Advancing Brick Kiln Detection in Satellite Imagery using Modern Object Detection Techniques

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Introduction

- Air pollution accounts for ~8.1 million premature deaths annually.
- Brick kilns contribute 8–14% of pollution in the Indo-Gangetic Plain.
- Their scattered, unorganized nature makes large-scale detection crucial for research and planning.
- This study leverages modern object detection techniques to enhance brick kiln detection from overhead imagery.

Objective

- Detection and classification of brick kilns.
- Improve detection accuracy using:
  1. **SOTA object detection** models
  2. Advanced **super-resolution** techniques

Dataset

3 types of brick kilns: Zigzag, FCBK, CFCBK

Region	Images	Zigzag	FCBK	CFCBK
Bihar	641	1000	120	10
Haryana	586	1000	120	10
Test Bihar	687	1000	120	10

Zig-Zag | FCBK | CFCBK

Image Size: 640 x 640

Brick Kiln Detection

- **Object Detection Models:**

YOLOv11m-obb | RF-DETR | RHINO

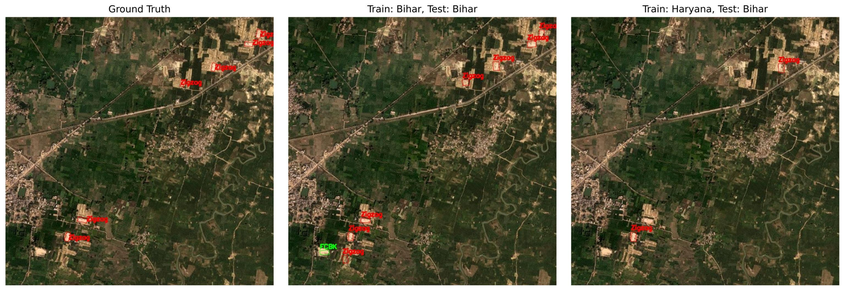
- **Experiments:**
  1. Converted annotations to model-specific formats.
  2. Trained all models on Bihar region dataset
  3. Tested on Test Bihar Dataset.

- **Evaluation:**
  1. Applied **Non-Maximum Suppression (NMS)** with IoU threshold of 0.33.
  2. Computed **mAP@50** (mean Average Precision at IoU threshold 0.5) scores using supervision.

- **Domain Adaptation:**

Trained on Haryana dataset and tested on the Test Bihar dataset.

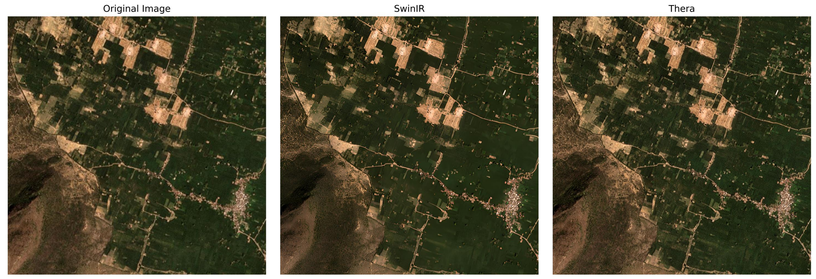
Model	Bihar to Bihar	Haryana to Bihar
YOLOv11m-obb	57.00	45.00
RFDETR Base	49.76	36.78
RFDETR Large	52.07	44.54
RHINO (Resnet50 Backbone)	**68.80**	52.60
RHINO (SwinT Backbone)	65.10	**57.58**



Rhino (SwinT Backbone) Detection Results
Same vs Cross-Region Training

Super-Resolution

- **SwinIR:** Swin Transformer-based image super-resolution model
- **Thera:** An aliasing-free arbitrary-scale super-resolution method using neural heat fields



Comparison between Original (640) and Super-Resolved Images (2560)

Model	Super Resolution	Bihar to Bihar	Haryana to Bihar
YOLOv11m-obb	SwinIR	57.50	46.00
	Thera	61.47	49.60
RFDETR Base	SwinIR	52.95	38.00
	Thera	53.05	33.38
RFDETR Large	SwinIR	55.10	43.33
	Thera	54.80	40.80
RHINO (Resnet50 Backbone)	SwinIR	75.32	50.30
RHINO (SwinT Backbone)	SwinIR	**77.78**	55.30
	Thera	76.73	**61.03**

Conclusion

- RHINO, a modern object detection model, significantly outperforms YOLO for brick kiln detection.
- Super-resolution techniques, like SwinIR and Thera, further boost detection accuracy by improving image quality.
- Models show some generalization across regions, with a slight performance drop.
- Overall, combining advanced detection methods with image super-resolution techniques offers a scalable and accurate approach to monitor brick kilns.

References

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