Object Detection 101

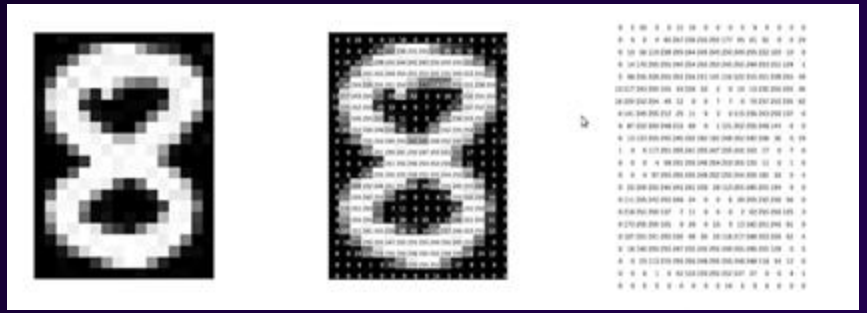
Welcome!

Today, we will show you guys how to use one key AI tools:

- YOLOv8
- YOLOv8-obb

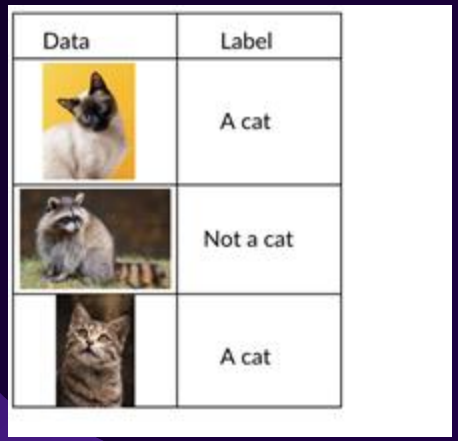
Computer Vision???

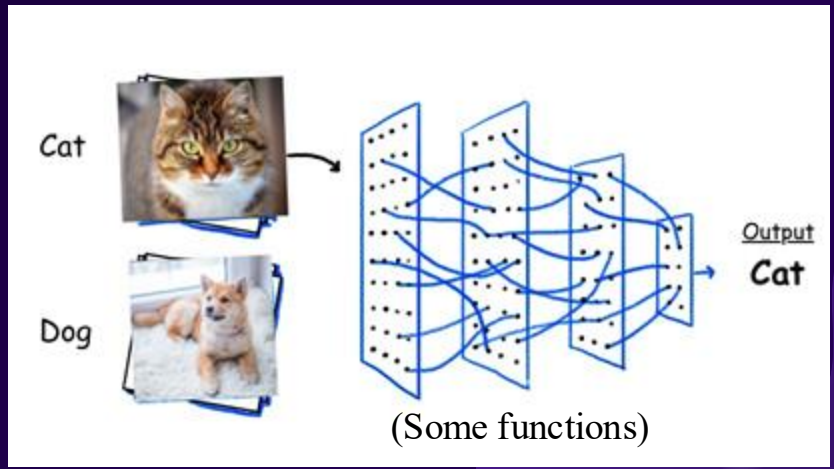
- How can computers see?
- **Low-level**: colors, intensity difference
- **High-level**: features, semantics



Main idea

- Give computer an **image** and a **label**. The label tells the computer what is in the picture.
- Computer **converts** the image to **numbers** and find **pattern**.
- Give computer a new image **without a label**. Computer predicts based on the pattern it learned before.
- If computer is correct, **keep** the pattern
- If it's wrong, **adjust** the pattern.
- This is repeated a looooooot of times, until computer is corrected and makes accurate guesses

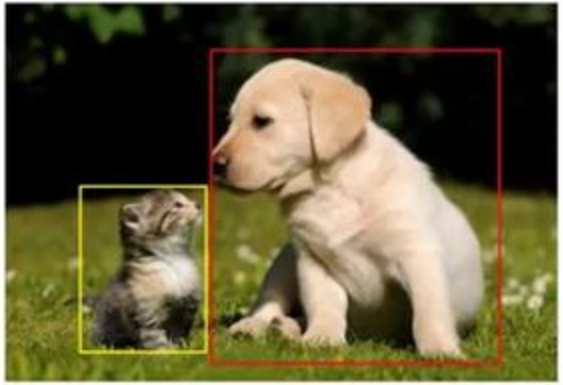




Is this a dog?

Image Classification

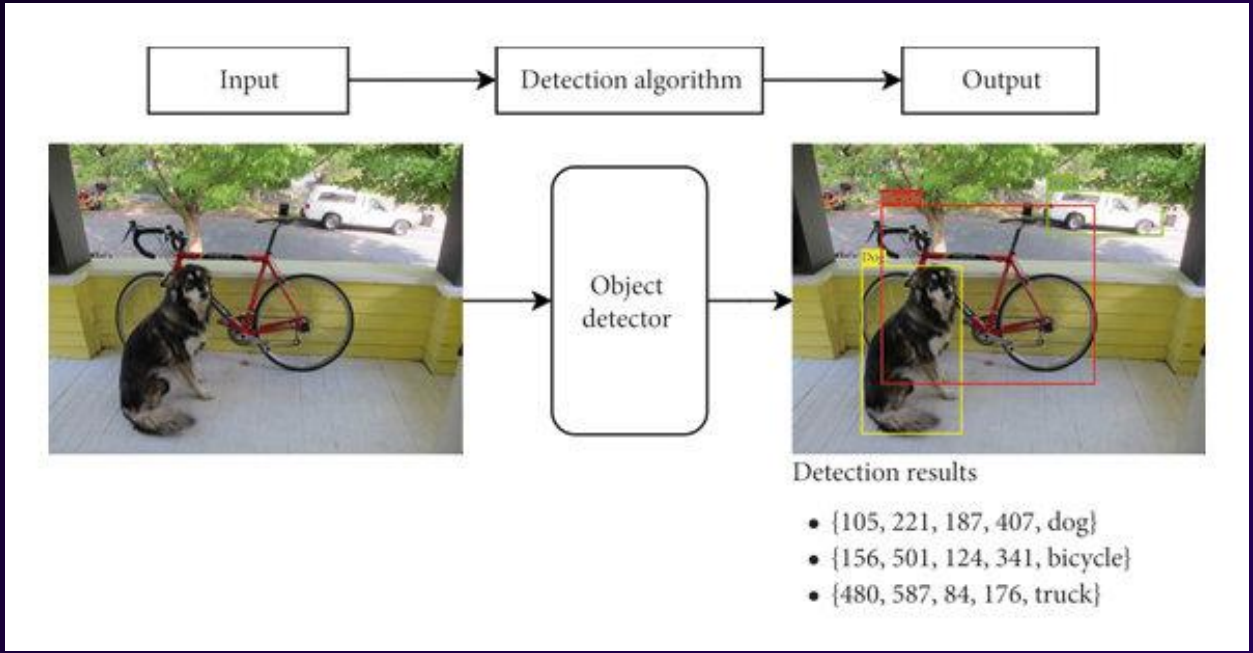
What is there in image and where?



Object Detection

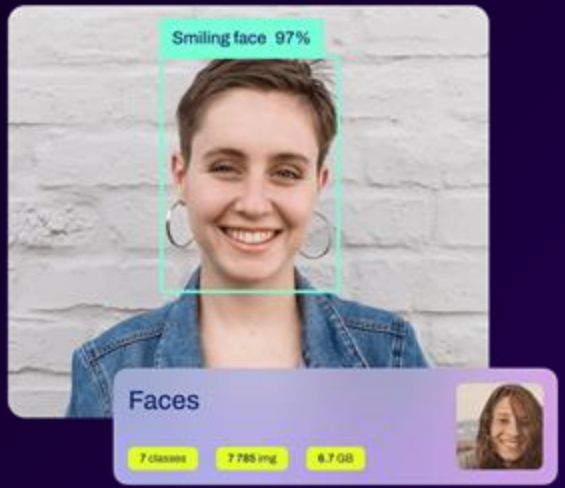
Object Detection…

The training works pretty much the same, but the algorithm has a few more things to calculate:



YOLOv8??

- VERY famous machine learning algorithm
- Intended to be used in REAL-TIME by doing the important calculations in a single step
- Supported by standard hardware (nothing too fancy needed)



How does it work?

NOTE: this is an overly simplified explanation.

The picture is divided into cells. For each cell, YOLOv8 guesses where objects are present (bounding boxes) and also guesses what each object is (class probabilities)

Then, YOLOv8 selects only the most likely one for each object in the picture.

Let us get our hands dirty with Yolov8!😎😎

STEP-BY-STEP SET up Environment

1. Run:
git clone https://github.com/HKUArmStrong/rac_workshop

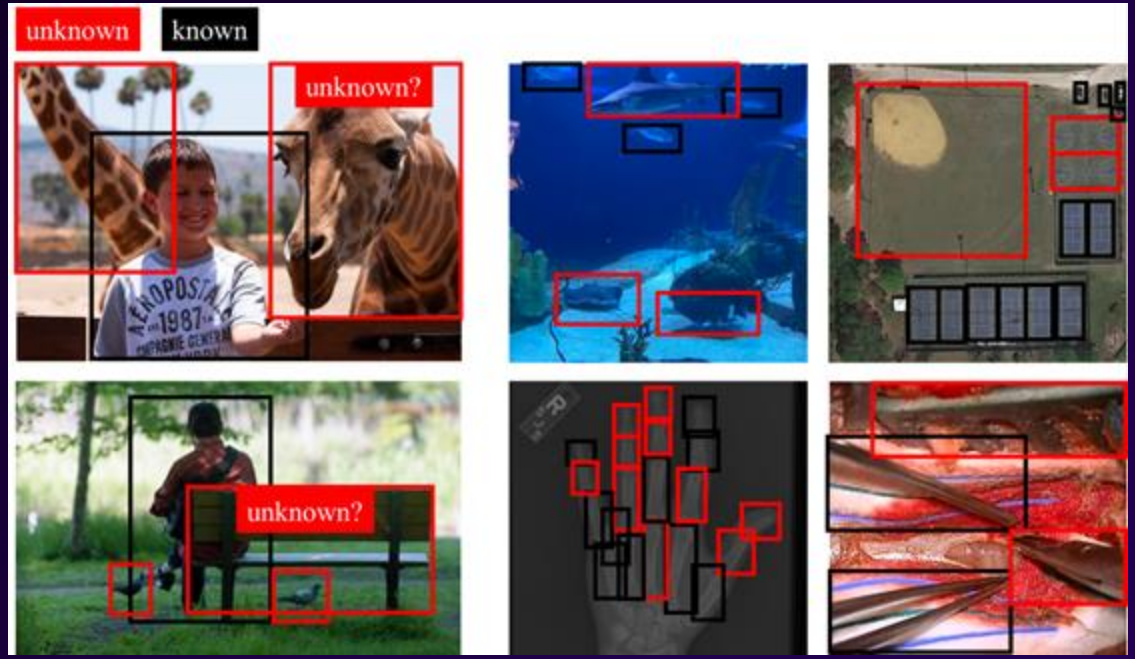
2. Setup Python environment:
conda create --name cv_workshop python=3.12
conda activate cv_workshop

3. With requirements.txt:
pip install -r requirements.txt

4. Switch to different .txt file at step 3 to be compatible to your system. (E.g., on Mac / with GPU / CPU only)

The only things Yolo can detect:

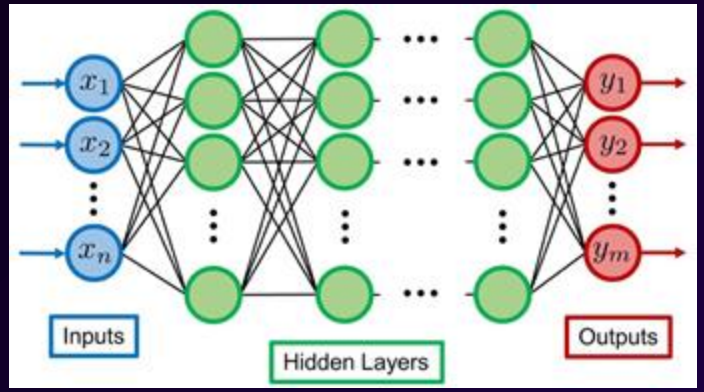
{0: 'person', 1: 'bicycle', 2: 'car', 3: 'motorcycle', 4: 'airplane', 5: 'bus', 6: 'train', 7: 'truck', 8: 'boat', 9: 'traffic light', 10: 'fire hydrant', 11: 'stop sign', 12: 'parking meter', 13: 'bench', 14: 'bird', 15: 'cat', 16: 'dog', 17: 'horse', 18: 'sheep', 19: 'cow', 20: 'elephant', 21: 'bear', 22: 'zebra', 23: 'giraffe', 24: 'backpack', 25: 'umbrella', 26: 'handbag', 27: 'tie', 28: 'suitcase', 29: 'frisbee', 30: 'skis', 31: 'snowboard', 32: 'sports ball', 33: 'kite', 34: 'baseball bat', 35: 'baseball glove', 36: 'skateboard', 37: 'surfboard', 38: 'tennis racket', 39: 'bottle', 40: 'wine glass', 41: 'cup', 42: 'fork', 43: 'knife', 44: 'spoon', 45: 'bowl', 46: 'banana', 47: 'apple', 48: 'sandwich', 49: 'orange', 50: 'broccoli', 51: 'carrot', 52: 'hot dog', 53: 'pizza', 54: 'donut', 55: 'cake', 56: 'chair', 57: 'couch', 58: 'potted plant', 59: 'bed', 60: 'dining table', 61: 'toilet', 62: 'tv', 63: 'laptop', 64: 'mouse', 65: 'remote', 66: 'keyboard', 67: 'cell phone', 68: 'microwave', 69: 'oven', 70: 'toaster', 71: 'sink', 72: 'refrigerator', 73: 'book', 74: 'clock', 75: 'vase', 76: 'scissors', 77: 'teddy bear', 78: 'hair drier', 79: 'toothbrush'}

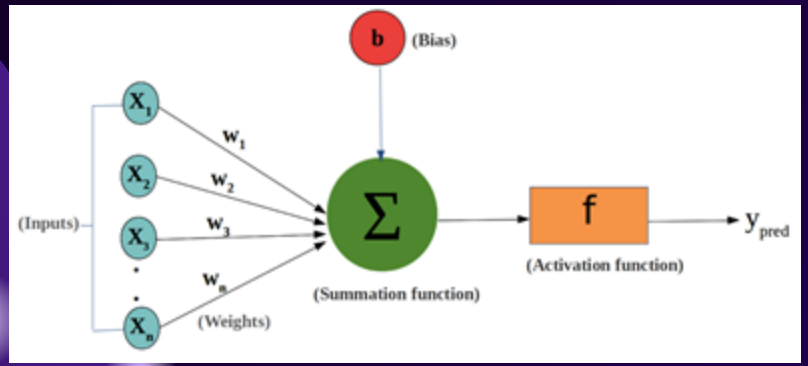


If you want to detect something else, **YOU MUST TRAIN THE MODEL!!!**

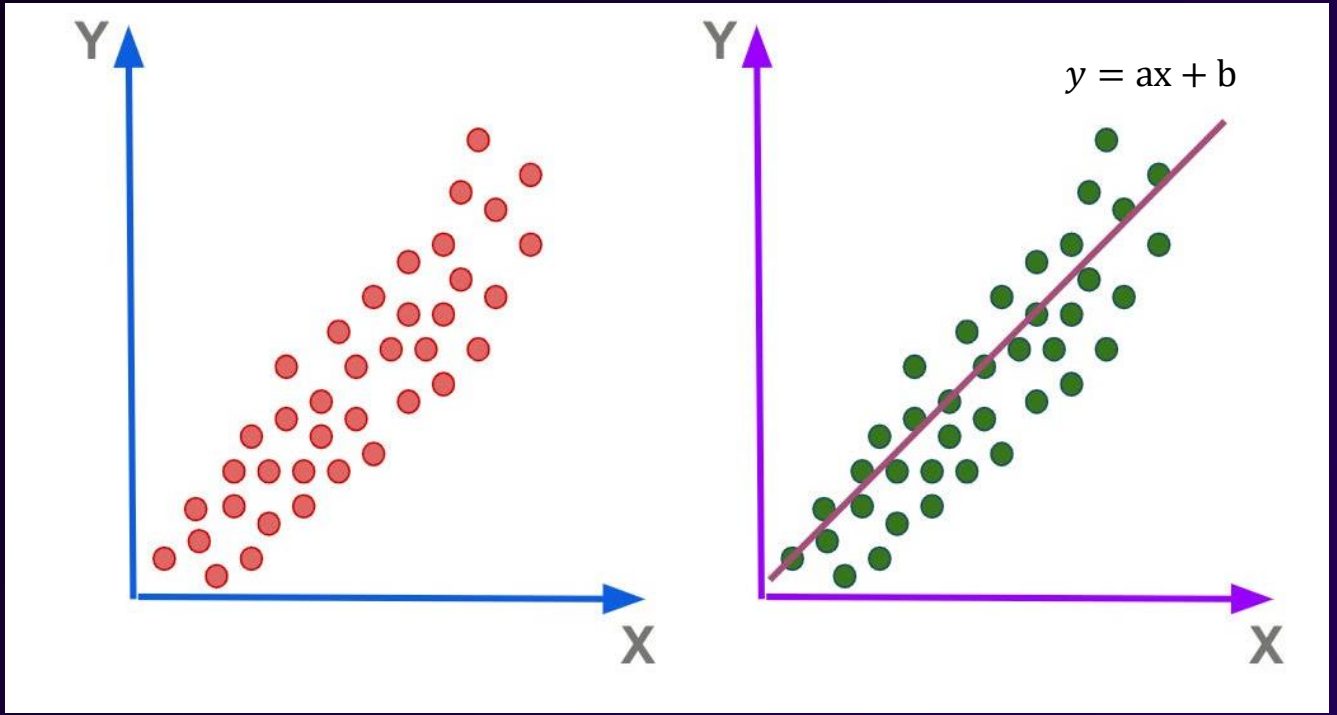
This is called **“closed-set object detection”…**

How to train a model?

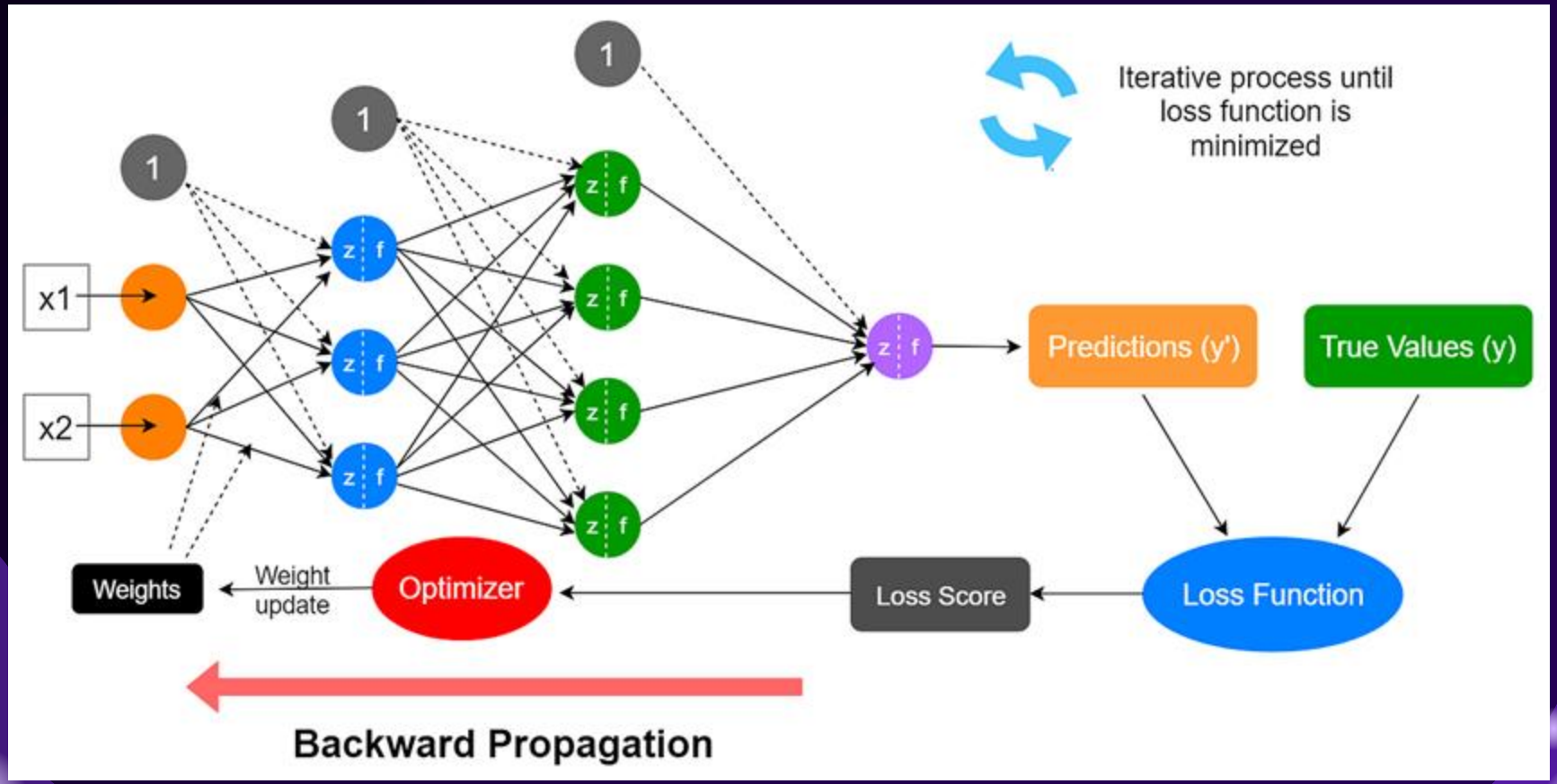




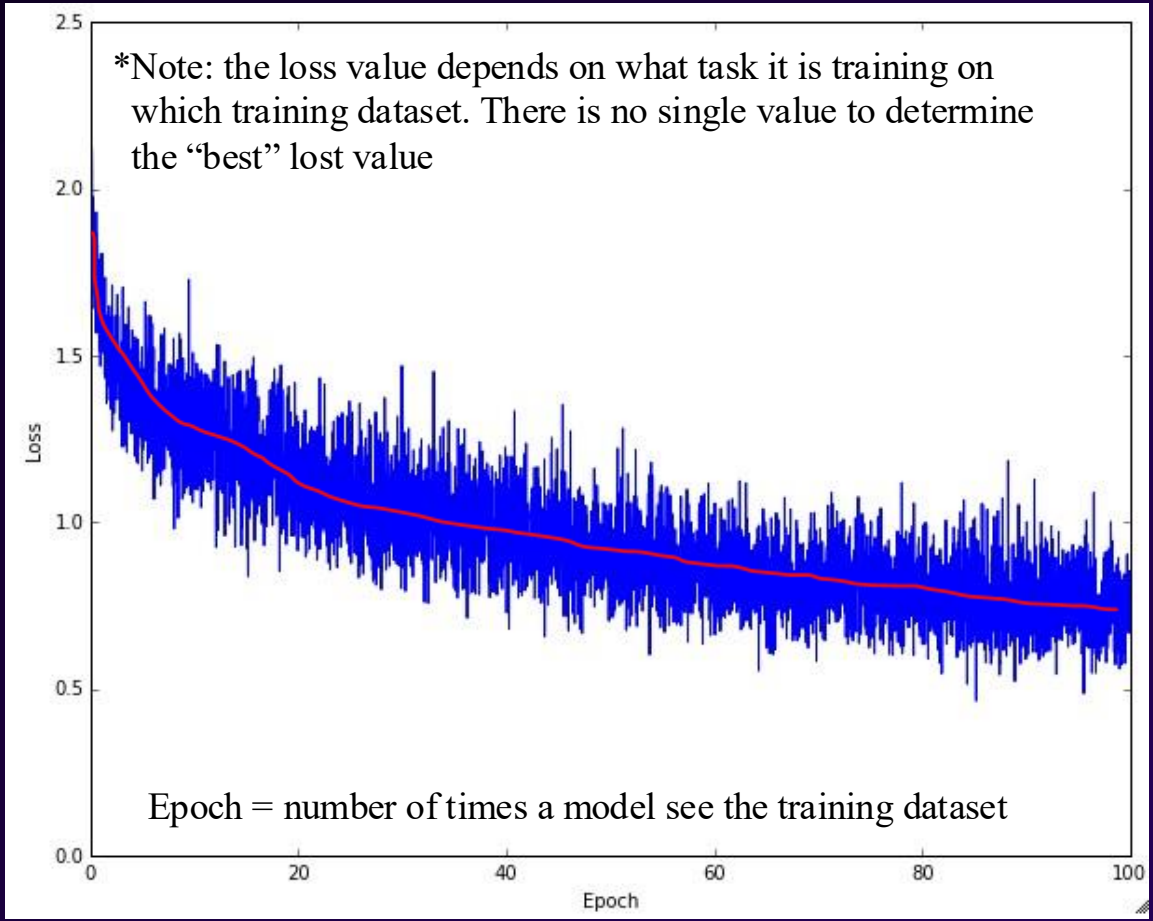
- We train the machine with thousands of samples so it can find **pattern**.
- The pattern can be modeled as a certain **function**
- This function will then used to predict the label of new images
- How can we create a good function to suit our purpose?



- Choose the best a **(weight)** and b **(bias)** to fit the line to the points. This is called **optimization**.
- We can apply the similar idea for finding patterns in images.
- How to optimize the parameters (weights + biases)? **Backpropagation!**


1
1
1
x1
x2
z f
z f
z f
z f
z f
z f
z f
Iterative process until loss function is minimized
Predictions (y')
True Values (y)
Loss Function
Loss Score
Optimizer
Weight update
Weights
Backward Propagation

This is an example of a good (enough) loss function



Overfitting & Underfitting

- Imagine you train the model with 1 image of Pomeranian on 1000 epochs for label “dog”.
- This is **overfitting**.
- Next time when you give the model an image of Husky, the model won’t classify it as “dog”

Training

“dog”

Testing

Not a “dog”

Overfitting & Underfitting

- Imagine you train the model with 1000 images of random animals on 1 epoch for label “animal”.
- This is **underfitting**.
- Next time when you give the model an image of an animal-looking monster, the model will classify as “animal”

Training

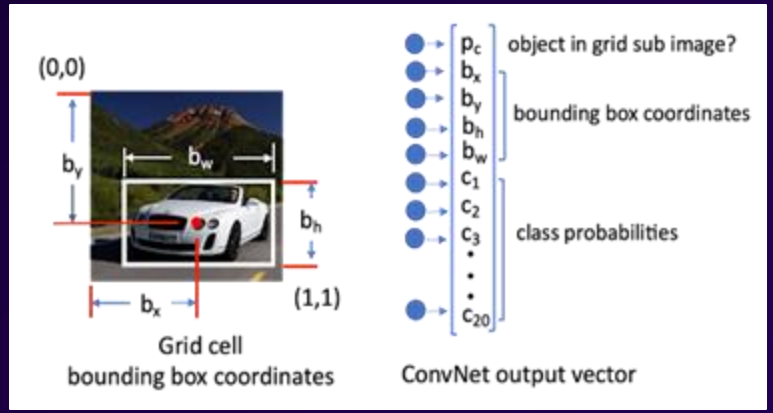
“animal”

Testing

“animal”

What about YOLOv8?

- The prediction (output) from YOLOv8 consists of **Objectness Score**, **Bounding Box Coordinates**, and each **Class Score**
- Then, it follows the training step: computing the loss against ground truth labels → adjust the weights and biases to improve accuracy
- This process repeats for multiple epochs until the prediction is sufficiently accurate.
- After training, **post-processing** is applied to the final predictions to filter overlapping boxes and return the final clean detection results

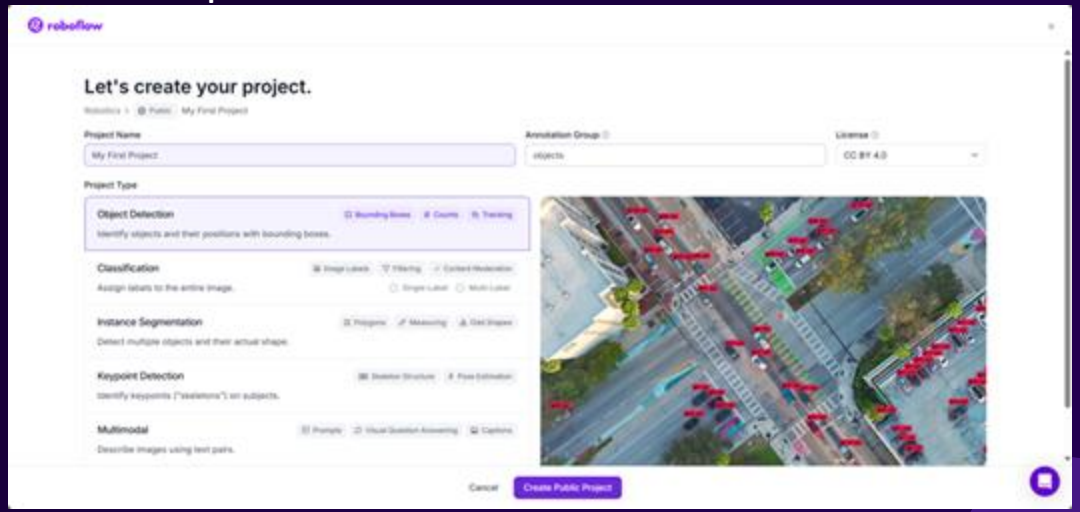


Custom Your Own Dataset

- Closed-Set for specific task!
- Create your Own Label for objects

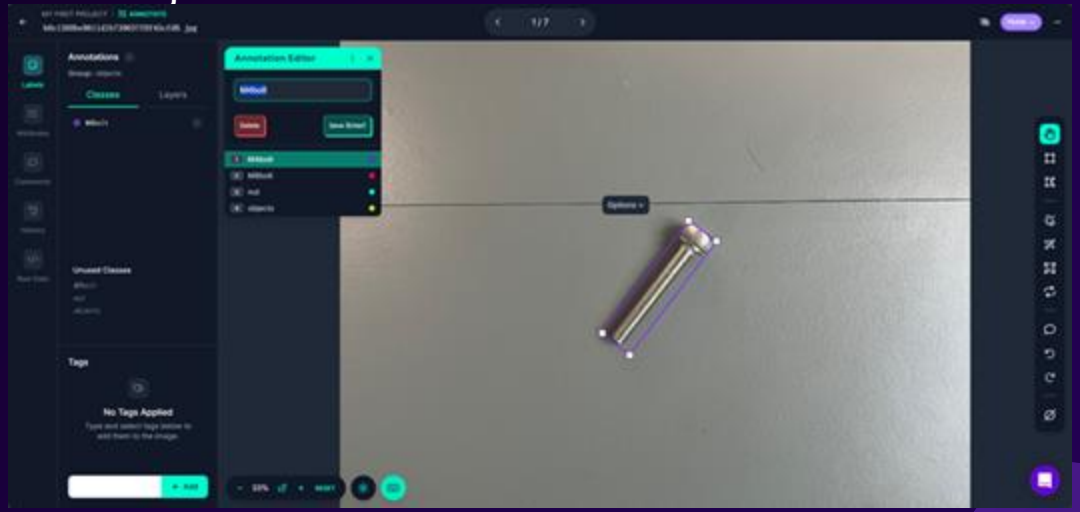
Custom Your Own Dataset

- Platform – Roboflow
- Procedure - Startup



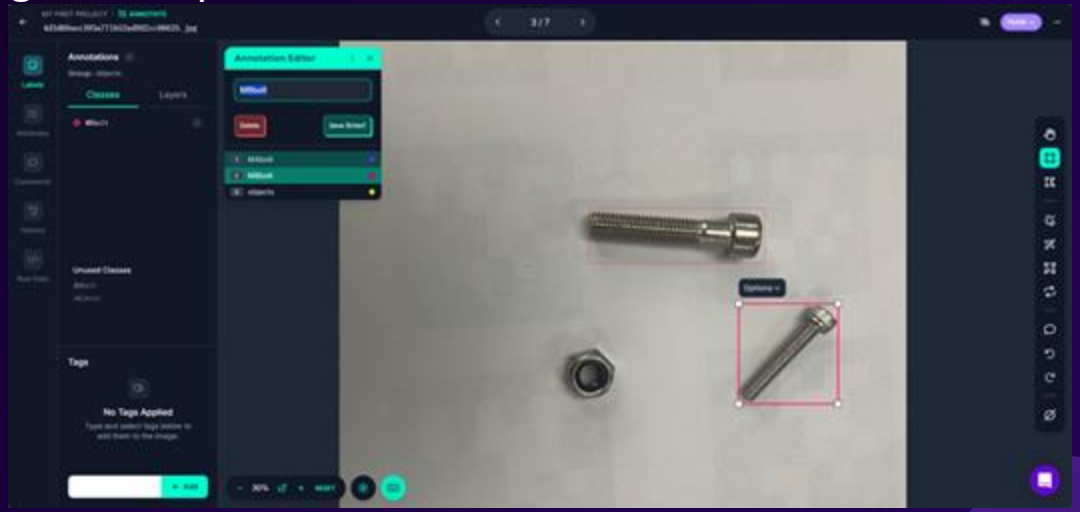
Custom Your Own Dataset

- Procedure – Label
- Single / Multi objects



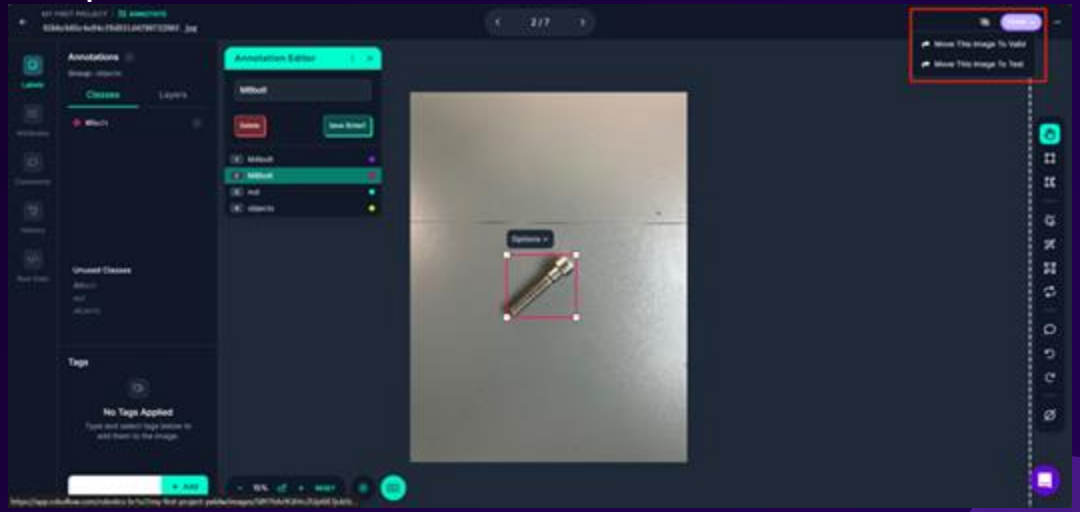
Custom Your Own Dataset

- Procedure – Label
- Bounding Box Shape



Custom Your Own Dataset

- Procedure – Label
- Data for Purpose



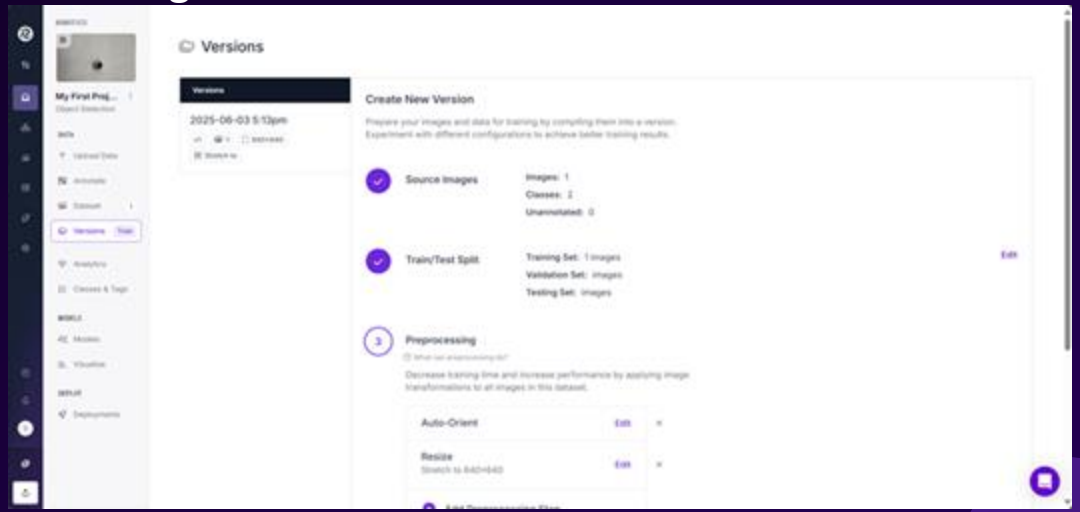
Custom Your Own Dataset

- Procedure – Add to Dataset

- Data for Purpose

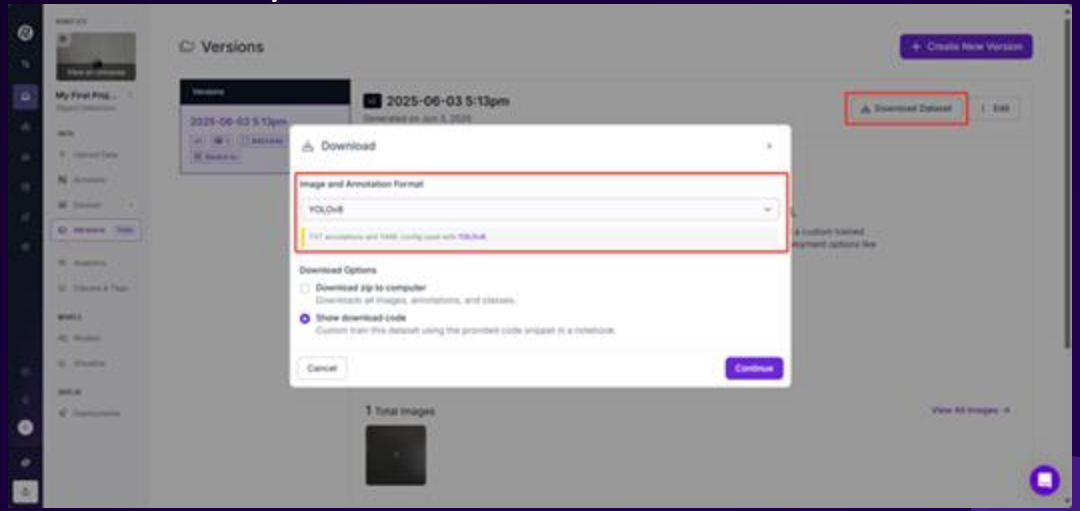
Custom Your Own Dataset

- Procedure – Processing
- Preprocess & Augmentation



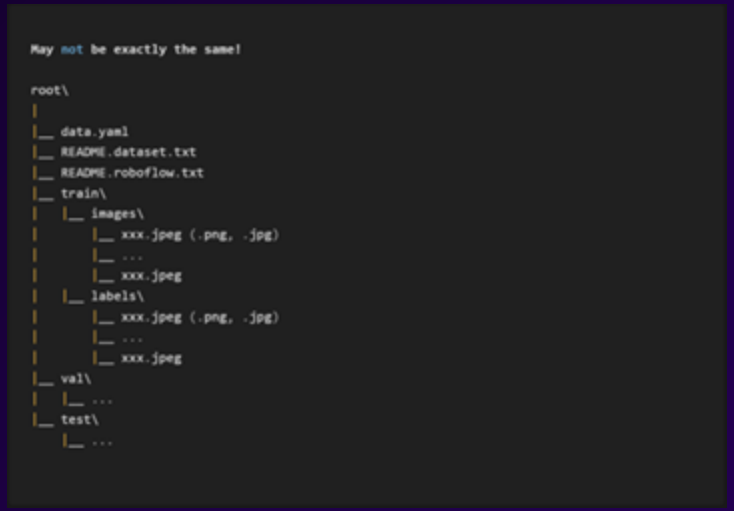
Custom Your Own Dataset

- Almost Done!
- Select and download your dataset



Custom Your Own Dataset

- Almost Done!
- Folder Structure



Custom Your Own Dataset

- Reference: Notion Page

Thanks!!

Any questions?