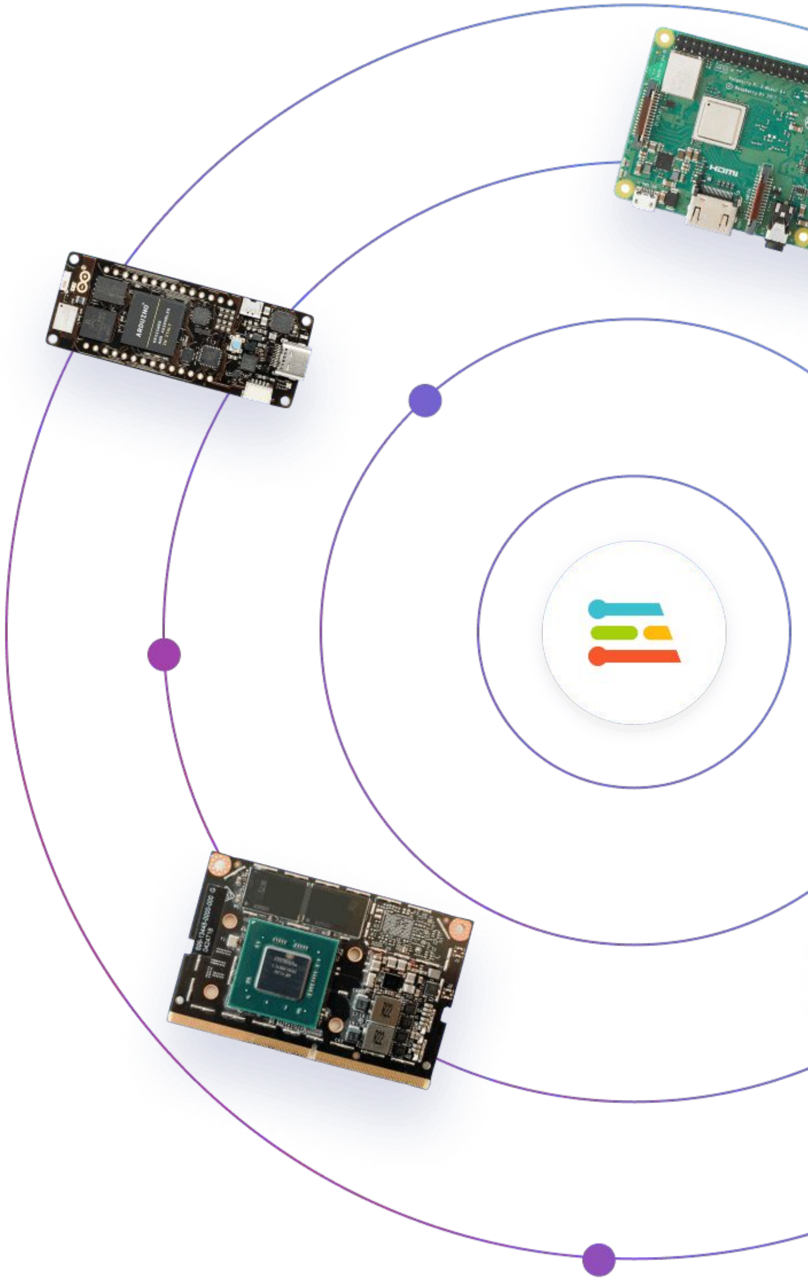
EDGE IMPULSE

Constrained Object Detection on Microcontrollers with FOMO

Agenda

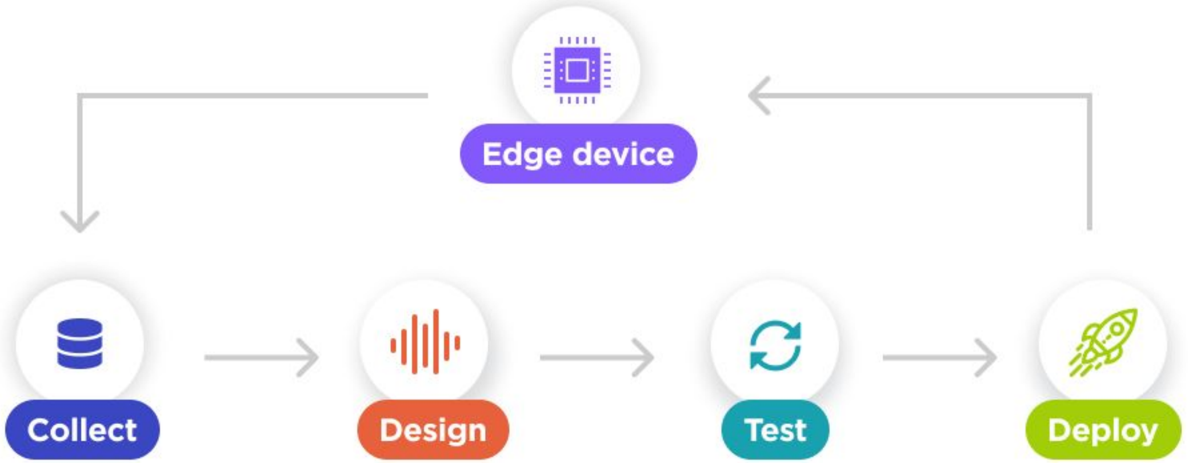
1. What is Edge Impulse?
2. Object Detection
3. Image Segmentation
4. Constrained Object Detection
5. FOMO Use Cases and Limitations
6. Live Demo

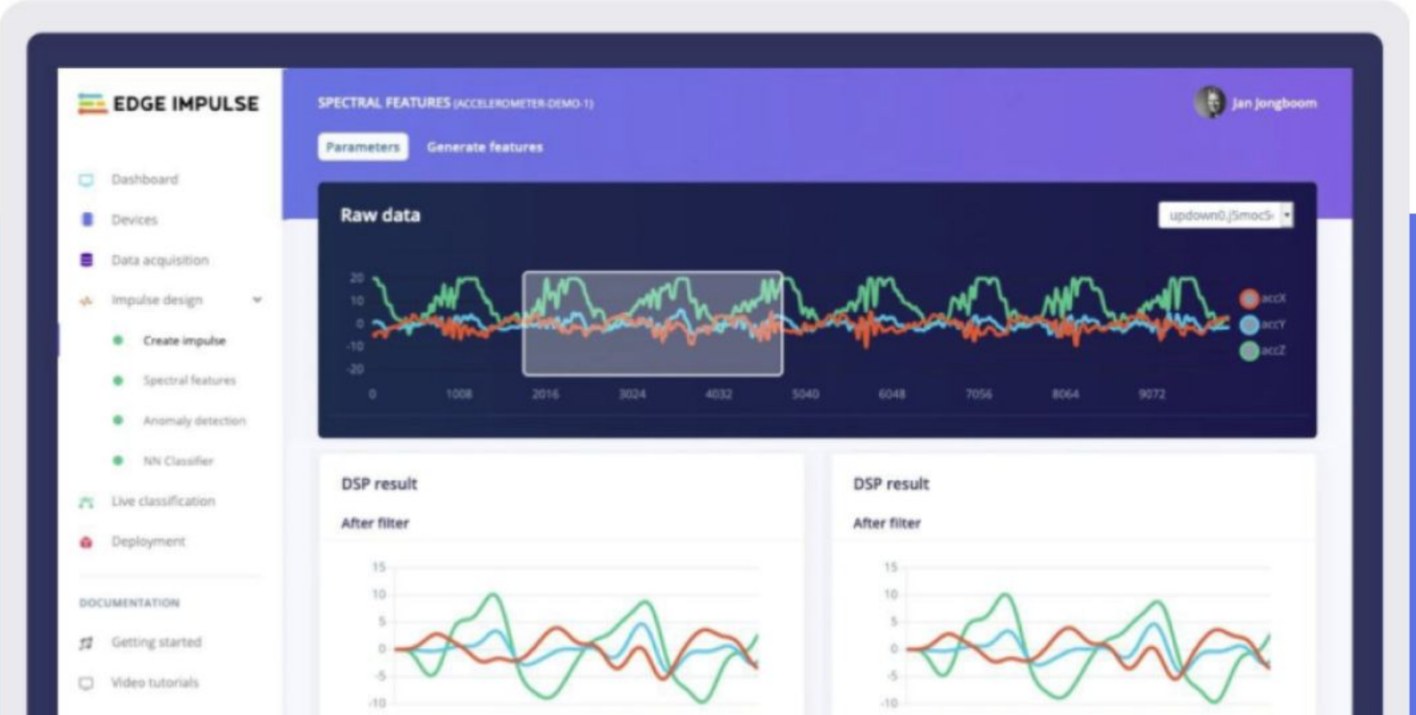


Edge Impulse

EDGE IMPULSE

Go to market faster with confidence





Object Detection

Image Classification

Background	Capacitor	Diode	LED	Resistor
0.00	0.00	0.00	0.00	1.00

Background	Capacitor	Diode	LED	Resistor
0.00	1.00	0.00	0.00	0.00

Image Classification

Background	Capacitor	Diode	LED	Resistor
0.00	0.04	0.00	0.28	0.68

Background	Capacitor	Diode	LED	Resistor
0.00	0.77	0.00	0.00	0.23

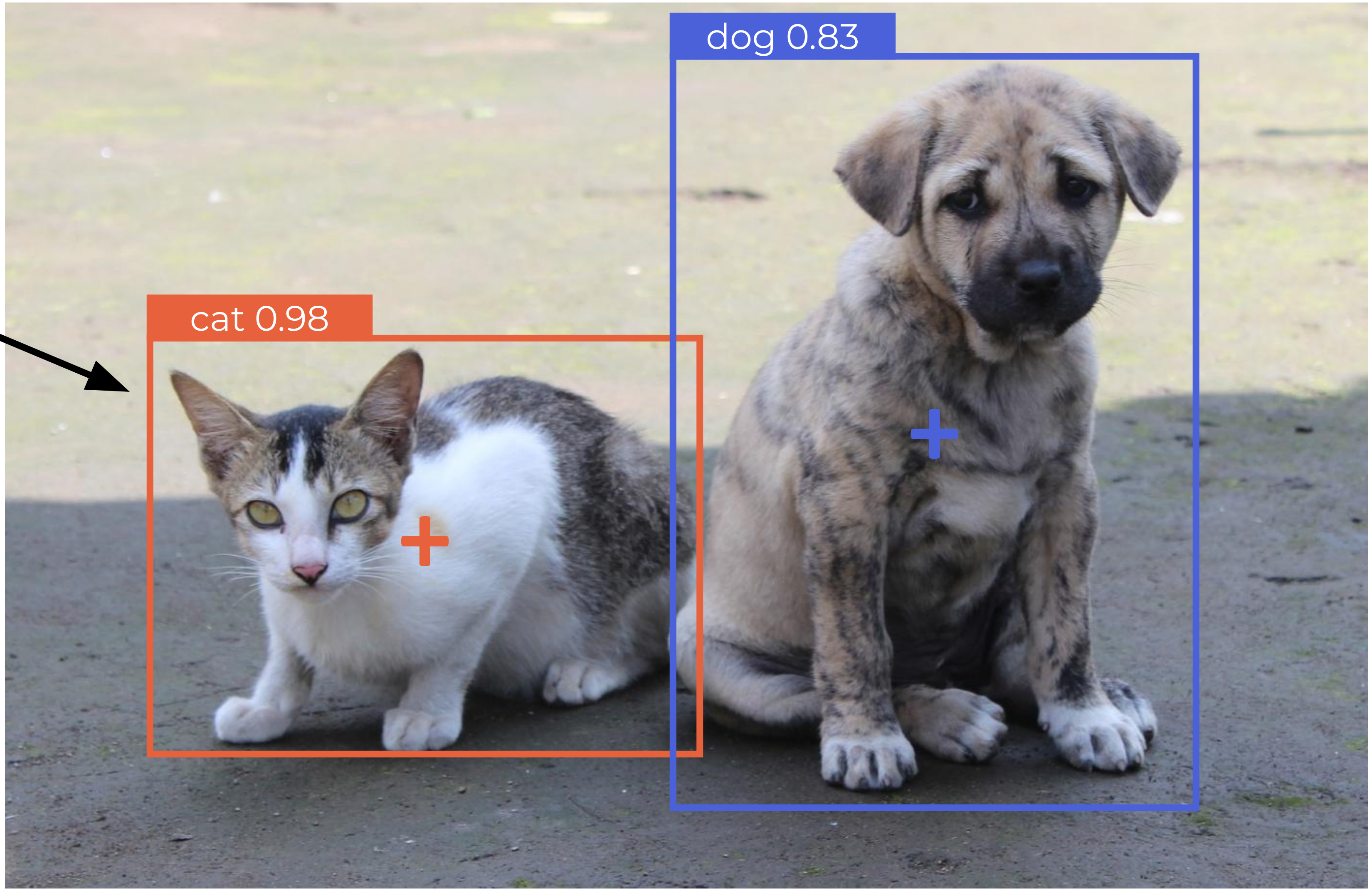
Definitions

- **Image Classification**: Predict class of object in an image
- **Object Localization**: Locate presence of object(s) in an image
- **Object Detection**: Locate and classify object(s) in an image

Object Detection

Object Detection

Bounding box




Model
dog
background

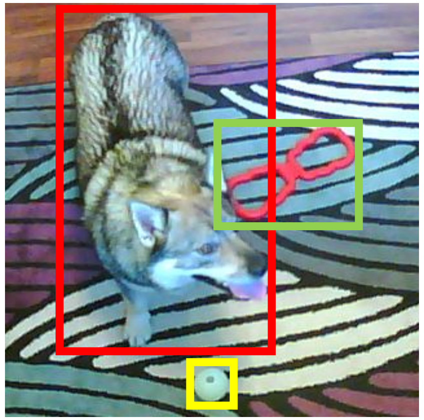

stride
Model
dog
background

48 x 100 ms =
4.8 seconds!
(~0.208 fps)

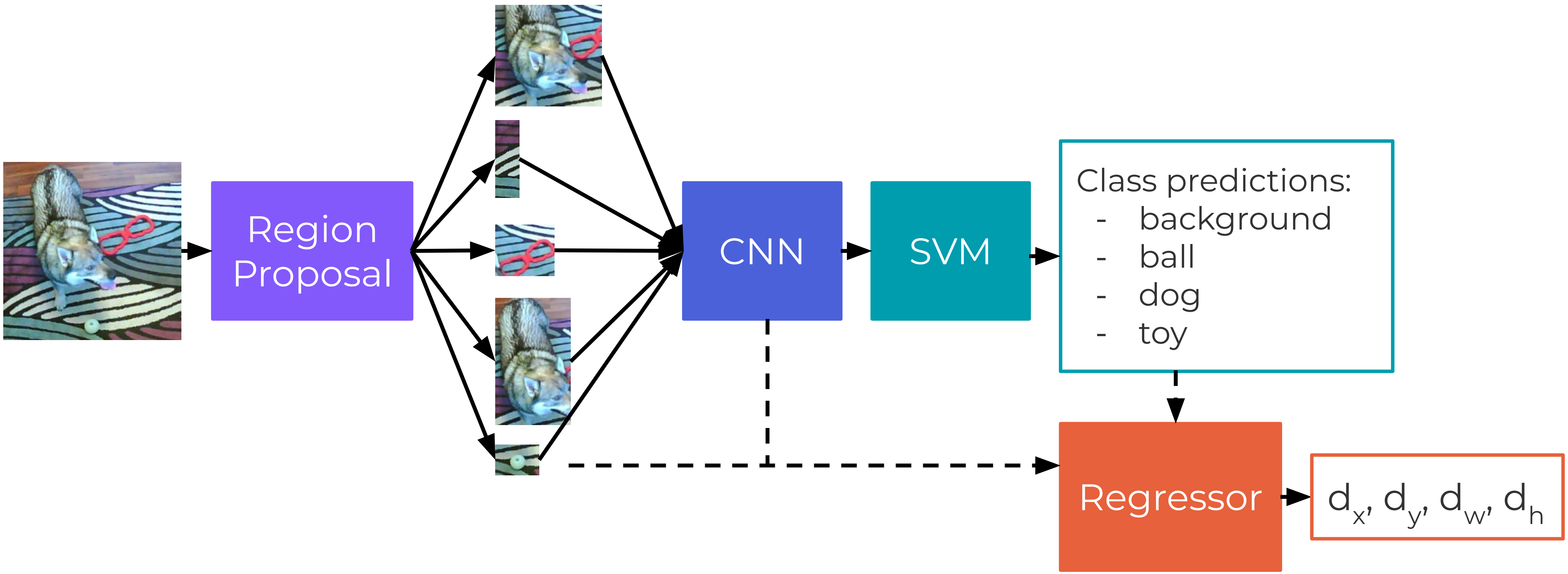
Object Detection Model

Object Detection Model

- **Object 1**
  - Class: dog (0.92)
  - Bounding box
    - (x_1, y_1)
    - (w_1, h_1)
- **Object 2**
  - Class: toy (0.85)
  - Bounding box
    - (x_2, y_2)
    - (w_2, h_2)
- **Object 3**
  - Class: ball (0.77)
  - Bounding box
    - (x_3, y_3)
    - (w_3, h_3)



Region-based CNN (R-CNN)



Single Shot MultiBox Detector (SSD)

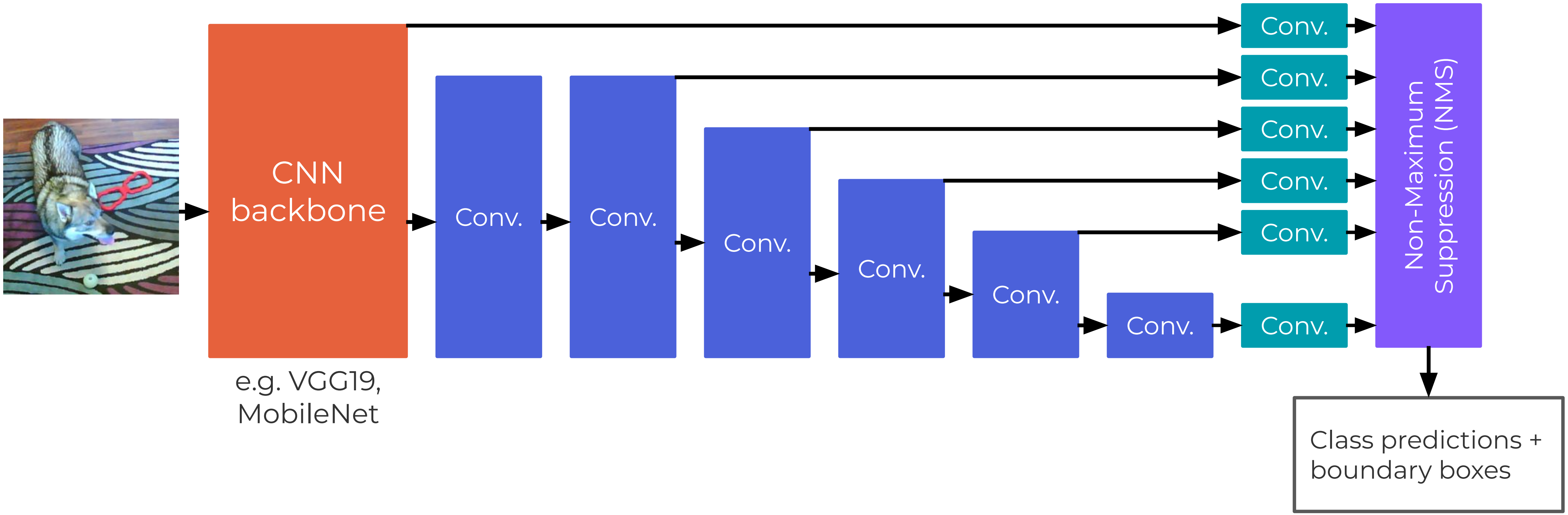


Image Segmentation

Image Segmentation

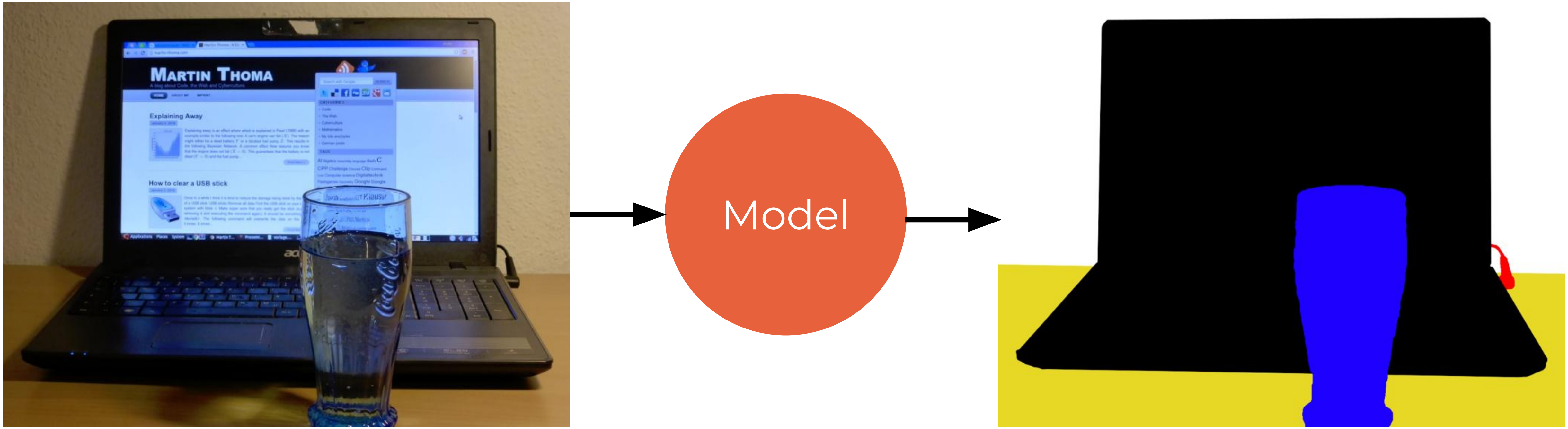


Image Segmentation

```
threshold = 145
seg = (img < threshold).astype(int)
```

Image Segmentation

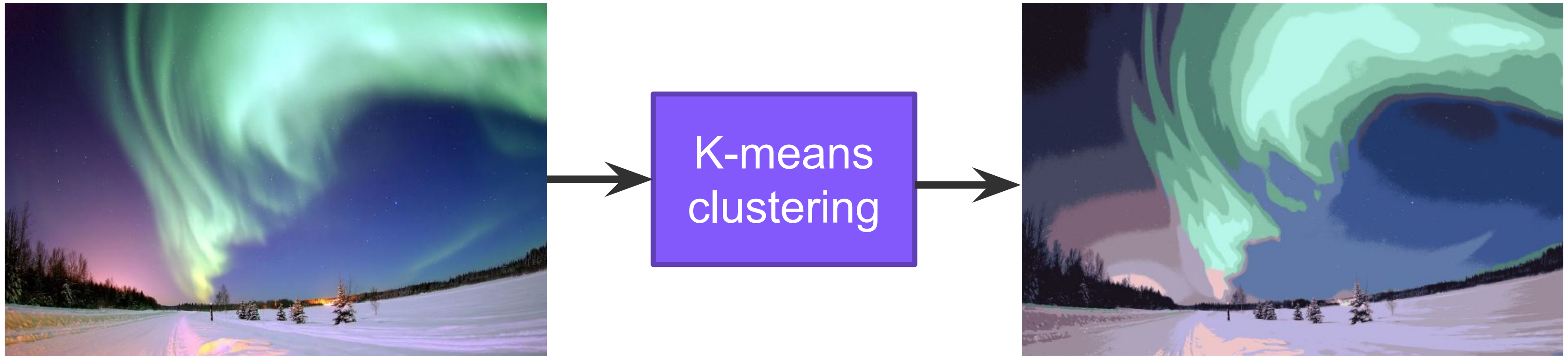
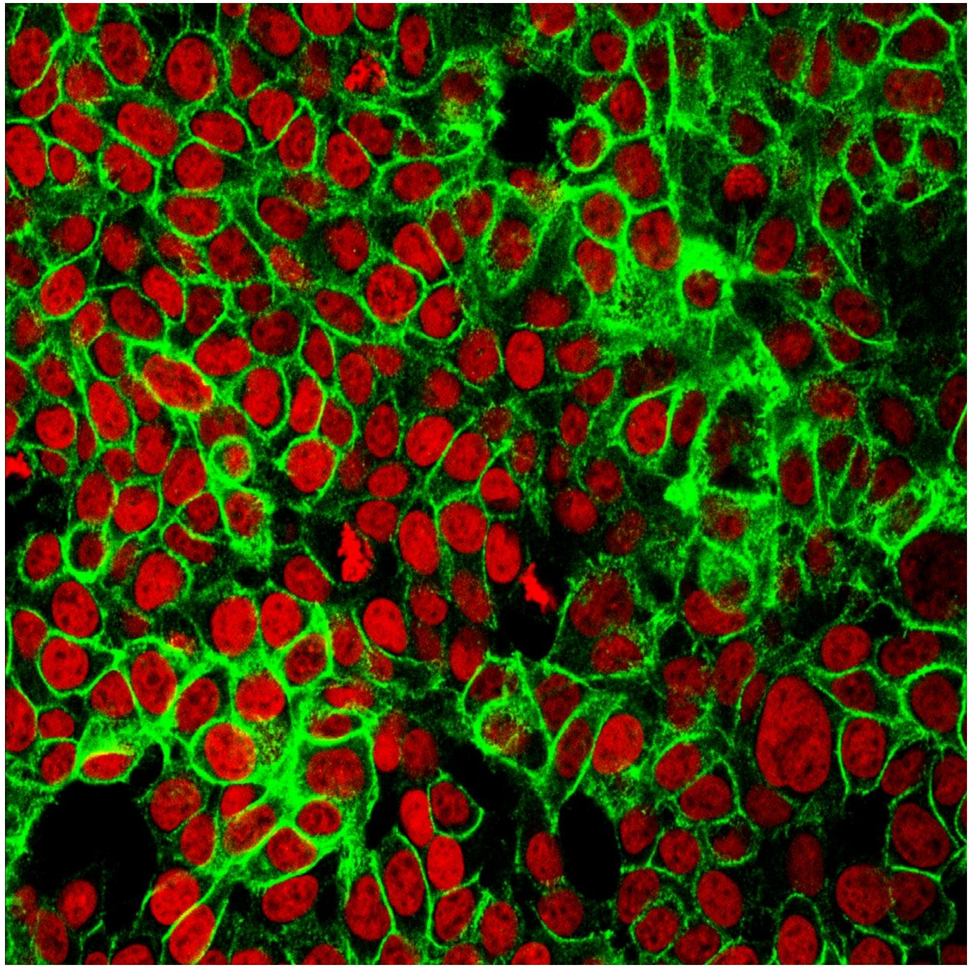
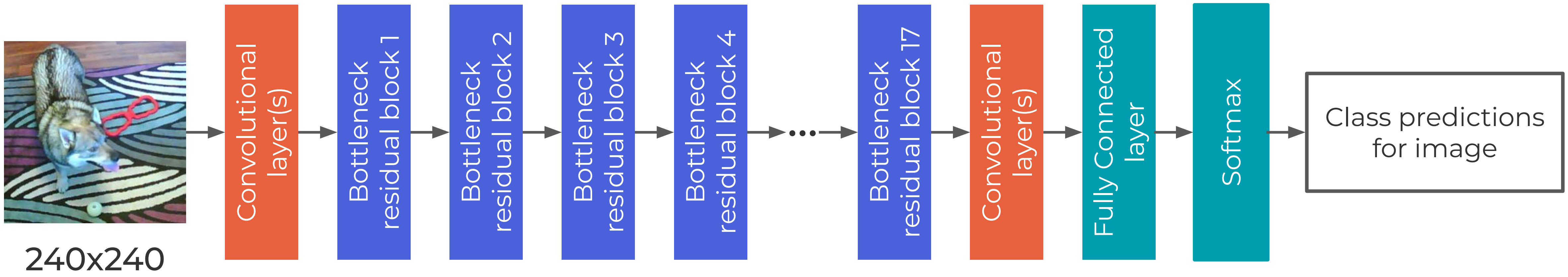


Image Segmentation Use Case



Constrained Object Detection

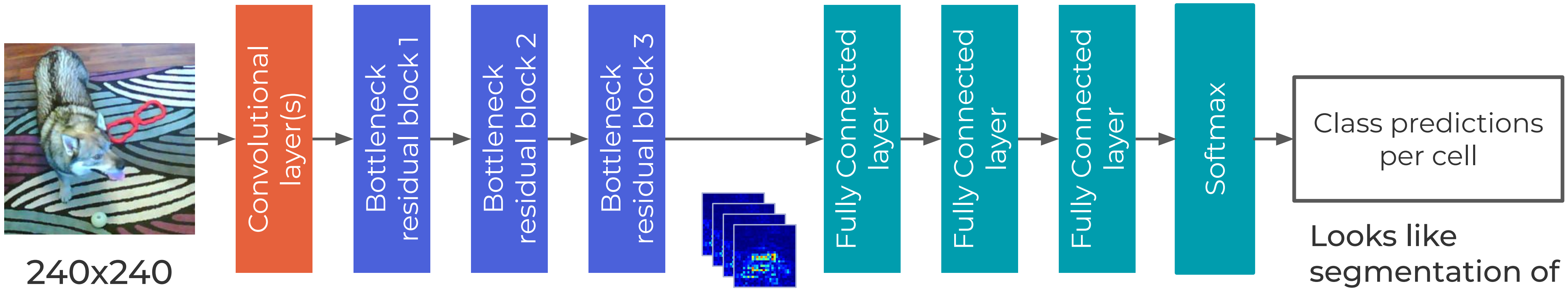
MobileNet V2



Faster Objects, More Objects (FOMO)

Height and width are each divided by 8 (default)

2D convolution with 1x1 kernel is used



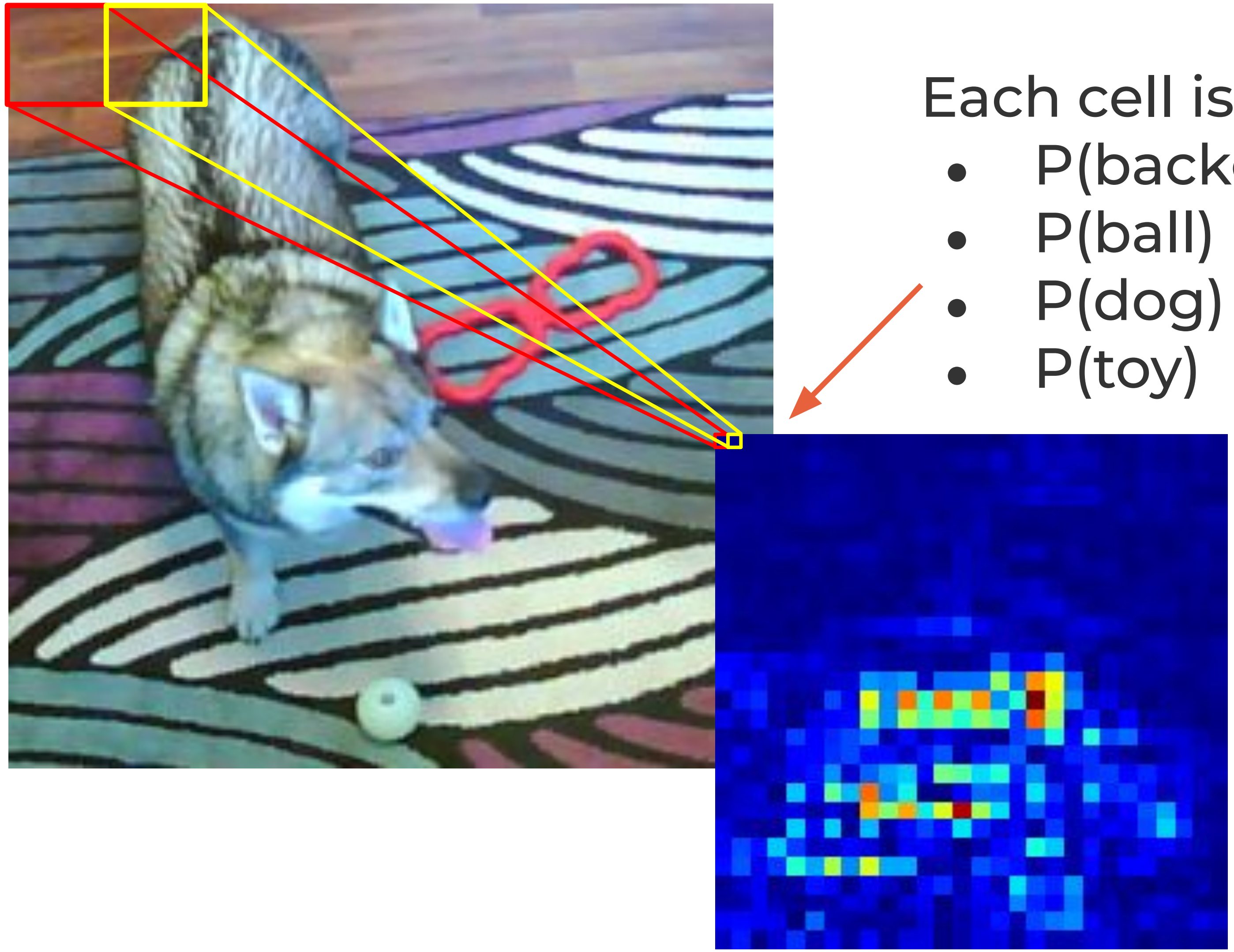
Weights in residual blocks are pre-trained from ImageNet

16 feature maps, each 30x30 cells

Looks like segmentation of feature maps

Faster Objects, More Objects (FOMO)

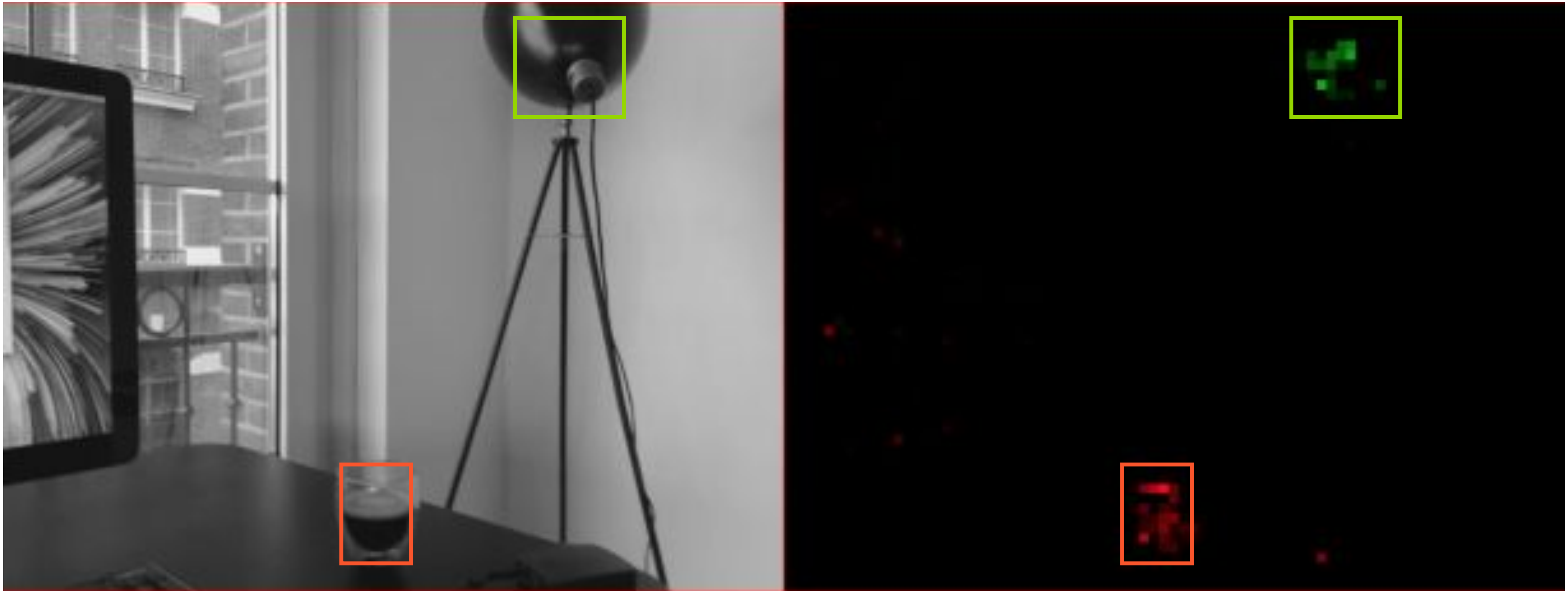
Receptive field



Each cell is given scores:

- P(background)
- P(ball)
- P(dog)
- P(toy)

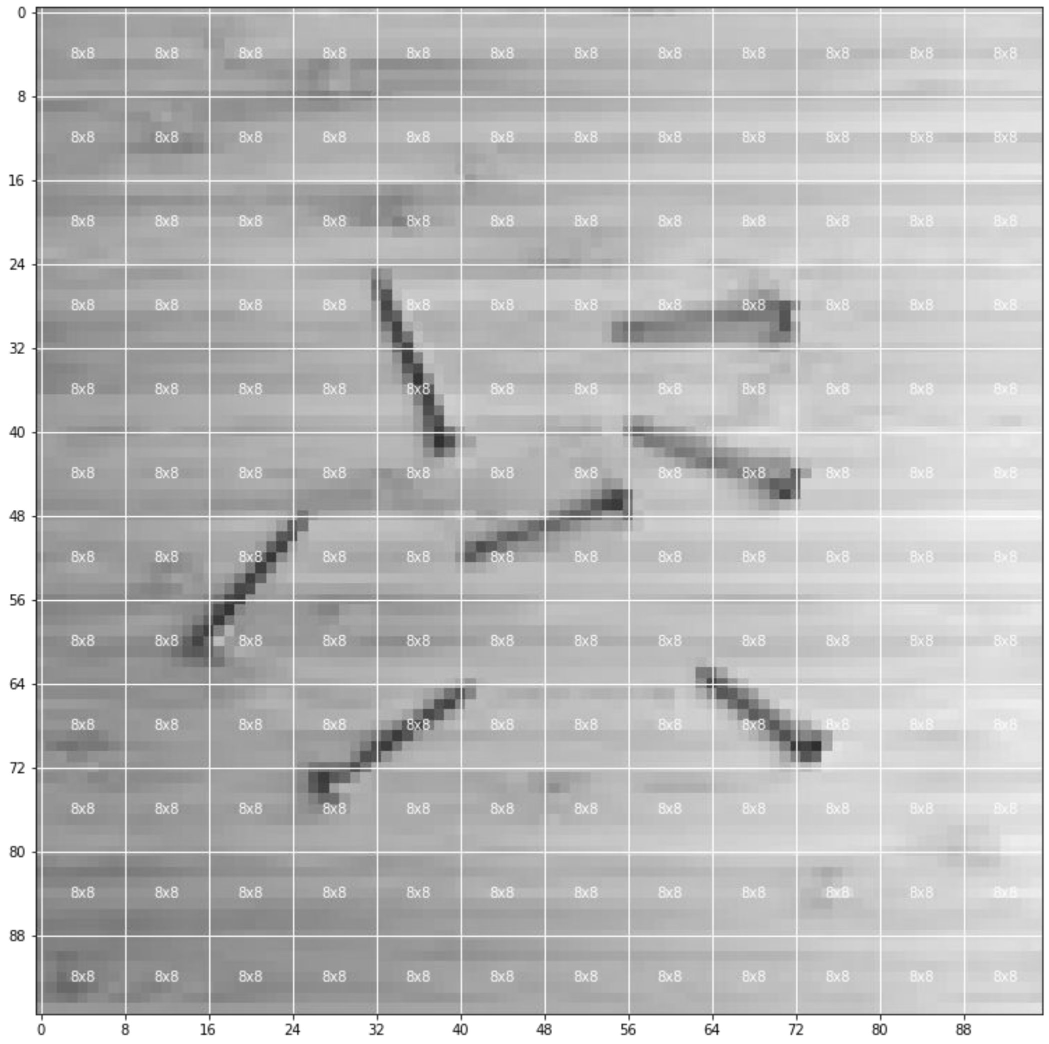
Faster Objects, More Objects (FOMO)



Faster Objects, More Objects (FOMO)

Example: screws

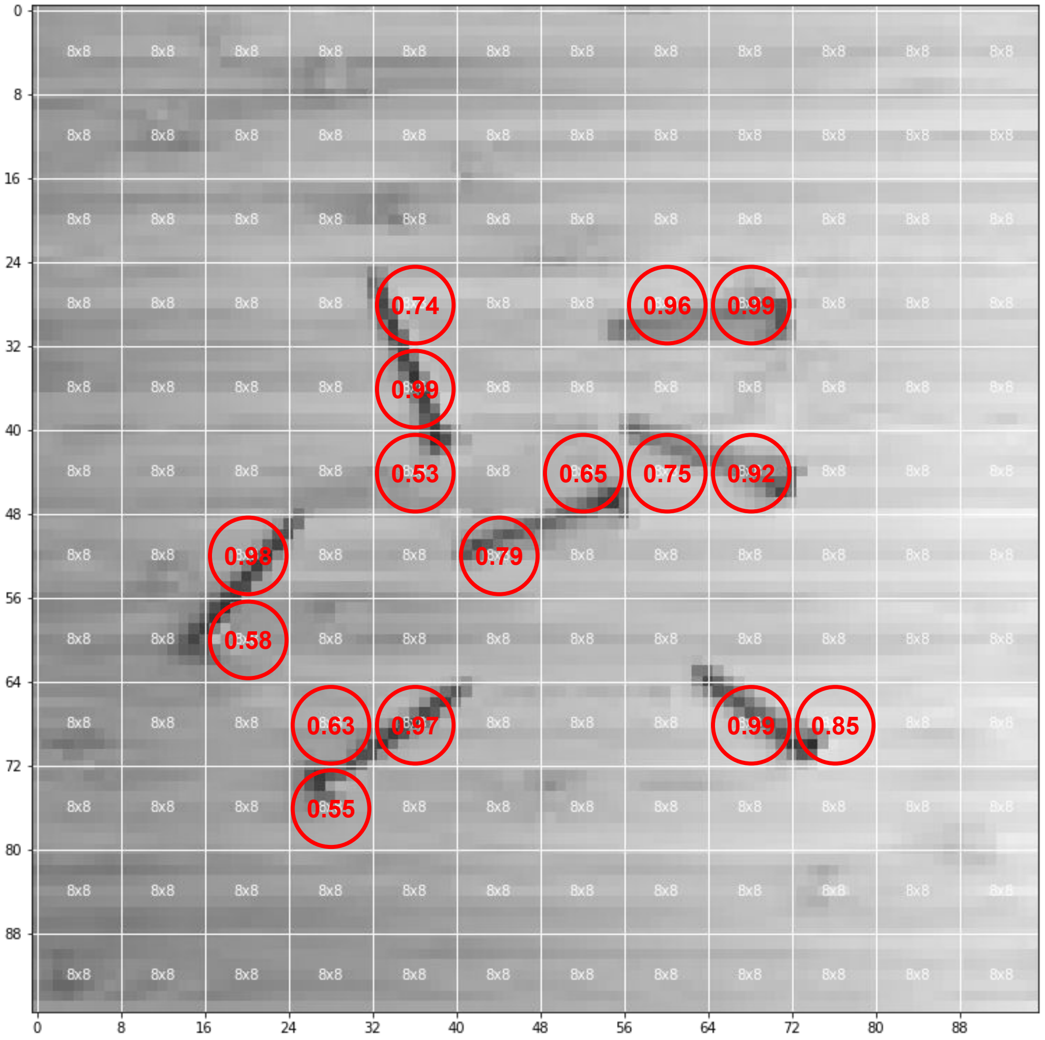
- Grayscale
- Image: 96x96
- Feature maps: 12x12



Faster Objects, More Objects (FOMO)

Example: screws

- Grayscale
- Image: 96x96
- Feature maps: 12x12

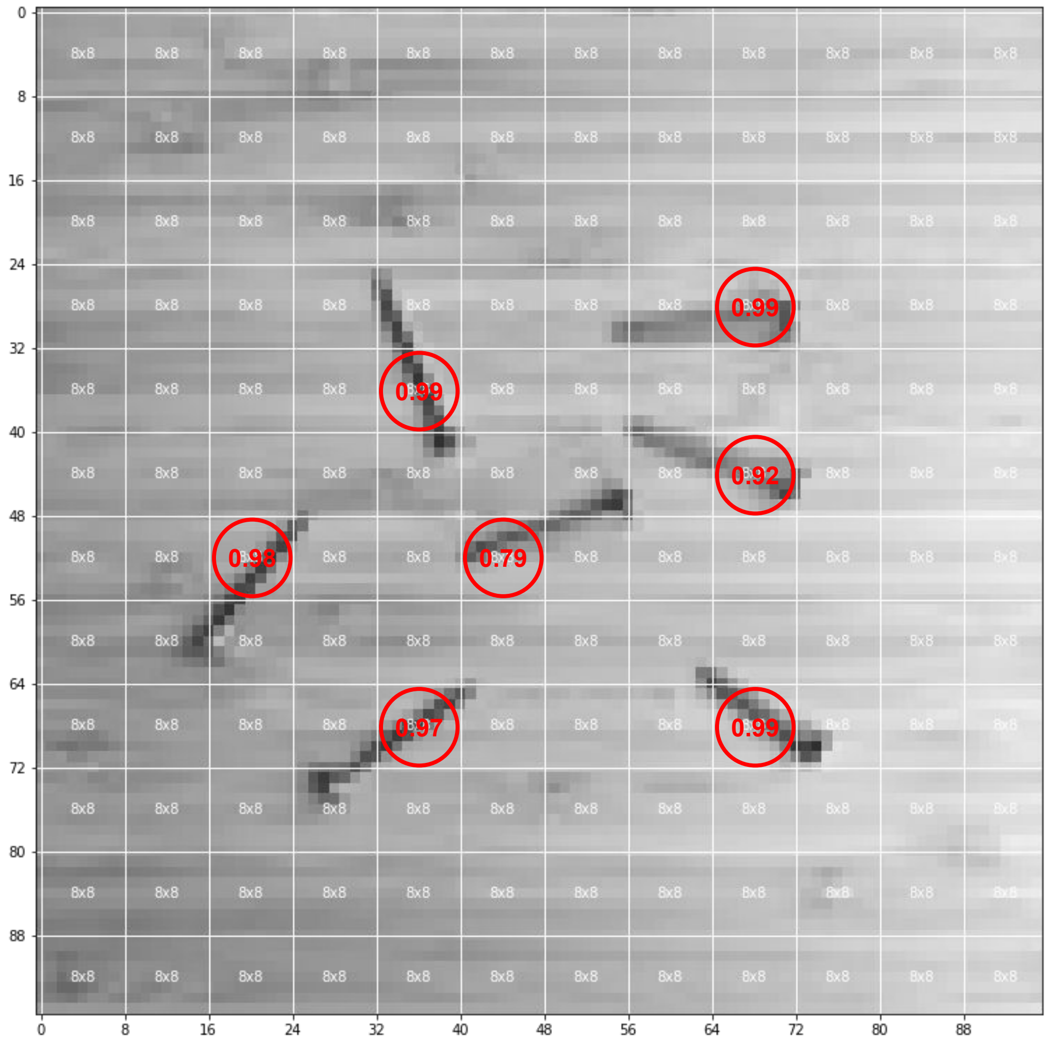


Faster Objects, More Objects (FOMO)

Example: screws

- Grayscale
- Image: 96x96
- Feature maps: 12x12

Neighboring cells with same class are removed (leaving highest scores)

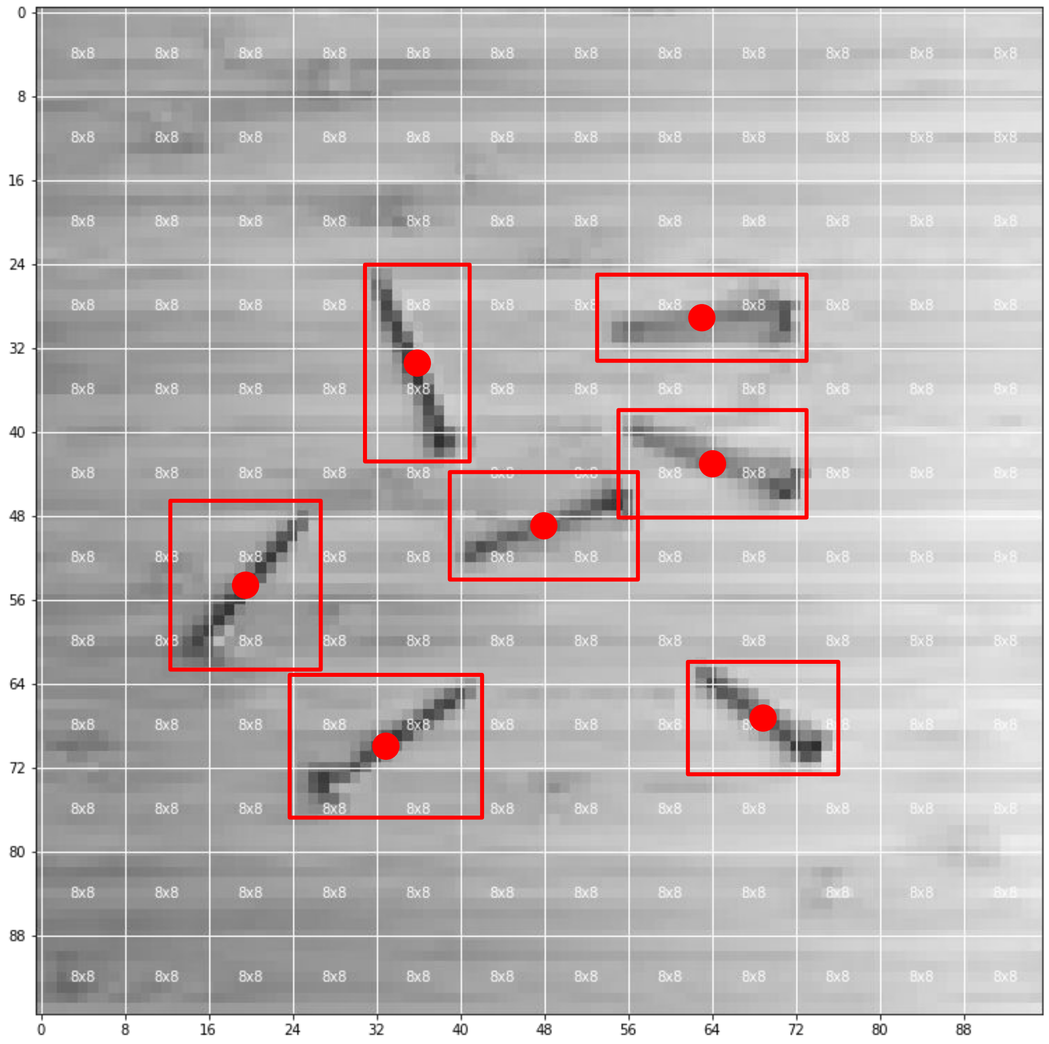


FOMO Ground Truth

Example: screws

- Grayscale
- Image: 96x96
- Feature maps: 12x12

User draws bounding boxes, tool picks cell with centroid of bounding box



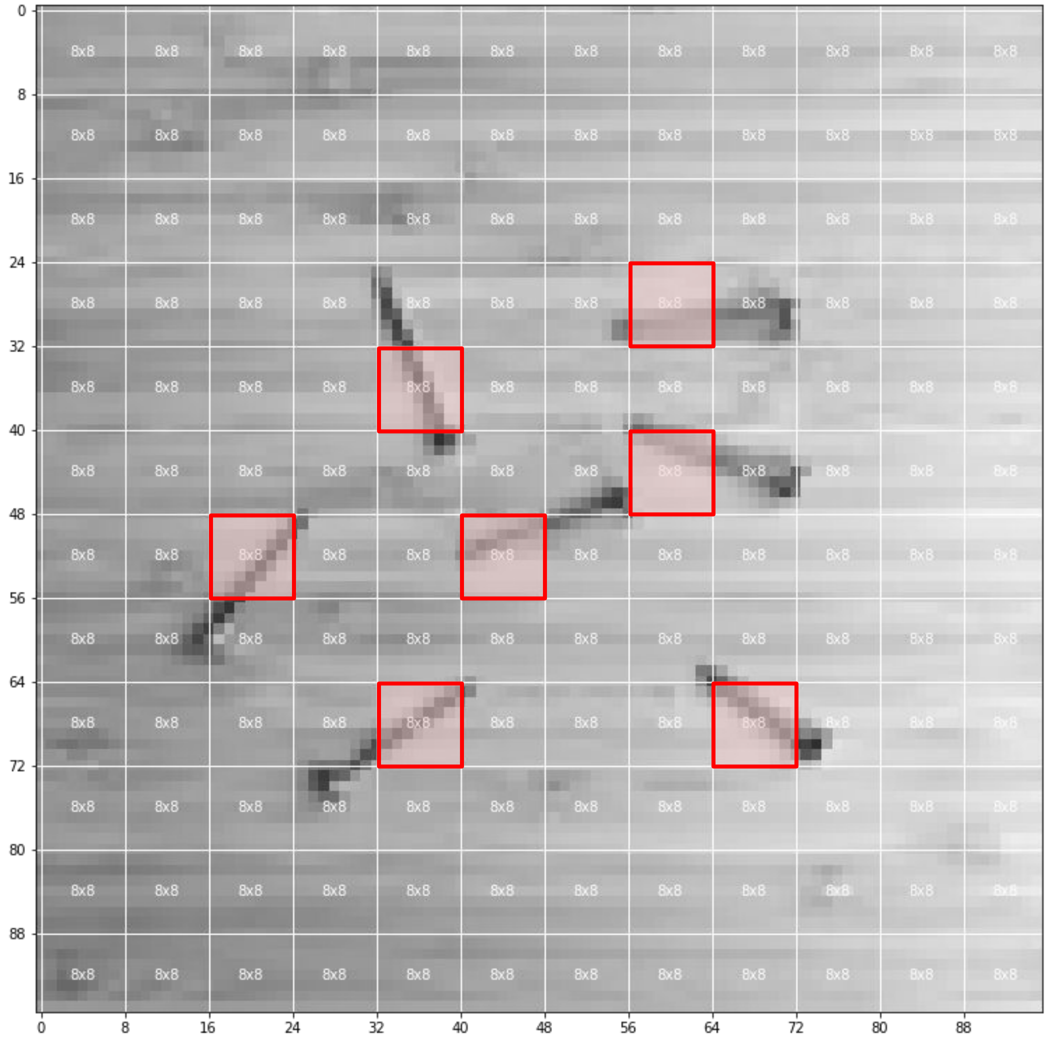
FOMO Ground Truth

Example: screws

- Grayscale
- Image: 96x96
- Feature maps: 12x12

User draws bounding boxes, tool picks cell with centroid of bounding box

Those cells are now representatives of that class



FOMO Uses + Limitations

Use Cases

Want to know **where** and **how many** objects there are

Recommendations for success:

- Objects are same size
- Objects are square/round
- Objects take up 1 cell

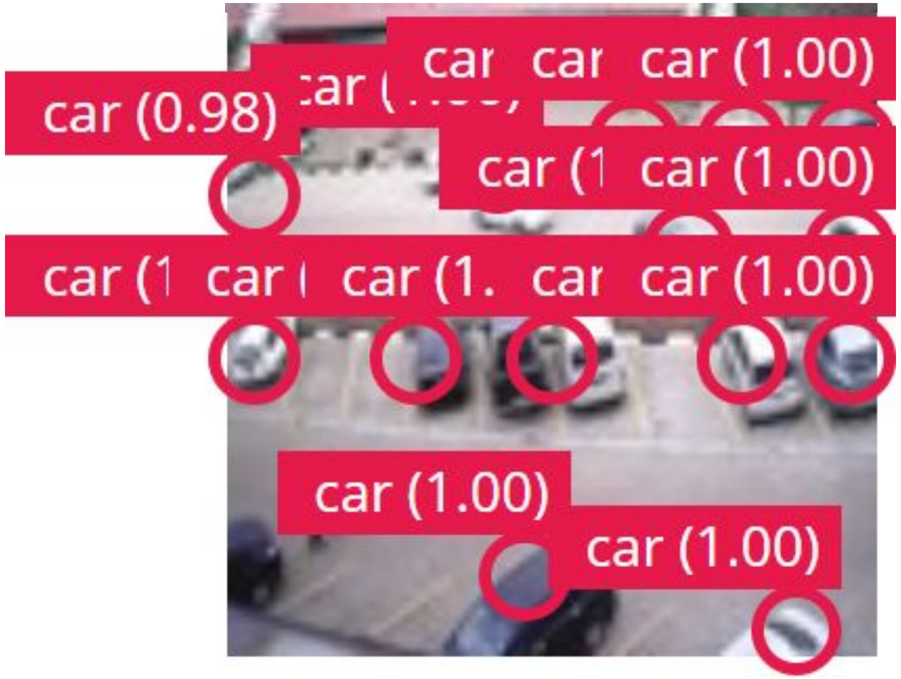
Very fast!

- Cortex-M7 at 480 MHz
- 240x240 image input
- 30 fps
- 245K RAM

https://matpalm.com/blog/counting_bees/

Limitations

- Each cell has its own classifier
- Small objects may be missed
- Neighboring objects may get lumped together
- Ends of oblong objects may be ignored
- Lots of objects/classes: use YOLOv5



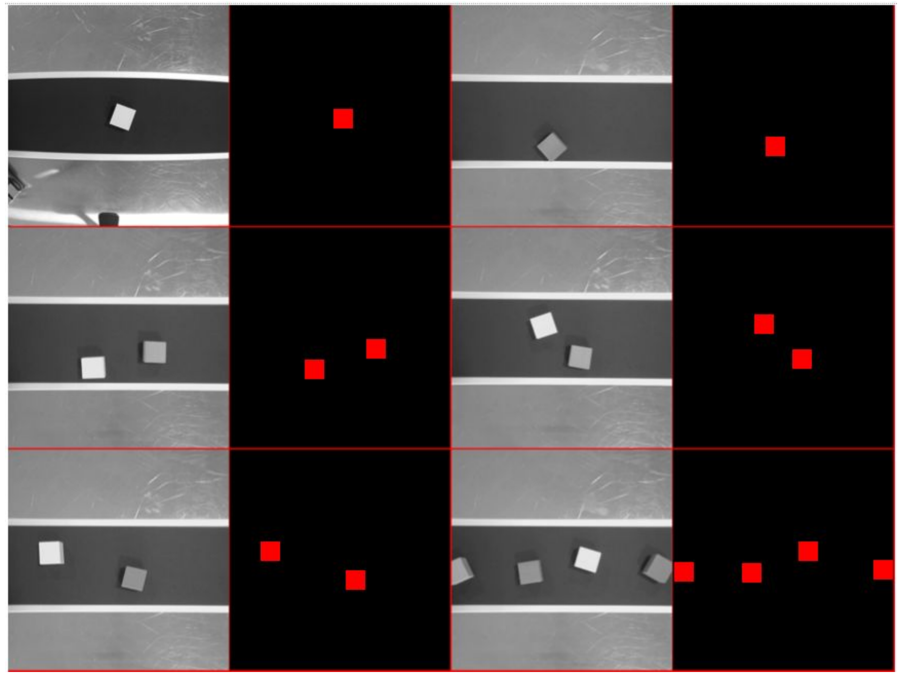
Demo

studio.edgeimpulse.com/public/89461/latest
studio.edgeimpulse.com/public/104110/latest

Getting Started

docs.edgeimpulse.com/docs/

- Tutorials > Counting objects using FOMO
- Various supported dev boards



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