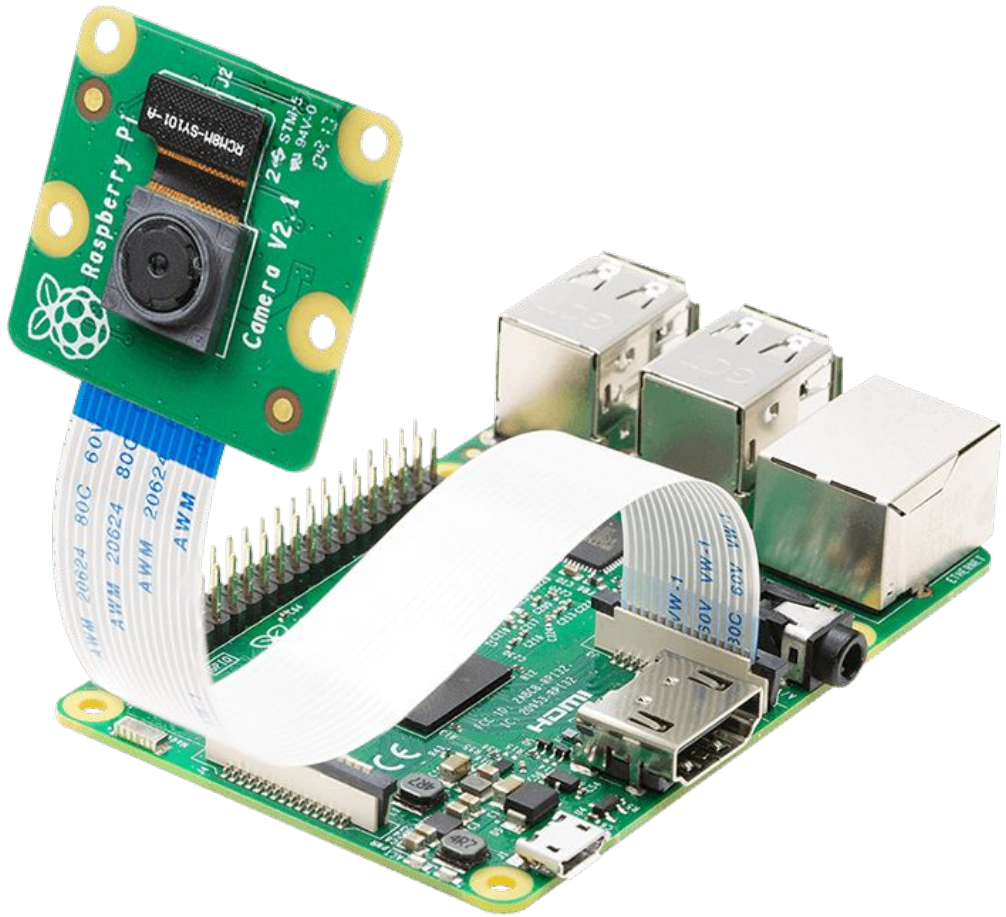
IESTI01 – TinyML

Embedded Machine Learning



16. a EdgeML with TensorFlow Lite

Image Classification & Object Detection Demo

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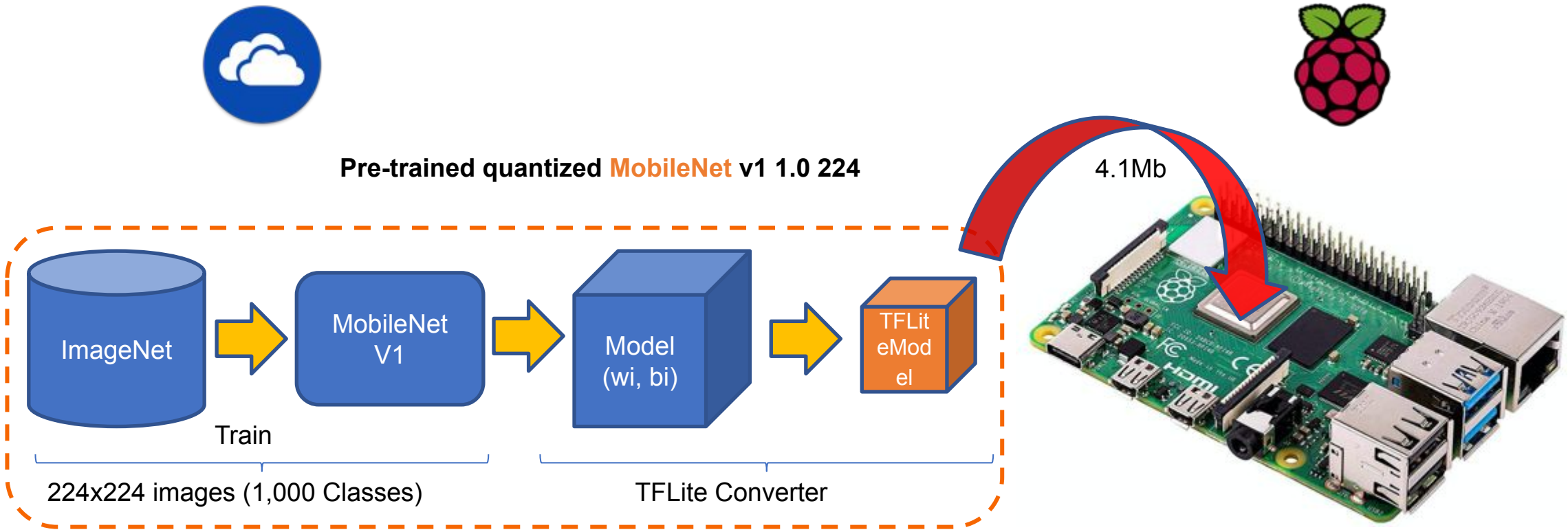
UNIFEI

Image Classification & Object Detection Live DEMO

Demo 1 – Image Classification



TF Lite Inference – Image Classification

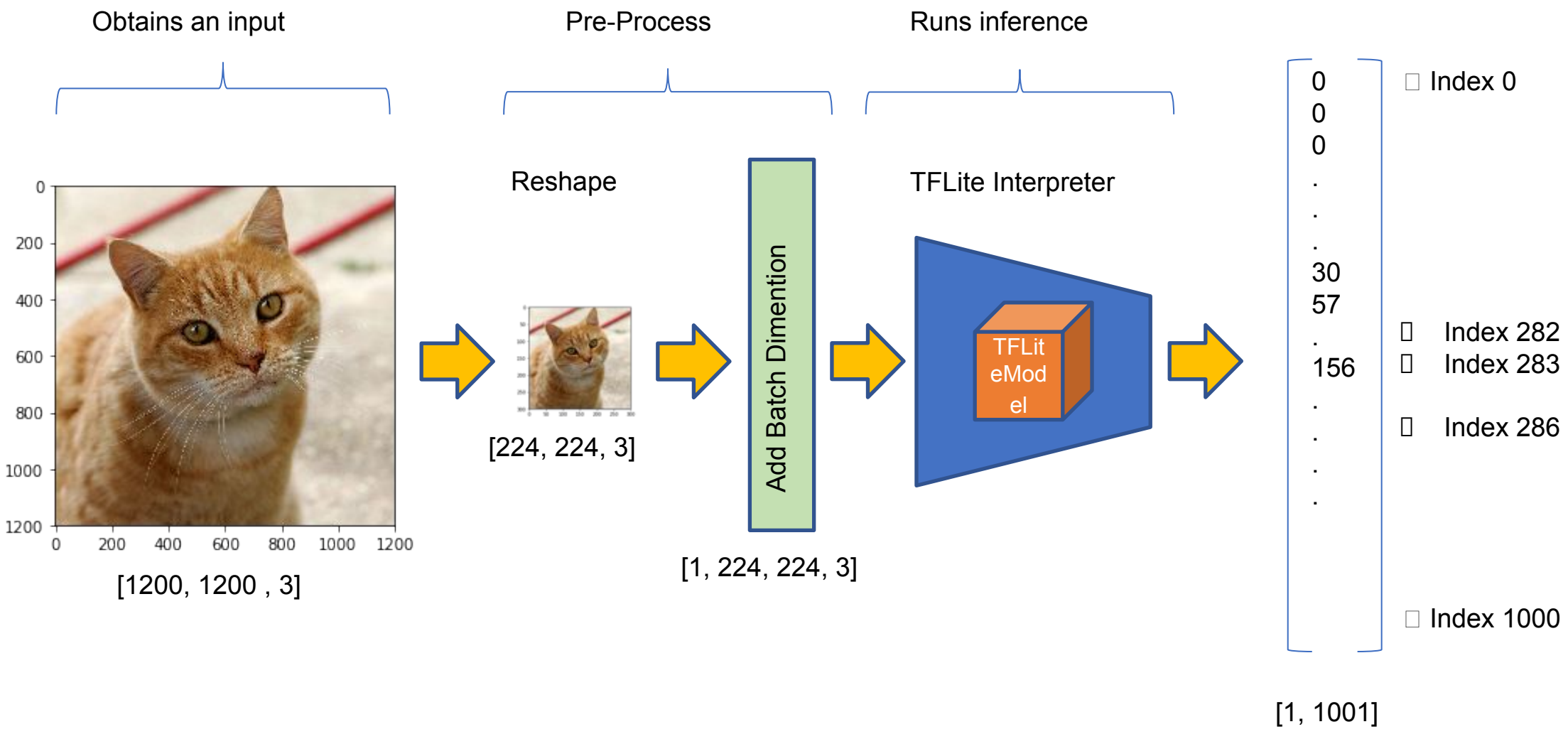
```
In [5]: 1 input_details

Out[5]: [{'name': 'input',
          'index': 88,
          'shape': array([  1, 224, 224,   3]),
          'dtype': numpy.uint8,
          'quantization': (0.0078125, 128),
          'quantization_parameters': {'scales': array([0.0078125], dtype=float32),
           'zero_points': array([128]),
           'quantized_dimension': 0}}]
```

Input Image Shape

```
In [6]: 1 output_details

Out[6]: [{'name': 'MobilenetV1/Predictions/Reshape_1',
          'index': 87,
          'shape': array([   1, 1001]),
          'dtype': numpy.uint8,
          'quantization': (0.00390625, 0),
          'quantization_parameters': {'scales': array([0.00390625], dtype=float32),
           'zero_points': array([0]),
           'quantized_dimension': 0}}]
```

Output model

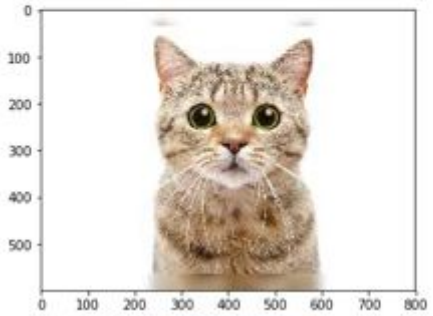
TF Lite Inference – Image Classification



TF Lite Inference – Demo - Postprocess

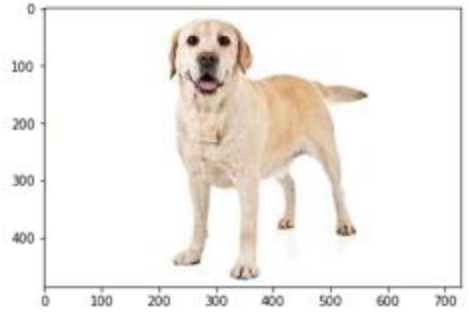
```
image_path = './images/cat_1.jpg'
image_classification(image_path, labels)
```

```
[PREDICTION]        [Prob]

Egyptian cat        : 64%
tabby               : 14%
bucket              : 3%
```



```
image_path = './images/dog_1.jpg'
image_classification(image_path, labels)
```

```
[PREDICTION]        [Prob]

Labrador retriever  : 83%
golden retriever    : 13%
bloodhound          : 0%
```



```
image_path = './images/pi_1.jpeg'
image_classification(image_path, labels)
```

```
[PREDICTION]        [Prob]

German shepherd     : 60%
dhole               : 16%
malinois            : 7%
```

```
image_path = './images/car_2.jpg'
image_classification(image_path, labels)
```

```
[PREDICTION]        [Prob]

minivan             : 76%
convertible         : 6%
jeep                : 4%
```

```
image_path = './images/ship_1.jpg'
image_classification(image_path, labels)
```

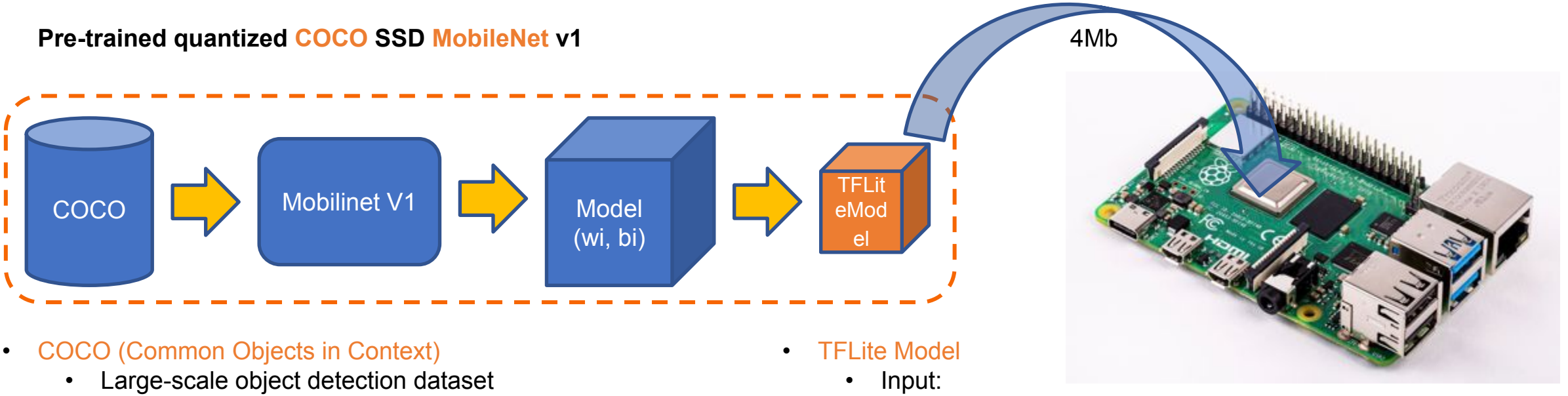
```
[PREDICTION]        [Prob]

liner               : 85%
trimaran            : 11%
aircraft carrier    : 0%
```

```
image_path = './images/table.jpg'
image_classification(image_path, labels)
```

```
[PREDICTION]        [Prob]

dining table        : 40%
table lamp          : 34%
desk                : 17%
```

Demo 2 – Object Detection

Pre-trained quantized COCO SSD MobileNet v1



- COCO (Common Objects in Context)
  - Large-scale object detection dataset
  - 200K labeled images
  - 91 Stuff categories

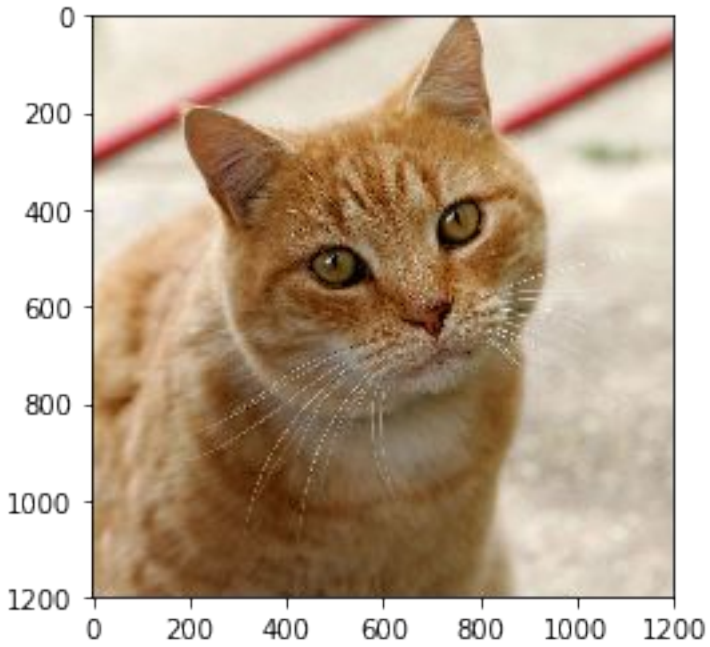
- MobileNet
  - “Depth- wise Separable” convolutions
  - Introduced by Google in 2017
  - Similar performance with state-of-the-art architectures (as VGG or Inception)
  - Much smaller network (20% of VGG parameters (7M)

- TFLite Model
  - Input:
    - Image: 300x300x3
    - Flattened Buffer: 270K bytes
    - Each byte: 0 to 255
  - Output:
    - Bounding Box (ymin, xmin, ymax, xmax)
    - Class ID (0 to 89) ("Stuff categories")
    - Score (0 to 1)

COCO Paper:
https://arxiv.org/pdf/1405.0312.pdf
MobileNet paper:
https://arxiv.org/pdf/1704.04861.pdf

TF Lite Inference – Object Detection

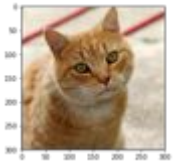
Obtains an input



[1200, 1200, 3]

Pre-Process

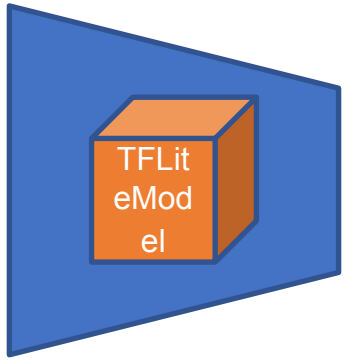
Reshape &
add dimention



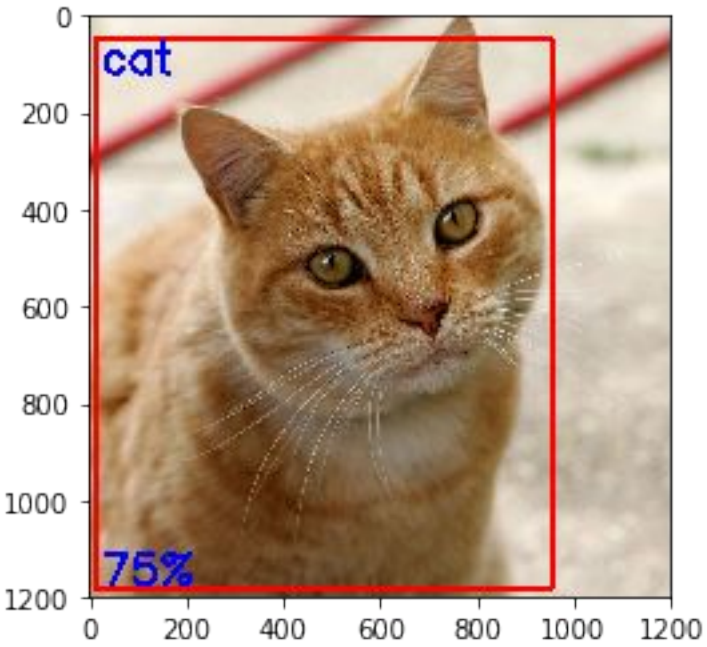
[1, 300, 300, 3]

Runs inference

TFLite Interpreter

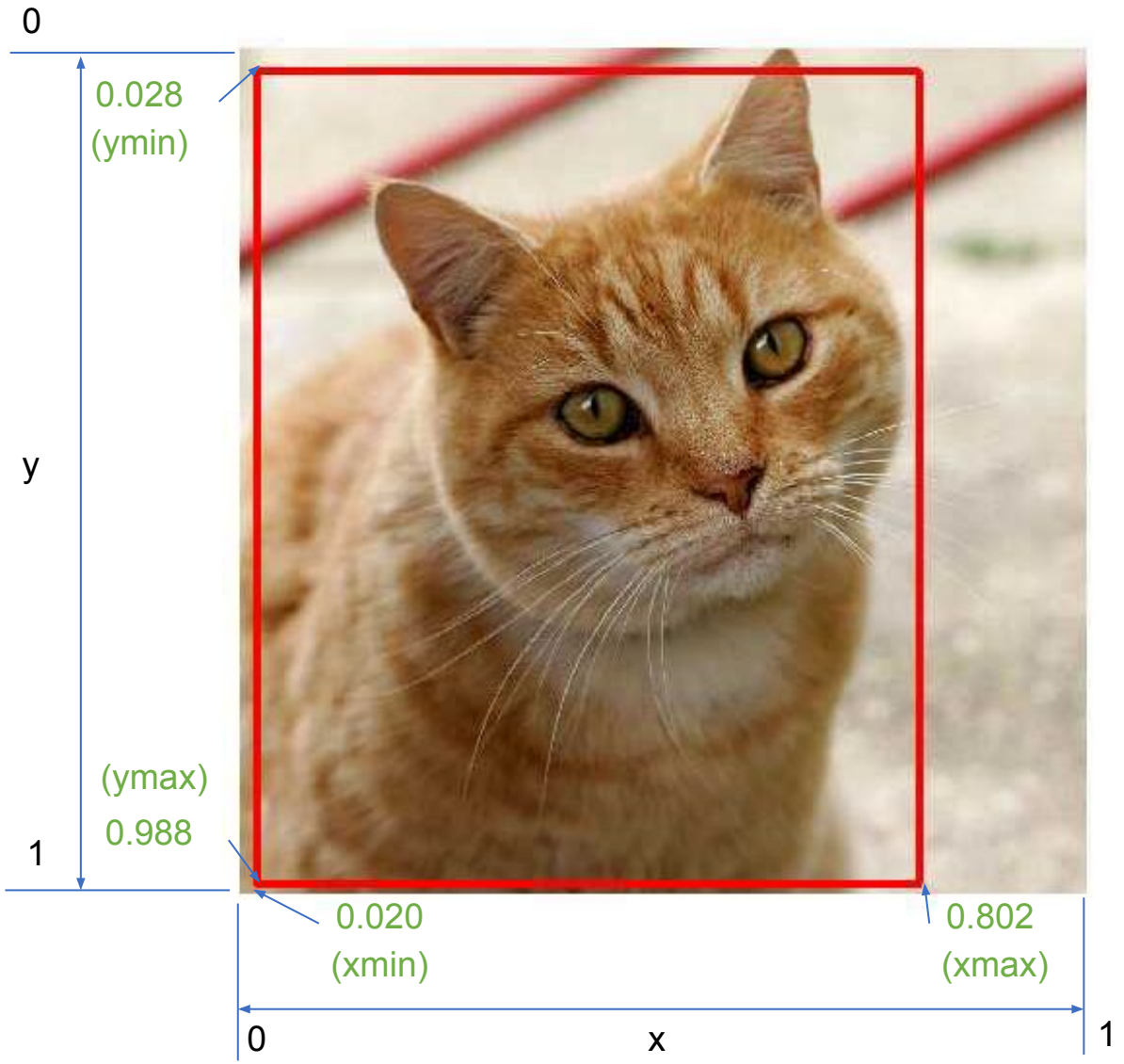


Postprocesses

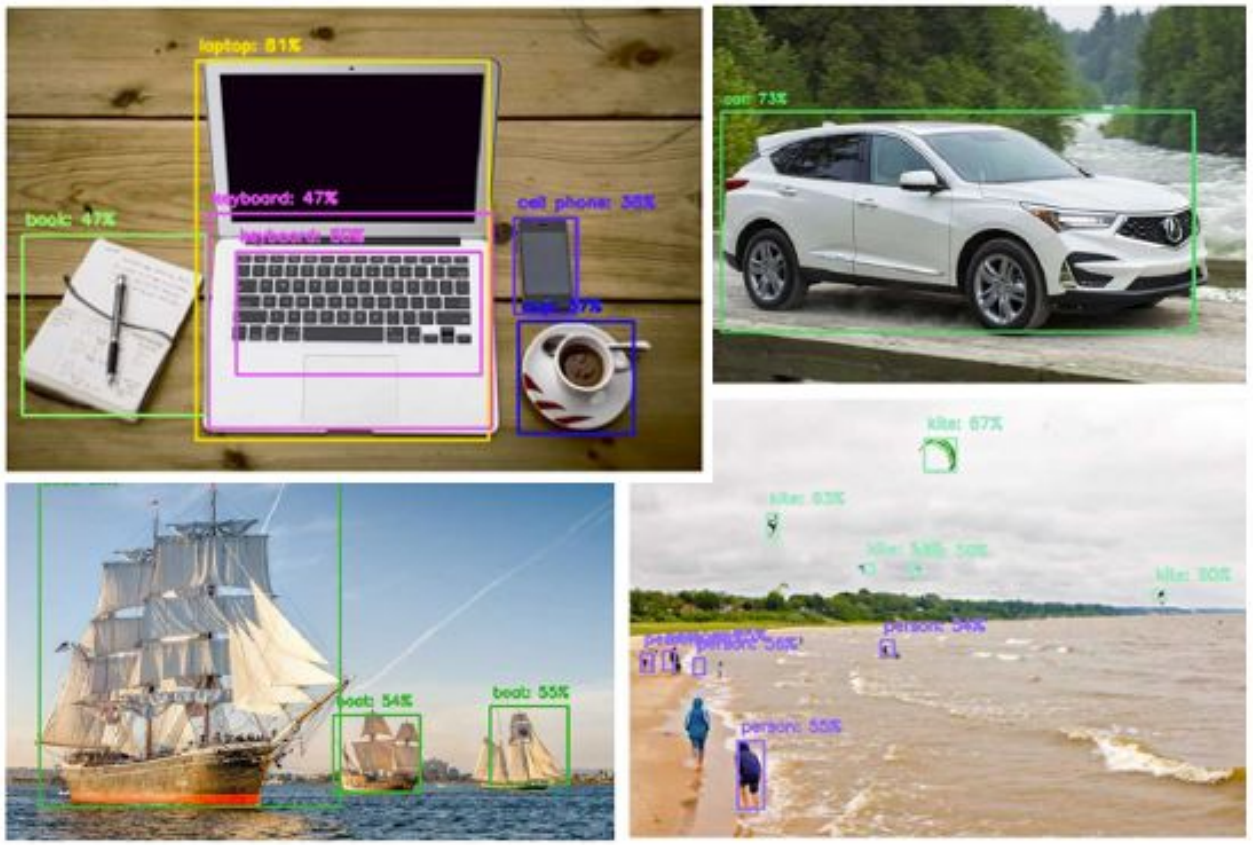


- [{**'bounding_box'**: array(
  [0.02801108, 0.02012181,
  0.9886069 , 0.802299]
- **'class_id'**: 16.0,
- **'score'**: 0.765625}]

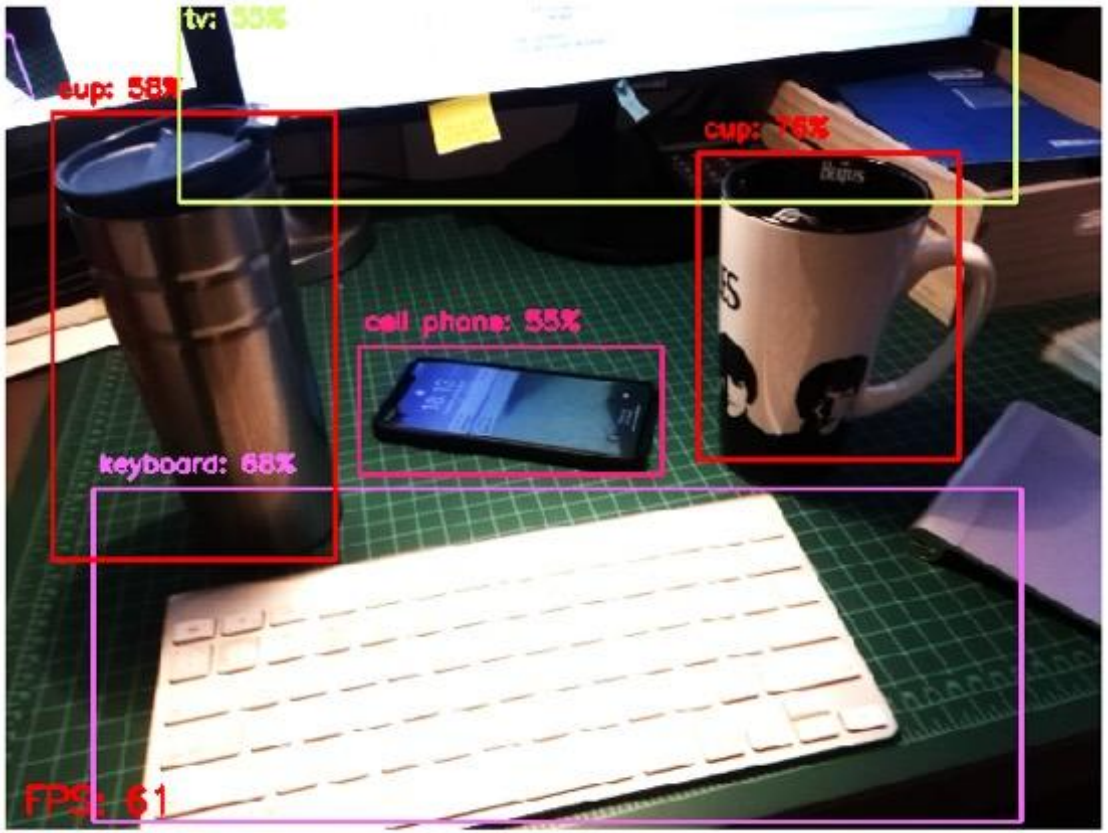
Bounding Box- Object Detection



TF Lite Inference – Demo – Postprocesses



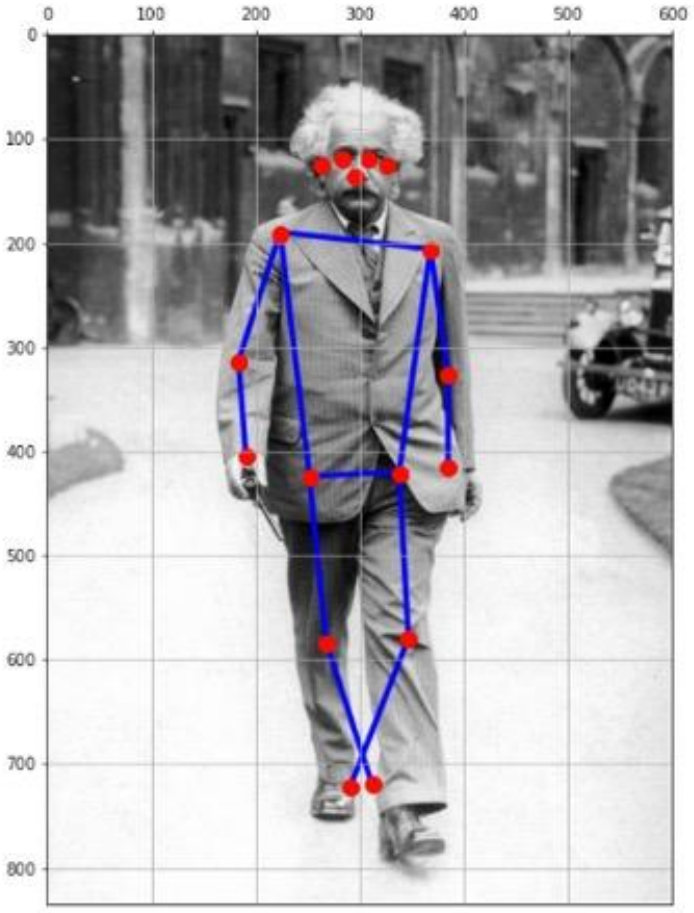
Photos



Live Video

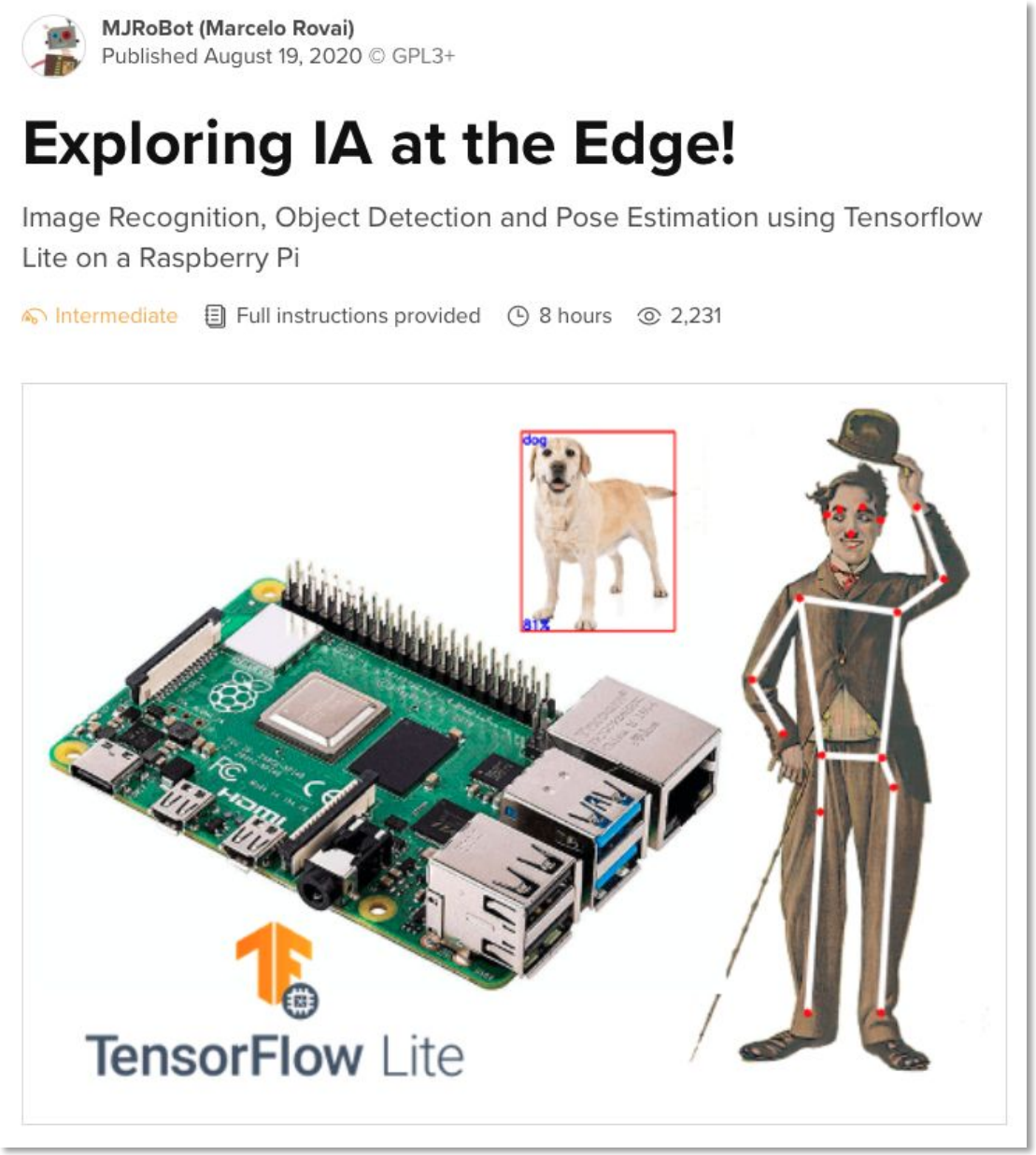
TensorFlow Lite – Other applications

- **Pose Estimation on RPi**



- **Gesture Recognition**
- **Speech Recognition**
- **Smart Replay**
- **Image Segmentation**
- **Text Classification**
- **On-device recommendation**
- **Style Transfer**

Example of style transfer



https://www.hackster.io/mjrobot/exploring-ia-at-the-edge-97588d

Main references

- Harvard School of Engineering and Applied Sciences - CS249r: Tiny Machine Learning
- Professional Certificate in Tiny Machine Learning (TinyML) – edX/Harvard
- Introduction to Embedded Machine Learning - Coursera/Edge Impulse
- Computer Vision with Embedded Machine Learning - Coursera/Edge Impulse
- Fundamentals textbook: “Deep Learning with Python” by François Chollet
- Applications & Deploy textbook: “TinyML” by Pete Warden, Daniel Situnayake
- Deploy textbook “TinyML Cookbook” by Gian Marco Iodice

I want to thank Shawn Hymel and Edge Impulse, Pete Warden and Laurence Moroney from Google, Professor Vijay Janapa Reddi and Brian Plancher from Harvard, and the rest of the TinyMLedu team for preparing the excellent material on TinyML that is the basis of this course at UNIFEI.

The IESTI01 course is part of the **TinyML4D**, an initiative to make TinyML education available to everyone globally.

Thanks

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