Madrid Rooftops Image Segmentation

Implementación Mask R-CNN para la segmentación de tejados residenciales, piscinas y canchas deportivas en la Comunidad de Madrid

Ana Blanco Delgado
Septiembre 2021

Inspiración

idealista/energy

Calle Prim, 11:

https://www.idealista.com/energy/calculadora-de-ahorro-solar/#ref=1350216VK4715A0001FW&lat=40.422026&lng=-3.6937241

293 € ahorro anual en la factura de la luz por vecino

23.009 € coste de la instalación de 61 paneles solares (15,6 KWp de potencia)

5 años tardaría la instalación en amortizarse.

190.746 € ahorro total durante 25 años de vida útil de la instalación

Ver detalles del cálculo de ahorro y financiación

Instalación solar óptima para el tejado de Calle Prim 11, Madrid

- 164 m² disponibles
- 61 paneles solares
- 3.043 horas de sol al año
- 15,6 KWp de potencia
- 38% de inclinación
- 6 tn de CO2 menos al año

El ahorro total contempla la pérdida de rendimiento de los paneles. Los cálculos están basados en un comportamiento regular de la instalación y son siempre orientativos y no vinculantes.

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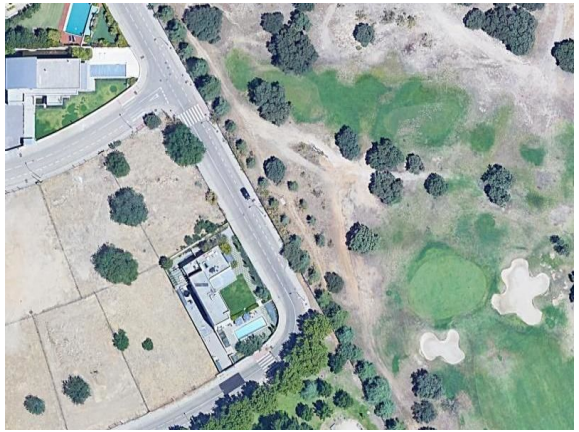
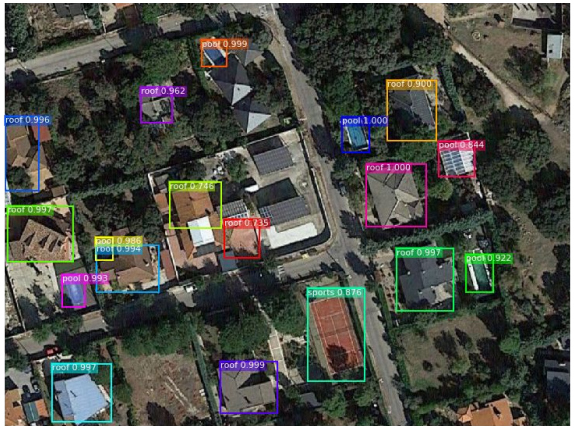
Computer vision tasks

Clasificación



Detección



Segmentación

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Mask R-CNN

Mask Region Convolutional Neural Network

Mask R-CNN paper oficial
https://arxiv.org/abs/1703.06870

Mask R-CNN for Object Detection and Segmentation
(repositorio open-source de Matterplot)
https://github.com/matterport/Mask_RCNN

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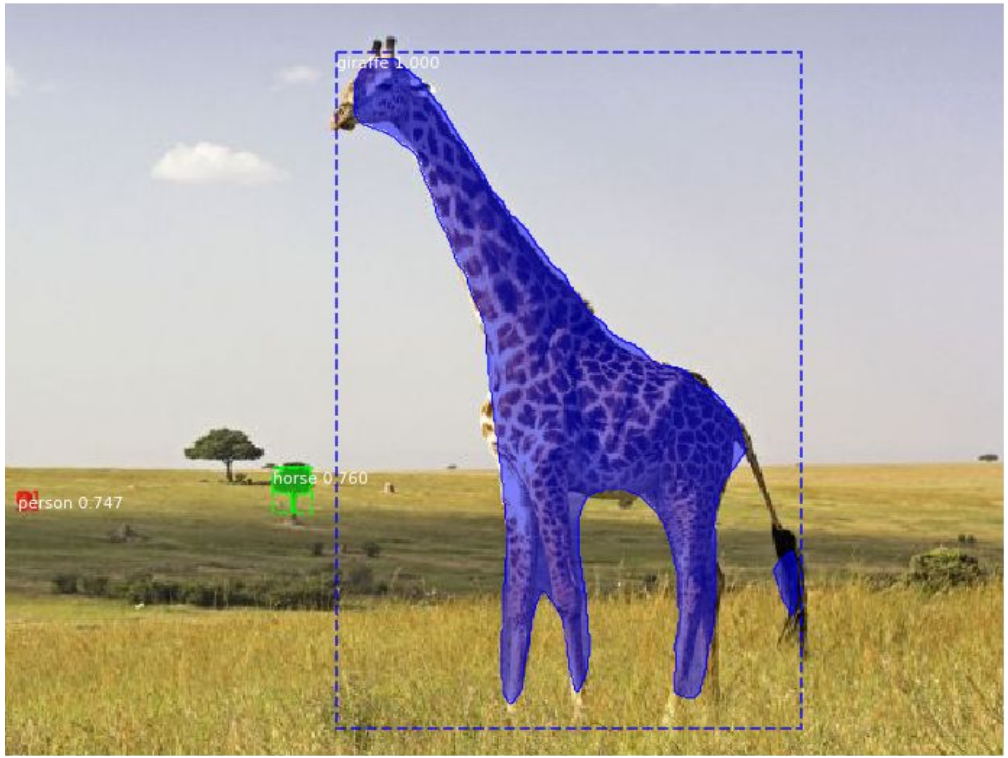
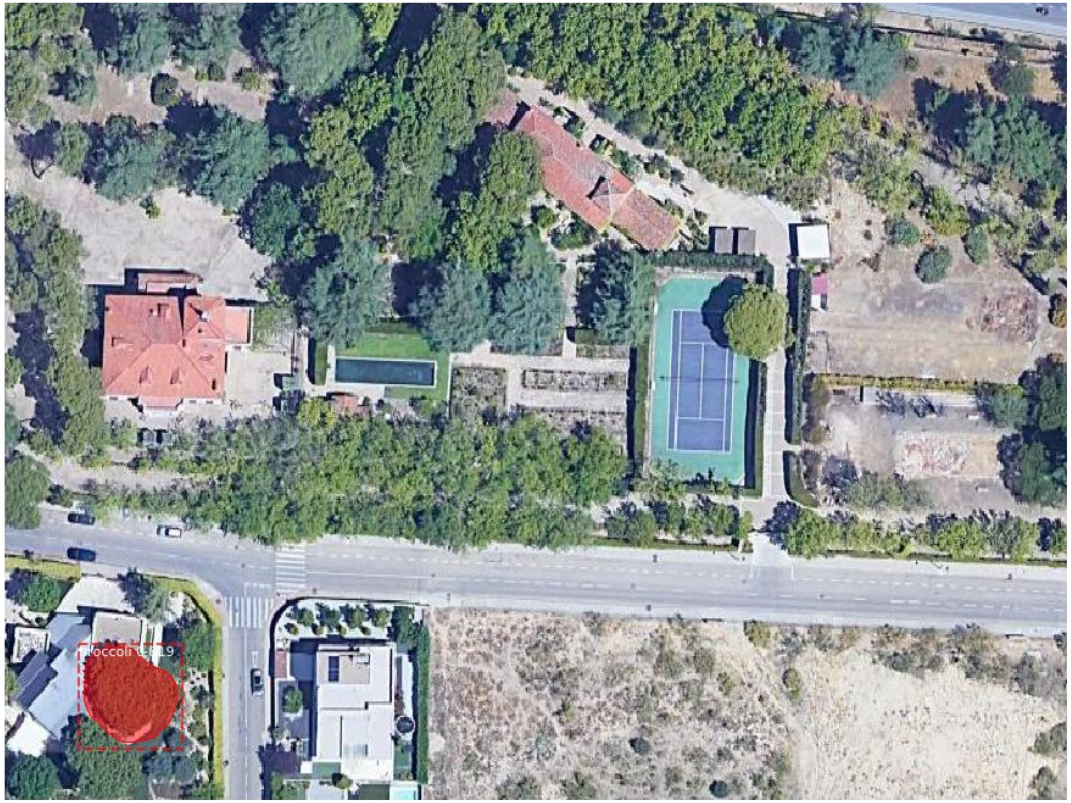
Mask R-CNN

COCO Dataset Classes: ['BG', 'person', 'bicycle', 'car', 'motorcycle', 'airplane', 'bus', 'train', 'truck', 'boat', 'traffic light', 'fire hydrant', 'stop sign', 'parking meter', 'bench', 'bird', 'cat', 'dog', 'horse', 'sheep', 'cow', 'elephant', 'bear', 'zebra', 'giraffe', 'backpack', 'umbrella', 'handbag', 'tie', 'suitcase', 'frisbee', 'skis', 'snowboard', 'sports ball', 'kite', 'baseball bat', 'baseball glove', 'skateboard', 'surfboard', 'tennis racket', 'bottle', 'wine glass', 'cup', 'fork', 'knife', 'spoon', 'bowl', 'banana', 'apple', 'sandwich', 'orange', 'broccoli', 'carrot', 'hot dog', 'pizza', 'donut', 'cake', 'chair', 'couch', 'potted plant', 'bed', 'dining table', 'toilet', 'tv', 'laptop', 'mouse', 'remote', 'keyboard', 'cell phone', 'microwave', 'oven', 'toaster', 'sink', 'refrigerator', 'book', 'clock', 'vase', 'scissors', 'teddy bear', 'hair drier', 'toothbrush']



Mask R-CNN

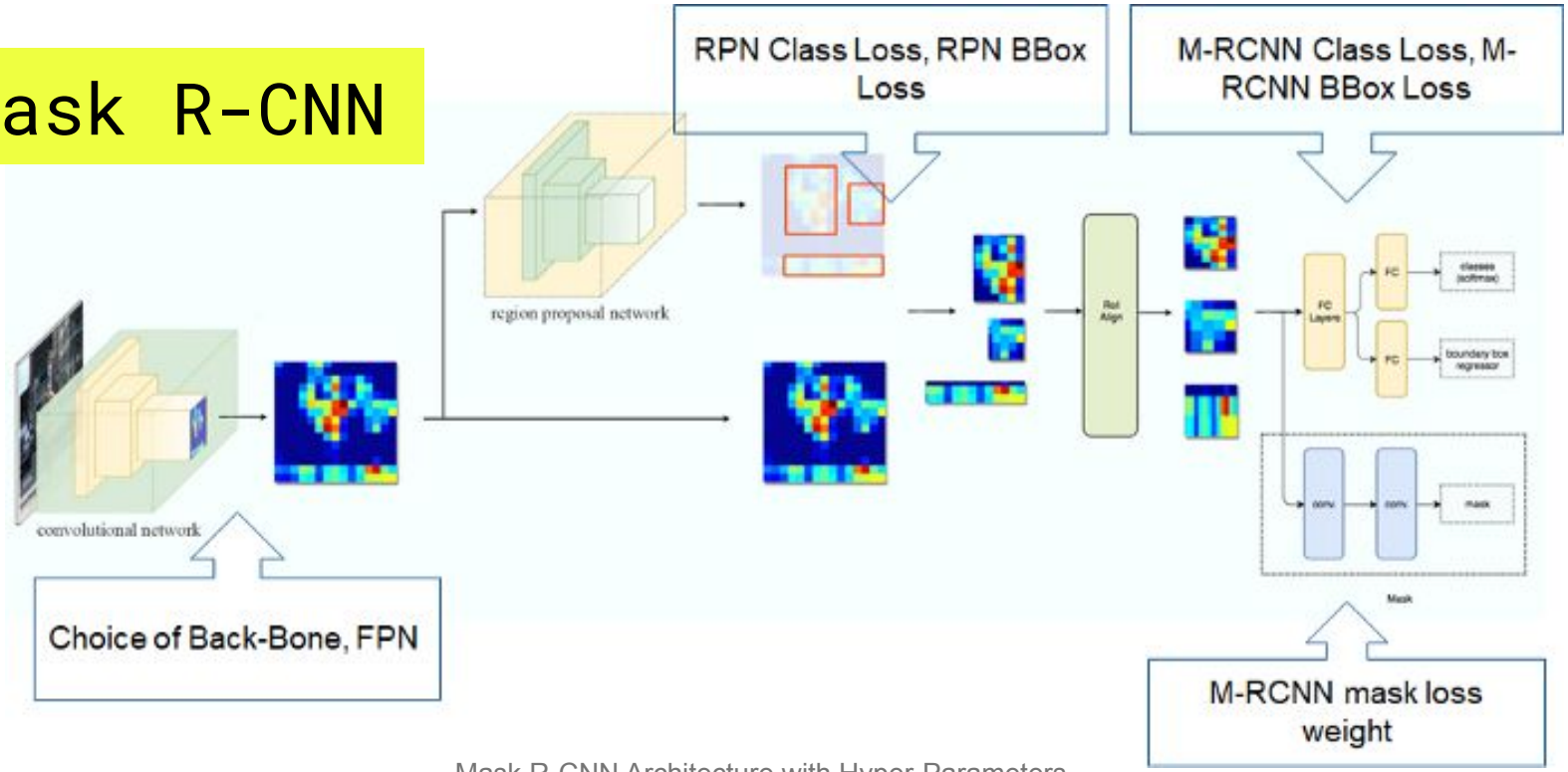


Mask R-CNN


tv 0.831
potted plant 0.86
.890


person 0.778
person 0.853
tv 0.831
broccoli 0.935
broccoli 0.390
potted plant 0.864

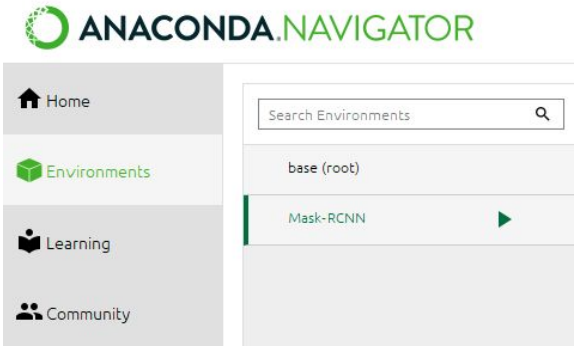
Mask R-CNN

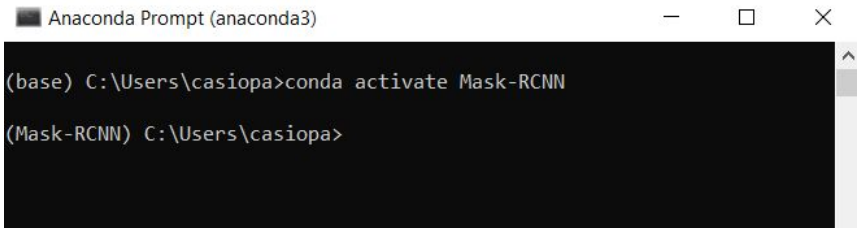


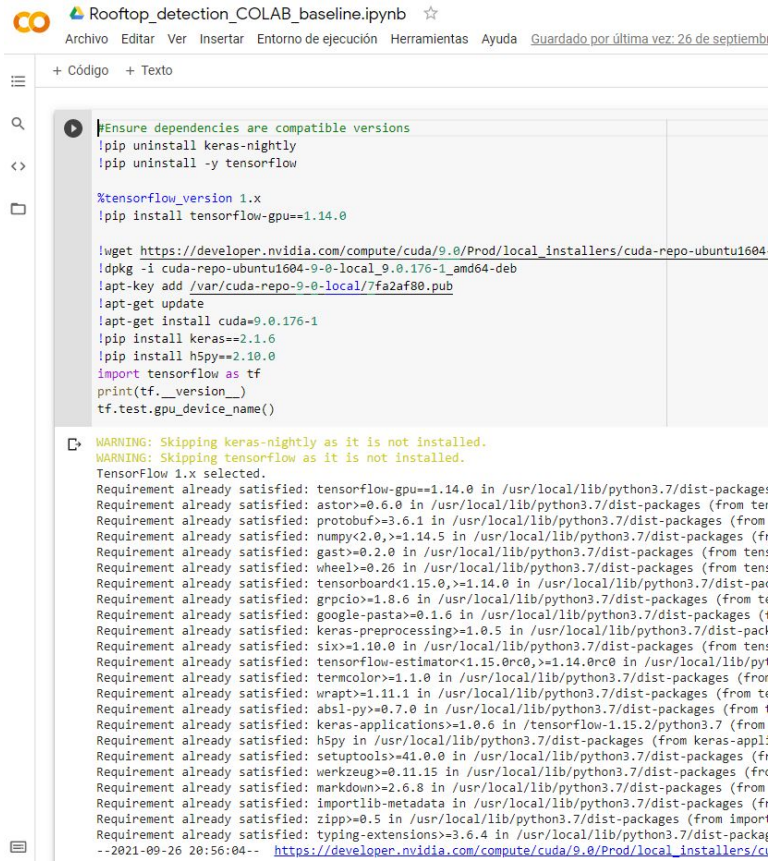
Mask R-CNN Architecture with Hyper-Parameters

Entorno de trabajo local y en Google Colab

Mask R-CNN







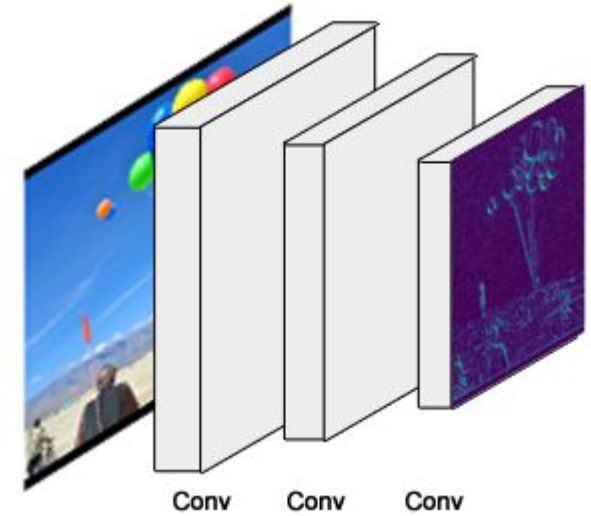
Mask R-CNN modules

1.Backbone | 2.RPN | 3.ROI-Clf/BB-Regr | 4.Segmentation

CNN ResNet101

`model.resnet_graph()`

Input image
1024 x 1024 x 3



Features
32 x 32 x 2048

1.Backbone | 2.RPN | 3.ROI-Clf/BB-Regr | 4.Segmentation

Feature Pyramid Networks (FPN)

`model.build()`

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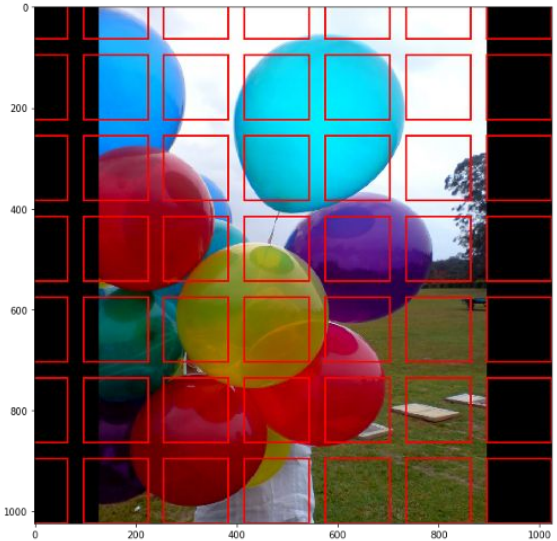
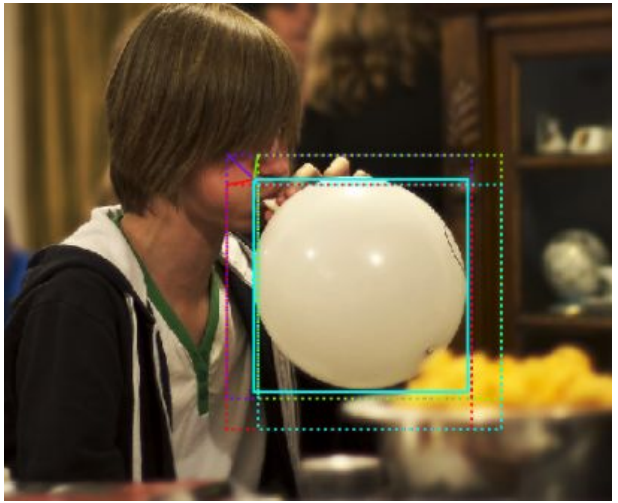
Region Proposal Network (RPN)

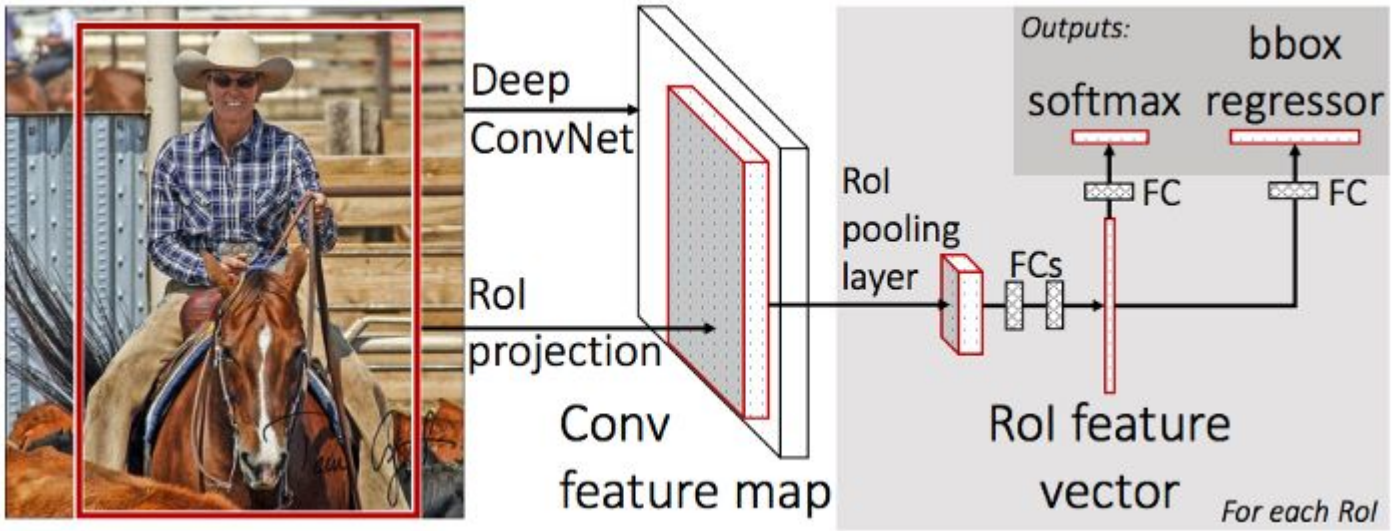
model.rpn_graph()





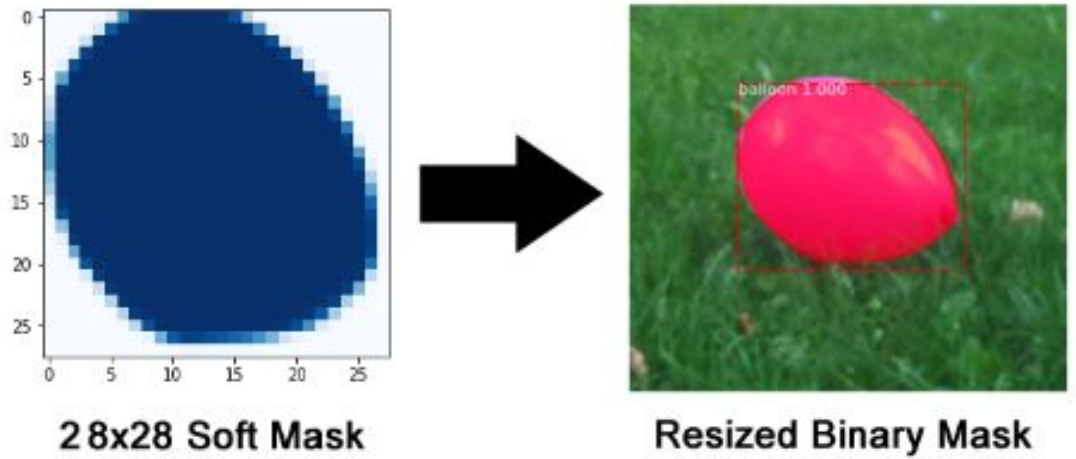
ROI Classifier & Bounding Box Regressor

`model.fpn_classifier_graph()`



Segmentation Masks

`model.build_fpn_mask_graph()`



Dataset

train_set	val_set	test_set
Image Count: 69 Polygon Count: 1488 Class Count: 4 0. BG 1. roof 2. pool 3. sports	Image Count: 22 Polygon Count: 545 Class Count: 4 0. BG 1. roof 2. pool 3. sports	Image Count: 11 Polygon Count: 258 Class Count: 4 0. BG 1. roof 2. pool 3. sports

Image Count: 102
Polygon Count: 2291

Aravaca, Cercedilla, Fuenfría, Navacerrada, Nuevo Baztán, Pozuelo, Somosaguas y Soto del Real

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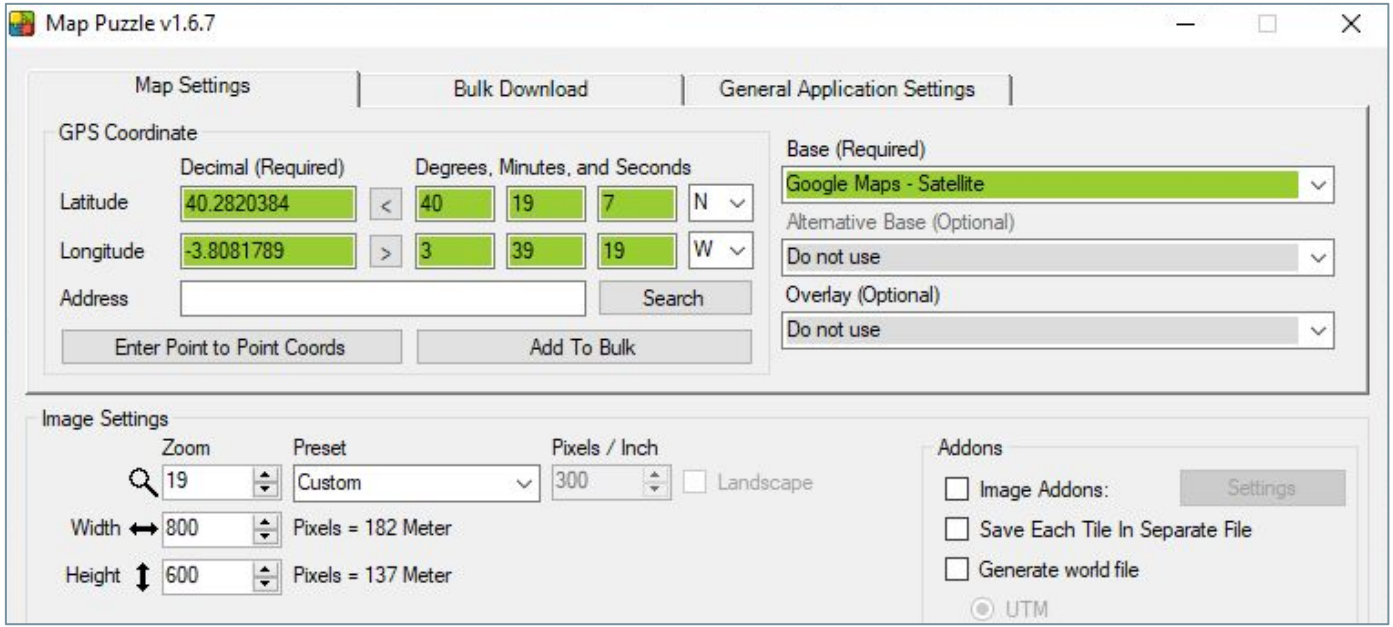
1. Imágenes

2. Annotations

Map Puzzle



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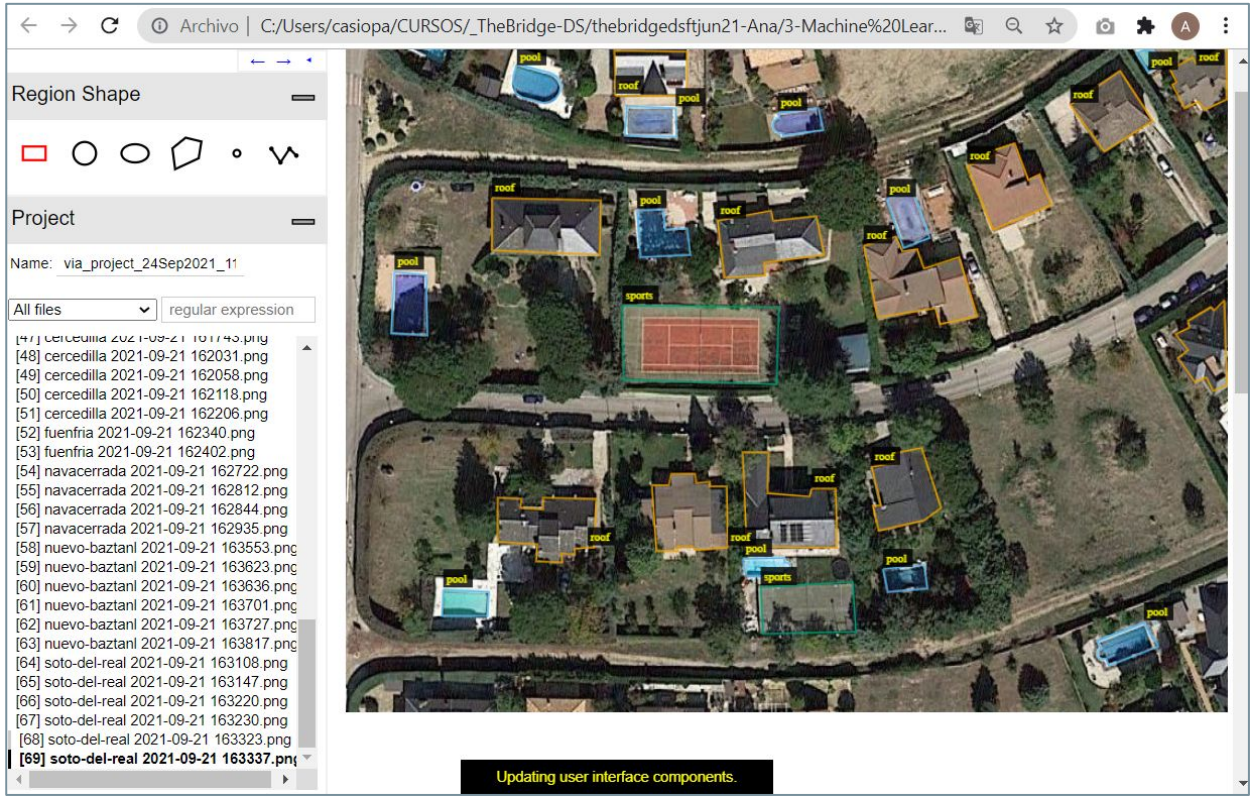
1. Imágenes

2. Annotations

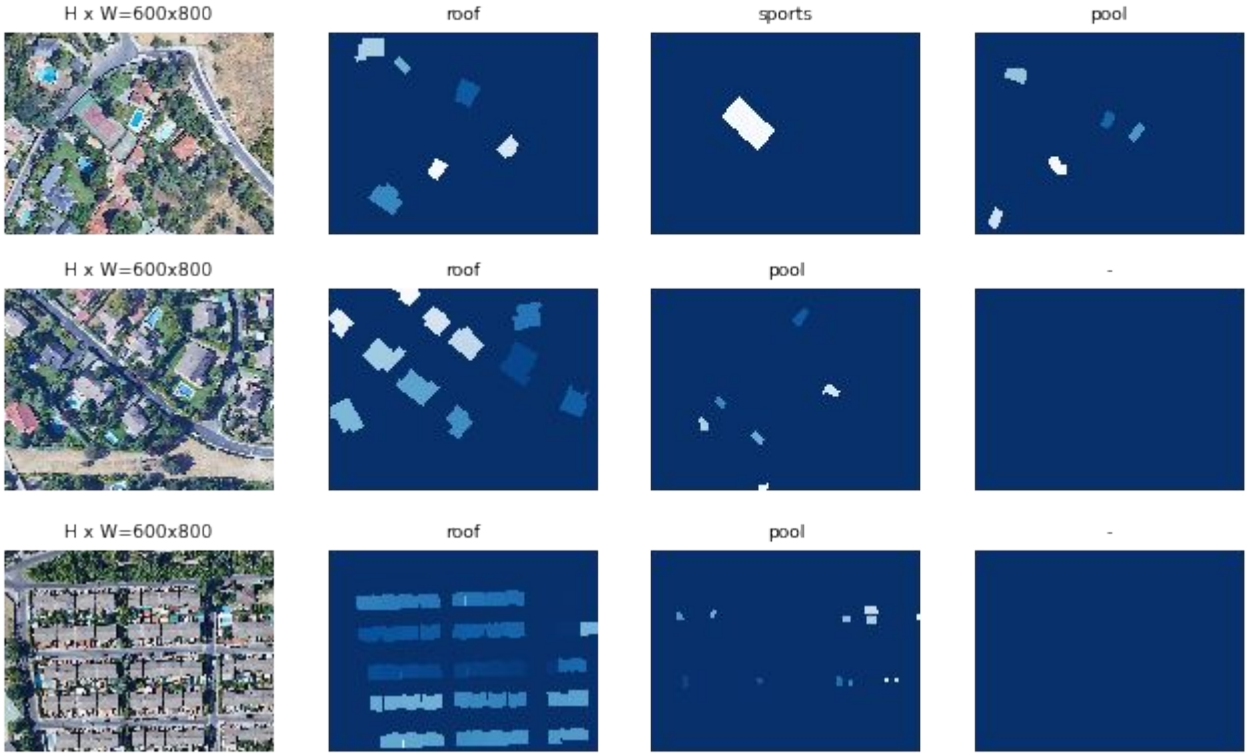
VGG Image Annotator (VIA)



Dataset

1. Imágenes

2. Annotations

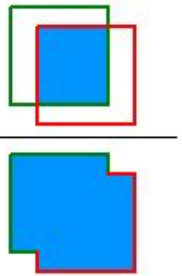


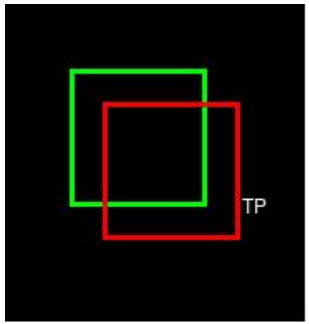
Object detection metrics

1. AP
2. mAP

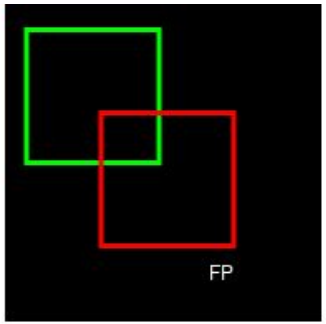
Intersect over Union (IoU)

$$IOU = \frac{\text{area of overlap}}{\text{area of union}} = \frac{\quad}{\quad}$$

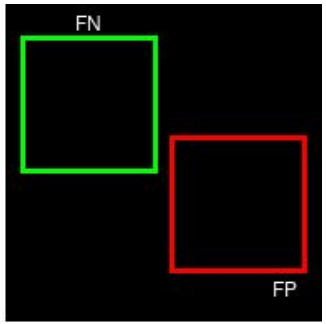




IoU = 0.86



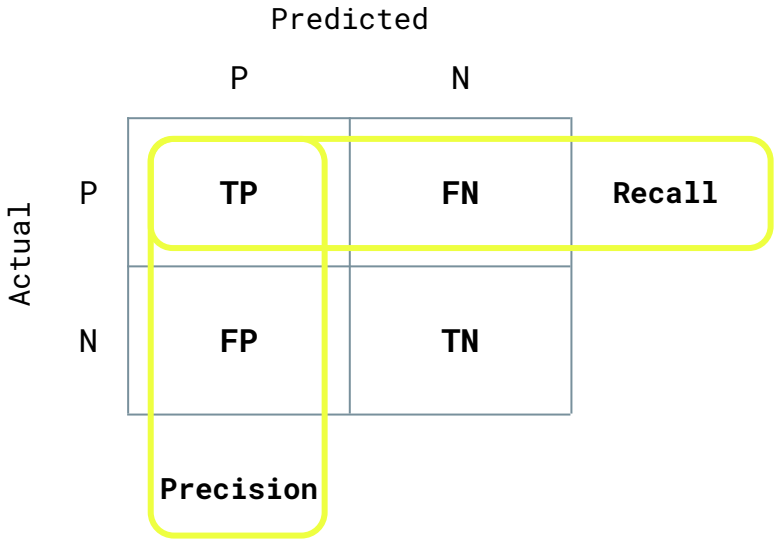
IoU = 0.24



IoU = 0

1.AP 2.mAP

Precision/Recall

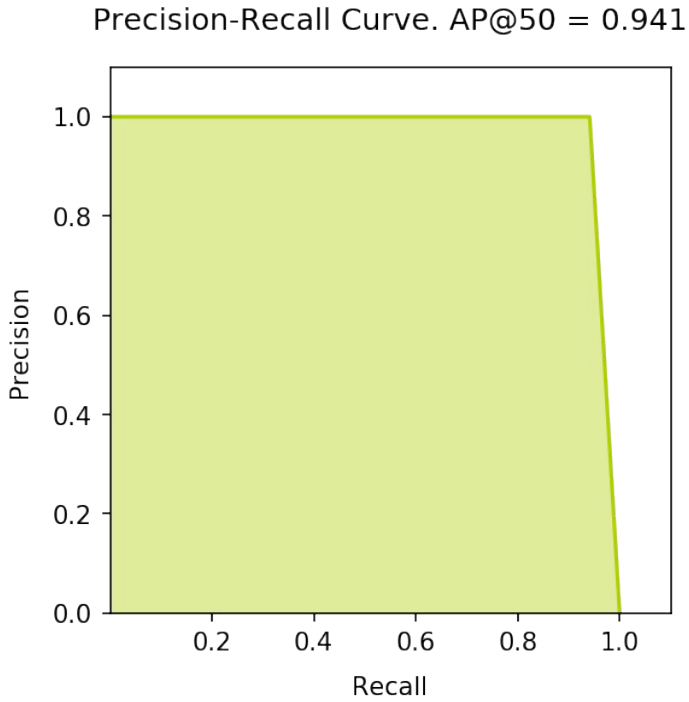


Object detection metrics

1.AP 2.mAP

Área bajo la curva Precision/Recall
AUC-PR

Average Precision
AP



Object detection metrics

Mean Average Precision Formula

$$\text{mAP@}\alpha = \frac{1}{n}\sum_{i=1}^{n} \text{AP}_i$$

Evaluación modelo

1.Baseline model

Learning Rate: 80 epochs: 0.001

Loss Weights:
'rpn_class_loss': 1.0
'rpn_bbox_loss': 1.0
'mrcnn_class_loss': 1.0
'mrcnn_bbox_loss': 1.0
'mrcnn_mask_loss': 1.0

Best model 60 epochs:
Train mAP@50: 0.720
Test mAP@50: 0.624

2. Hyperparameter tuning

Learning Rate: 10 epochs: 0.001
+10 epochs: 0.0005

Loss Weights:
'rpn_class_loss': 1.0
'rpn_bbox_loss': 0.8
'mrcnn_class_loss': 6.0
'mrcnn_bbox_loss': 6.0
'mrcnn_mask_loss': 6.0

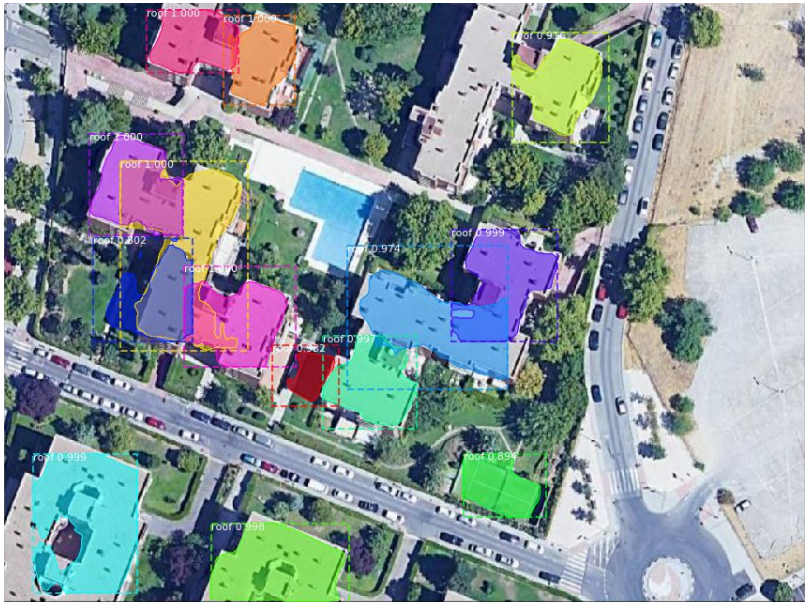
Augmentation 50%: Fliplr(0.5)
Blur [1, 5]

Train mAP@50: 0.562
Val mAP@50: 0.469

Test_set prediction image

1.Edificios

2.Casas

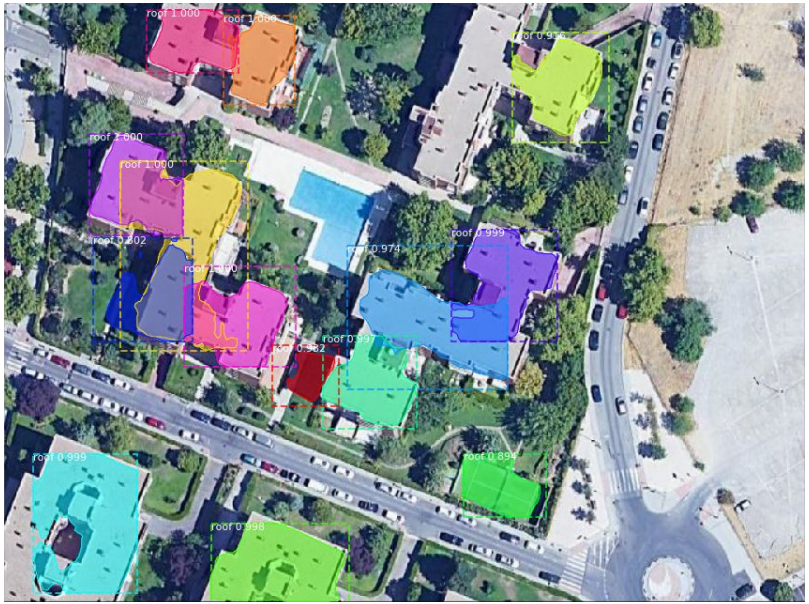


pozuelo 2021-09-13 200628.png

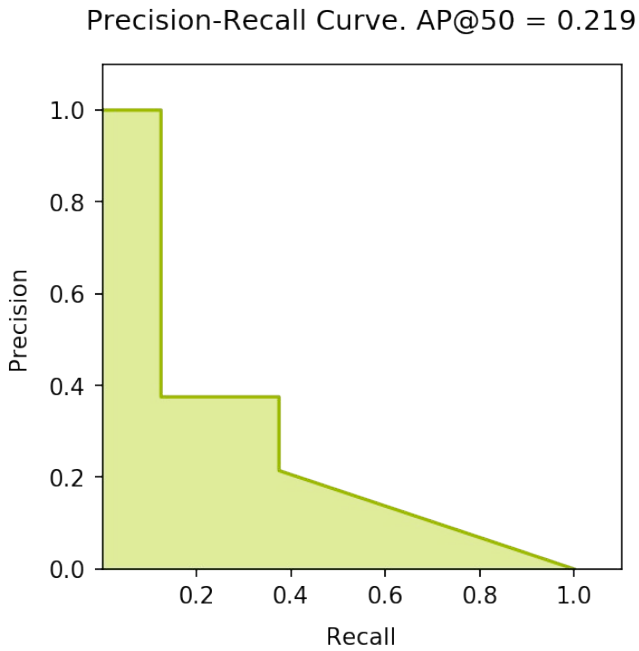
Test_set prediction image

1.Edificios

2.Casas



pozuelo 2021-09-13 200628.png



1.Edificios

2.Casas

somosaguas 2021-09-13 194952.png

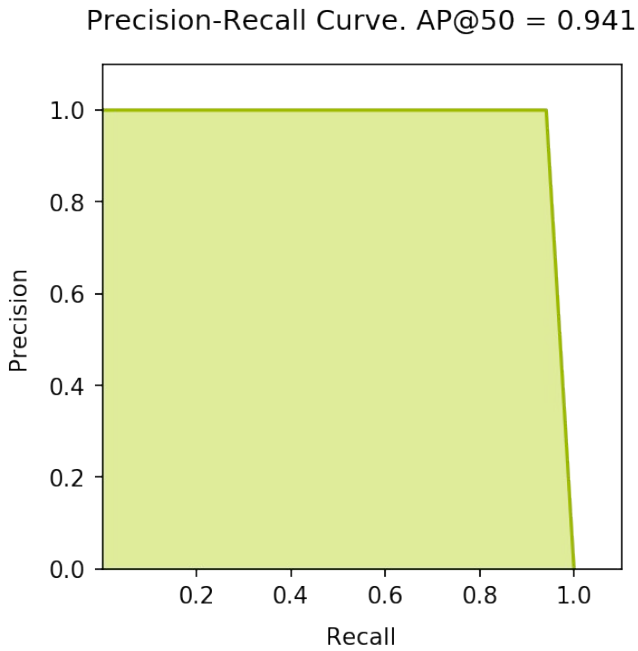

Predicted
Actual
roof (1.00)
roof (1.00)
pool (1.00)
pool (1.00)
pool (1.00)
pool (1.00)
roof (1.00)
roof (1.00)
pool (1.00)
pool (1.00)
roof (1.00)
pool (1.00)
roof (1.00)
pool (1.00)
pool (0.82)
roof (0.74)
roof
roof
roof
roof
roof
roof
pool
pool
pool
pool
pool
pool
pool
pool
pool
roof
0.906 match
0.922 match
0.803 match
0.821 match
0.749 match
0.787 match
0.915 match
0.907 match
0.835 match
0.840 match
0.886 match
0.794 match
0.861 match
0.742 match
0.707 match
0.841 match
0.000

Test_set prediction image

1.Edificios

2.Casas

somosaguas 2021-09-13 194952.png



Modelo orientado para segmentar:

- Viviendas residenciales aisladas (casas, chalets)
- Instancias por imagen < 20
- Imágenes con buena resolución

Madrid Rooftops Image Segmentation project

Septiembre 2021

https://github.com/casiopa/Madrid_Rooftops