

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

idealista/energy

Calle Prim, 11:

<https://www.idealista.com/energy/calcula-dora-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

☀️ 3.043 horas de sol al año

⚡ 38% de inclinación

🔋 61 paneles solares

⚡ 15,6 KWp de potencia

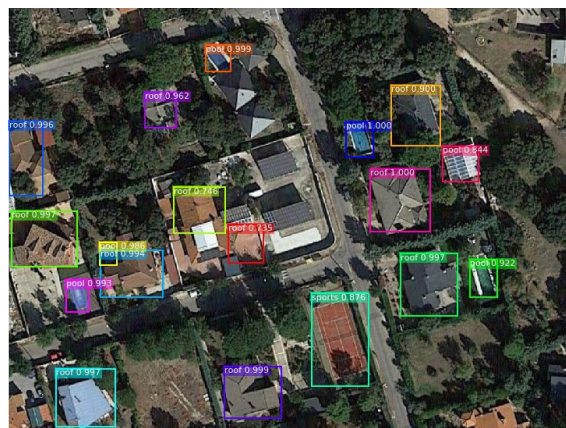
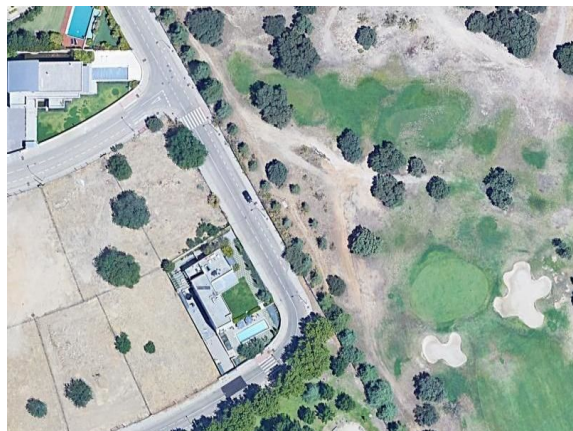
🌳 6 tn de CO2 menos al año

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.

Madrid Rooftop Image Segmentation project

Detección

Segmentación



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Mask R-CNN

Mask Region Convolutional Neural Network

Mask R-CNN paper oficial

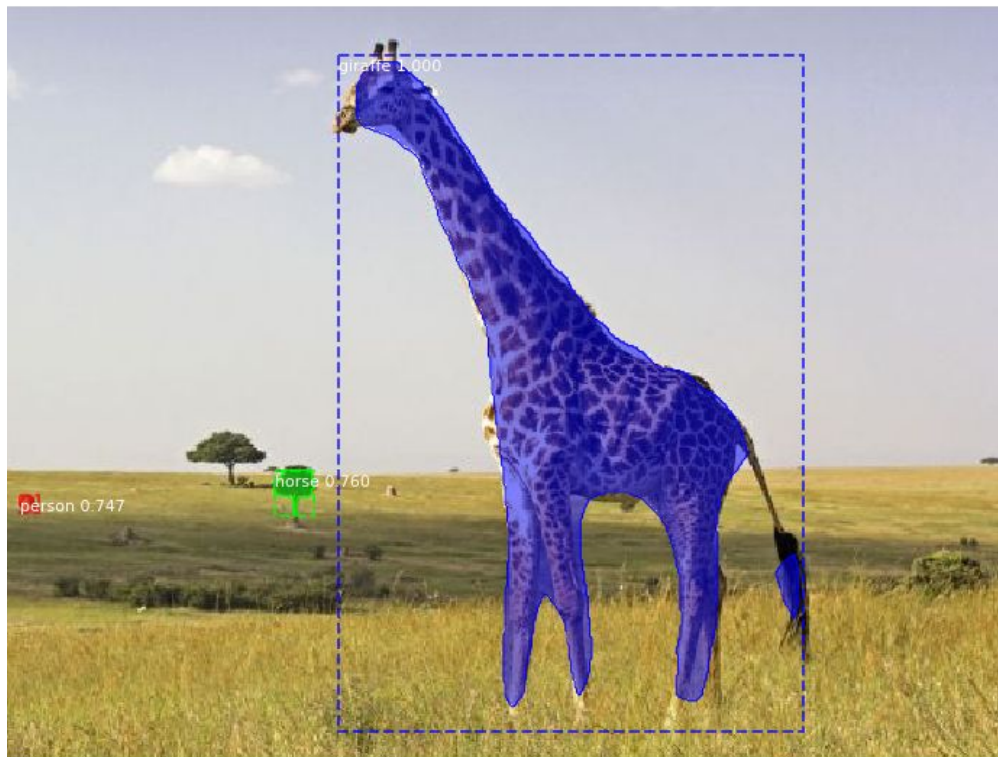
<https://arxiv.org/abs/1703.06870>

Mask R-CNN for Object Detection and Segmentation
(repositorio open-source de Matterplot)

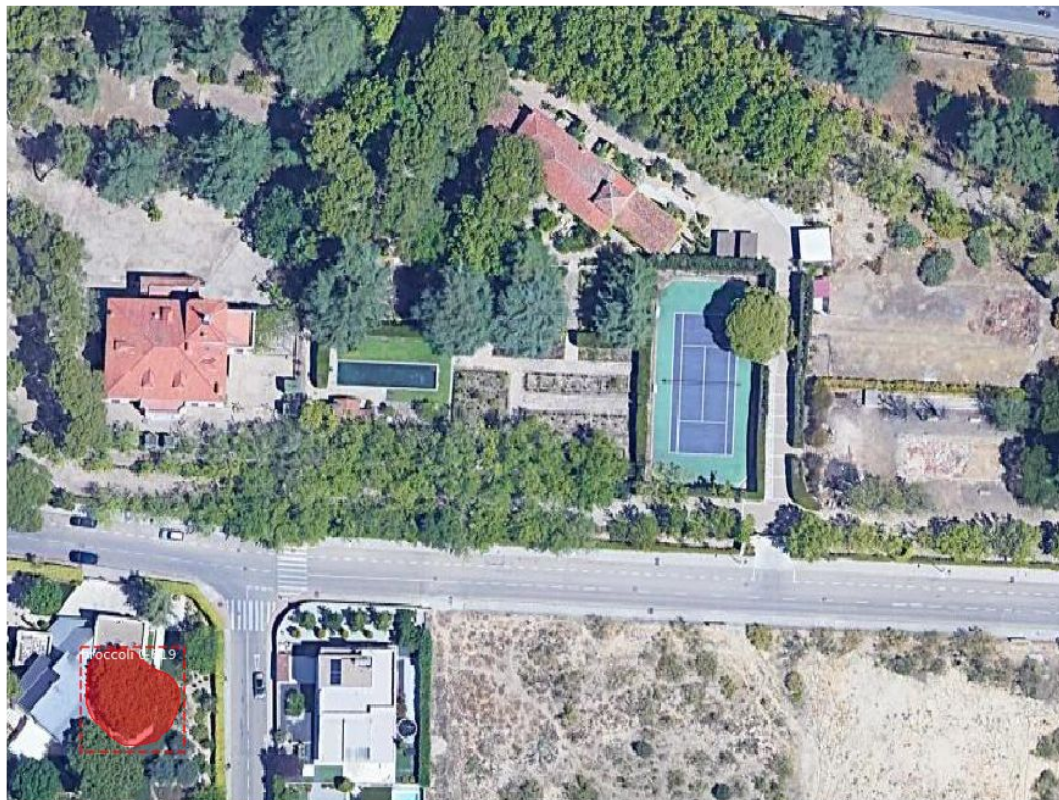
https://github.com/matterport/Mask_RCNN

Mask R-CNN

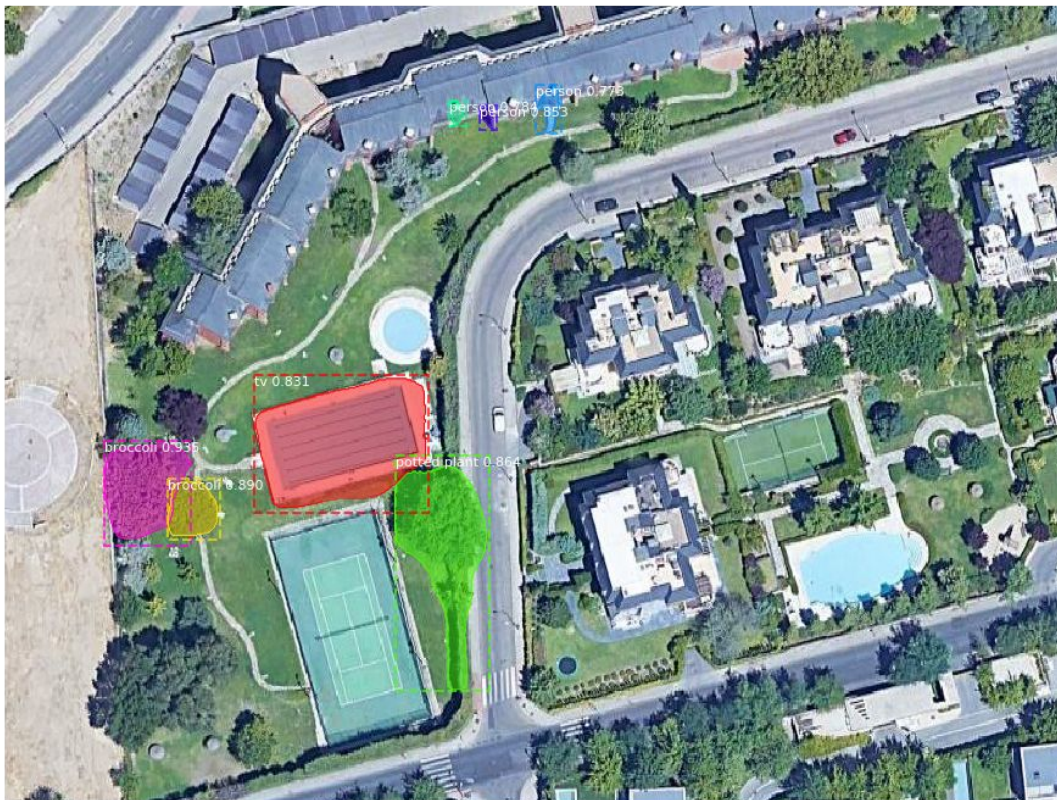
COCO Dataset Classes: ['BG', 'person', 'bicycle', 'car', 'motorcycle', 'airplane', 'bus', 'train', 'truck', 'boat', 'traffic light', 'fire hydrant', 'stop sign', 'parking meter', 'bench', 'bird', 'cat', 'dog', 'horse', 'sheep', 'cow', 'elephant', 'bear', 'zebra', 'giraffe', 'backpack', 'umbrella', 'handbag', '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']



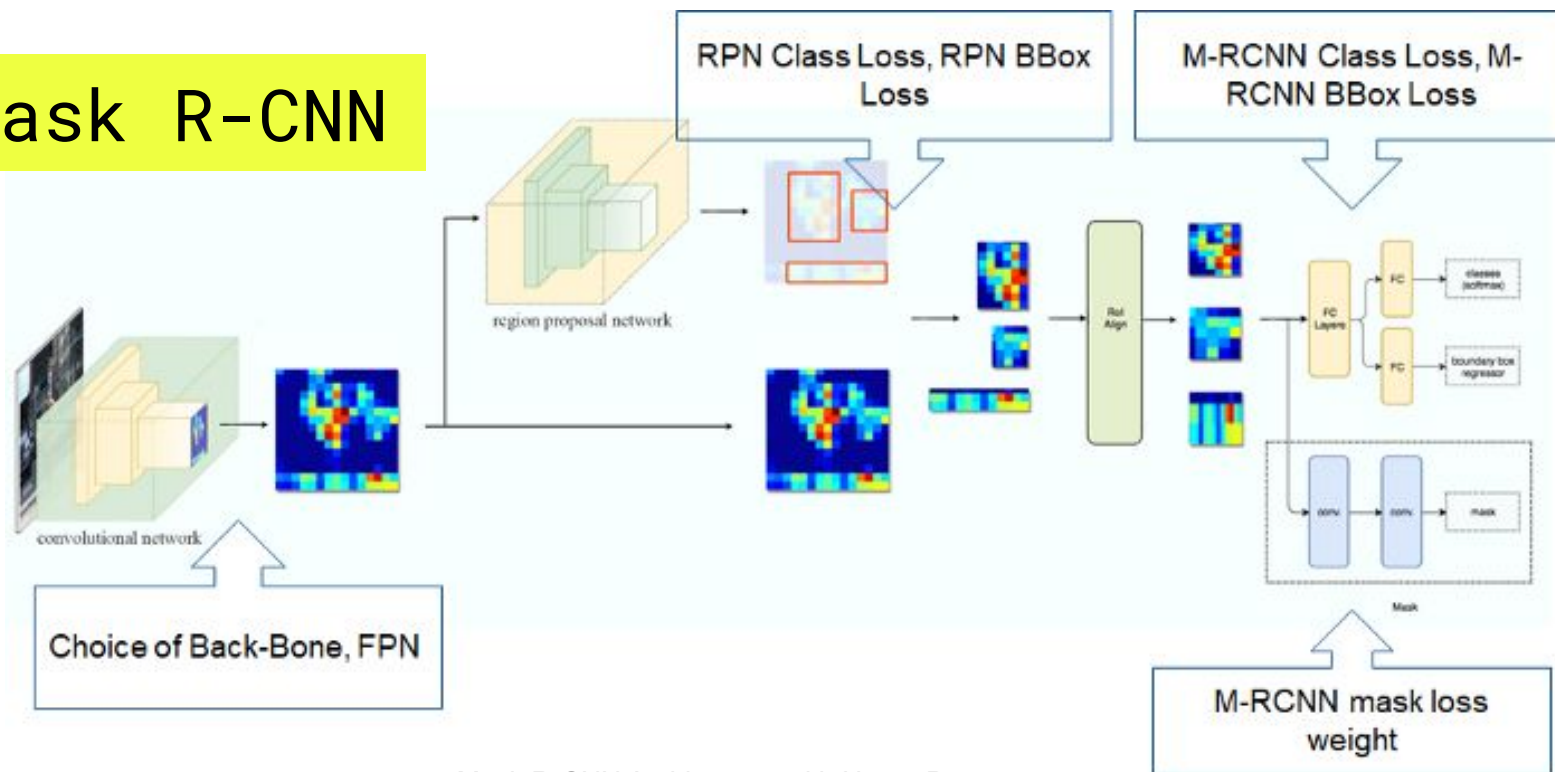
Mask R-CNN



Mask R-CNN

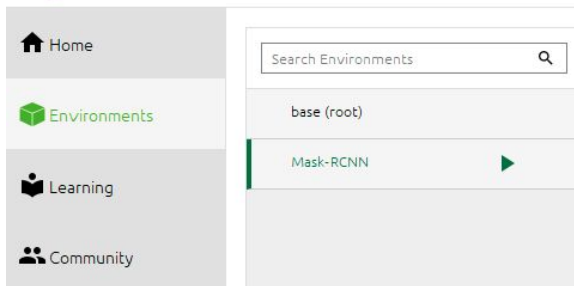


Mask R-CNN



Mask R-CNN Architecture with Hyper-Parameters

Mask R-CNN



Anaconda Prompt (anaconda3)

```
(base) C:\Users\casiopa>conda activate Mask-RCNN  
(Mask-RCNN) C:\Users\casiopa>
```

```
Rooftop_detection_COLAB_baseline.ipynb ☆  
Archivo Editar Ver Insertar Entorno de ejecución Herramientas Ayuda Guardado por última vez: 26 de septiemb  
+ Código + Texto  
▶ Ensure dependencies are compatible versions  
!pip uninstall keras-nightly  
!pip uninstall -y tensorflow  
  
%tensorflow_version 1.x  
!pip install tensorflow-gpu==1.14.0  
  
!wget https://developer.nvidia.com/compute/cuda/9.0/Prod/local_installers/cuda-repo-ubuntu1604  
!dpkg -i cuda-repo-ubuntu1604-9-0-local_9.0.176-1_amd64-deb  
!apt-key add /var/cuda-repo-9-0-local/7fa2af80.pub  
!apt-get update  
!apt-get install cuda-9.0.176-1  
!pip install keras==2.1.6  
!pip install h5py==2.10.0  
import tensorflow as tf  
print(tf.__version__)  
tf.test.gpu_device_name()  
  
⚠ WARNING: Skipping keras-nightly as it is not installed.  
⚠ WARNING: Skipping tensorflow as it is not installed.  
TensorFlow 1.x selected.  
Requirement already satisfied: tensorflow-gpu==1.14.0 in /usr/local/lib/python3.7/dist-packages  
Requirement already satisfied: astor>=0.6.0 in /usr/local/lib/python3.7/dist-packages (from ter  
Requirement already satisfied: protobuf>=3.6.1 in /usr/local/lib/python3.7/dist-packages (from  
Requirement already satisfied: numpy<2.0,>=1.14.5 in /usr/local/lib/python3.7/dist-packages (fr  
Requirement already satisfied: gast>=0.2.0 in /usr/local/lib/python3.7/dist-packages (from ten  
Requirement already satisfied: wheel>=0.26 in /usr/local/lib/python3.7/dist-packages (from ten  
Requirement already satisfied: tensorboard<1.15.0,>=1.14.0 in /usr/local/lib/python3.7/dist-pa  
Requirement already satisfied: grpcio>=1.8.6 in /usr/local/lib/python3.7/dist-packages (from t  
Requirement already satisfied: google-pasta>=0.1.6 in /usr/local/lib/python3.7/dist-packages (f  
Requirement already satisfied: keras-preprocessing>=1.0.5 in /usr/local/lib/python3.7/dist-pa  
Requirement already satisfied: six>=1.10.0 in /usr/local/lib/python3.7/dist-packages (from ten  
Requirement already satisfied: tensorflow-estimator<1.15.0rc0,>=1.14.0rc0 in /usr/local/lib/py  
Requirement already satisfied: termcolor>=1.1.0 in /usr/local/lib/python3.7/dist-packages (from  
Requirement already satisfied: wrapt>=1.11.1 in /usr/local/lib/python3.7/dist-packages (from t  
Requirement already satisfied: absl-py>=0.7.0 in /usr/local/lib/python3.7/dist-packages (from  
Requirement already satisfied: keras-applications>=1.0.6 in /usr/local/lib/python3.7/dist-packa  
Requirement already satisfied: h5py in /usr/local/lib/python3.7/dist-packages (from keras-appl  
Requirement already satisfied: setuptools>=41.0.0 in /usr/local/lib/python3.7/dist-packages (fr  
Requirement already satisfied: werkzeug>=0.11.15 in /usr/local/lib/python3.7/dist-packages (fr  
Requirement already satisfied: markdown>=2.6.8 in /usr/local/lib/python3.7/dist-packages (from  
Requirement already satisfied: importlib-metadata in /usr/local/lib/python3.7/dist-packages (fr  
Requirement already satisfied: zipp>=0.5 in /usr/local/lib/python3.7/dist-packages (from import  
Requirement already satisfied: typing-extensions>=3.6.4 in /usr/local/lib/python3.7/dist-packa  
--2021-09-26 20:56:04-- https://developer.nvidia.com/compute/cuda/9.0/Prod/local_installers/c
```

1. Backbone

2. RPN

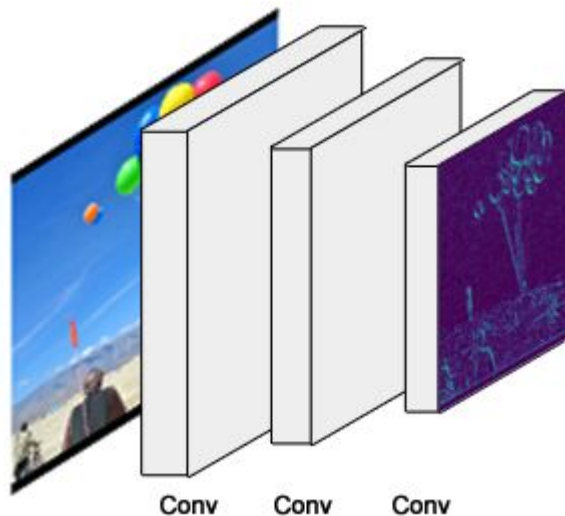
3. ROI-Clf/BB-Regr

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()`



1.Backbone

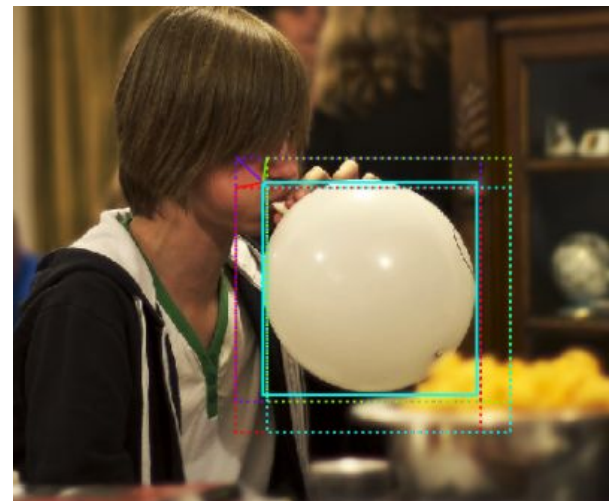
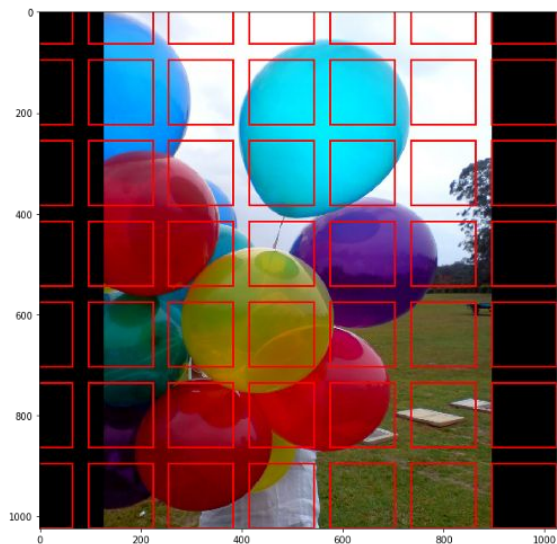
2.RPN

3.ROI-Clf/BB-Regr

4.Segmentation

Region Proposal Network (RPN)

`model.rpn_graph()`



1.Backbone

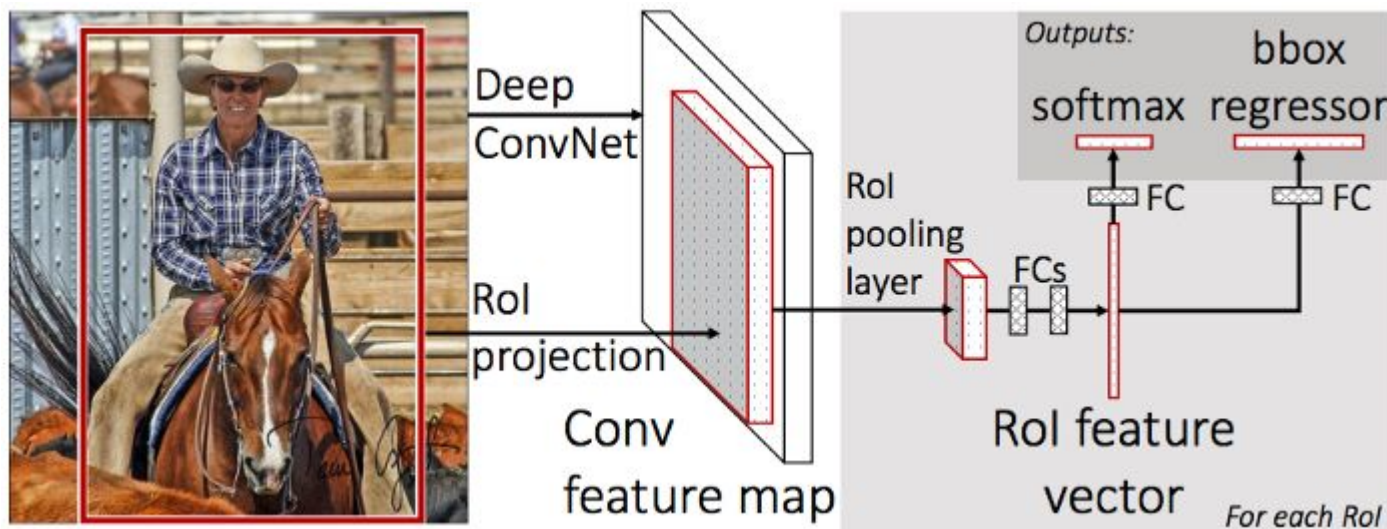
2.RPN

3.ROI-Clf/BB-Regr

4.Segmentation

ROI Classifier & Bounding Box Regressor

```
model.fpn_classifier_graph()
```



1.Backbone

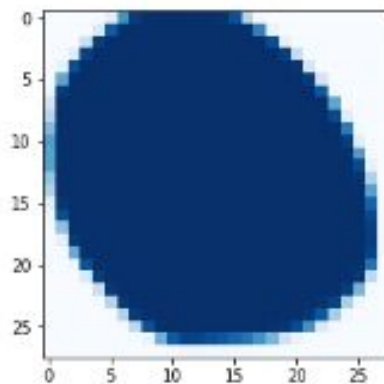
2.RPN

3.ROI-Clf/BB-Regr

4.Segmentation

Segmentation Masks

```
model.build_fpn_mask_graph()
```



28x28 Soft Mask



Resized Binary Mask

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

1. Imágenes

2. Annotations

Map Puzzle

The screenshot shows the 'Map Puzzle v1.6.7' application window. It has three tabs: 'Map Settings', 'Bulk Download', and 'General Application Settings'. The 'Map Settings' tab is active and contains the following sections:

- GPS Coordinate**
 - Decimal (Required)**: Latitude is 40.2820384, Longitude is -3.8081789.
 - Degrees, Minutes, and Seconds**: Latitude is 40° 19' 7" N, Longitude is 3° 39' 19" W.
 - Address**: An empty text field with a 'Search' button.
 - Buttons**: 'Enter Point to Point Coords' and 'Add To Bulk'.
- Base (Required)**: A dropdown menu set to 'Google Maps - Satellite'.
- Alternative Base (Optional)**: A dropdown menu set to 'Do not use'.
- Overlay (Optional)**: A dropdown menu set to 'Do not use'.

The 'Image Settings' section at the bottom contains:

- Zoom**: A slider set to 19.
- Preset**: A dropdown menu set to 'Custom'.
- Pixels / Inch**: A slider set to 300.
- Landscape**: An unchecked checkbox.
- Width**: A slider set to 800, with a note 'Pixels = 182 Meter'.
- Height**: A slider set to 600, with a note 'Pixels = 137 Meter'.

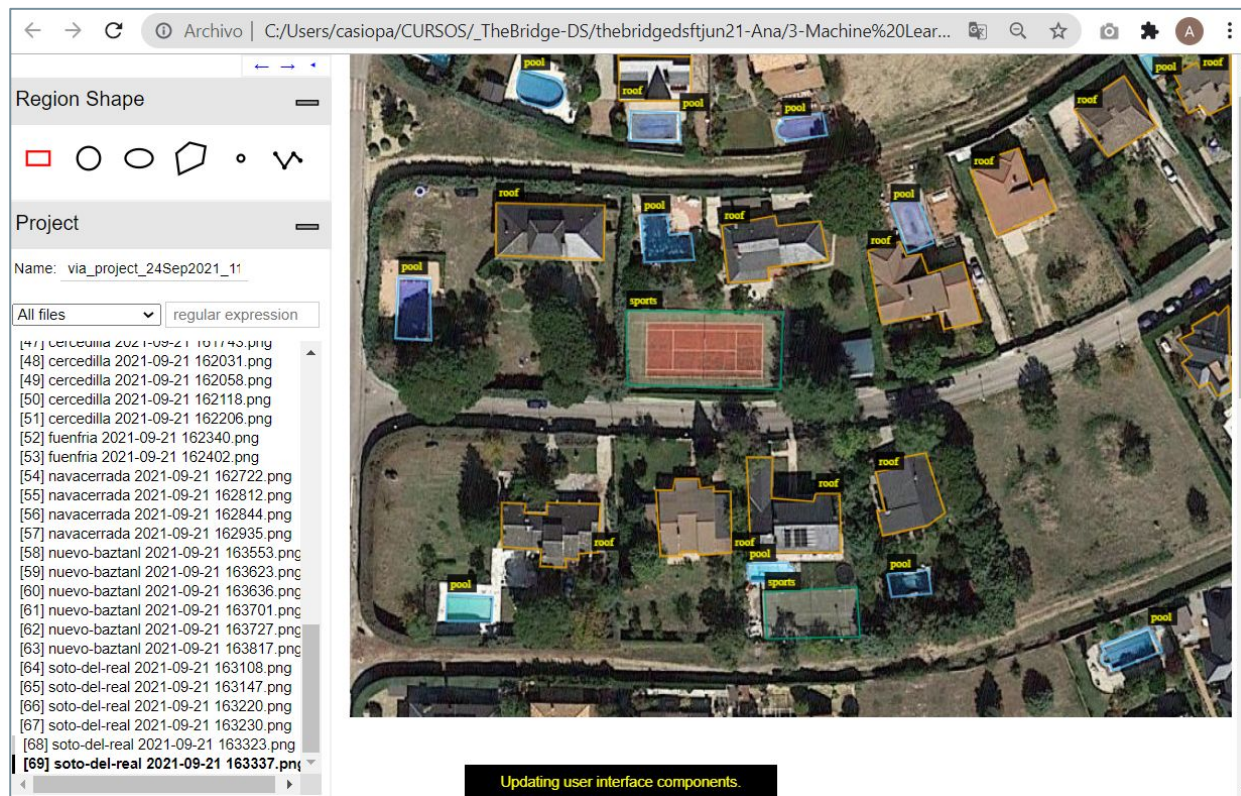
The 'Addons' section on the right includes:

- Image Addons:** An unchecked checkbox with a 'Settings' button.
- Save Each Tile In Separate File**: An unchecked checkbox.
- Generate world file**: An unchecked checkbox.
- UTM**: A radio button that is selected.

1. Imágenes

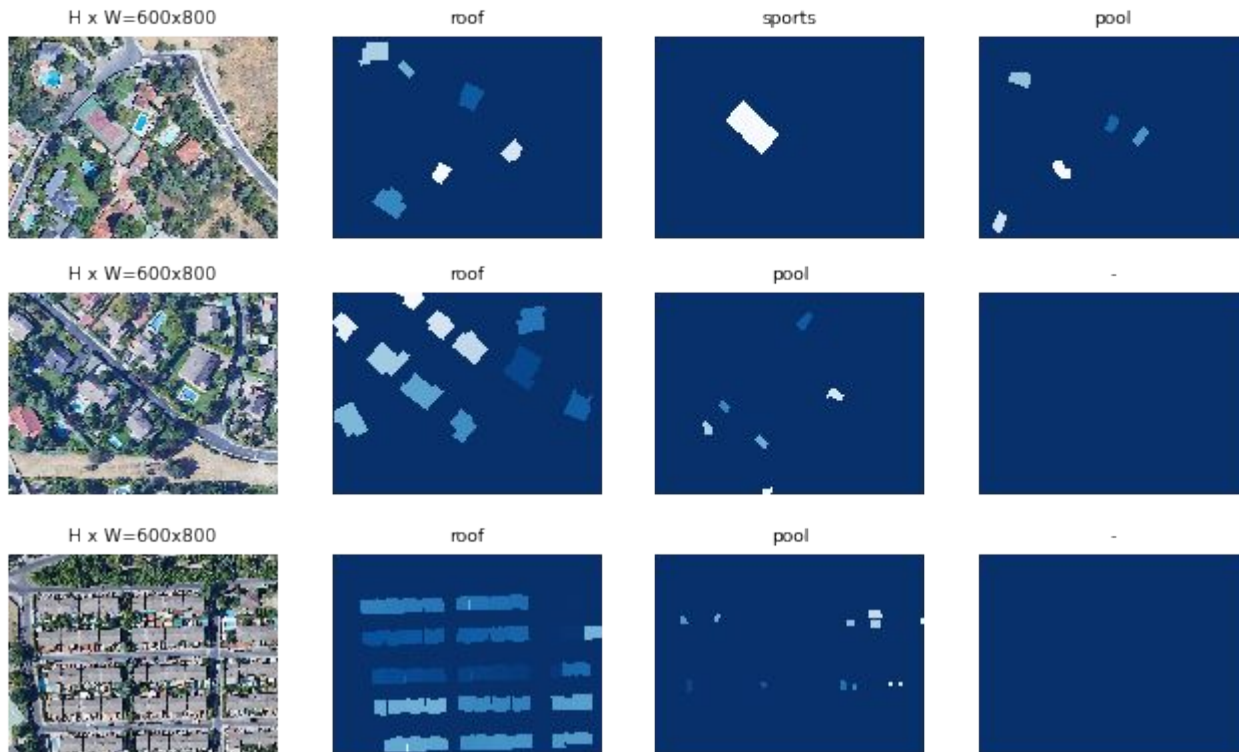
2. Annotations

VGG Image Annotator (VIA)



1. Imágenes

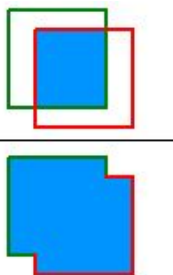
2. Annotations

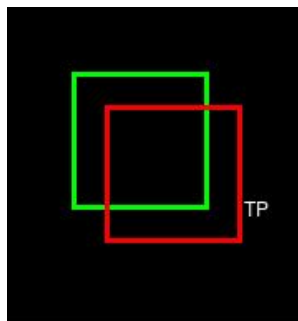


1.AP

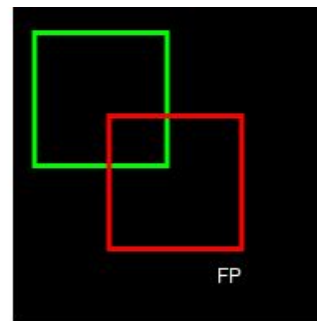
2.mAP

Intersect over Union (IoU)

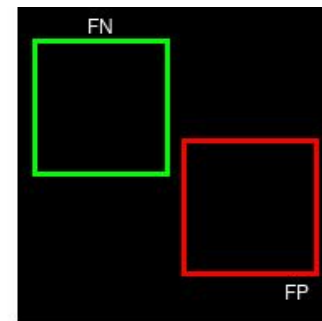
$$IOU = \frac{\text{area of overlap}}{\text{area of union}} = \frac{\text{area of intersection}}{\text{area of union}}$$




IoU = 0.86



IoU = 0.24



IoU = 0

1.AP

2.mAP

Precision/Recall

		Predicted		
		P	N	
Actual	P	TP	FN	Recall
	N	FP	TN	
		Precision		

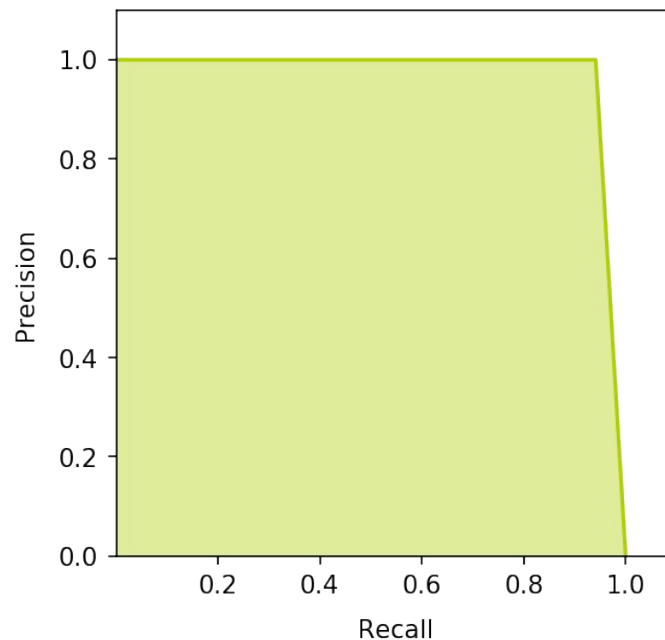
1.AP

2.mAP

Área bajo la curva
Precision/Recall
AUC-PR

Average Precision
AP

Precision-Recall Curve. $AP@50 = 0.941$



1.AP

2.mAP

Mean Average Precision
Formula

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

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%: Flip1r(0.5)
Blur [1, 5]

Train mAP@50: 0.562

Val mAP@50: 0.469

Test_set prediction image

Madrid Rooftop Image Segmentation project

1.Edificios

2.Casas



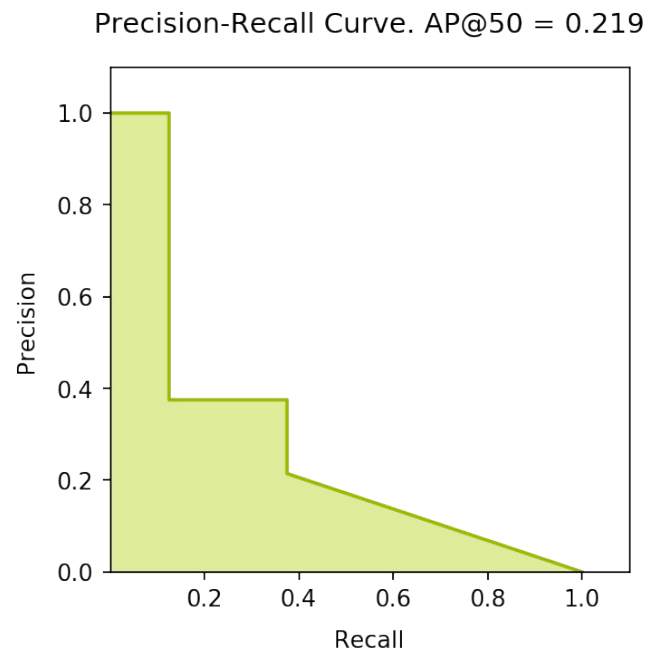
pozuelo 2021-09-13 200628.png

Predicted

roof (1.00)	0.000	0.000	0.579 match	0.000	0.000	0.000	0.000	0.000
roof (1.00)	0.000	0.000	0.000	0.000	0.000	0.400	0.000	0.000
roof (1.00)	0.000	0.000	0.283	0.000	0.000	0.000	0.000	0.000
roof (1.00)	0.000	0.000	0.000	0.000	0.000	0.457	0.000	0.000
roof (1.00)	0.000	0.000	0.295	0.000	0.000	0.000	0.000	0.000
roof (1.00)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.629 match
roof (1.00)	0.000	0.000	0.000	0.330	0.000	0.000	0.000	0.000
roof (1.00)	0.000	0.000	0.000	0.000	0.000	0.000	0.912 match	0.000
roof (1.00)	0.000	0.000	0.000	0.256	0.000	0.000	0.000	0.000
roof (0.97)	0.000	0.000	0.000	0.389	0.000	0.000	0.000	0.000
roof (0.93)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
roof (0.92)	0.000	0.000	0.000	0.000	0.308	0.000	0.000	0.000
roof (0.89)	0.000	0.736 wrong	0.000	0.000	0.000	0.000	0.000	0.000
roof (0.80)	0.000	0.000	0.163	0.000	0.000	0.000	0.000	0.000
pool								
sports								
roof								
roof								
roof								
roof								
roof								
roof								

Actual

2.Casas



Test_set prediction image

Madrid Rooftop Image Segmentation project

1.Edificios

2.Casas

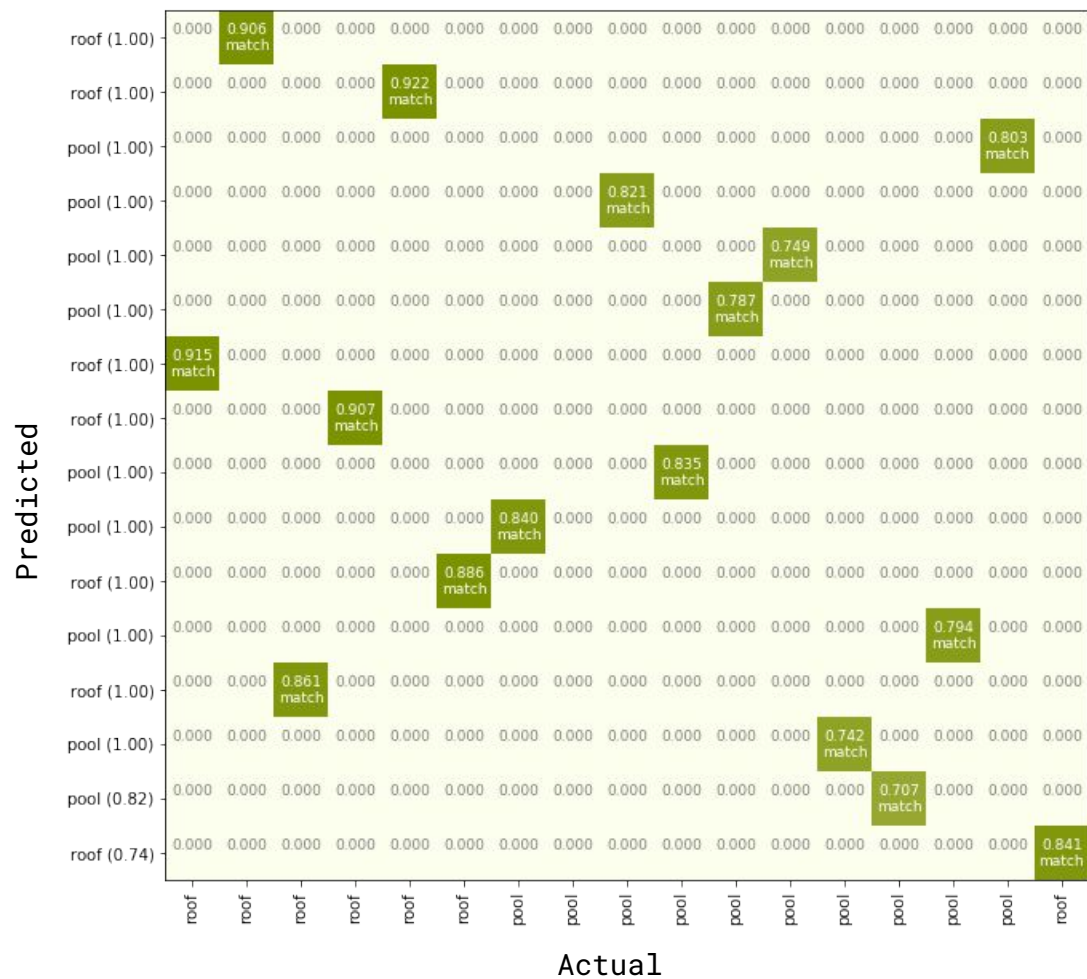


somosaguas 2021-09-13 194952.png

Predicted

roof (1.00)	0.000	0.906 match	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
roof (1.00)	0.000	0.000	0.000	0.000	0.922 match	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
pool (1.00)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.803 match	0.000
pool (1.00)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.821 match	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
pool (1.00)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.749 match	0.000	0.000	0.000	0.000	0.000	0.000	0.000
pool (1.00)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.787 match	0.000	0.000	0.000	0.000	0.000	0.000	0.000
roof (1.00)	0.915 match	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
roof (1.00)	0.000	0.000	0.000	0.000	0.907 match	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
pool (1.00)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.835 match	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
pool (1.00)	0.000	0.000	0.000	0.000	0.000	0.000	0.840 match	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
roof (1.00)	0.000	0.000	0.000	0.000	0.000	0.886 match	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
pool (1.00)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.794 match	0.000	0.000
roof (1.00)	0.000	0.000	0.881 match	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
pool (1.00)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.742 match	0.000	0.000	0.000	0.000	0.000	0.000
pool (0.82)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.707 match	0.000	0.000	0.000
roof (0.74)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.841 match	0.000
	roof	roof	roof	roof	roof	roof	pool	pool	pool	pool	pool	pool	pool	pool	pool	pool	pool	pool	roof

Actual



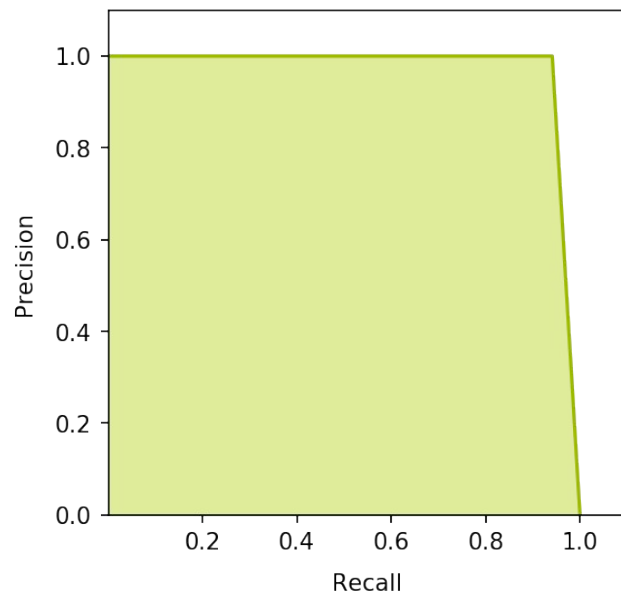
1.Edificios

2.Casas



somosaguas 2021-09-13 194952.png

Precision-Recall Curve. $AP@50 = 0.941$



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