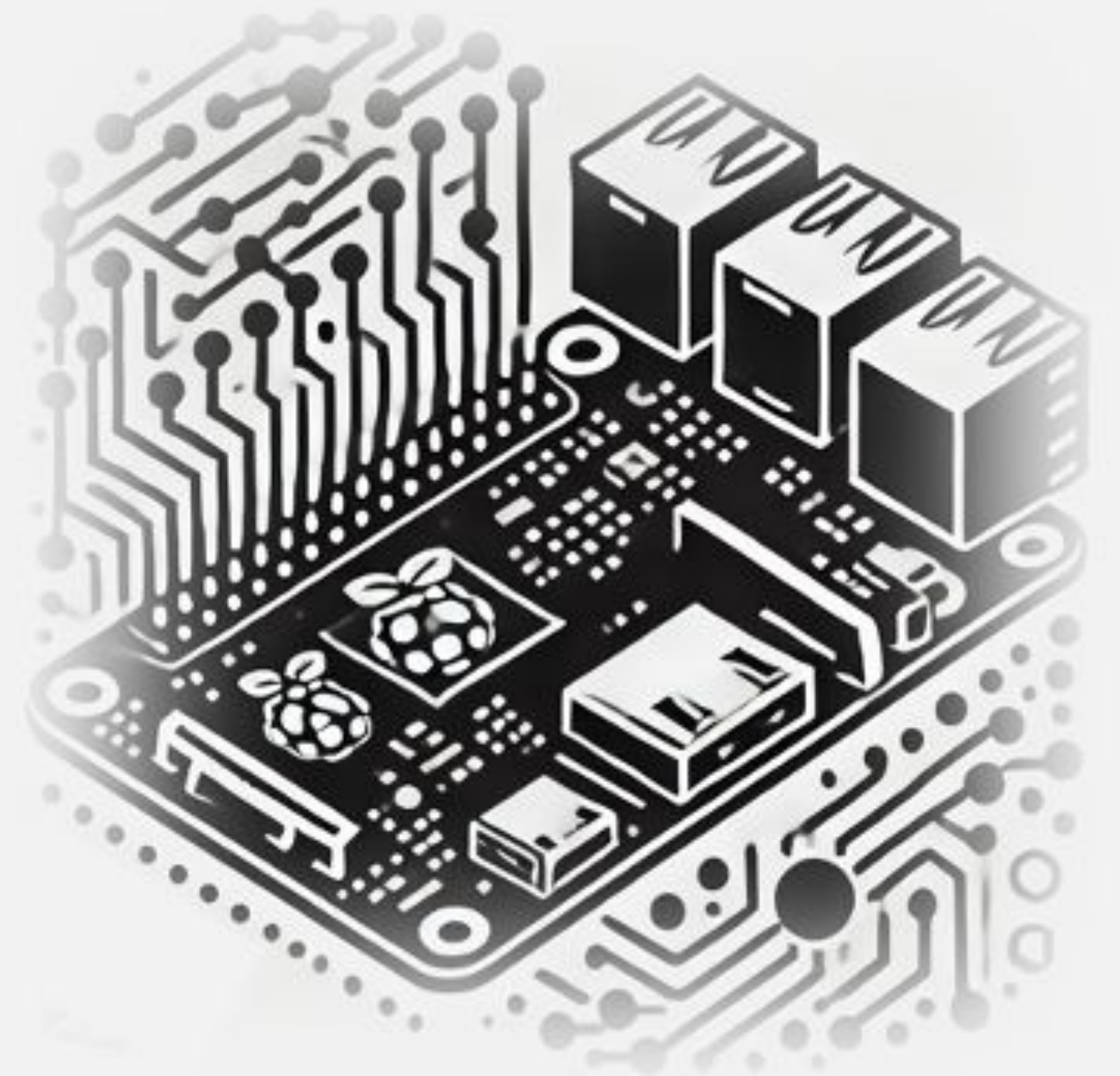


IEST105 – Edge AI

Machine Learning System Engineering

-
13. Use of EdgeML for a
Non-Invasive Beehive
Monitoring System



Universidade Federal de Itajubá - UNIFEI

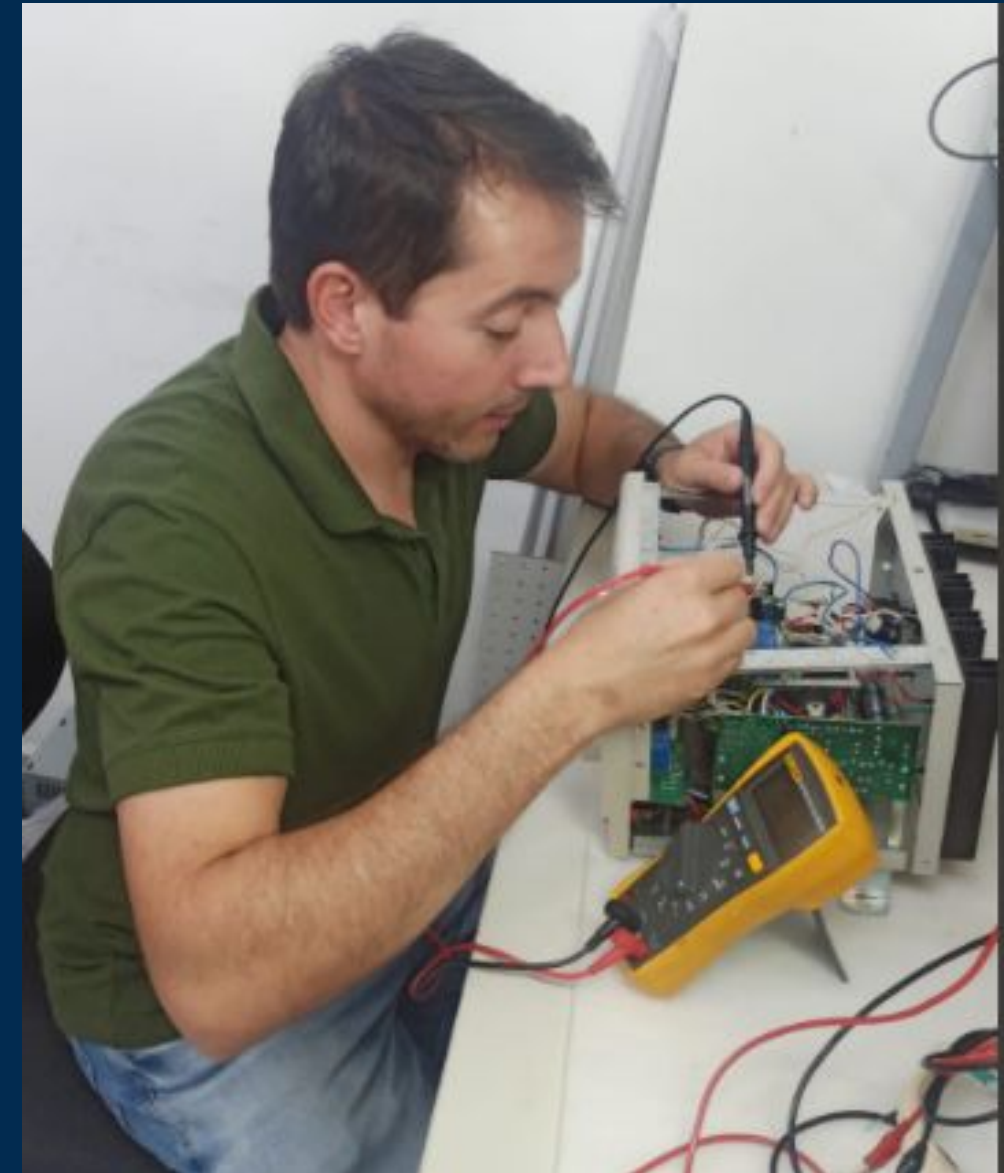
Uso de EdgeML para um sistema de monitoramento não invasivo de colmeias

Apresentador: José Anderson dos Reis



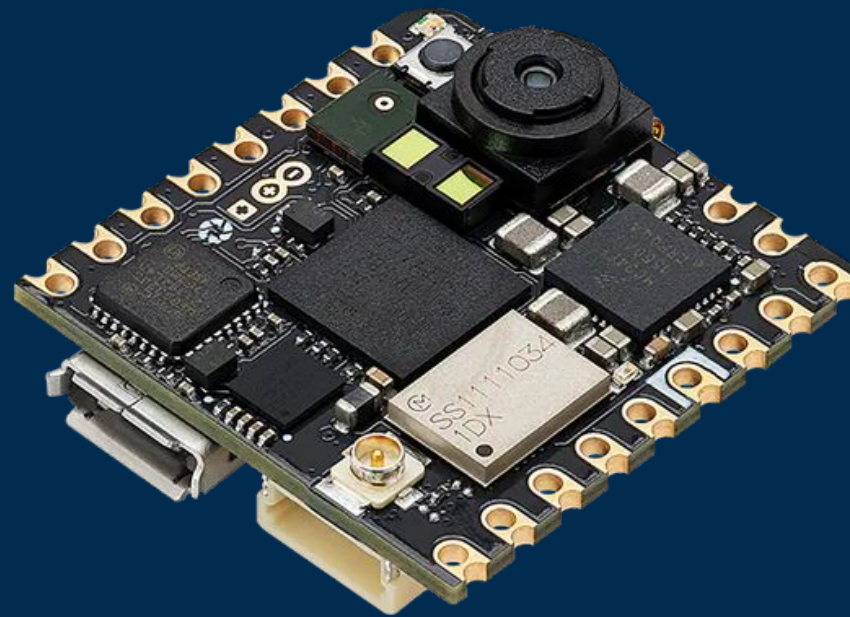
Sobre mim

- Itajubá MG
- Técnico em eletrônica SENAI
- Mestrando Engenharia Eletrônica UNIFEI
- 15 anos de experiência com montagem e layout de placas de circuito impresso





Primeiras abordagens



- Nicla Vision
- STM32H747AI6 Dual Arm® Cortex® M7/M4 IC:
- 1x Arm® Cortex® M7 core up to 480 MHz
- 1x Arm® Cortex® M4 core up to 240 MHz
- \$107.88

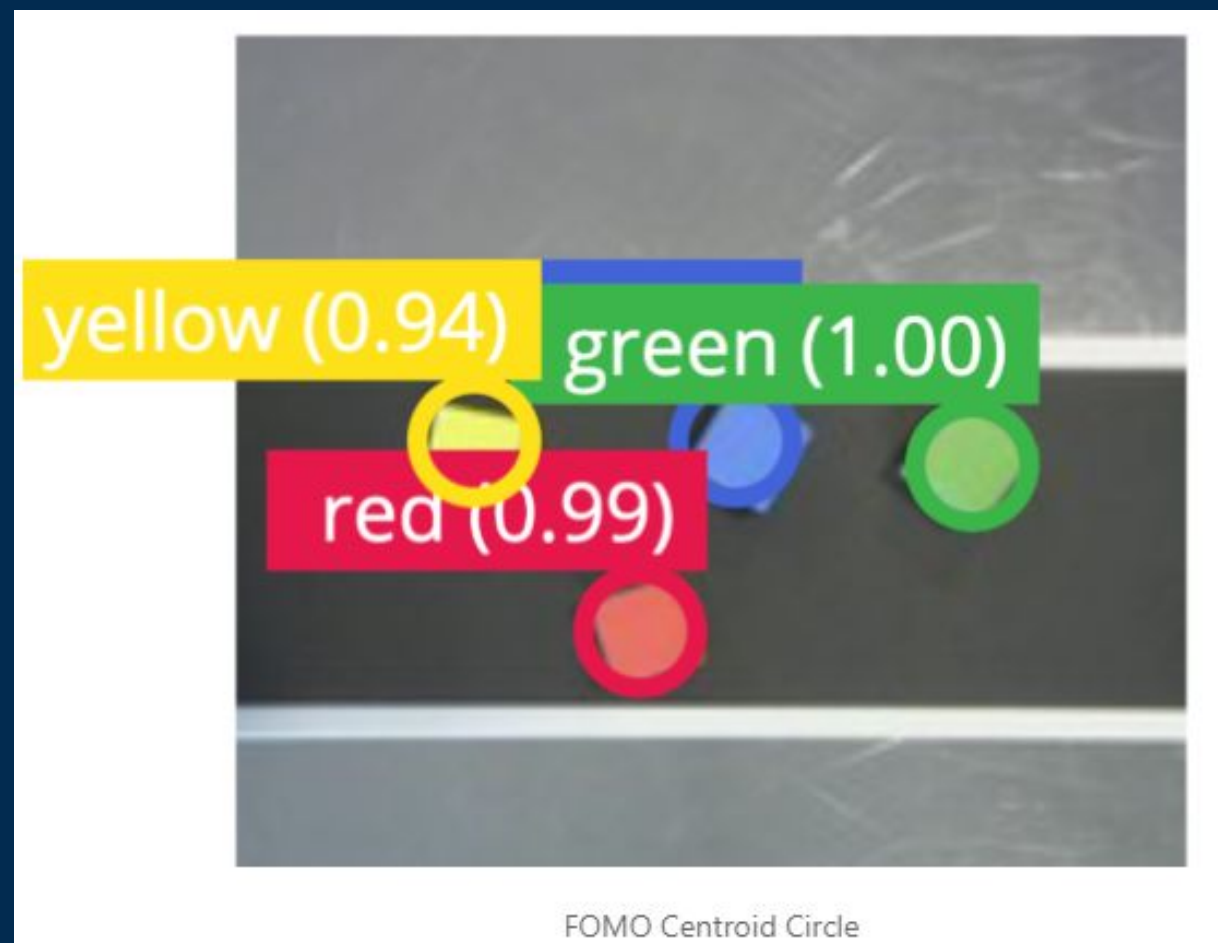


- Xiao Esp32 sense
- Dual-core, Xtensa operando até 240 MHz
- \$25,00

Object Detection



FOMO (Faster Objects, More Objects)



- Desenvolvido pela Edge Impulse
- Detecção de objetos em microcontroladores e dispositivos com recursos limitados
- Em vez de prever caixas delimitadoras, ele identifica apenas os centróides (pontos centrais) dos objetos, reduzindo a

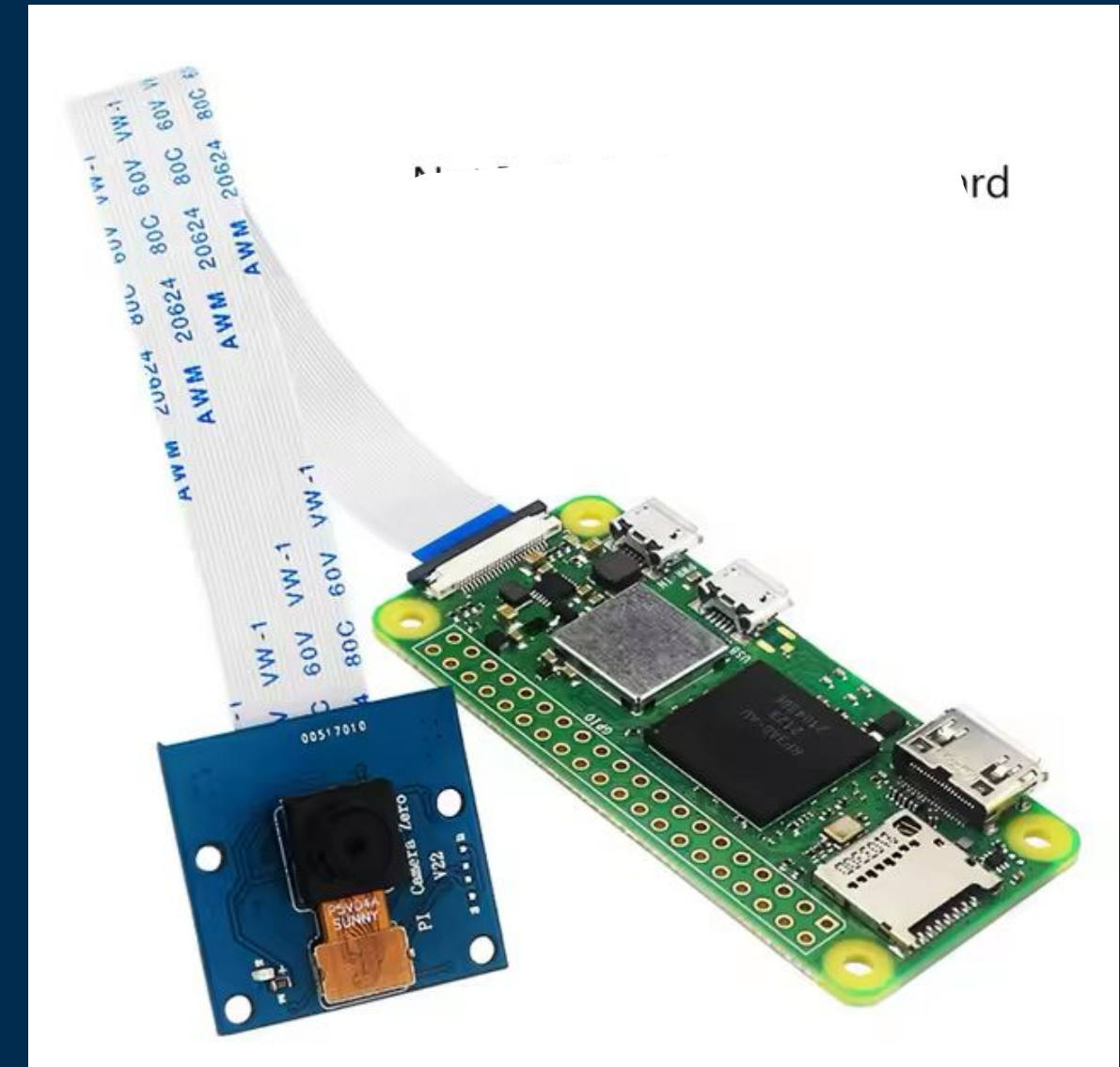
Raspberry Pi Zero 2W



- Processor: 1GHz quad-core 64-bit

Arm Cortex-A53 CPU

- RAM: 512MB SDRAM
- Wireless: 2.4GHz 802.11 b/g/n
wireless LAN, Bluetooth 4.2, BLE
- Ports: Mini HDMI, micro USB OTG,
CSI-2 camera connector
- Power: 5V via micro USB port



\$15,00

Object Detection



YOLO (You Only Look Once)

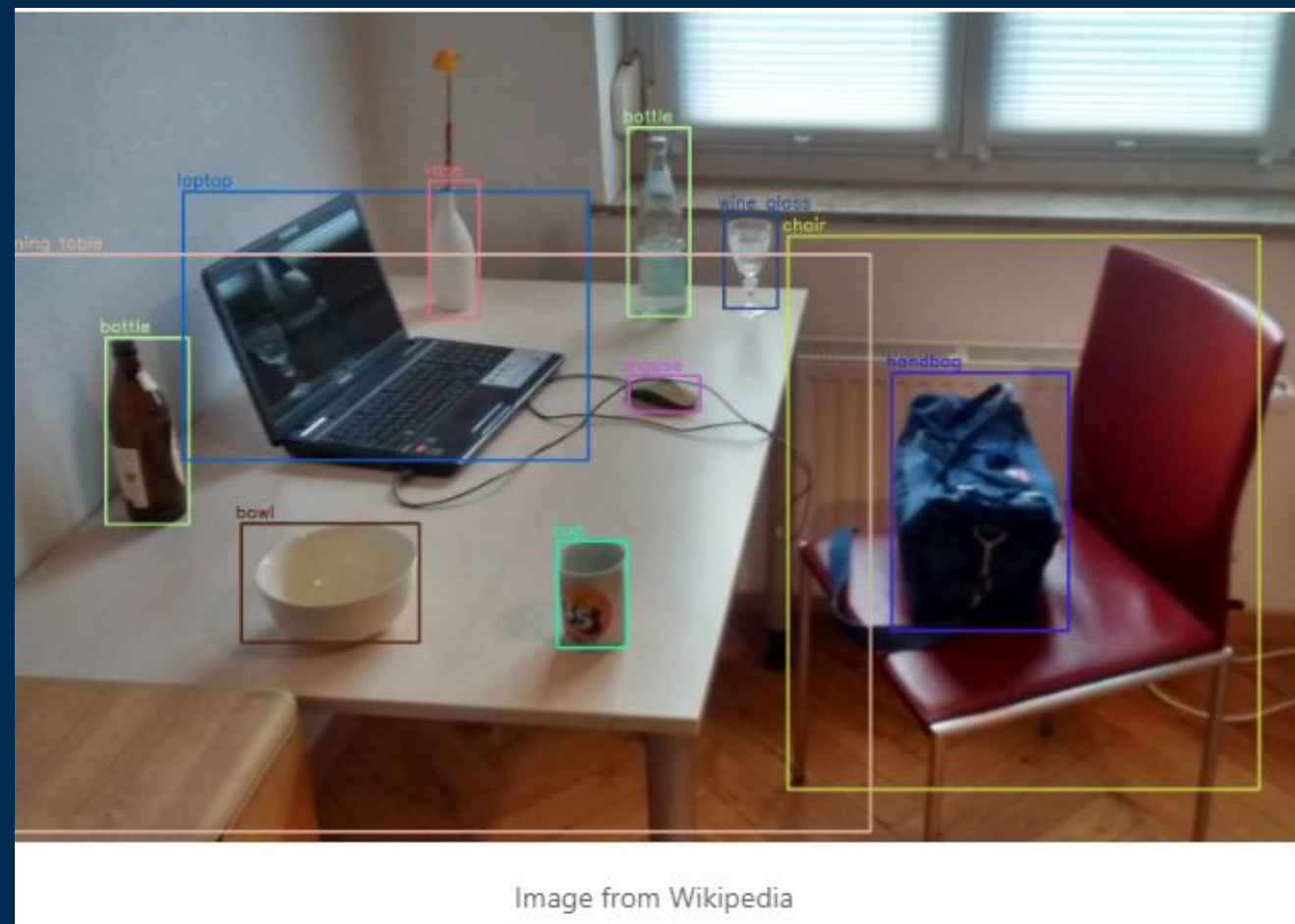


Image from Wikipedia

- Boa precisão
- Ampla comunidade de suporte e aplicabilidade geral
- Rodar bem em equipamentos como o Raspberry Pi
- Porém, em microcontroladores muito limitados, a execução é difícil devido às altas demandas

Comparação



Feature	YOLO (Typical Edge Versions)	FOMO
Primary Output	Bounding Boxes (x, y, width, height)	Object Centroids (x, y)
Model Size	Larger (Megabytes)	Very Small (Kilobytes, e.g., <200KB)
Computational Load	Higher	Very Low
Speed on RPi	Moderate to Good (e.g., 5-25+ FPS)	Very Fast (e.g., 30-60+ FPS)
Speed on ESP32-CAM	Generally Slow / Impractical	Good for Real-Time (e.g., 5-15+ FPS)
Accuracy	Generally Higher, more robust	Good for defined tasks, sensitive to object size/spacing
Object Size Info	Yes	No (only location)
Power Consumption	Higher	Lower
Complexity	More complex to implement from scratch	Simpler, especially with Edge Impulse
Best For	Detailed object analysis, varied object sizes	Fast presence/location detection, counting, resource-starved devices
Hardware Sweet Spot	Raspberry Pi, Jetson Nano, similar SBCs	ESP32-CAM, Arduino (with vision shield), other MCUs

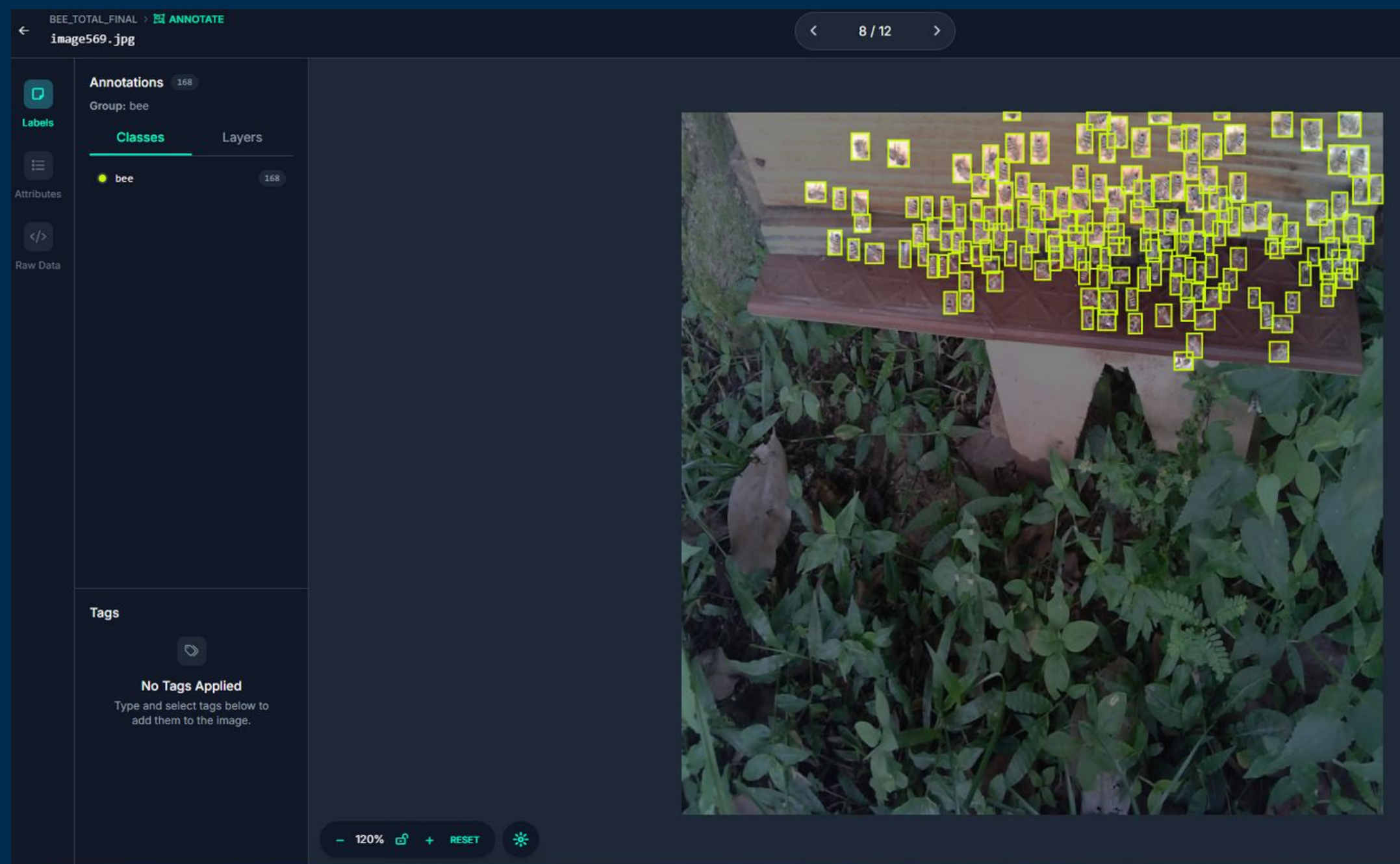
Captura do Dataset



- Utilizando a Xiao Esp32 sense



Labeling Roboflow



10

Total de abelhas nessa figura 168

Label Assist



Label Assist

Use the predictions from a public model or a model trained by [Roboflow Train](#) as a starting point for annotating new images in this dataset.

[Your Models](#) [Public Models](#)

PROJECT

BeeM

MODEL

v2 - 2025-01-15 3:19pm (96.7% mAP)

Cancel Continue



Label assist 78 abelhas



Ajuste manual 91 abelhas

1

1

Pré Processamento



Versions

2025-02-04 4:18pm

v1 4574 640x640

Stretch to

Version Name:

2025-09-18 3:44pm

✓ Source Images

Images: 1.991
Classes: 1
Unannotated: 0

✓ Train/Test Split

Training Set: 1.4k images
Validation Set: 389 images
Testing Set: 192 images

3 Preprocessing

What can preprocessing do?

Decrease training time and increase performance by applying image transformations to all images in this dataset.

Auto-Orient

Edit

×

Resize

Stretch to 640x640

Edit

×

+ Add Preprocessing Step

Continue

Data Augmentation



4

Augmentation

[?](#) What can augmentation do?

Create new training examples for your model to learn from by generating augmented versions of each image in your training set.

Flip
Vertical

Edit

×

90° Rotate
Clockwise, Counter-Clockwise

Edit

×

+

Add Augmentation Step



Use Previous Augmentations

Use augmentations from a previous version.

Continue

Clear All

Dataset Final



Versions

2025-02-04 4:18pm

v1 4574 640x640

Stretch to Anderson Reis

v1 2025-02-04 4:18pm

Generated on Feb 4, 2025 by Anderson Reis

Download Dataset Edit

This version doesn't have a model.

Train an optimized, state of the art model with Roboflow or upload a custom trained model to use features like Label Assist and Model Evaluation and deployment options like our auto-scaling API and edge device support.

Custom Train

Available Credits: 1

How to Upload Custom Weights

4574 Total Images

View All Images →

Dataset Split

TRAIN SET

3993 Images

87%

VALID SET

389 Images

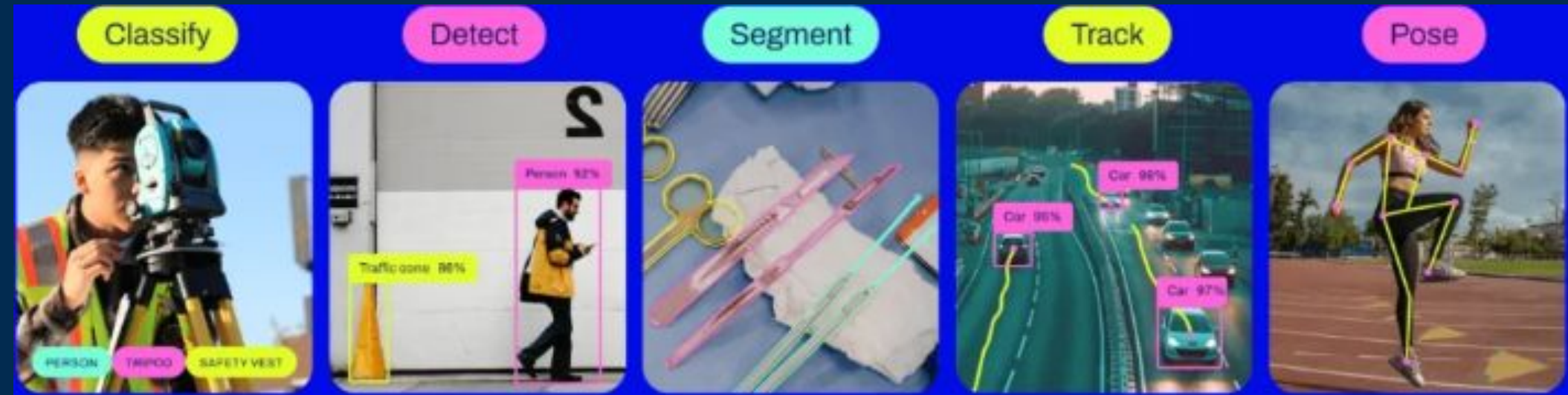
9%

TEST SET

192 Images

4%

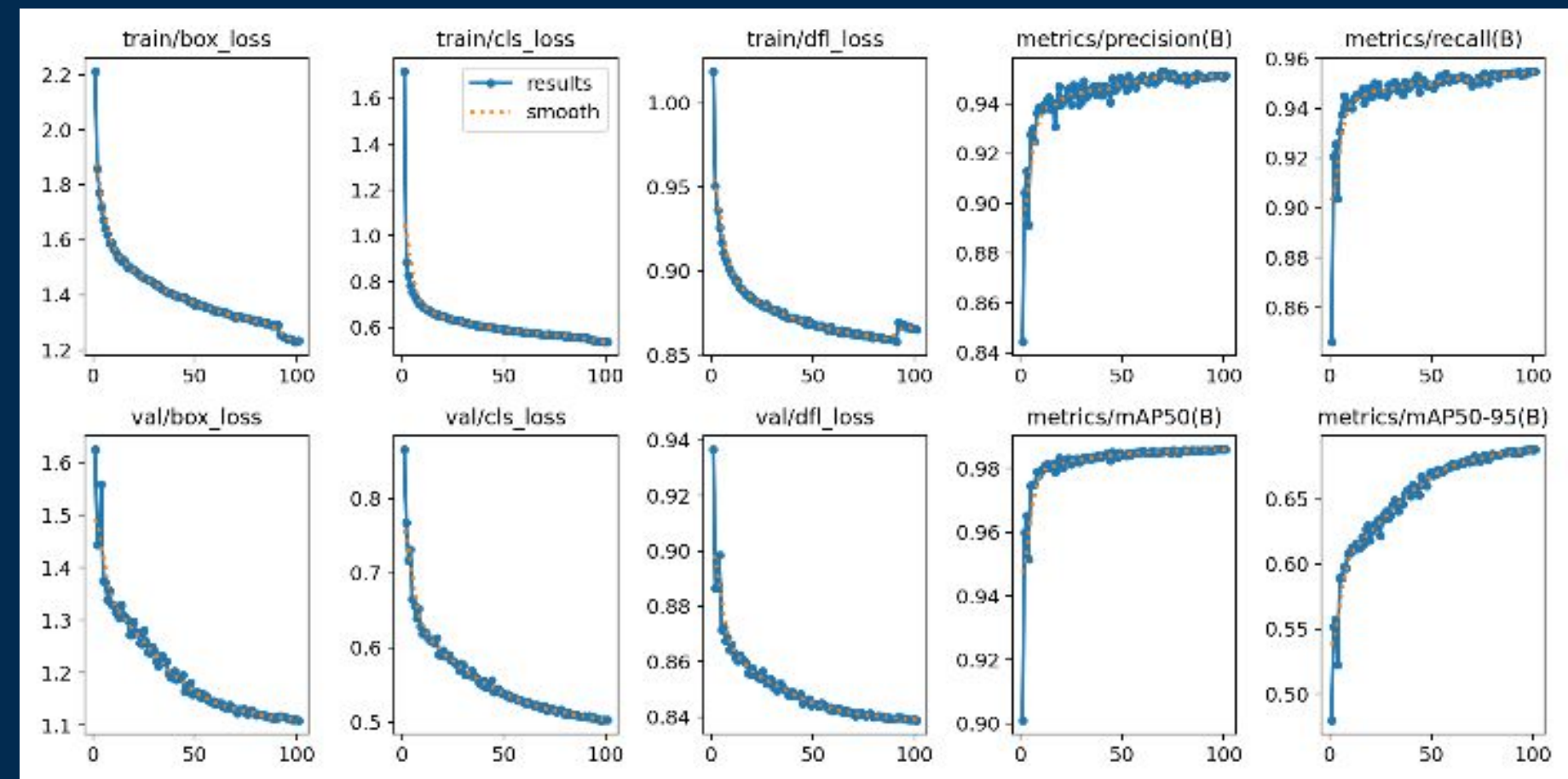
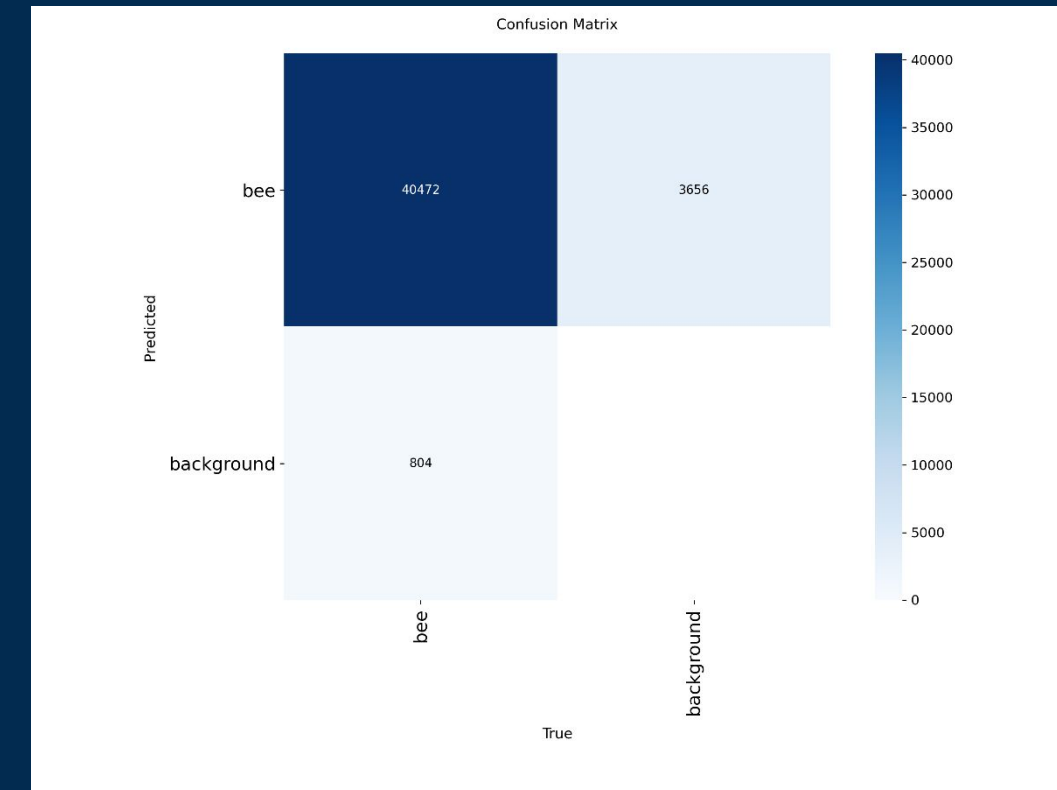
Treinamento do Modelo



Model	size (pixels)	mAP ^{val} 50-95	Speed CPU ONNX (ms)	Speed A100 TensorRT (ms)	params (M)	FLOPs (B)
YOLOv8n	640	37.3	80.4	0.99	3.2	8.7
YOLOv8s	640	44.9	128.4	1.20	11.2	28.6
YOLOv8m	640	50.2	234.7	1.83	25.9	78.9
YOLOv8l	640	52.9	375.2	2.39	43.7	165.2
YOLOv8x	640	53.9	479.1	3.53	68.2	257.8

Metricas de Treinamento

- Intersecção sobre União (IoU)
- Precisão e Recall
- (Mean Average Precision) (mAP) *multiplas classes
- F1 score



Questions?

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UNIFEI