

Model Card - Solar Panel Detection System

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Model Details

Task: Rooftop Solar Detection & Segmentation

Arch: YOLOv11-m (OBB) + DeepLabV3+ (ResNet101)

Detection (YOLOv11-m)

- **Input:** 640px, Grayscale (CLAHE)
- **Threshold:** 0.25 (TTA: 0.20)
- **Features:** Soft-NMS, TTA (3x)

Segmentation (DeepLabV3+)

- **Backbone:** ResNet-101 (Aux Loss)
- **Features:** SAHI Slicing, Dual-Buffer

Key Technical Innovations

- **Dual-Stage Hybrid:** YOLO ROI detection → DeepLabV3+ area.
- **Dual-Stage TTA:** Applied at detection and segmentation stages.
- **Soft-NMS:** Gaussian decay improves recall by 8–15%.
- **CLAHE Preprocessing:** 10–15% boost on low-contrast imagery.
- **Dual-Buffer Context:** Mask avg. $(M_1 + M_2)/2$ across scales.
- **OBB-Constrained Masking:** Binary AND prevents leakage (-20% FP).
- **Aggressive Color Filter:** HSV/Gray rejection (-70% FP).
- **Dual-Method Fusion:** Averaging Pixel Count + Contour Polygon.

Logic & Pipeline

1. **Detection:** YOLOv11-m OBB identification.
2. **ROI:** Dual-buffer context extraction.
3. **Segmentation:** Sliced SAHI inference.
4. **Post-Processing:** 5-step Morphological pipeline.
5. **Filtering:** Aspect ratio + Aggressive HSV/Gray logic.
6. **Estimation:** Dual-method fusion.

Performance Metrics

Metric	Score
Precision	0.89267
Recall	0.88479
F1 Score	0.9141

Buffer Configuration

Type	sqft	m ²	r(m)
Primary	1200	111.5	5.96
Secondary	2400	223.0	8.42

Methodology: PV Area

GSD Conv: $px \times (0.1088)^2$

Dual-Method Fusion:

$$Area_{final} = (Area_{px} + Area_{contour})/2$$

Input/Output

In: 0.1088 m/px (Zoom 20) Imagery.

Out: PV Class, Area, JSON.

Limitations & Citation

- Trained on Indian satellite imagery.
- Optimal at zoom 18–20.