Single-Shot Visual Object Detectors on Nano-Drones
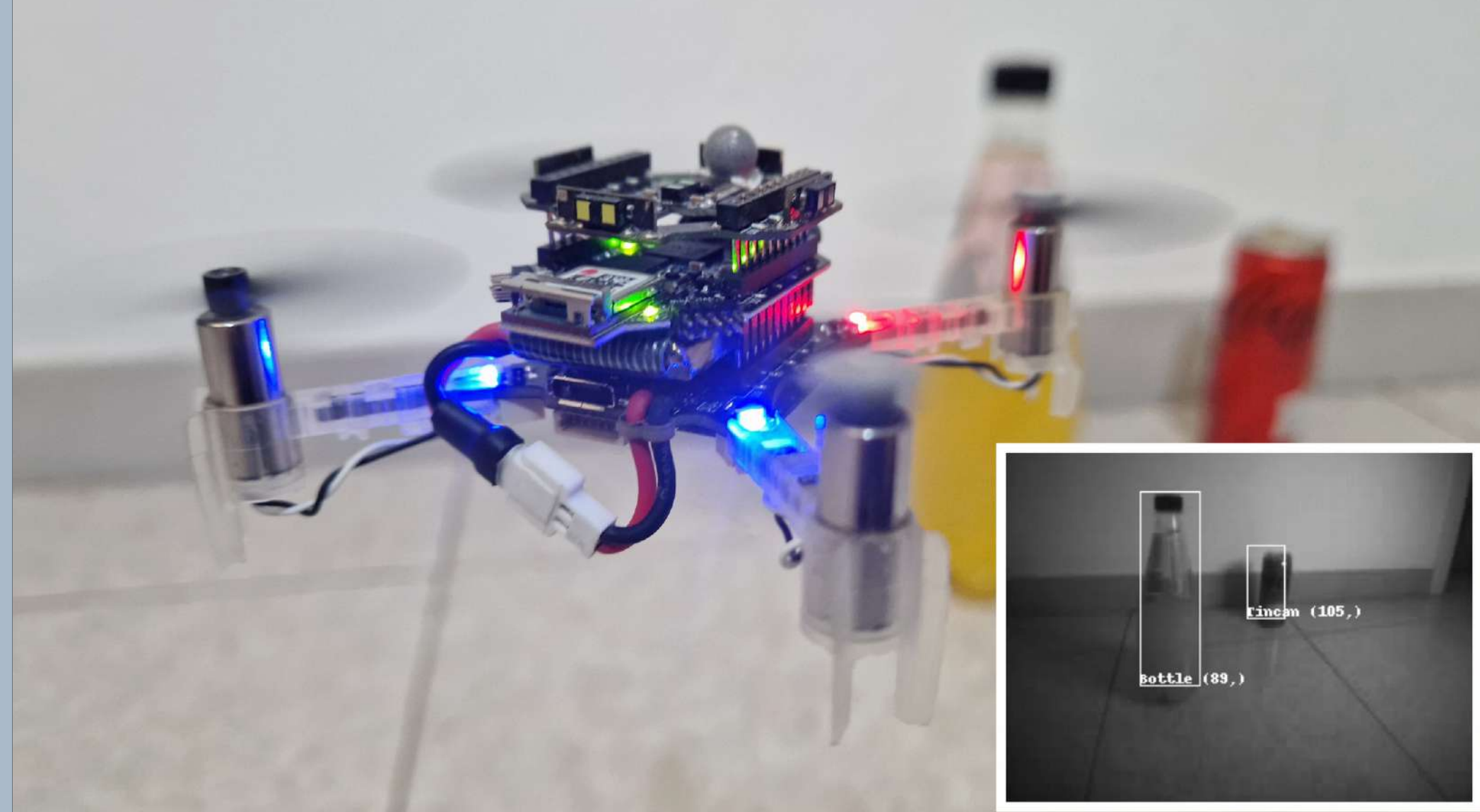
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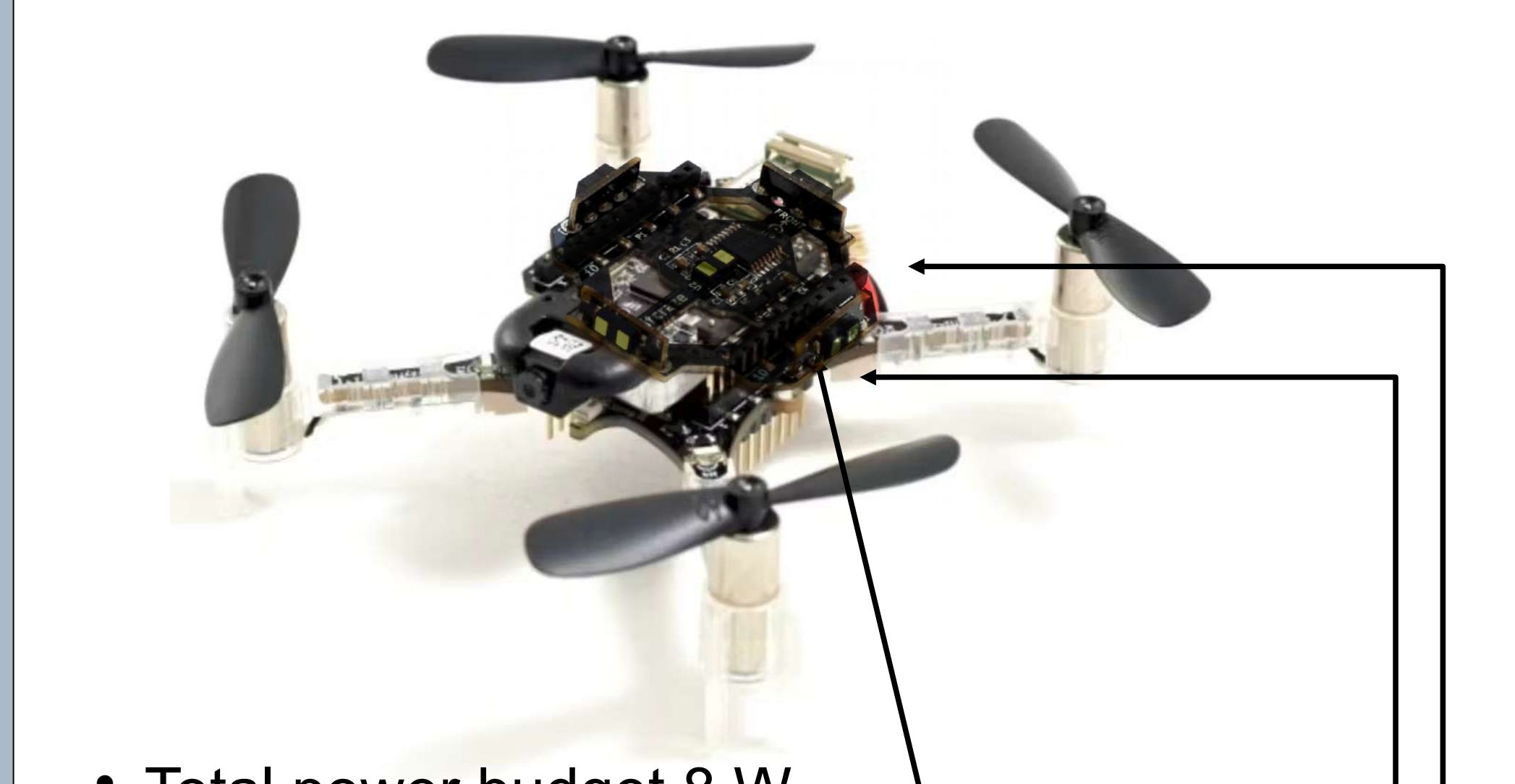
DEMO

Introduction

Running object detectors on nano-drones:
- Total power for computations <1W
- Real-time performance
- MCU class processors

Robotic platform

Nano-drone: weight 27g, diameter 10 cm.

- Total power budget 8 W
- STM32F405 MCU runs state estimation and actuation controls
- Flow deck: optical flow and height measurements
- Multi-ranger deck: line of sight distance measurements within [0,4] meters at 20 Hz.

GAP 8
- Cluster clock 175 MHz
- L3 memory 8 MB
- Fabric Controller 250 MHz
- 320X240 px greyscale camera
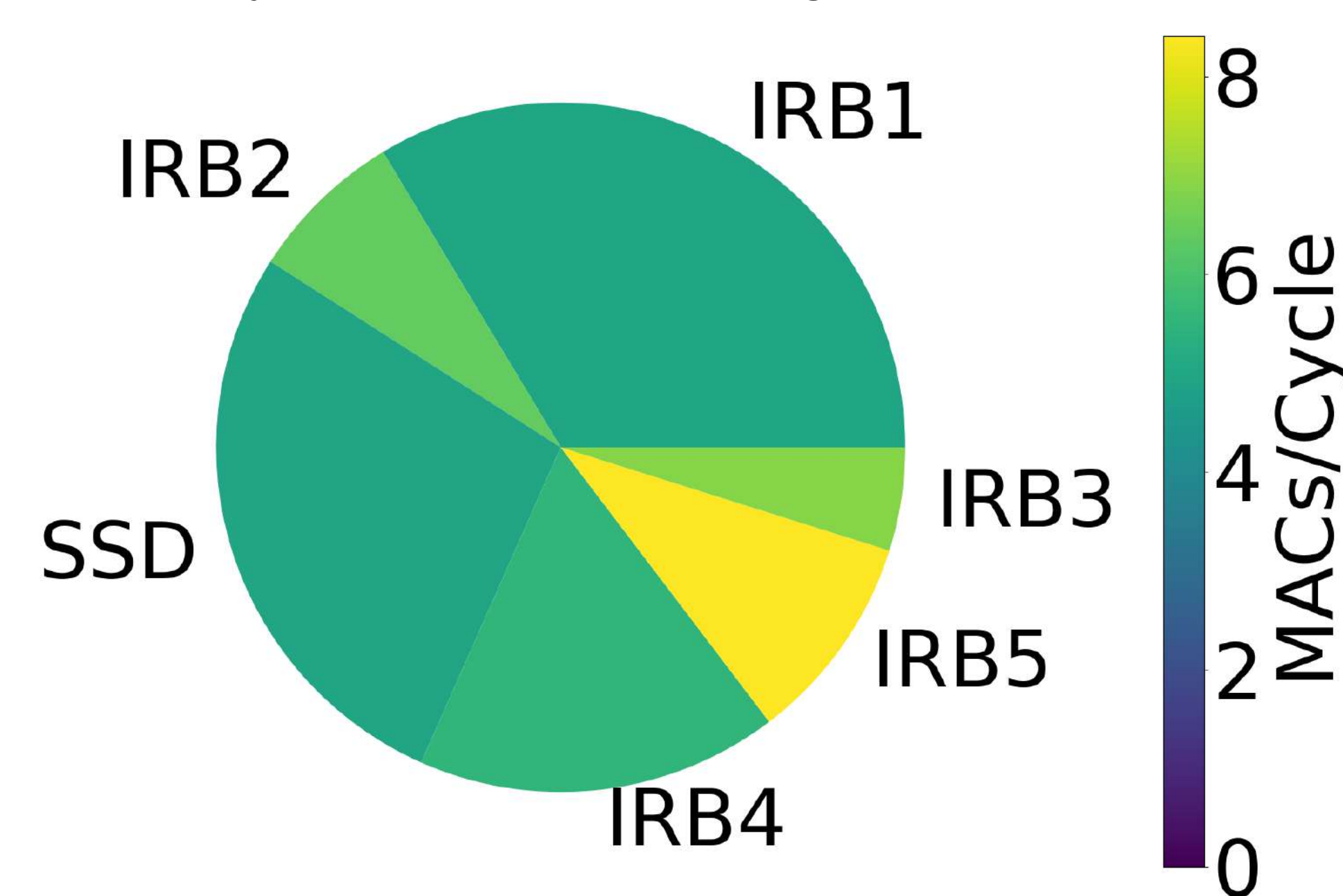- Wi-Fi for data streaming

RISC-V

GREENWAVES TECHNOLOGIES

MobileNet V2 SSD

INVERTED RESIDUAL BLOCK (IRB)

SINGLE SHOT DETECTOR (SSD)
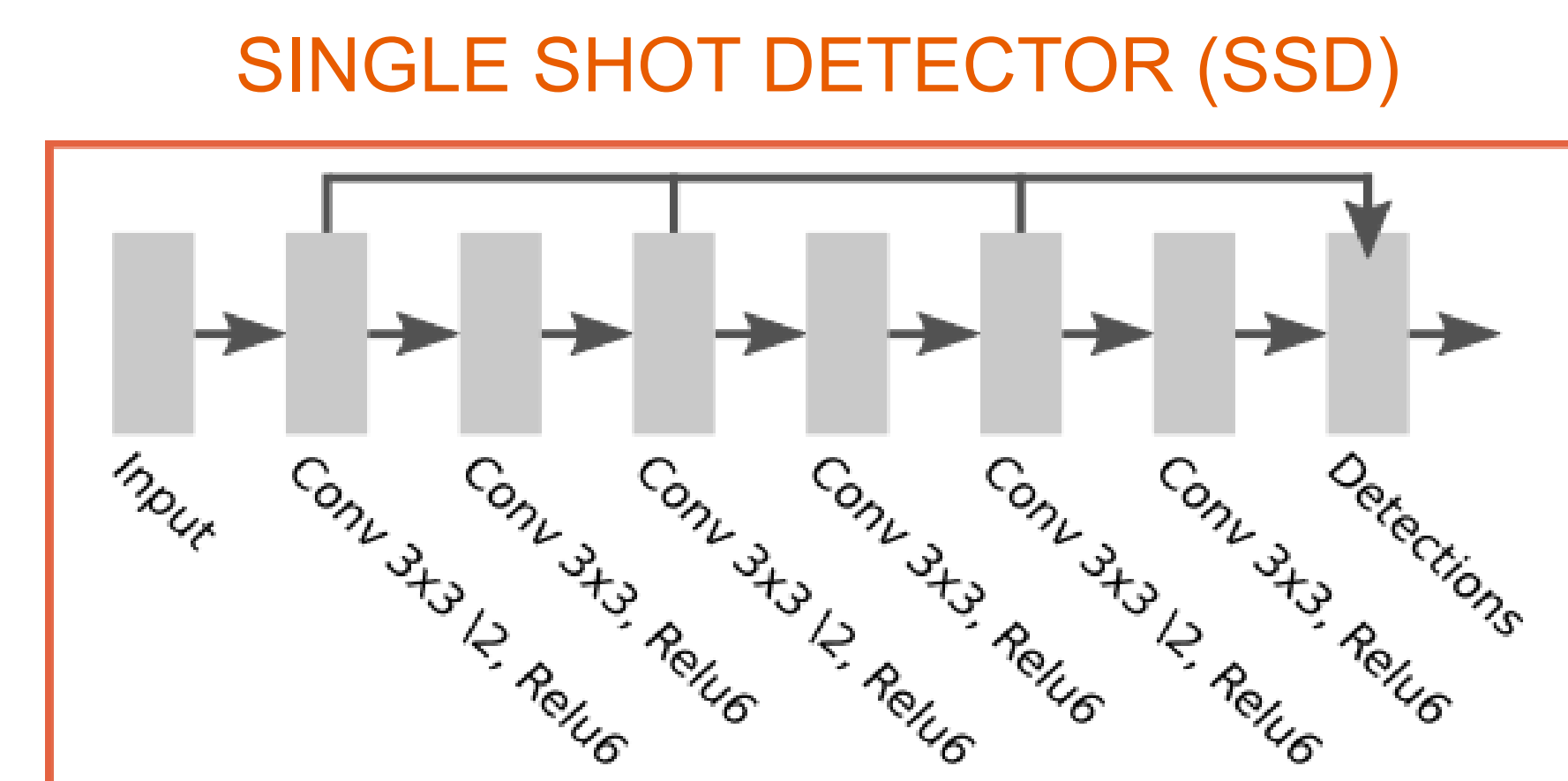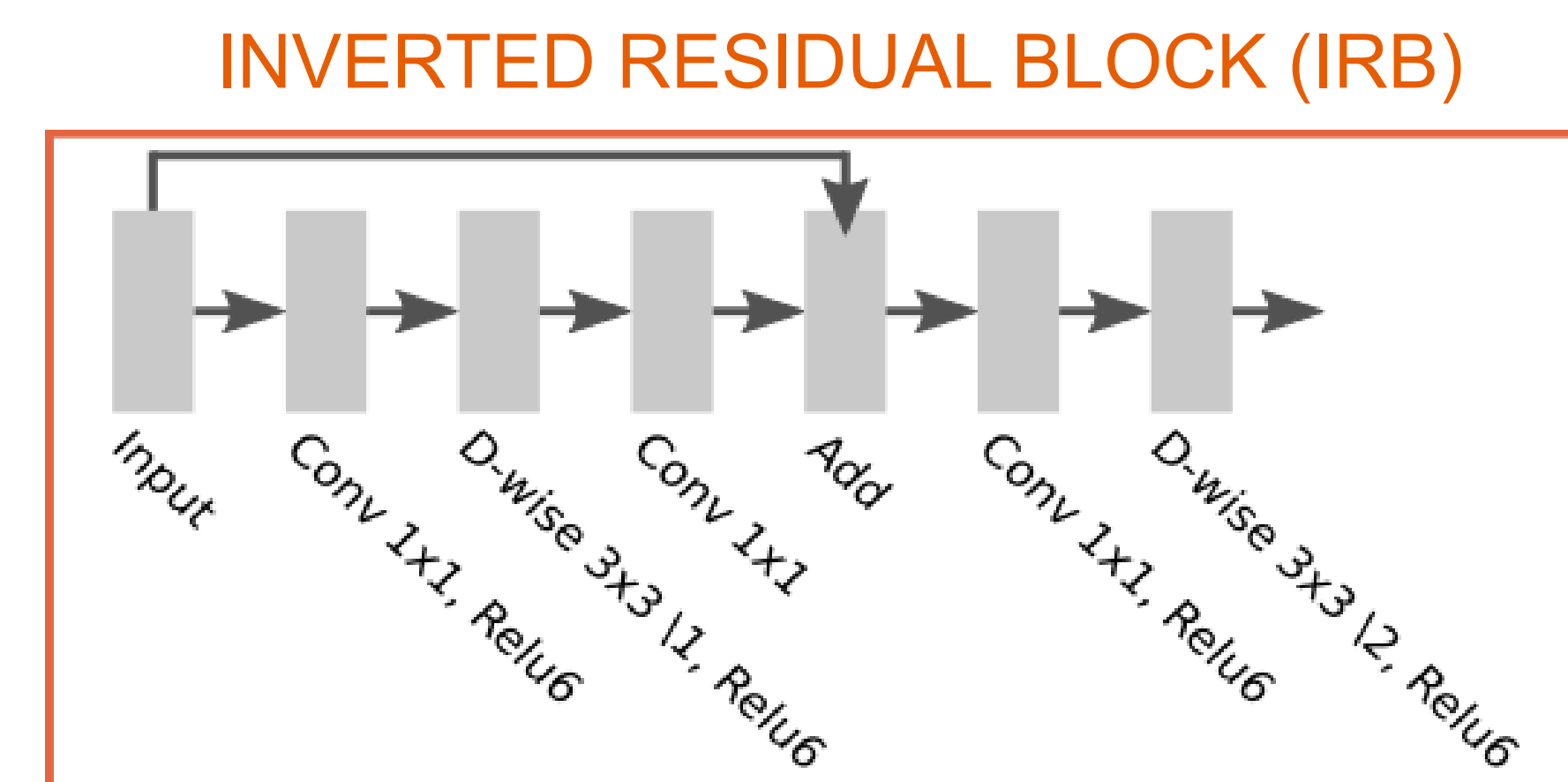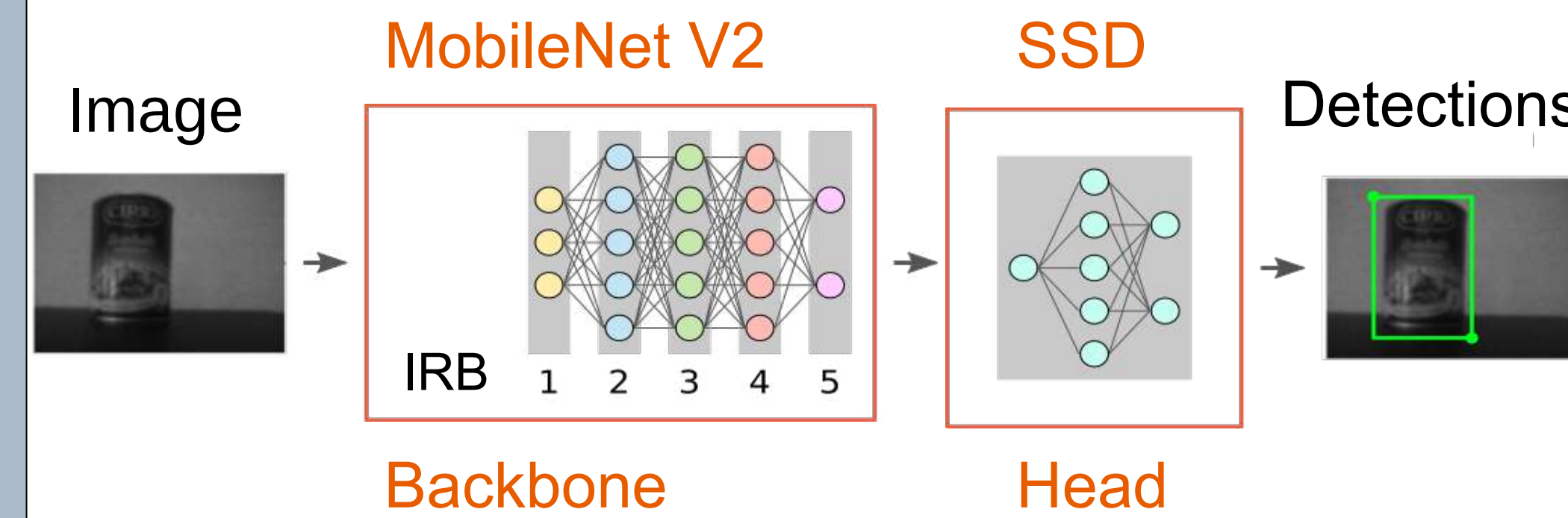
α depth multiplier: multiplies the number of channels of each layer

Depth multiplier	Parameters [M] (SSD)	MAC [M]
α=1	4.67 (0.67)	534
α=0.75	2.68 (0.55)	358
α=0.5	1.34(0.43)	193

Cycles for each building block

Deploying SSD

- Models are trained on OpenImages dataset.
- RMSProp optimizer Learning rate of $8 \cdot 10^{-4}$.
- Images resized to 320x240
- Augmentations randomly applied with 50% probability: flipping, brightness adjustment, random cropping and grayscale conversion


Google OpenImages example image   Himax camera image
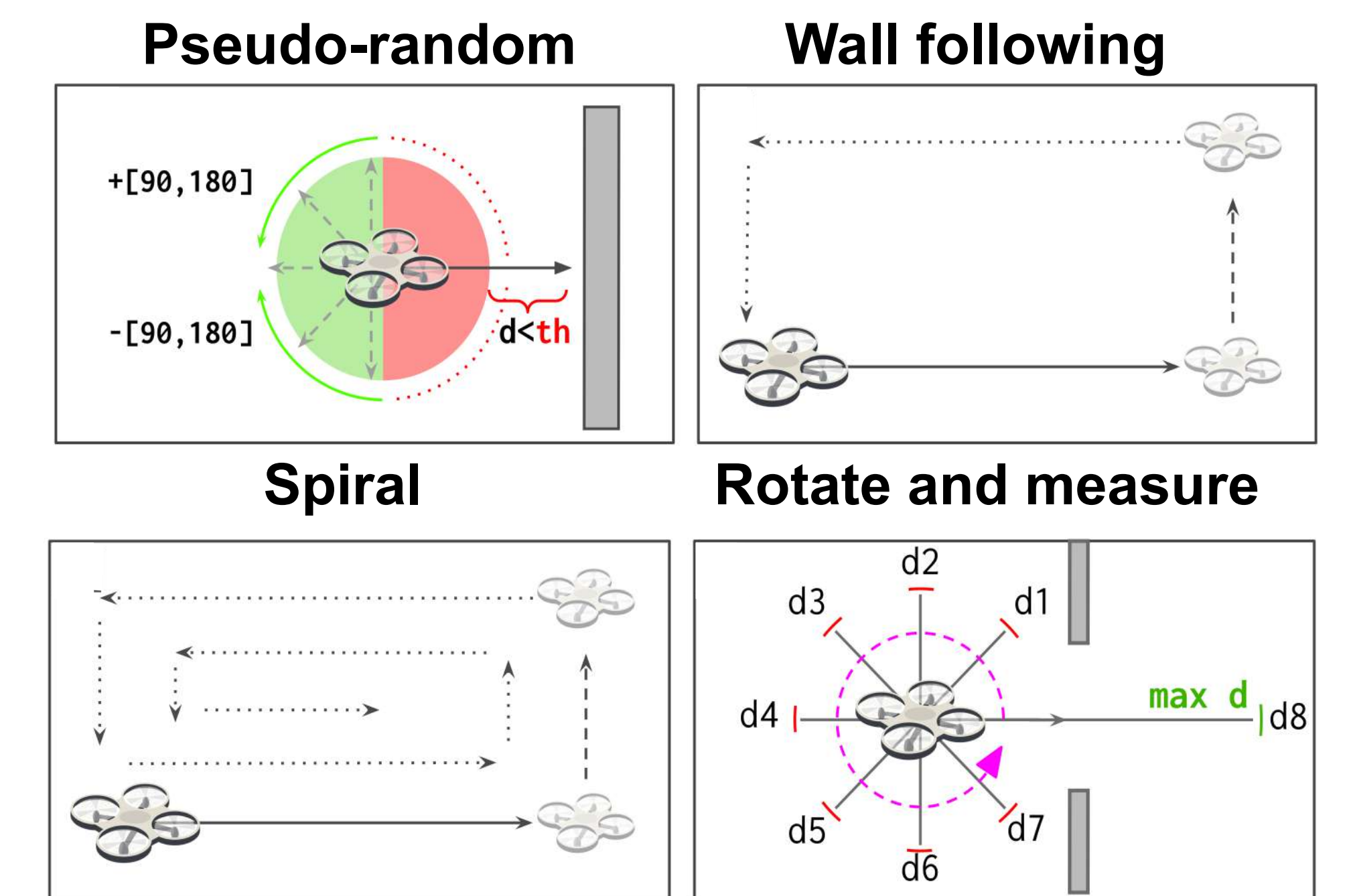
Finetuning on Himax camera images

Testing dataset	Fine tuning	Format	SSD size		
			1	0.75	0.5
OpenImages	no	float32	**59%**	**47%**	**43%**
Himax	no	float32	**50%**	**41%**	**29%**
Himax	yes	float32	**55%**	**46%**	**43%**
Himax	yes	int8	**50%**	**48%**	**32%**

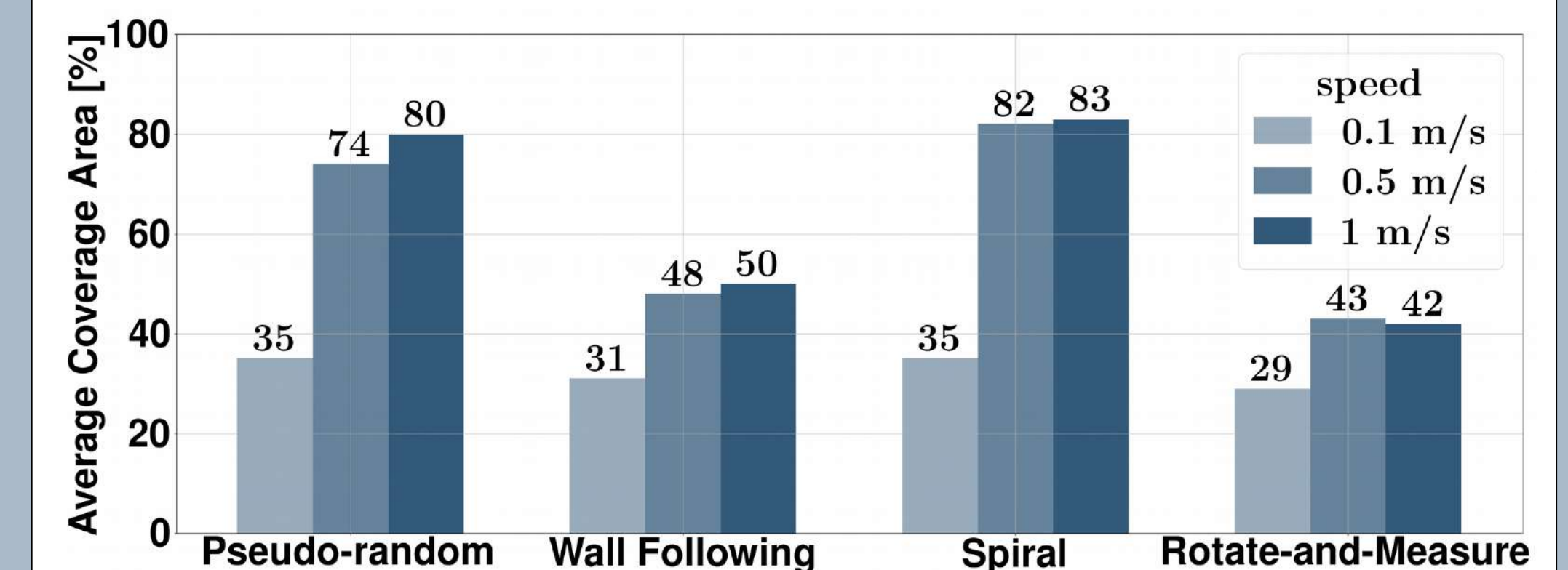| SSD	mAP	Throughput	Efficiency
1x	50%	1.6 FPS	5.3 MAC/cycle
0.75x	48%	2.3 FPS	5.9 MAC/cycle
0.5x	32%	4.3 FPS	5.3 MAC/cycle

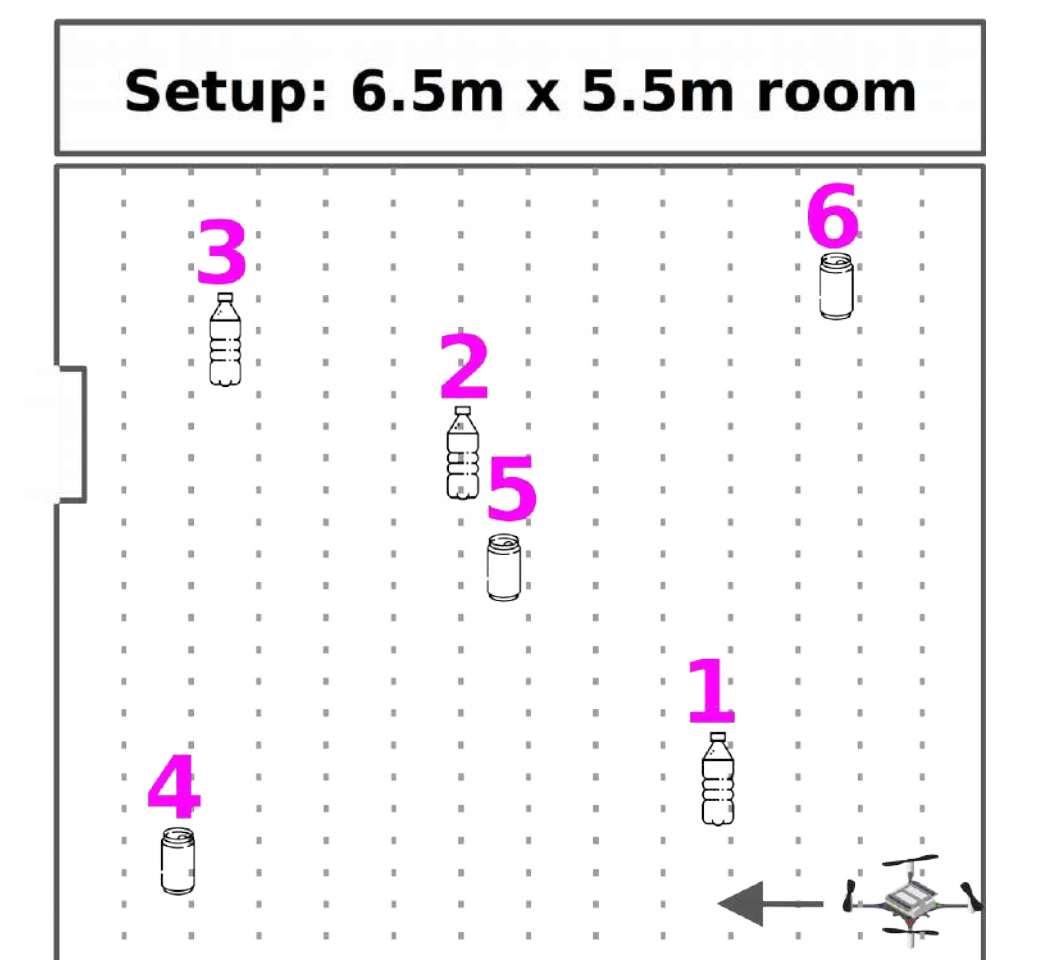### Cycles by layer type
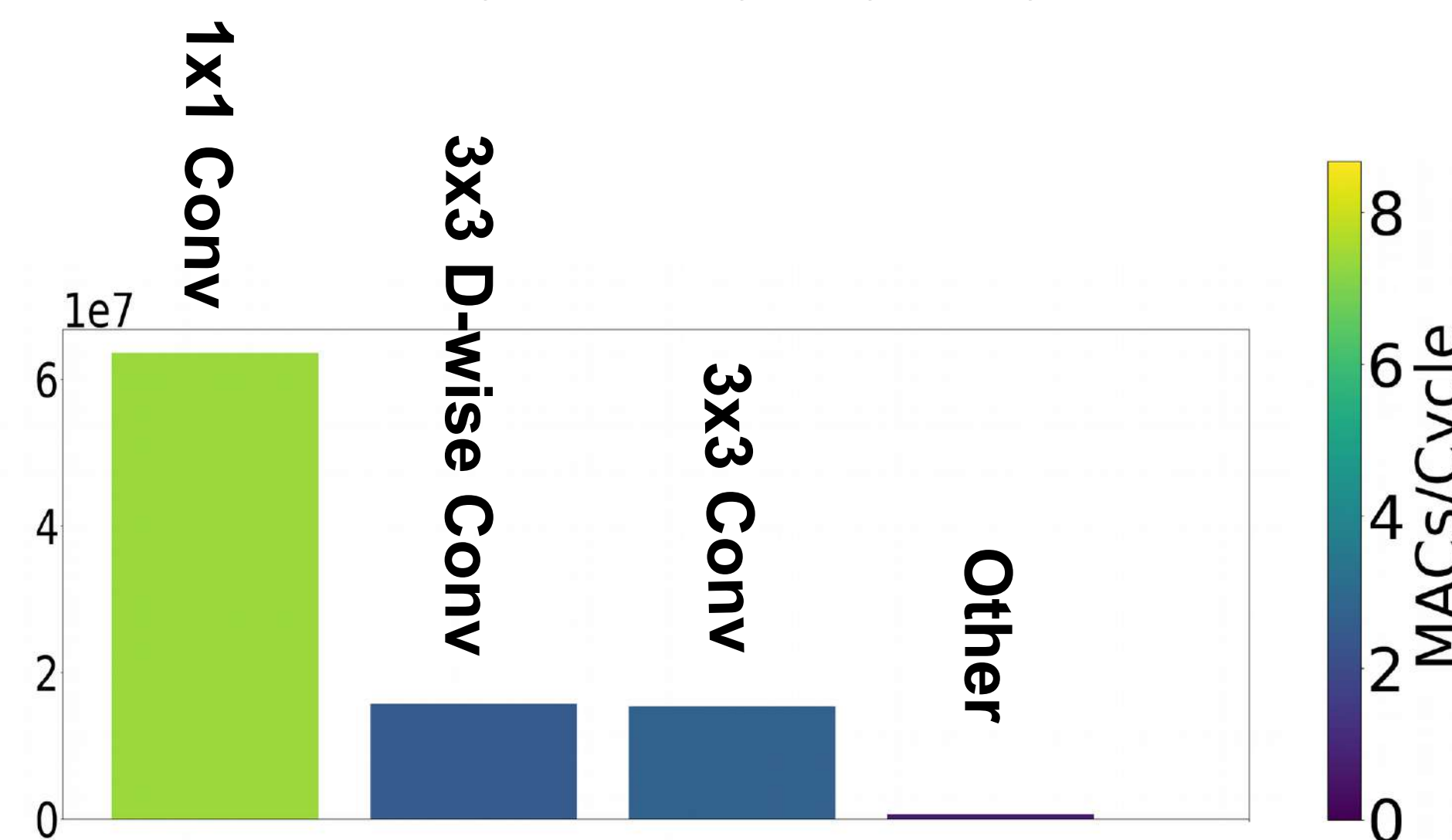
Explorations policies

3 exploration speeds

End-to-end evaluation

Targets:
- 3 bottles
- 3 tin cans

Metric:

Detection rate = $\frac{\text{\#Detected Objects}}{\text{\#Present Objects}}$

SSD	Flight speed [m/s]	Detection rate			
		Pseudo random	Wall following	Spiral	Rotate and measure
	0.1	27%	**63%**	67%	**53%**
1.0x	0.5	**90%**	50%	**73%**	**53%**
	1	83%	53%	70%	47%

Object detection is possible in real time (1.6FPS) with a detection rate of 90%