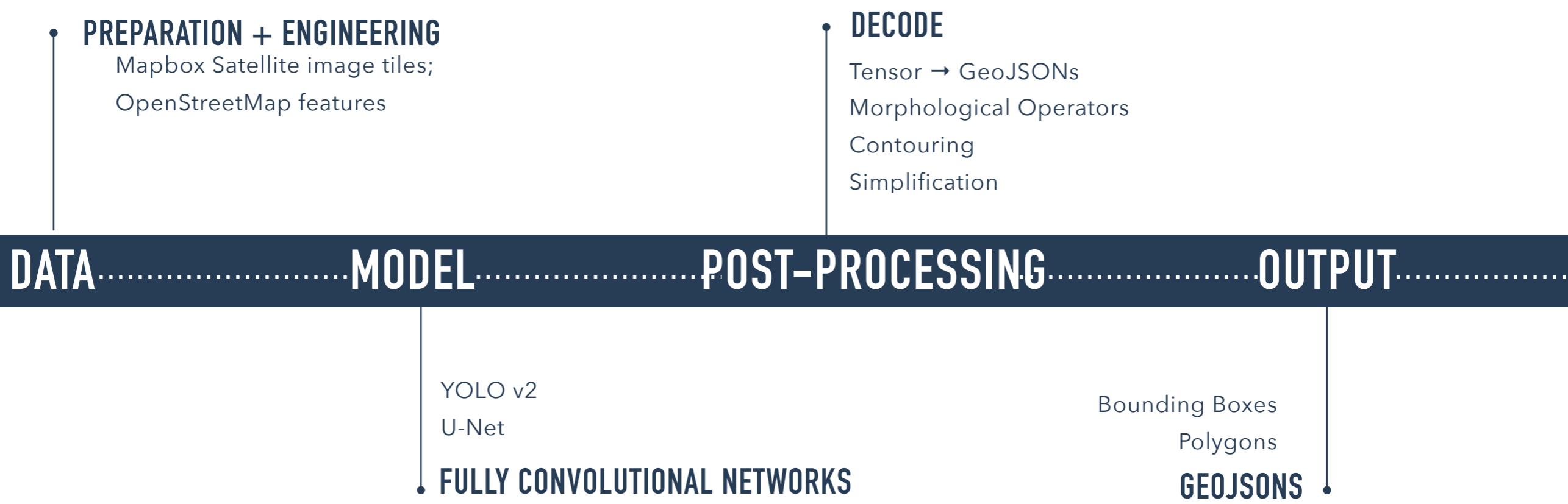


The background of the image is a composite of various aerial and satellite photographs. It includes a top-down view of a city street with cars, a large industrial facility with tall smokestacks, a residential area with houses and trees, and a globe showing the outlines of continents. There are also small icons of a satellite in space and an airplane flying.

Scalable Computer Vision w/  
**Aerial & Satellite Imagery**





## DESIGNED WITH OPEN-SOURCE TOOLS

- Training data compiled from OpenStreetMap (labels) and [Mapbox Maps API](#) (image tiles from [mapbox.satellite](#))
- Designed our processing pipelines and tools with open-source libraries like SciPy, [Rasterio](#), [Fiona](#), Keras, PyTorch, OpenCV, [Osmium](#), [JOSM](#).

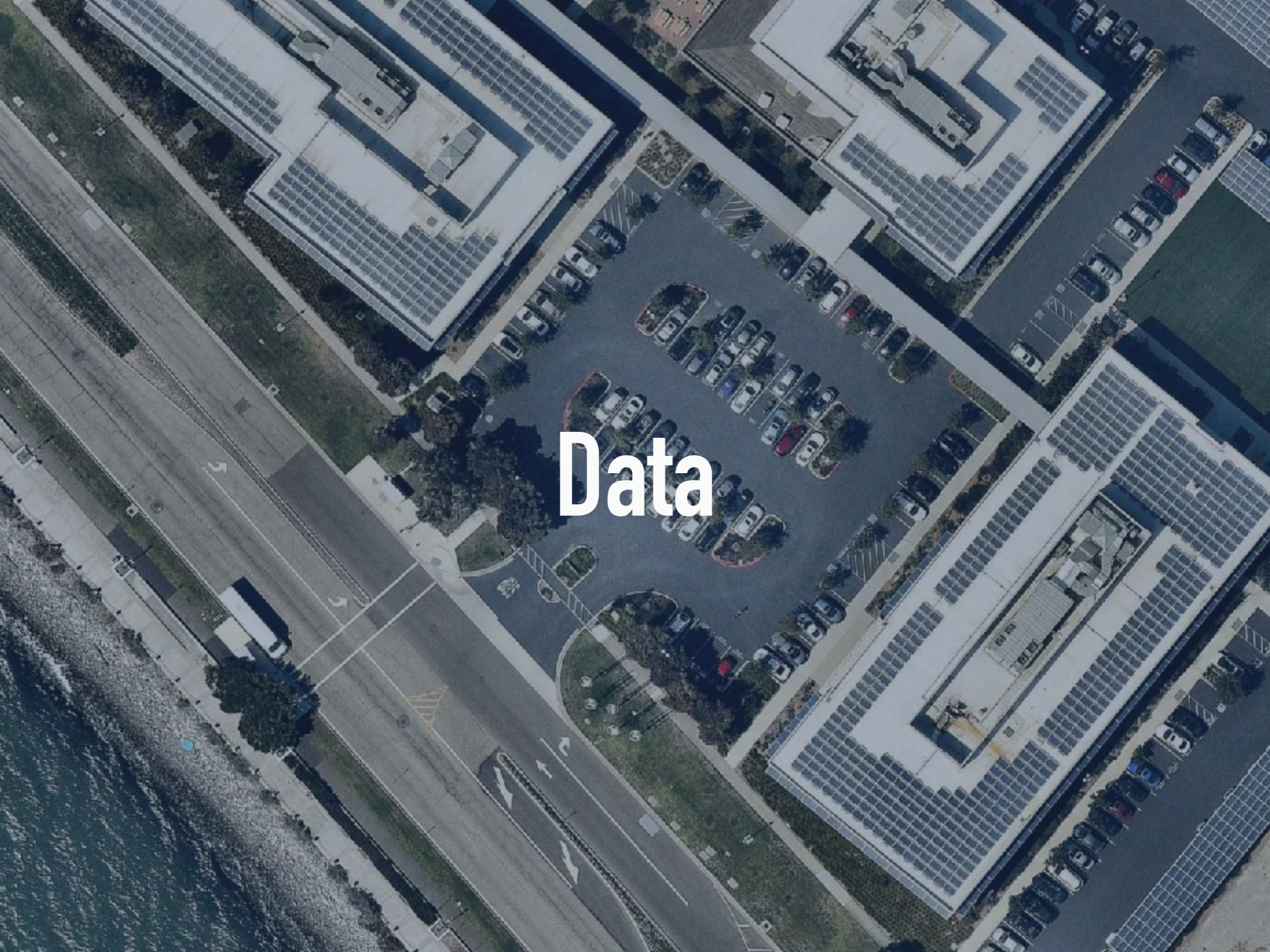


P Y T R C H



TensorFlow



An aerial photograph of a large industrial or commercial complex. The image shows several large buildings with white and grey facades, many of which have extensive solar panel arrays installed on their roofs. There are multiple parking lots filled with various vehicles, including cars and trucks. The surrounding area includes some green spaces and other industrial structures. The overall scene is a mix of urban development and renewable energy infrastructure.

Data

## DATA PREPARATION – OBJECT DETECTION

- ⦿ Where are the turn lane markings?
- ⦿ What are the most common turn lane markings?

▶ [OpenStreetMap tags](#)

turn:lane=\*

turn:lane:forward=\*

turn:lane:backward=\*



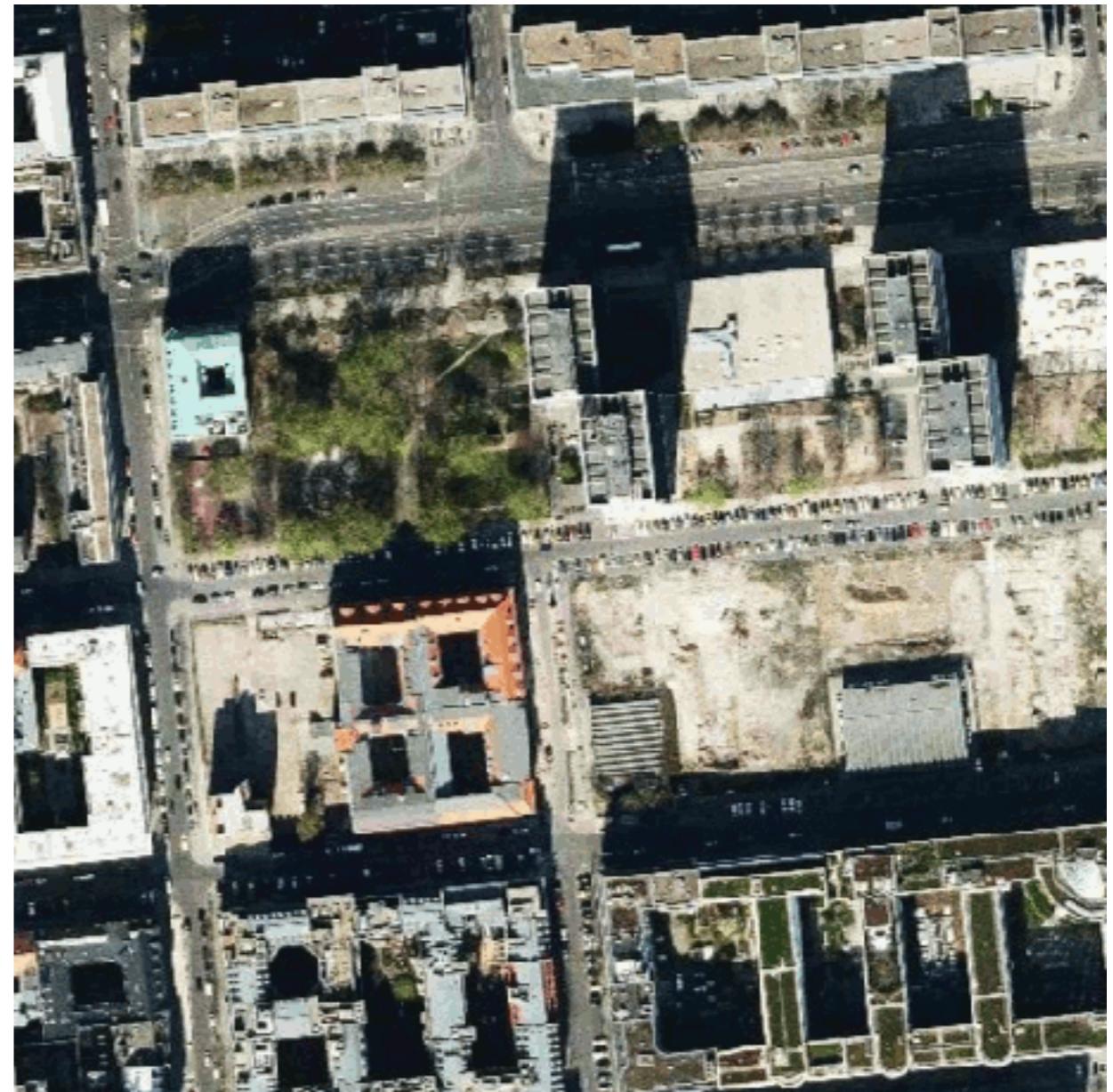
## DATA PREPARATION – SEMANTIC SEGMENTATION

- Generate polygons from OpenStreetMap tags

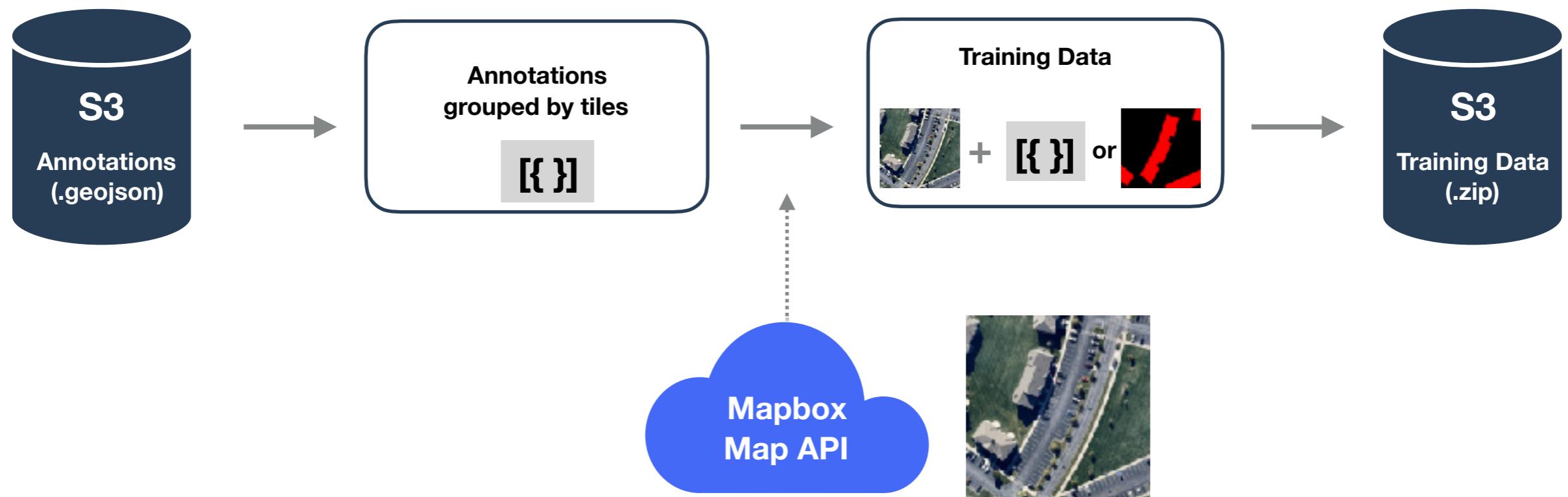
```
amenity=parking=*
```

```
building=*
```

- Exclude ones that are not visible in satellite imagery.



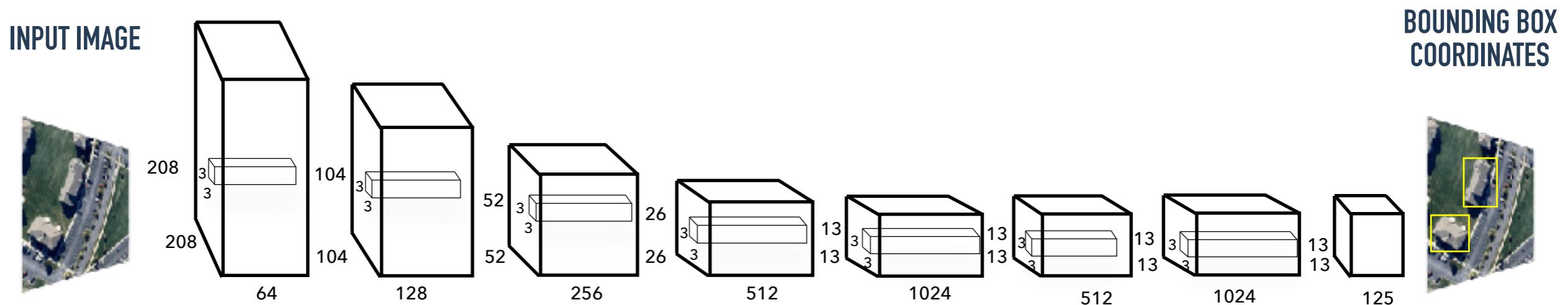
# DATA ENGINEERING



An aerial photograph of a city street scene. In the foreground, there's a large, dark green tree on the left and a building with a red roof on the right. A road with white dashed lines runs through the center. In the background, there are more buildings, trees, and a small park area with a circular path.

Model

# OBJECT DETECTION MODELS



- Full convolutional neural network (example above) jointly trains classification and detection.
- YOLOv2 (speed vs. accuracy)
  - Classification model Darknet-19 pre-trained on ImageNet (224 x224), fine tuned to (448x 448)
  - Detection: modify Darknet-19
  - Batch normalization, dimension clusters

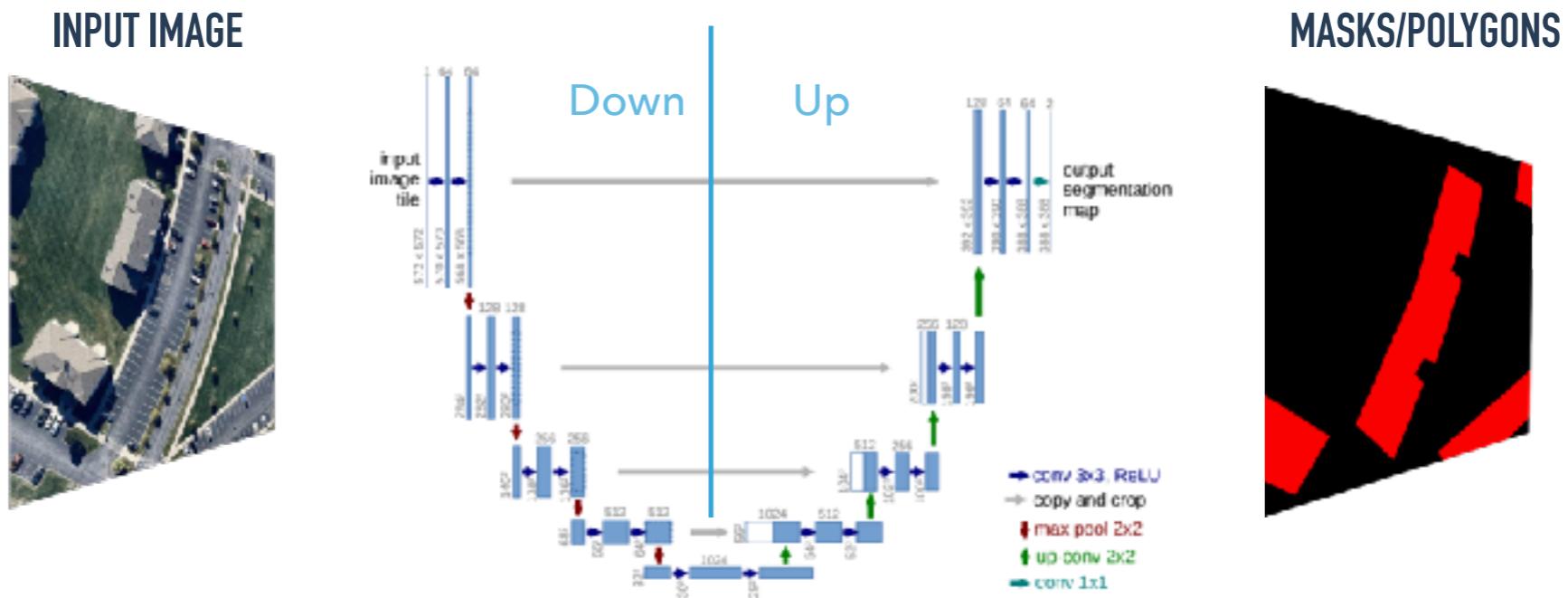


**MODEL  
CONVNETS**

**POST-PROCESSING**  
DECODE + SIMPLIFY

**OUTPUT**  
GEOJSONS

# SEGMENTATION MODELS



- ⦿ **U-Net** : Parking Lots vs. Background (Binary)
- ⦿ **PSPNet** : Parking Lots vs. Buildings vs. Roads etc (Multi-class)

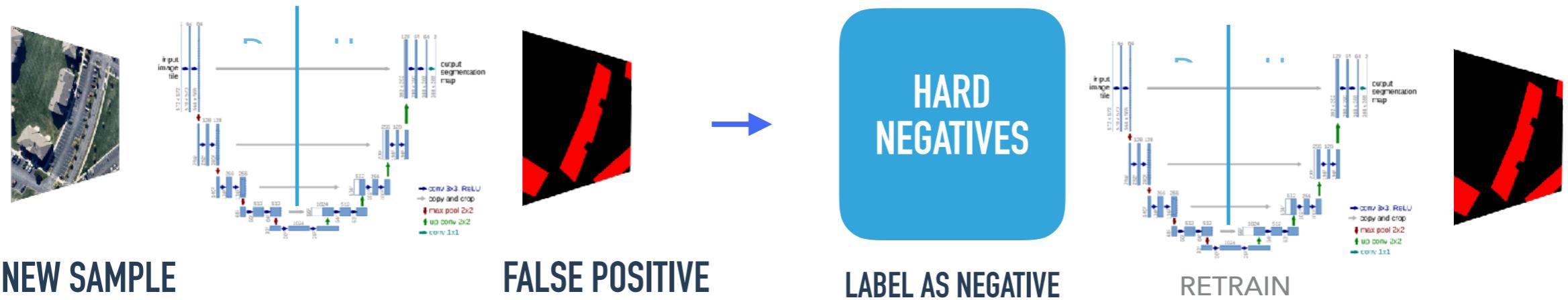


MODEL  
CONVNETS

POST-PROCESSING  
DECODE + SIMPLIFY

OUTPUT  
GEOJSONS

# HARDING NEGATIVE MINING



- ➊ A technique used to improve model performance
- ➋ Explicitly create a negative sample out of a falsely detected patch, and add that negative to your training set and retrain.



MODEL  
CONVNETS

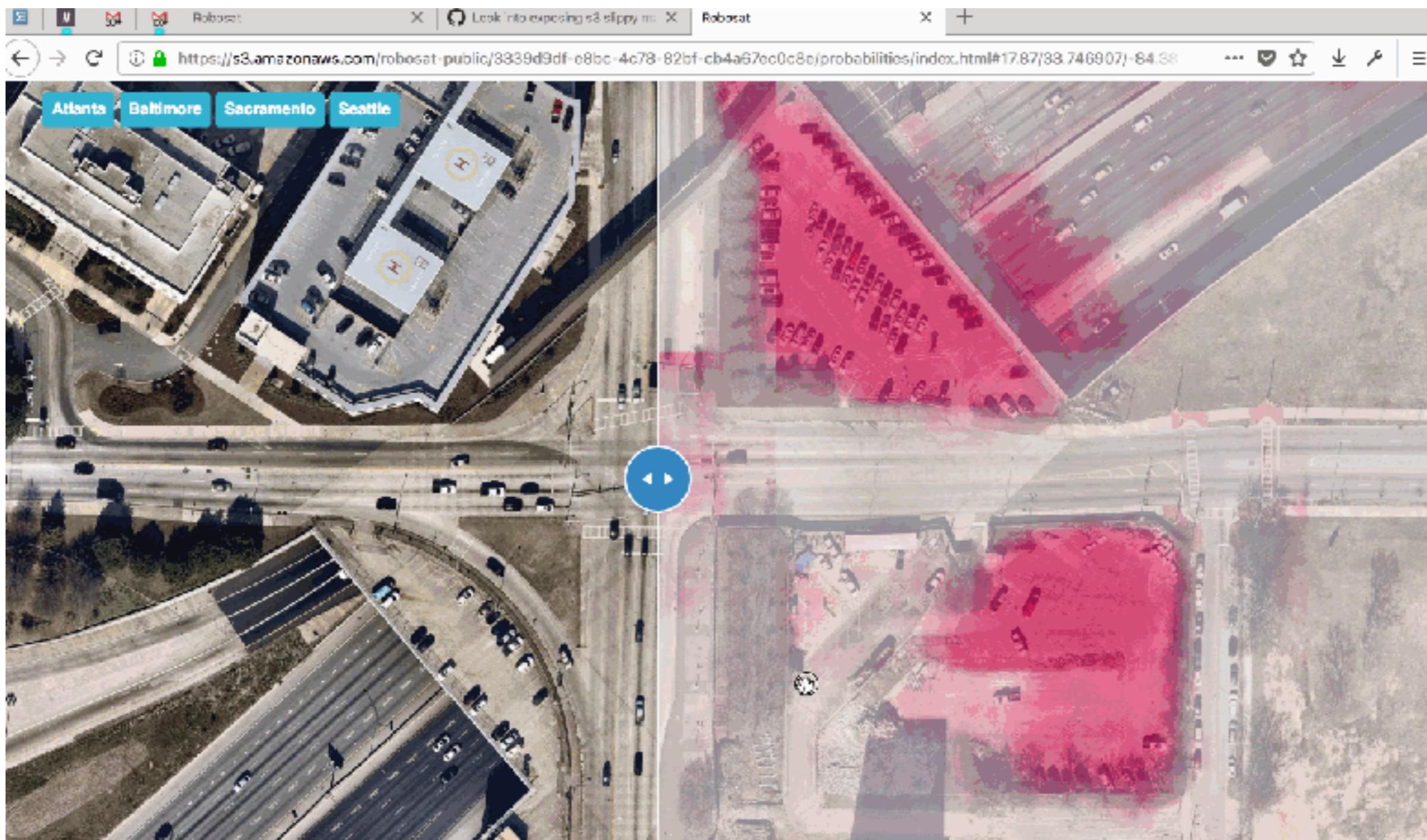
POST-PROCESSING  
DECODE + SIMPLIFY

OUTPUT  
GEOJSONS

# VISUALIZE OUTPUT (TURN LANE MARKING DETECTION)

The image shows a satellite view of a city area with a large roundabout in the center. Overlaid on the map are red and white polygons, which represent the detected turn lane markings. The interface includes a sidebar with settings for 'Model' (set to 'convnets'), 'Max Depth' (set to 5), 'Max Zoom' (set to 17), 'Map ID' (set to 'mapbox.satellite'), and a 'Run' button. Below the map, there are 'Labels' set to 'AI' and a 'Threshold: 0.5' slider.

# VISUALIZE OUTPUT (PARKING LOT SEGMENTATION)



 DATA  
PREP + ENG

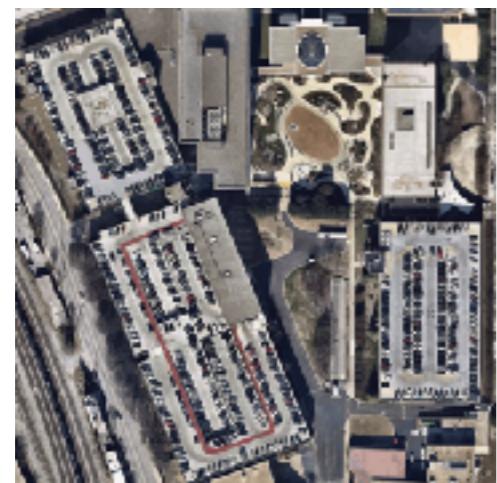
MODEL  
CONVNETS

POST-PROCESSING  
DECODE + SIMPLIFY

OUTPUT  
GEOJSONS

The background of the image is a high-resolution aerial photograph of a dense urban area. A prominent feature is a large stadium or arena under construction in the center-right portion of the frame. The stadium's distinctive white retractable roof and its surrounding construction cranes are clearly visible. The surrounding cityscape includes numerous buildings of varying heights, roads with vehicle traffic, and several other landmarks like a red-roofed structure and a green dome. The overall scene is a mix of industrial activity and urban development.

# Post-Processing



ORIGINAL IMAGE



PROBABILITY MASK



NOISE REMOVAL + CONTOURING



SIMPLIFY



REMOVE TILE BORDER ARTIFACTS



MERGE ADJACENT POLYGONS

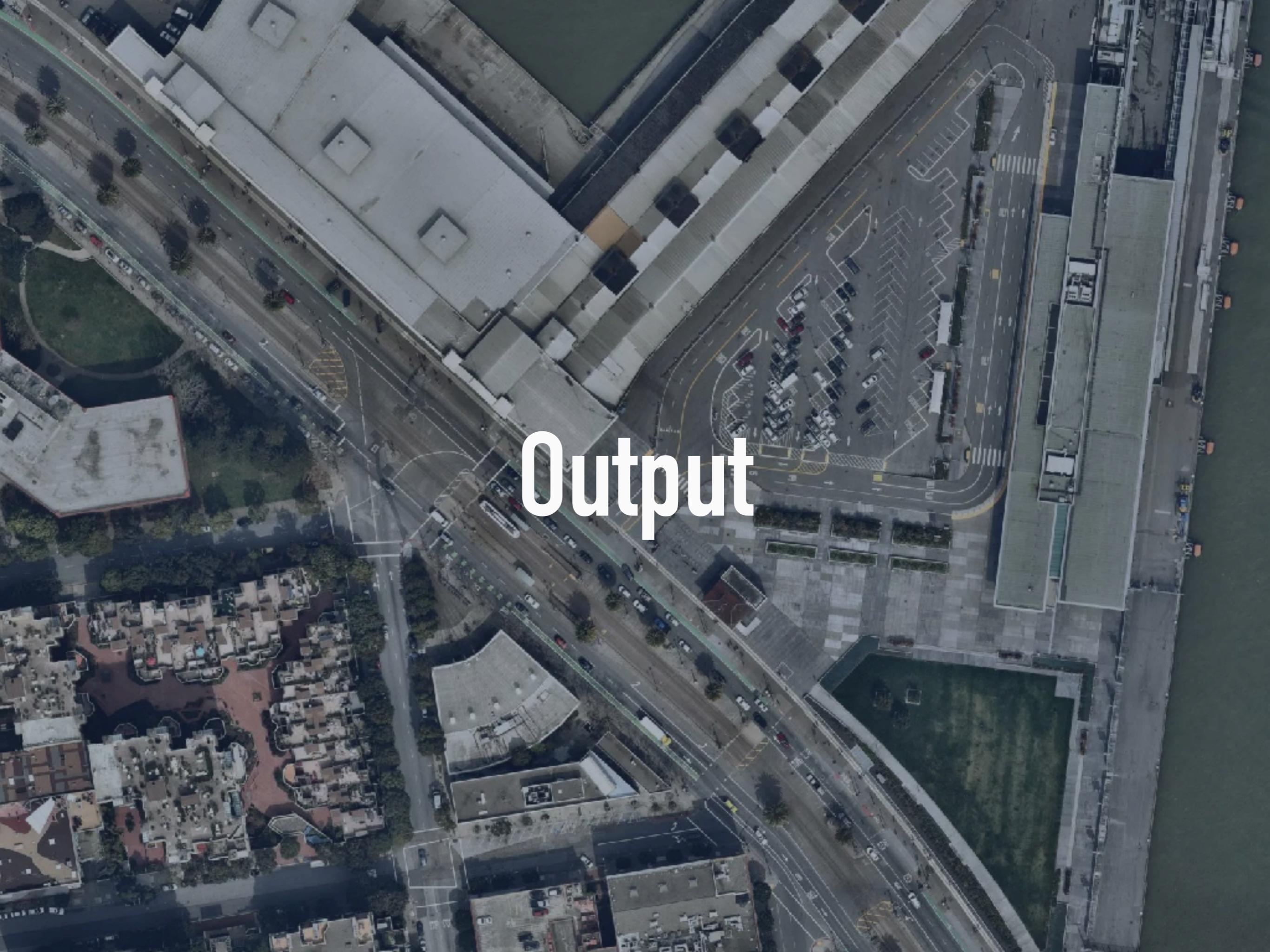
DATA  
PREP + ENG

MODEL  
CONVNETS



POST-PROCESSING  
DECODE + SIMPLIFY

OUTPUT  
GEOJSONS

An aerial photograph of a coastal city. The image shows a multi-lane highway running along the top edge, with several cars visible. Below the highway are several large, light-colored industrial or warehouse buildings with flat roofs. To the right of these buildings is a large parking lot filled with cars. Further down the image, there are more buildings, including some with red roofs and some with green roofs. A small body of water is visible on the far right. The overall scene is a mix of urban and industrial development.

Output

## TURN LANE MARKINGS DETECTION

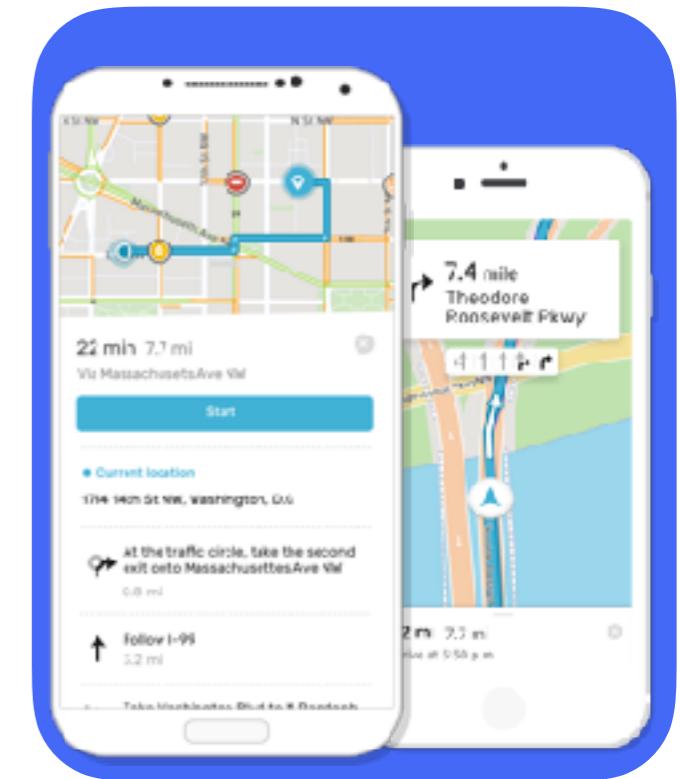
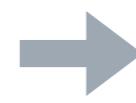


turn:lane=left|through|right

turn:lane:forward=left|through;right

turn:lane:backward=left|through;right

OpenStreetMap Tags

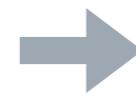


## PARKING LOT SEGMENTATION



amenity=parking=\*

building=\*



DATA  
PREP + ENG

MODEL  
CONVNETS

POST-PROCESSING  
DECODE + SIMPLIFY



OUTPUT  
GEOJSONS

## ONGOING WORK

- ➊ Turn lane Marking Detection:

- ➌ Open source dataset, consisting of 54,000 annotated turn lane markings from New York City, Washington D.C., Denver, Philadelphia, and Tampa.

- ➋ Parking Lot Segmentation:

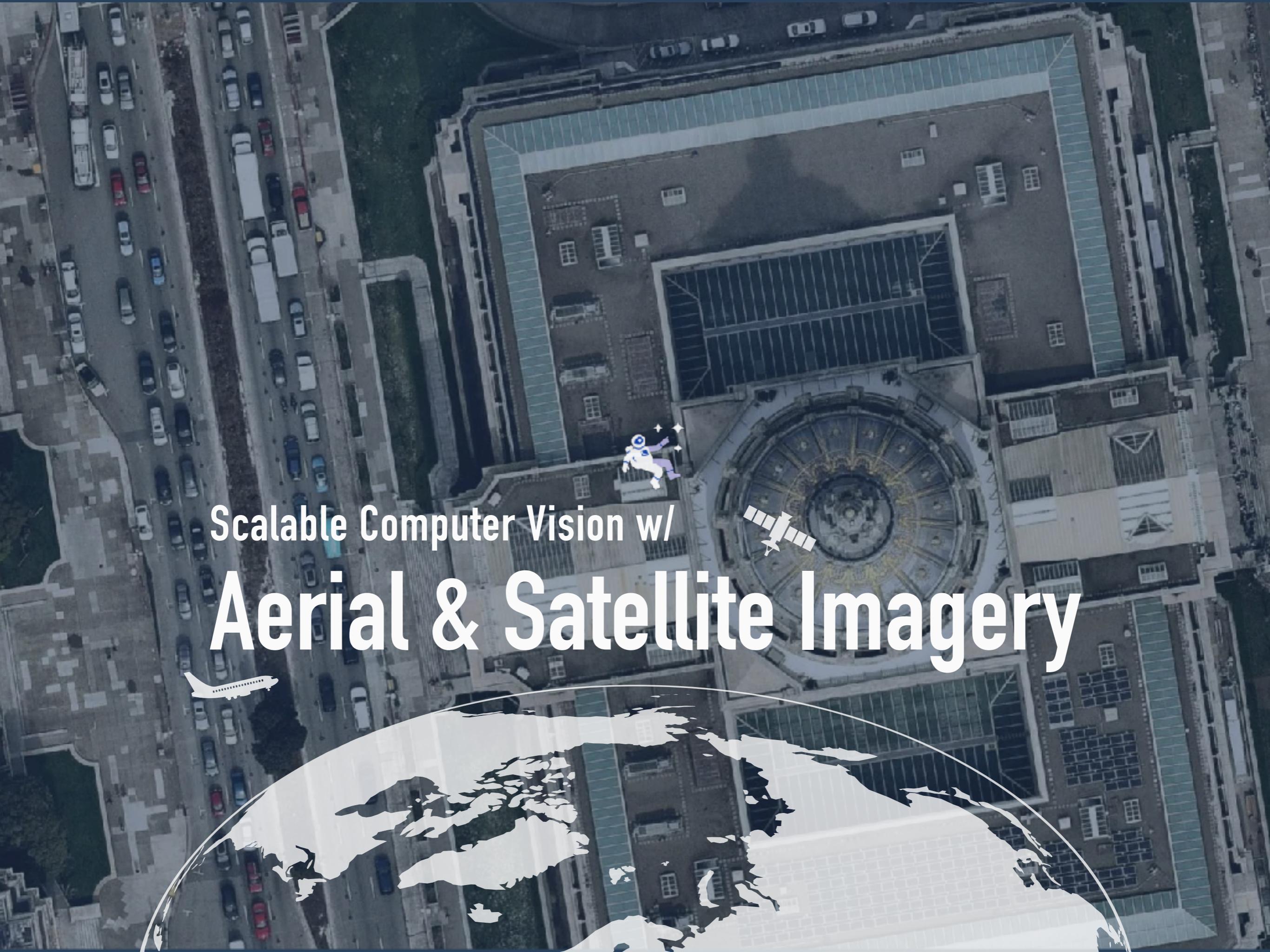
- ➌ Open source tools and pipeline <https://github.com/mapbox/robosat>
  - ➌ Model improvements

DATA  
PREP + ENG

MODEL  
CONVNETS

POST-PROCESSING  
DECODE + SIMPLIFY

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GEOJSONS



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