COUNTING PHOTOVOLTAIC AND SOLAR PANELS FROM AERIAL IMAGERY

Complements of Machine Learning 24/25

Lacuna Solar Survey Challenge

- Hugo Veríssimo 124348
- João Cardoso 50750

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universidade
de aveiro

PROJECT OVERVIEW

THE PROBLEM

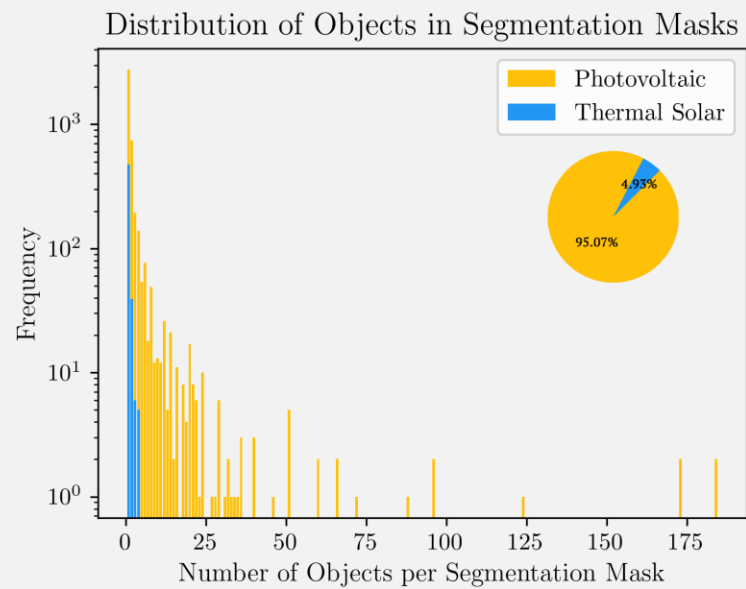From aerial imagery:

- Count thermal solar panels
- Count photovoltaic panels

STATE OF THE ART

DATA ANALYSIS

- 4419 images (75/25)

- Segmentation masks for panel groups

- Metadata

RAW DATA

Distribution of Objects in Segmentation Masks

Placement Classes

Origin Classes

Inaccuracies in Polygon Annotations

Misaligned Vertices (6/3)

Excessive Object Inclusion (141/8)
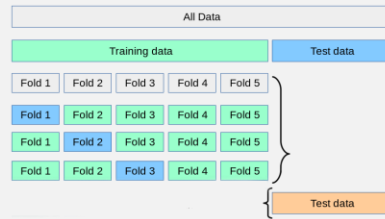

Segmentation Mask

(1) Thermal Solar
(4) Photovoltaic

PREPROCESSING

- Fix or remove innacurate polygons
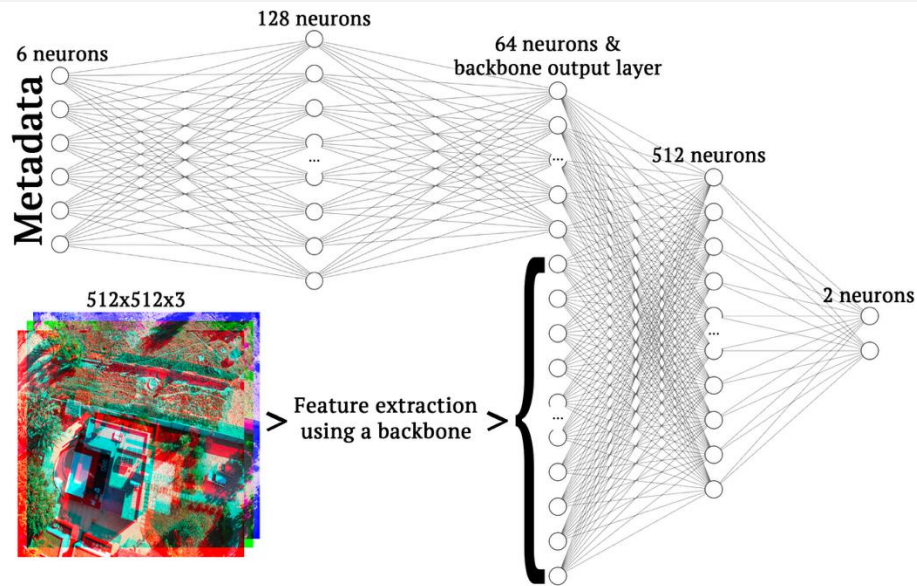
- Resize images to 512 x 512

DEEP LEARNING MODELS

IMAGE-BASED REGRESSION

- DenseNet121, EfficientNetv2B3 and ResNet101

Hyperparameter search space

Hyperparameter	Possible Values
Batch size	$\{\mathbf{16}, 32, 64\}$
Optimizer	**AdamW**
Learning rate	$[\mathbf{10^{-5}}, 10^{-3}]$
Weight decay	$[\mathbf{10^{-5}}, 10^{-3}]$
Dropout	$\{0.2, 0.3, \mathbf{0.4}\}$
Scheduler	**CosineAnnealingWarmRestarts**
T_0	$\{3, \mathbf{5}, 7, 10\}$
T_mult	$\{1, \mathbf{2}, 3, 5\}$
Loss	**HuberLoss**
δ	**1**

IMAGE-BASED REGRESSION - RESULTS
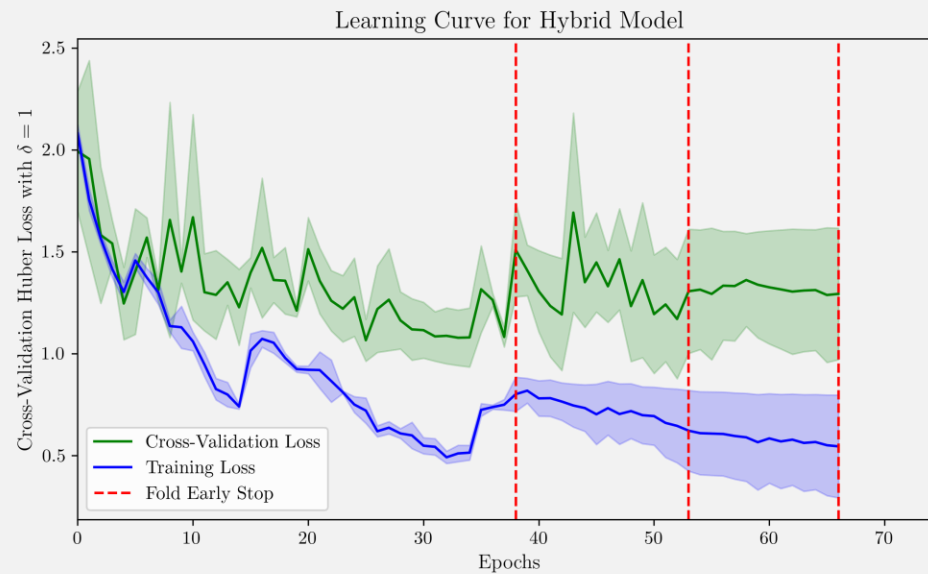
Error metrics

Dataset	MAE	Support
Train Set	0.5127	3312
Test Set	0.8434	1107

OBJECT DETECTION

Hyperparameter search space

Hyperparameter	Possible Values
Batch size	$\{16, \mathbf{32}\}$
Model	$\{\mathbf{yolov8l}, \text{yolo11m}, \text{yolo11l}\}$
Image size	**512**
Augmentation	**True**
Early stopping patience	$[15, \mathbf{25}]$
cls	$[0.5, \mathbf{1.5}]$
lr0	$[\mathbf{10^{-5}}, 10^{-3}]$
lrf	$[0.1, \mathbf{1}]$
mixup	$[0, \mathbf{0.75}]$
copy_paste	$[0, \mathbf{0.75}]$
scale	$[0.5, \mathbf{1}]$

Cross-Validation MAE Distribution by Obj. Det. Model
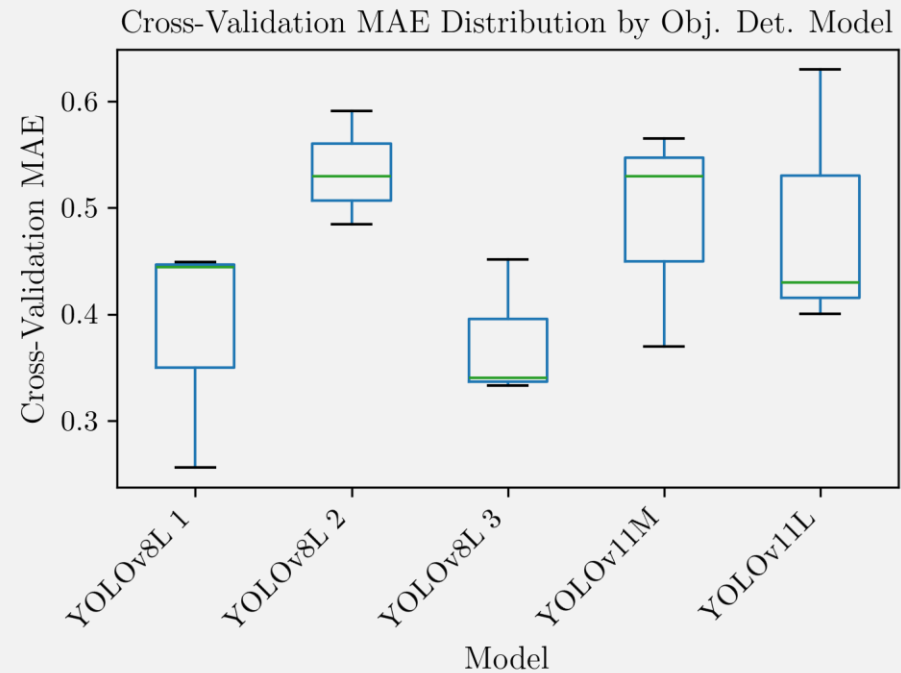
OBJECT DETECTION - RESULTS

F1-Confidence Curve

- thermal
- photovoltaic
- all classes 0.80 at 0.351

Learning Curve for Object Detection Model

- Cross-Validation Loss
- Training Loss
- Fold Early Stop
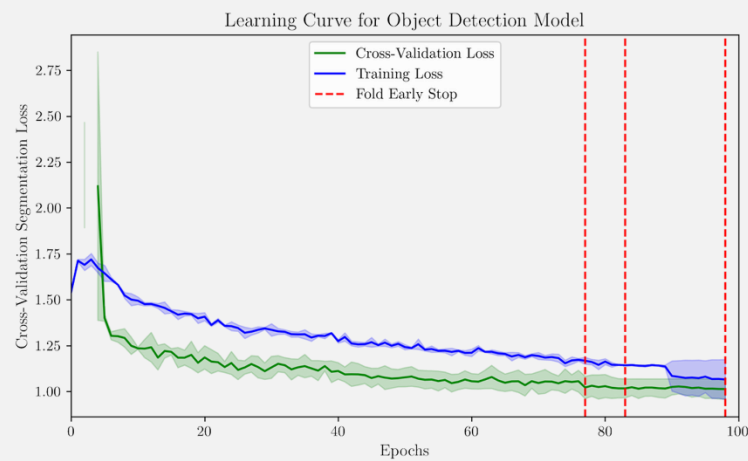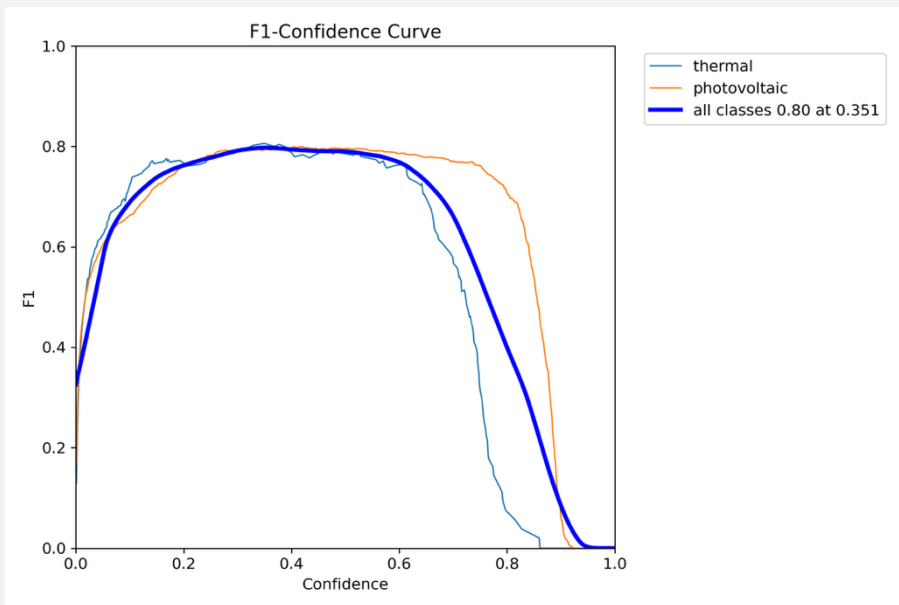
Error metrics

Dataset	MAE	Support
Train Set	1.4330	3312
Test Set	1.2645	1107

INSTANCE SEGMENTATION

Hyperparameter search space

Hyperparameter	Possible Values
Batch size	$\{\mathbf{8}, 32, 16\}$
Model	$\{$yolov8l-seg, yolo11m-seg, **yolo11l-seg**$\}$
Image size	**512**
Augmentation	**True**
Early stopping patience	$[10, \mathbf{25}]$
cls	$[\mathbf{0.5}, 2.5]$
lr0	$[10^{-4}, \mathbf{10^{-3}}]$
lrf	$\{0.01, \mathbf{0.1}, 1\}$
mixup	$[\mathbf{0}, 0.5]$
copy_paste	$[\mathbf{0}, 0.8]$
scale	$[\mathbf{0.5}, 1]$

Cross-Validation MAE Distribution by Inst. Seg. Model
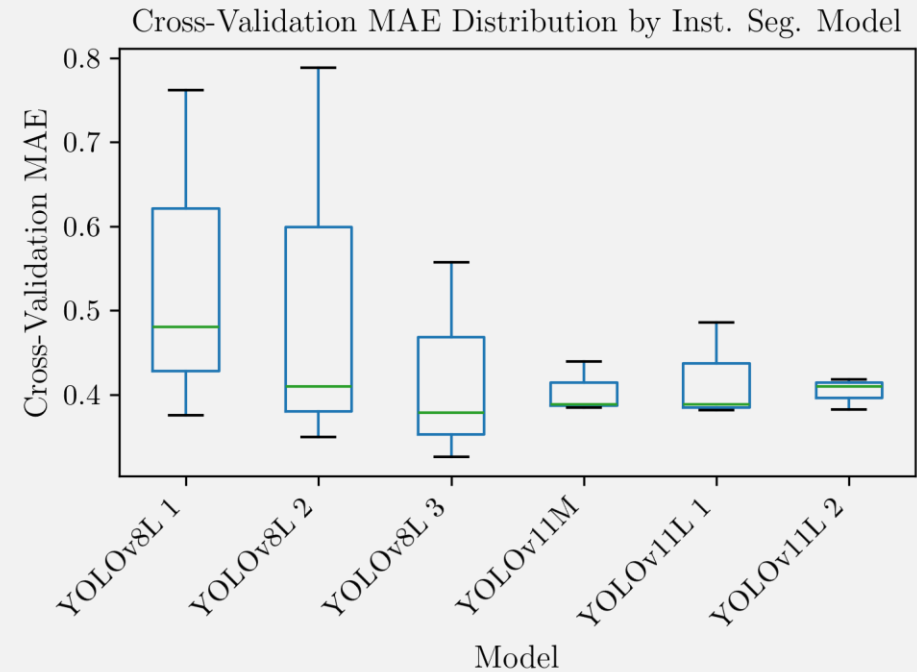
INSTANCE SEGMENTATION - RESULTS
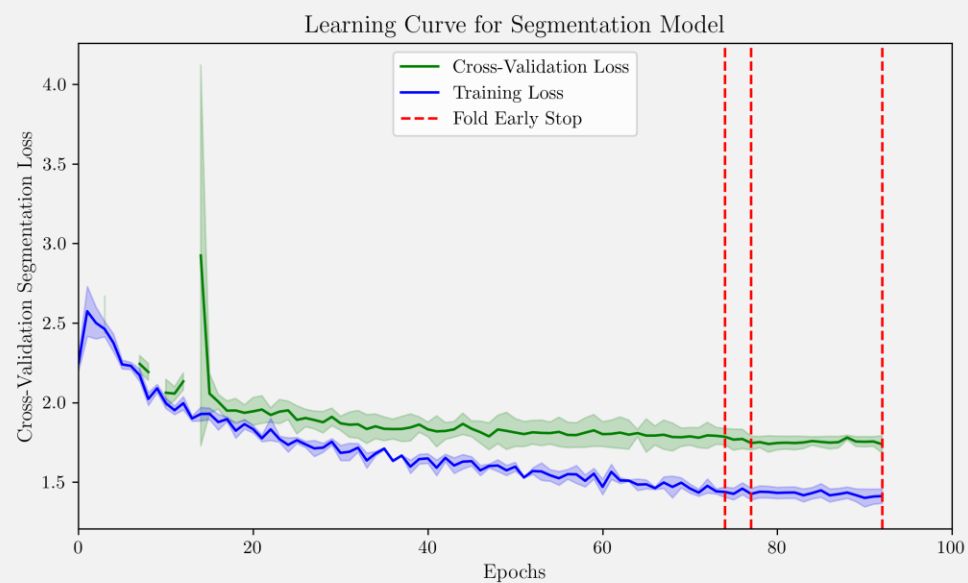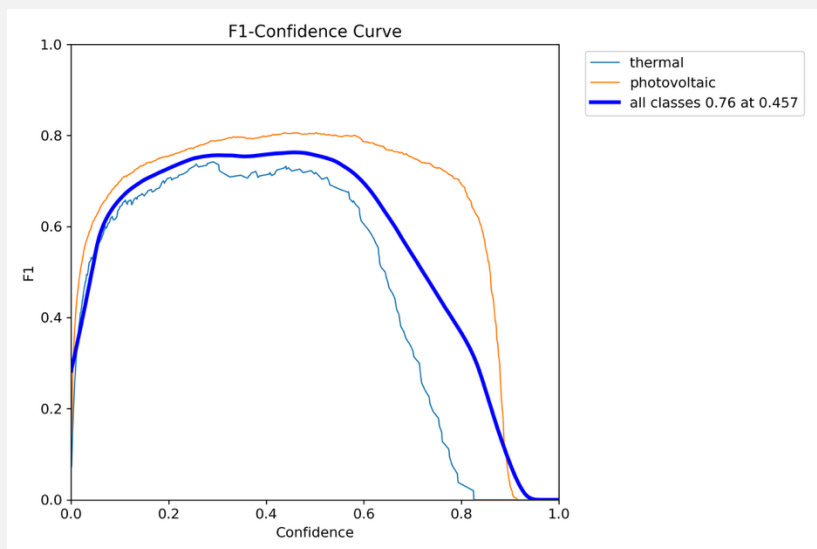
Error metrics

Dataset	MAE	Support
Train Set	1.5645	3312
Test Set	1.3415	1107

RESULTS ANALYSIS

MAE Distribution Across Each Fold on the Test Set
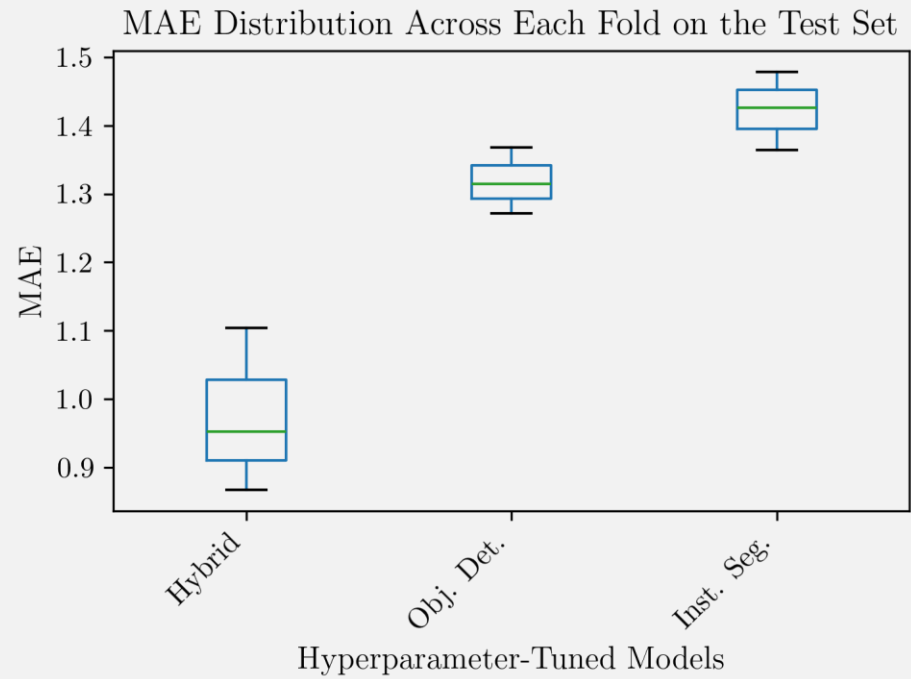
Error metrics for the fine-tuned models along with the best performers in the competition

Model	MAE (Test Set)
Hybrid	0.8434
Obj. Det.	1.2645
Inst. Seg.	1.3415
Team Lacuna (1st)	0.3299
K_Junior (2nd)	0.5698

AKA DISCUSSION W LIT BENCHMARK

CONCLUSIONS