images for each defect
   - Varying dimensions, sizes, backgrounds

Our solution uses all available datasets

Our Solution: Two-Step Defect Detection

Small object detection



1. First-step detection:
   - Pole detection: YOLOv8
     - Training data: Video frames
   - Cropping
2. Second-step detection:
   - Defect detection: YOLOv8
     - Training data: Cropped images

Our Solution: Two-Step Defect Detection

Table I: The numbers of images and labels for each model

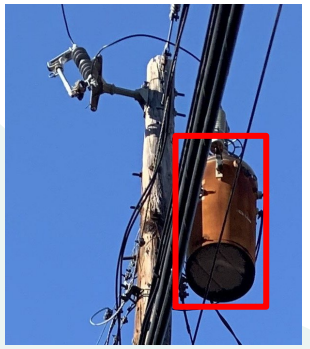
Stage	Model	Object	Images	Labels
First step	Model 1	asset-included crossarm	613	635
	Model 2	pole	1585	1878
Second step	Model 3	open cutout	512	531
		closed cutout		516
	Model 4	rusted transformer	1261	719
		good transformer		915
	Model 5	missing animal protection	453	488
		animal guard		536
	Model 6	floating primary	672	526
		good primary		1443
	Model 7	vined pole	806	398
		good pole		411

First-step AI models

- Asset-included crossarm
- Pole

Second-step AI models

- Defect
- Good



vs.

Rusted transformer Good transformer

Demo: Defect Detection Results

Defects:

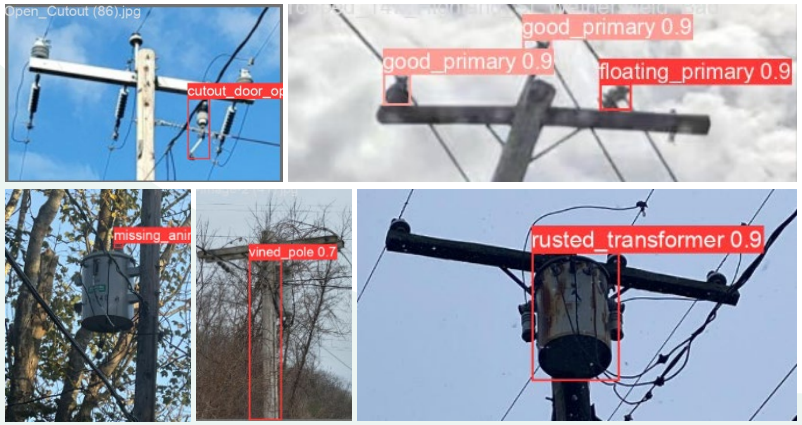
- Open cutout
- Rusted XFMR
- Vined pole
- Double pole

Defect Detection Results

Table II: Performance of each AI model

Stage	Model	Object	Precision	Recall	mAP50	mAP50-95
First step	Model 1	asset-included crossarm	95.5%	93.5%	96.5%	85.3%
	Model 2	pole	91.4%	93.0%	95.7%	78.5%
Second step	Model 3	open cutout	98.5%	96.8%	98.9%	82.4%
		closed cutout	97.6%	97.0%	99.2%	76.4%
	Model 4	rusted transformer	97.5%	95.3%	99.1%	88.5%
		good transformer	95.2%	96.9%	98.1%	87.9%
	Model 5	missing animal protection	83.7%	81.5%	87.8%	48.3%
		animal guard	82.8%	83.3%	90.6%	50.8%
	Model 6	floating primary	94.1%	92.1%	96.2%	71.4%
		good primary	97.4%	95.0%	98.6%	78.7%
	Model 7	vined pole	90.6%	94.2%	96.3%	72.6%
		good pole	93.2%	96.9%	96.2%	76.6%

- **First-step AI models:**
  - Precision, recall > 90%
  - A robust foundation
- **Second-step AI models:**
  - Missing animal protection: Precision, recall > 80%
  - Others: Precision, recall > 90%



Comparison Results

Comparison between direct and two-step detection

Direct detection results

Two-step detection results

- Higher precision and recall
- Fewer false positives

Conclusions

Traditional Distribution Inspections

- 1 driver, 1 inspector
- Limited resources, time consuming, unsafe

Video and AI-based Inspections

- Drivers only focus on driving (No inspections while driving)
- Huge cost savings, faster assessment and recovery, multiple purpose benefits with same efforts

Two-Step Defect Detection

- Small object detection
- All available datasets
- Better precision and recall scores