



deeplearning.ai





deeplearning.ai





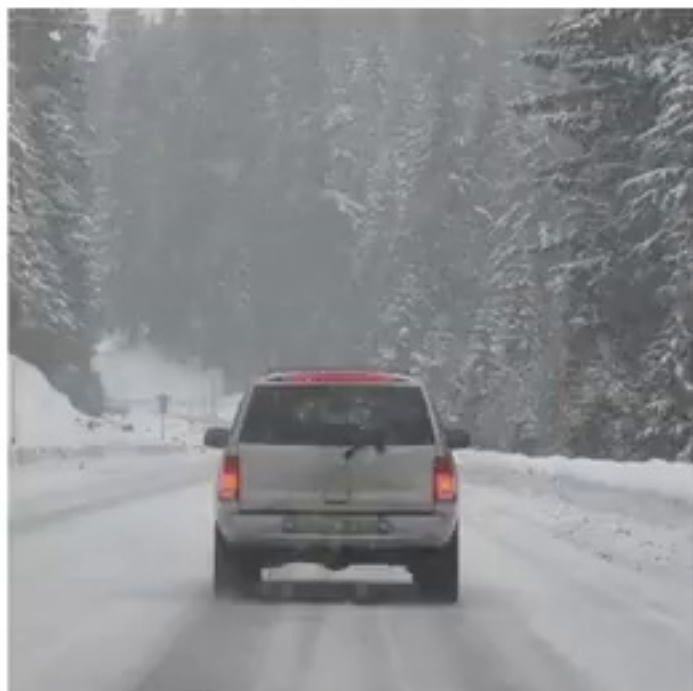
deeplearning.ai

Object Detection

Object
localization

What are localization and detection?

Image classification



What are localization and detection?

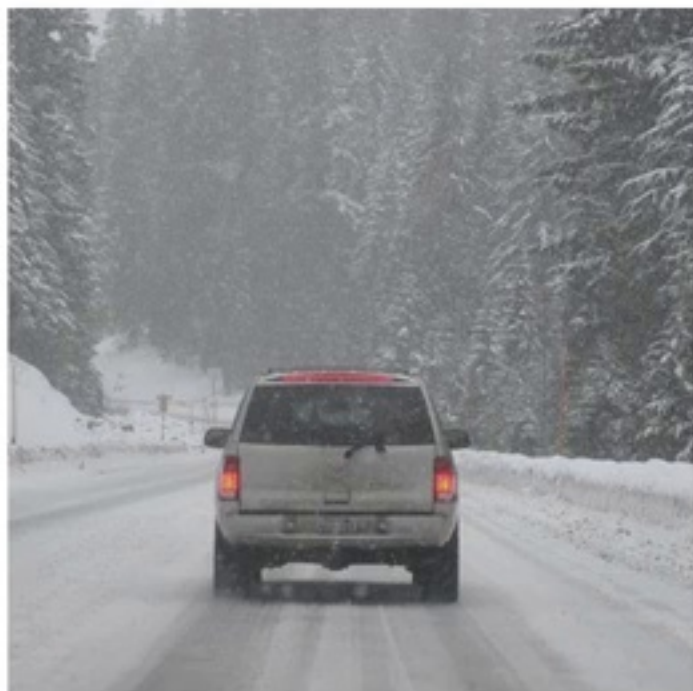
Image classification



"Car"

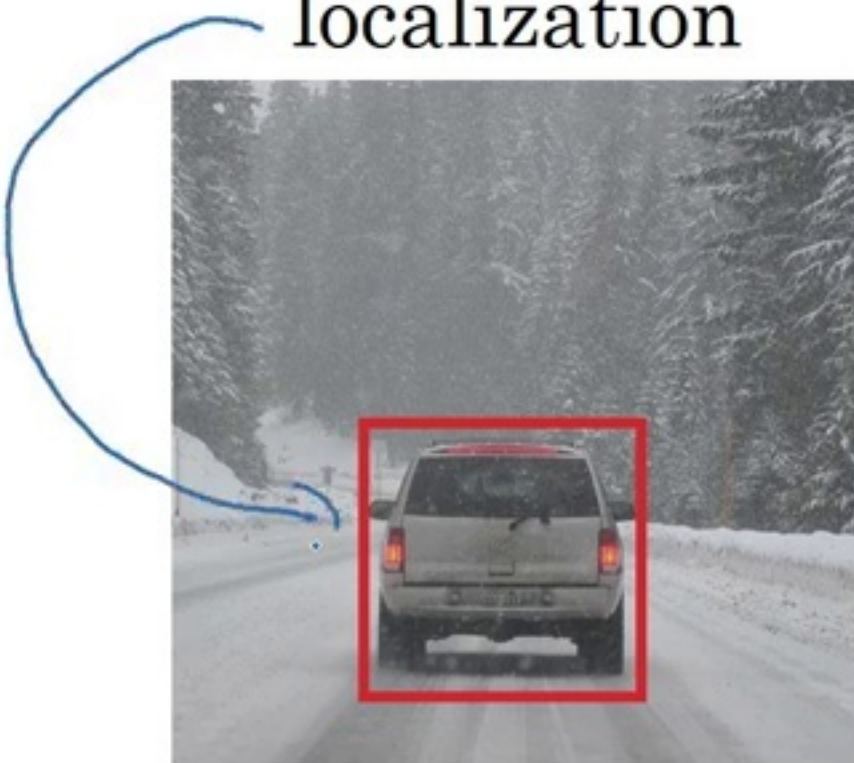
What are localization and detection?

Image classification



"Car"

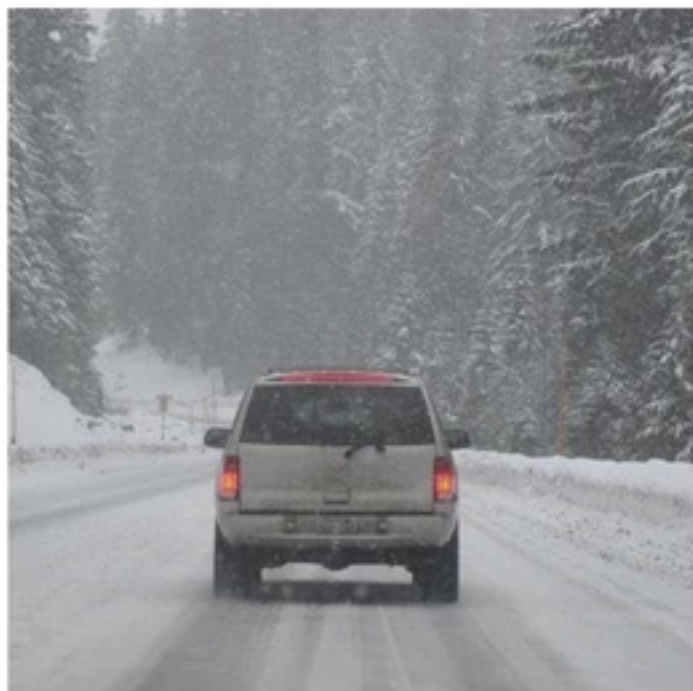
Classification with
localization



"Car"

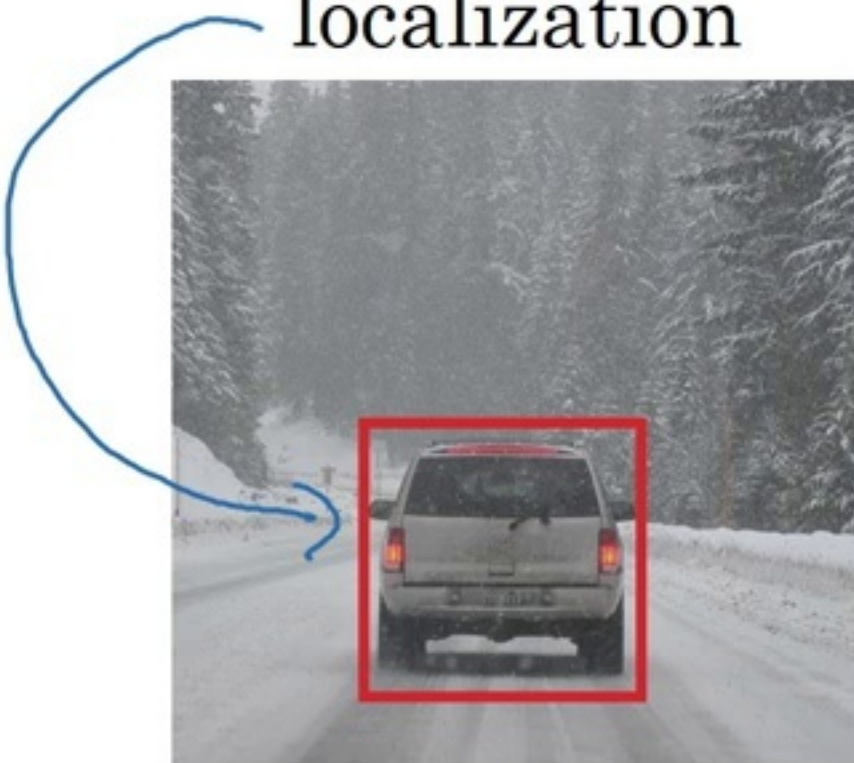
What are localization and detection?

Image classification



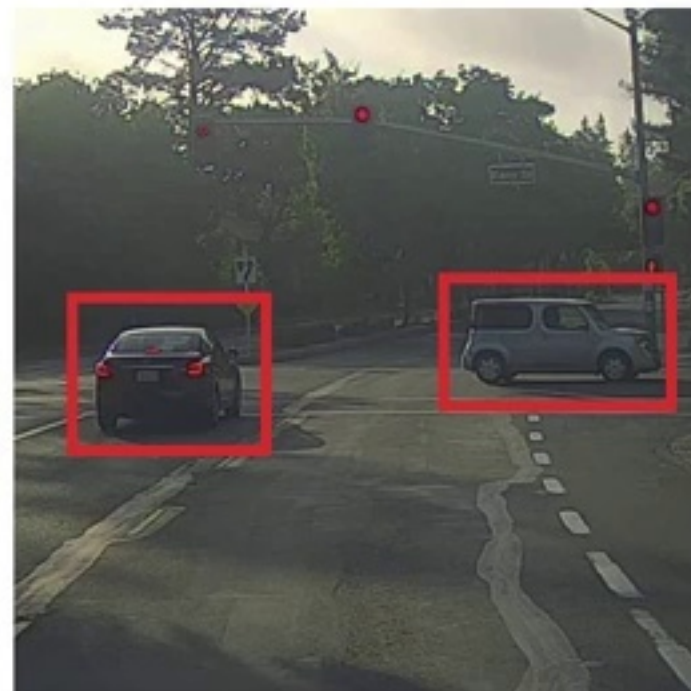
"Car"

Classification with
localization



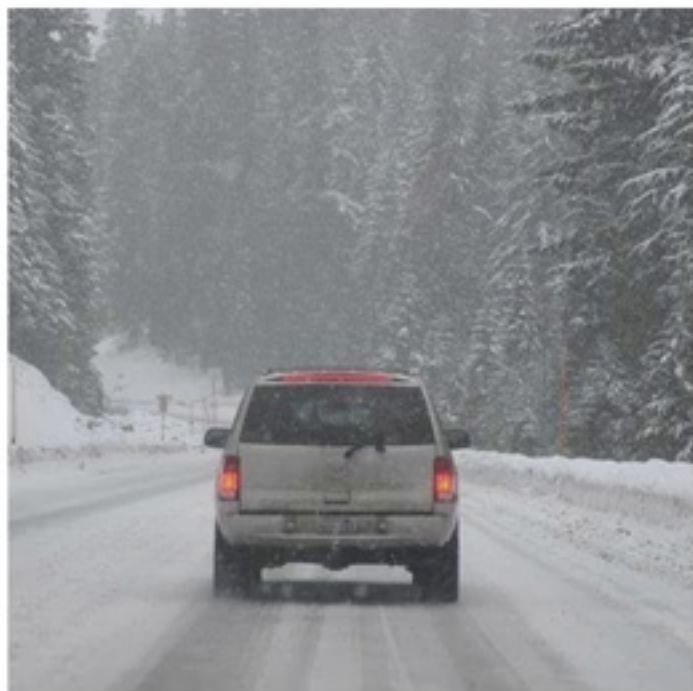
"Car"

Detection



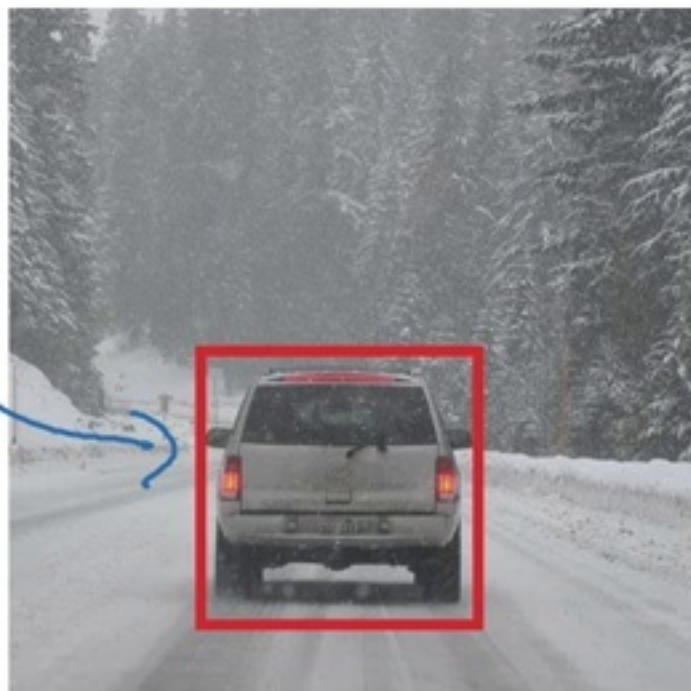
What are localization and detection?

Image classification



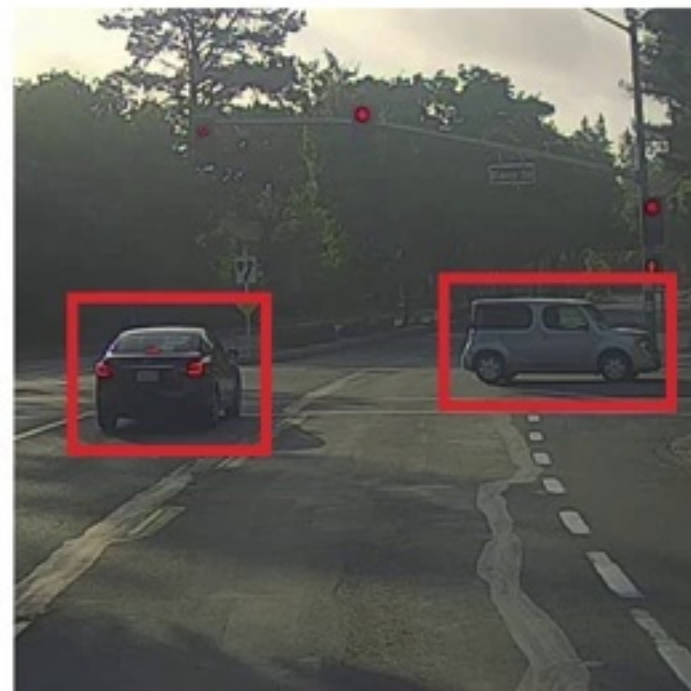
"Car"

Classification with localization



"Car"

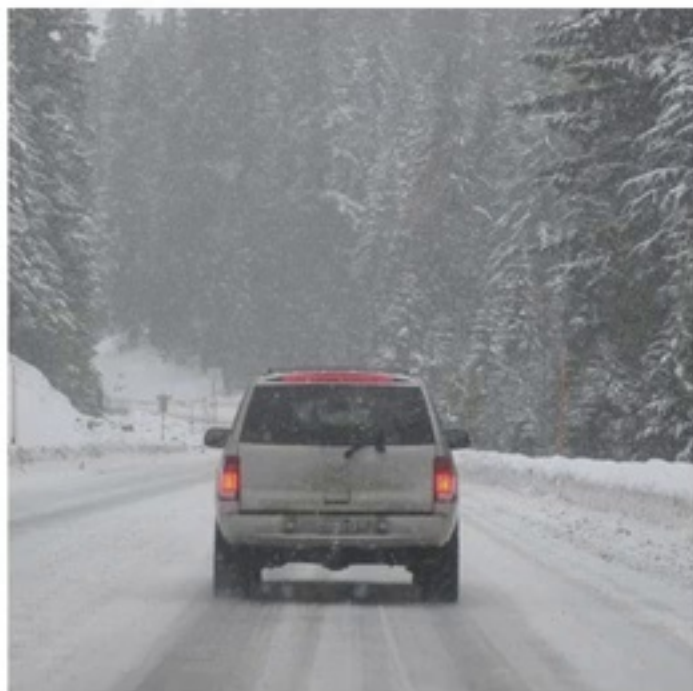
Detection



1 object

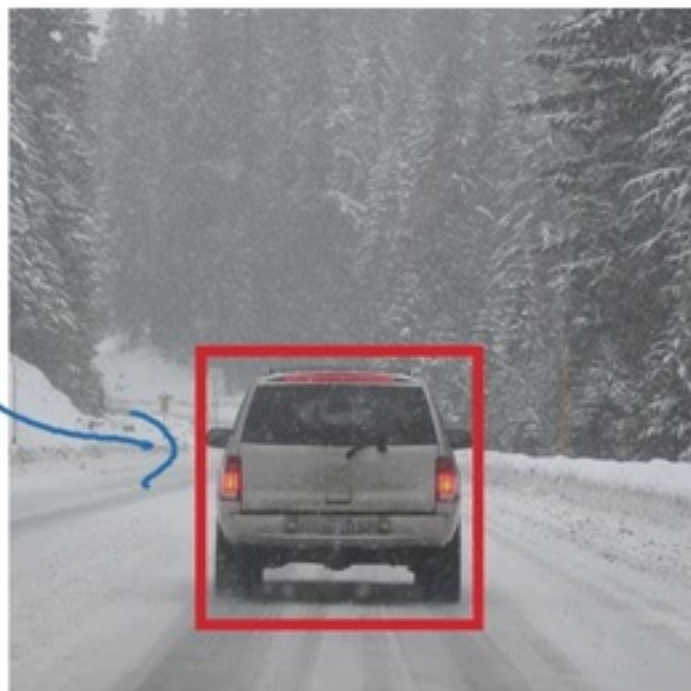
What are localization and detection?

Image classification



"Car"

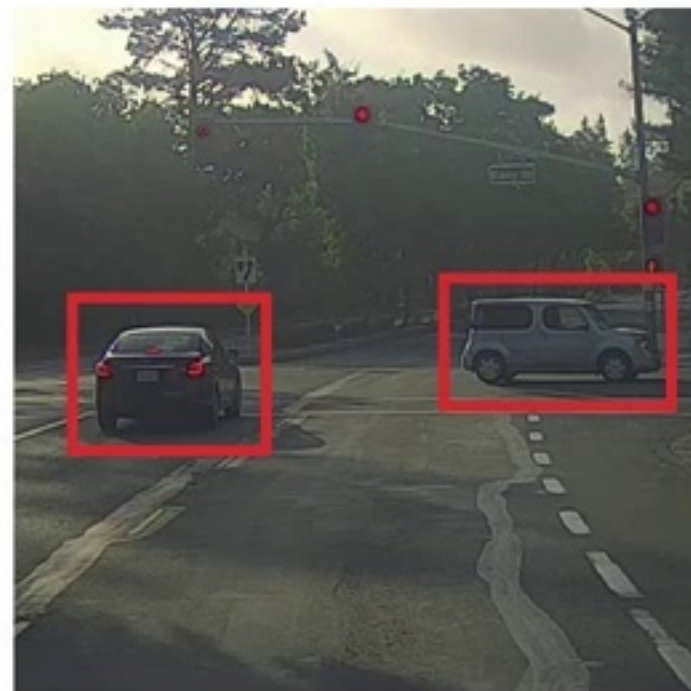
Classification with
localization



"Car"

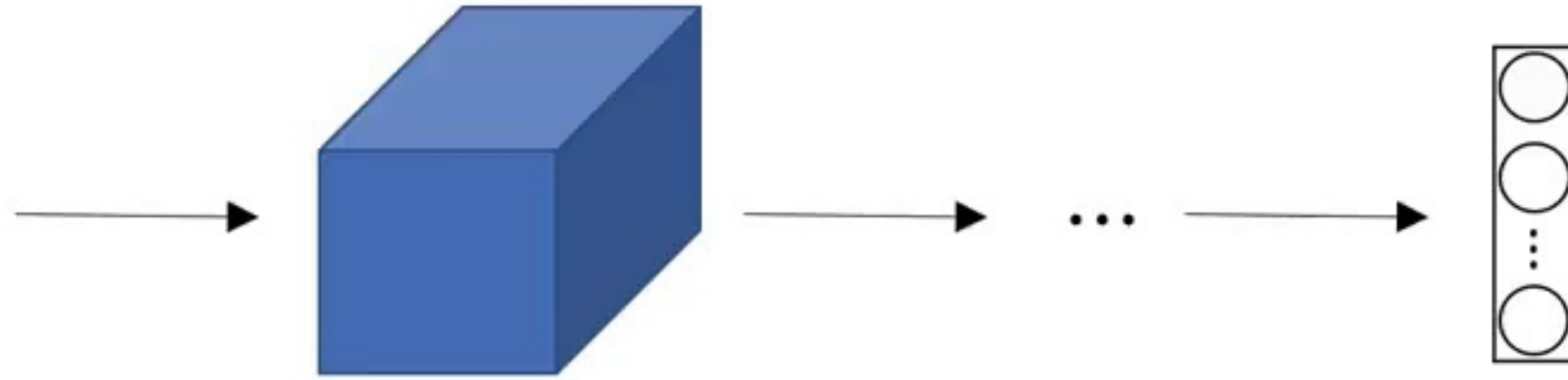
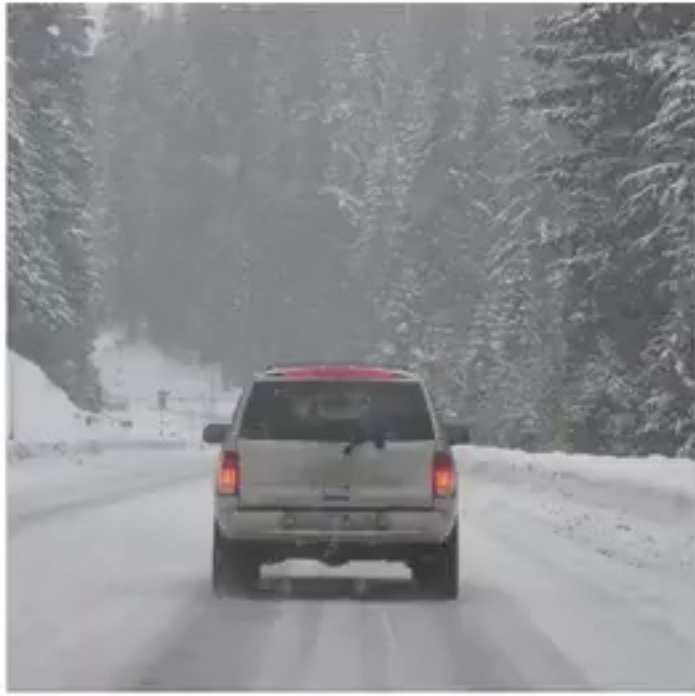
1 object

Detection

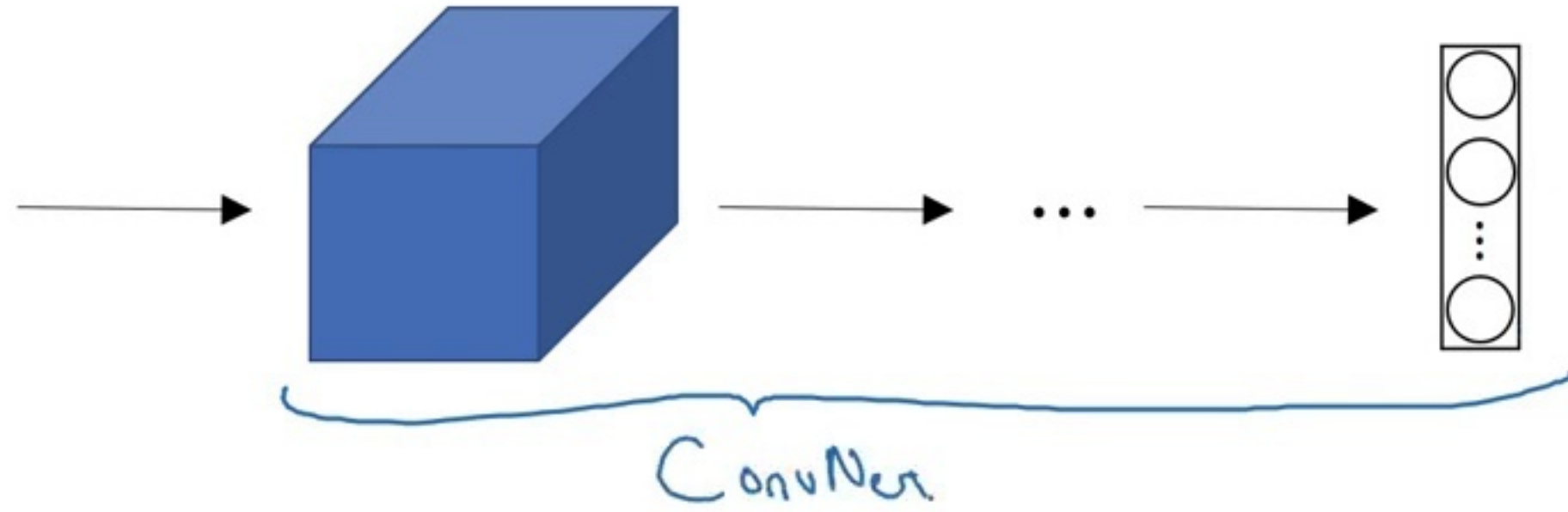


multiple
objects

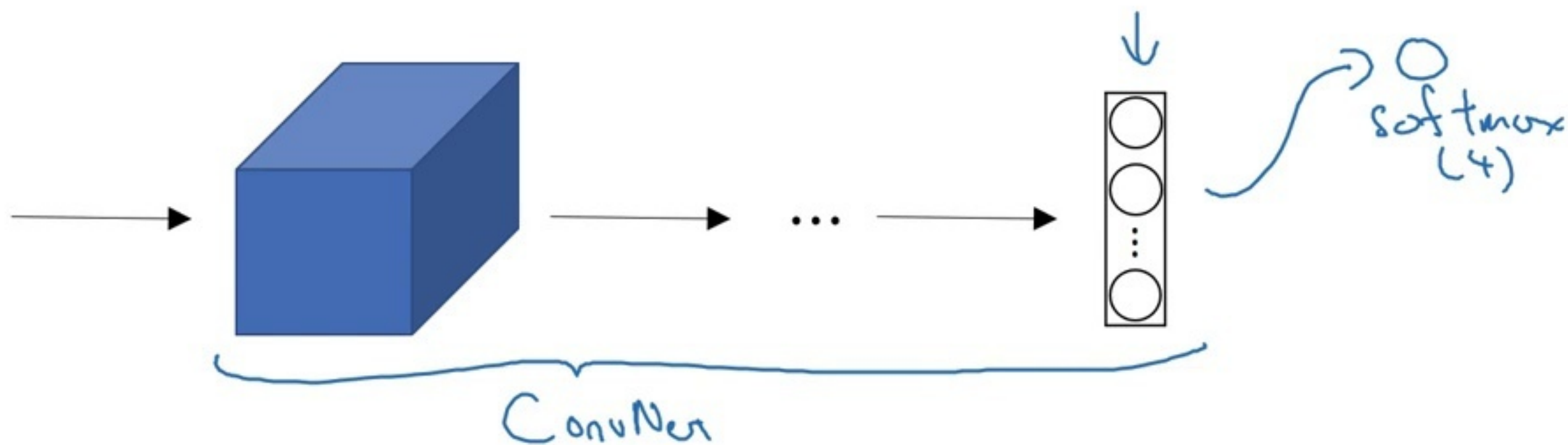
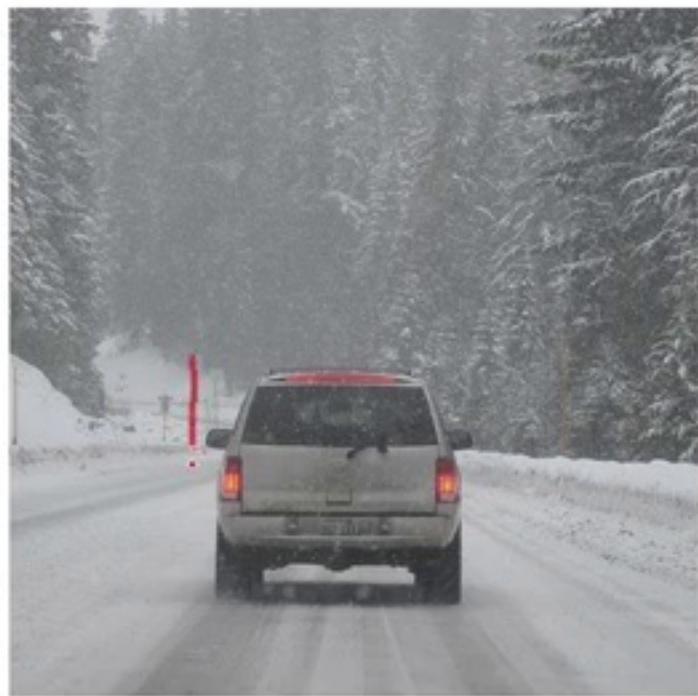
Classification with localization



Classification with localization



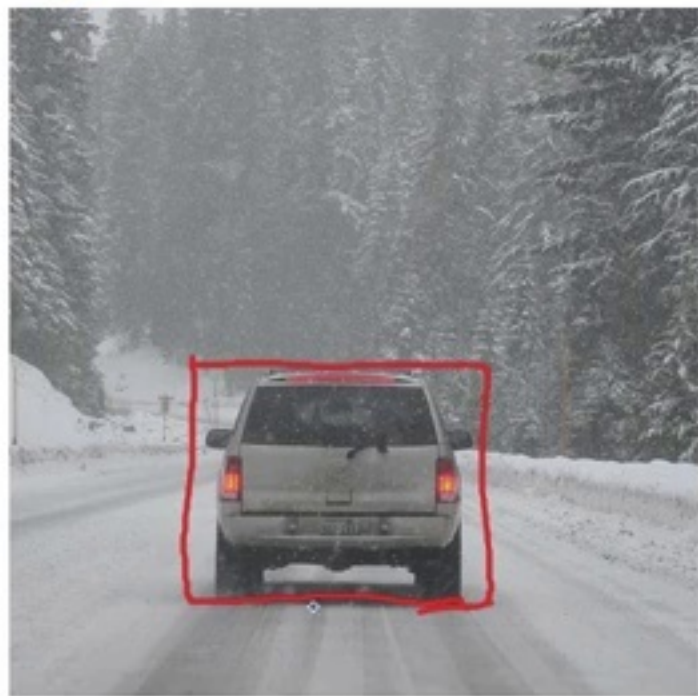
Classification with localization



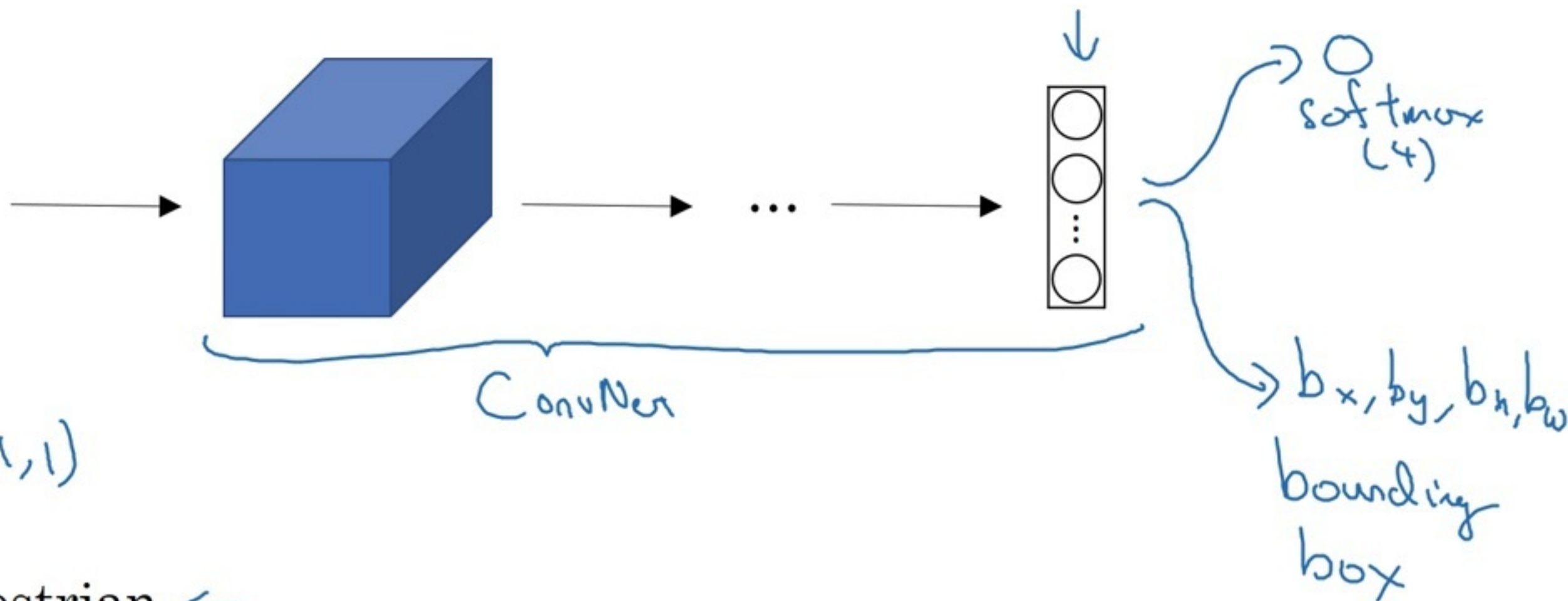
- 1 - pedestrian ←
- 2 - car ←
- 3 - motorcycle ←
- 4 - background

Classification with localization

(0,0)



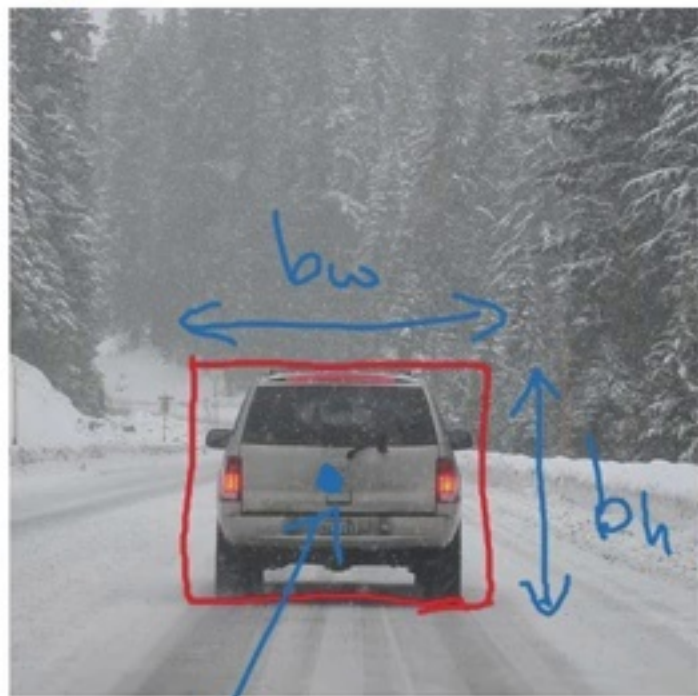
(1,1)



- 1 - pedestrian ←
- 2 - car ←
- 3 - motorcycle ←
- 4 - background

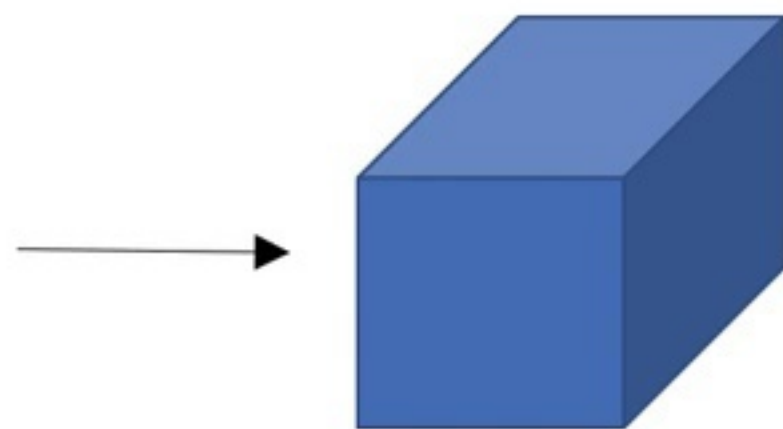
Classification with localization

(0,0)



(1,1)

b_x, b_y



...



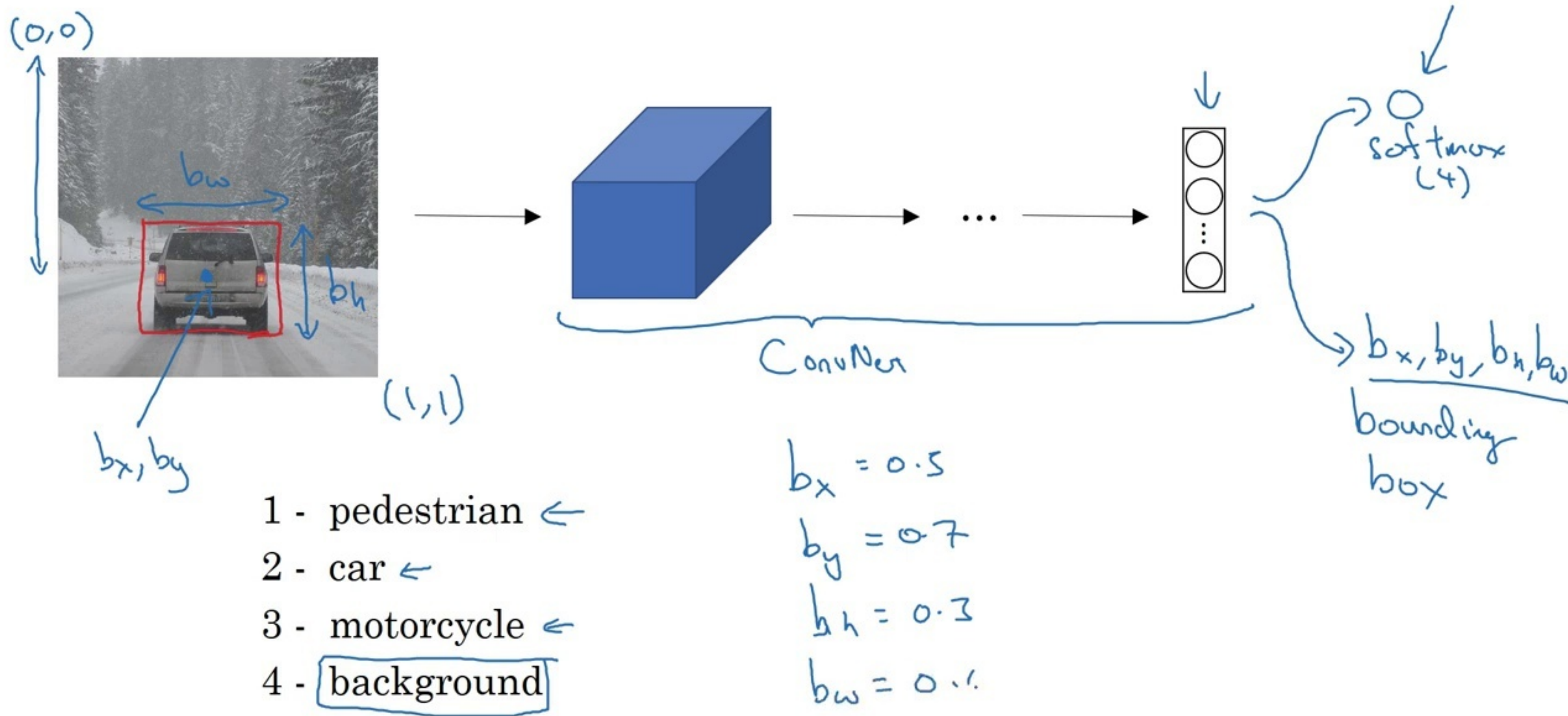
softmax
(4)

ConvNet

b_x, b_y, b_h, b_w
bounding
box

- 1 - pedestrian ←
- 2 - car ←
- 3 - motorcycle ←
- 4 - background

Classification with localization



Defining the target label y

1 - pedestrian

2 - car

3 - motorcycle

4 - background

Need to output b_x, b_y, b_h, b_w , class label (1-4)

Defining the target label y

- 1 - pedestrian
- 2 - car
- 3 - motorcycle
- 4 - background \leftarrow

Need to output b_x, b_y, b_h, b_w , class label (1-4)

$$y = \begin{bmatrix} p_c \\ b_x \\ b_y \\ b_h \\ b_w \\ c_1 \\ c_2 \\ c_3 \end{bmatrix}$$

is there any object?

Defining the target label y

- 1 - pedestrian
- 2 - car
- 3 - motorcycle
- 4 - background ←

Need to output b_x, b_y, b_h, b_w , class label (1-4)



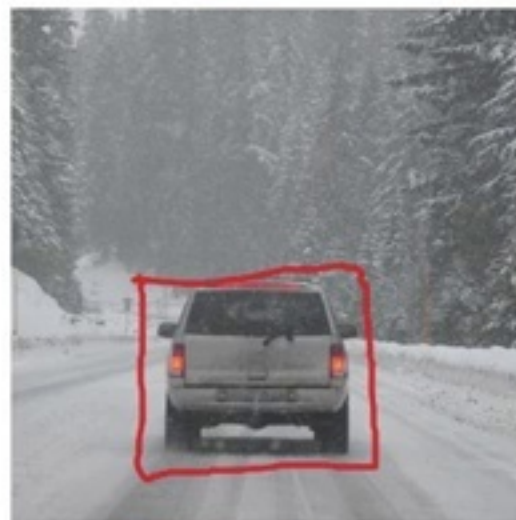
$$y = \begin{bmatrix} p_c \\ b_x \\ b_y \\ b_h \\ b_w \\ c_1 \\ c_2 \\ c_3 \end{bmatrix}$$

is there any object?

Defining the target label y

- 1 - pedestrian
- 2 - car ←
- 3 - motorcycle
- 4 - background ←

Need to output b_x, b_y, b_h, b_w , class label (1-4)



$x =$

$$y = \begin{bmatrix} p_c \\ b_x \\ b_y \\ b_h \\ b_w \\ c_1 \\ c_2 \\ c_3 \end{bmatrix}$$

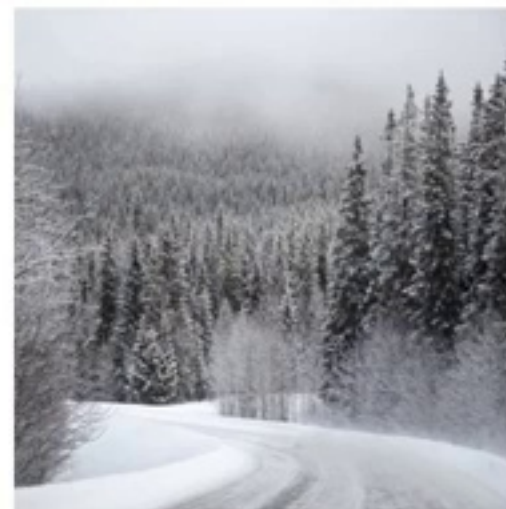
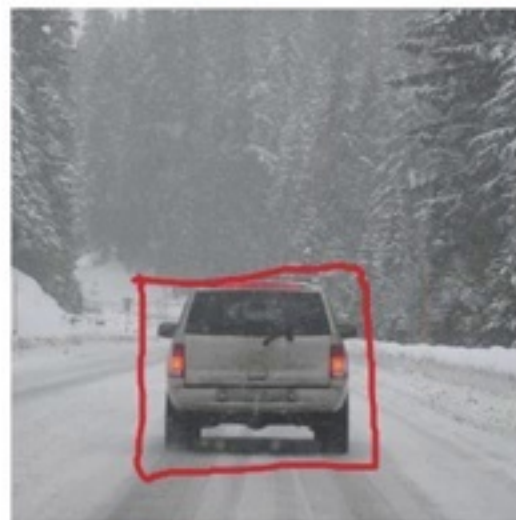
is there any
object?

$$\begin{bmatrix} 1 \\ b_x \\ b_y \\ b_h \\ b_w \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

Defining the target label y

- 1 - pedestrian
- 2 - car ←
- 3 - motorcycle
- 4 - background ←

Need to output b_x, b_y, b_h, b_w , class label (1-4)



$$y = \begin{bmatrix} p_c \\ b_x \\ b_y \\ b_h \\ b_w \\ c_1 \\ c_2 \\ c_3 \end{bmatrix}$$

is there any
object?

$$\begin{bmatrix} 1 \\ b_x \\ b_y \\ b_h \\ b_w \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

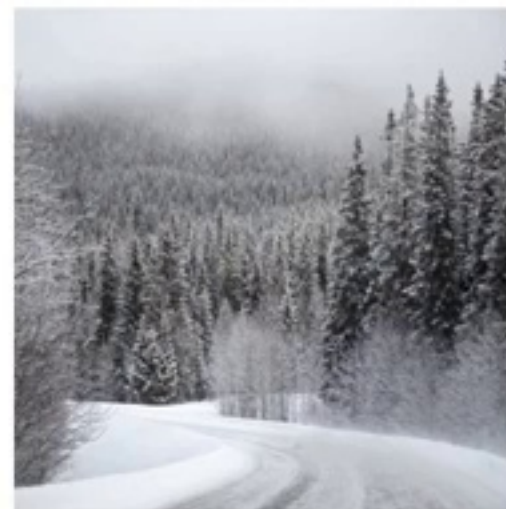
$$\begin{bmatrix} 0 \\ \sim \\ \sim \\ \sim \\ \sim \\ \sim \\ \sim \\ \sim \end{bmatrix}$$

← "don't
care"

Defining the target label y

- 1 - pedestrian
- 2 - car ←
- 3 - motorcycle
- 4 - background ←

Need to output b_x, b_y, b_h, b_w , class label (1-4)



$x =$

is there any object?

$$\mathcal{L}(\hat{y}, y) = \begin{cases} (\hat{y}_1 - y_1)^2 + (\hat{y}_2 - y_2)^2 \\ + \dots + (\hat{y}_8 - y_8)^2 \end{cases} \text{ if } y_1 = 1$$

$y =$
↑

$$\therefore \begin{bmatrix} p_c \\ b_x \\ b_y \\ b_h \\ b_w \\ c_1 \\ c_2 \\ c_3 \end{bmatrix}$$

(x, y)

$$\begin{bmatrix} 1 \\ b_x \\ b_y \\ b_h \\ b_w \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

↑

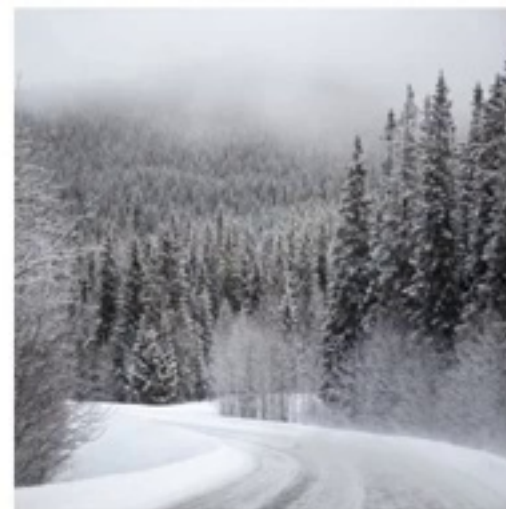
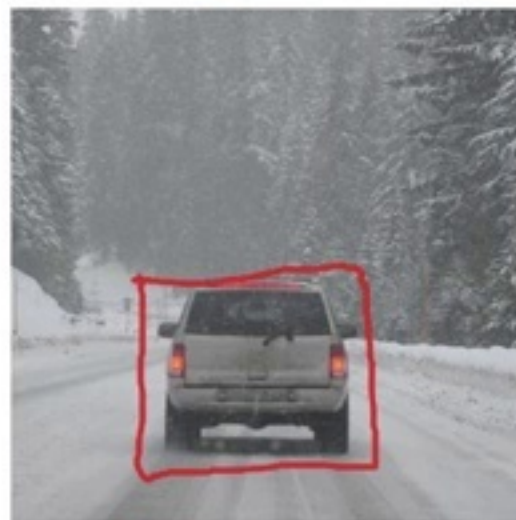
$$\begin{bmatrix} 0 \\ \sim \\ \sim \\ \sim \\ \sim \\ \sim \\ \sim \\ \sim \end{bmatrix}$$

← "don't care"

Defining the target label y

- 1 - pedestrian
- 2 - car ←
- 3 - motorcycle
- 4 - background ←

Need to output b_x, b_y, b_h, b_w , class label (1-4)



$x =$

is there any object?

$$\mathcal{L}(\hat{y}, y) = \begin{cases} (\hat{y}_1 - y_1)^2 + (\hat{y}_2 - y_2)^2 + \dots + (\hat{y}_8 - y_8)^2 & \text{if } y_1 = 1 \\ (\hat{y}_1 - y_1)^2 & \text{if } y_1 = 0 \end{cases}$$

$$y = \begin{bmatrix} p_c \\ b_x \\ b_y \\ b_h \\ b_w \\ c_1 \\ c_2 \\ c_3 \end{bmatrix}$$

(x, y)

$$\begin{bmatrix} 1 \\ b_x \\ b_y \\ b_h \\ b_w \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

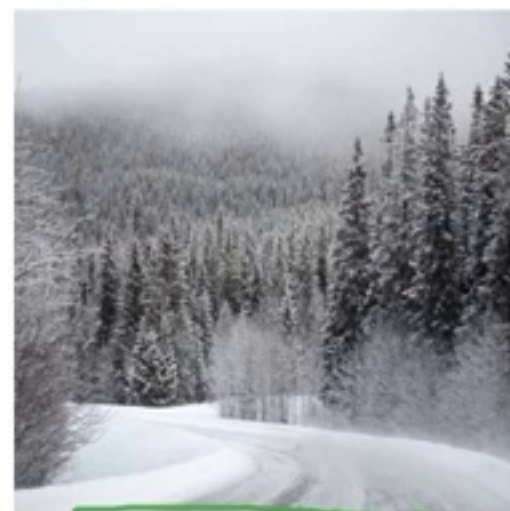
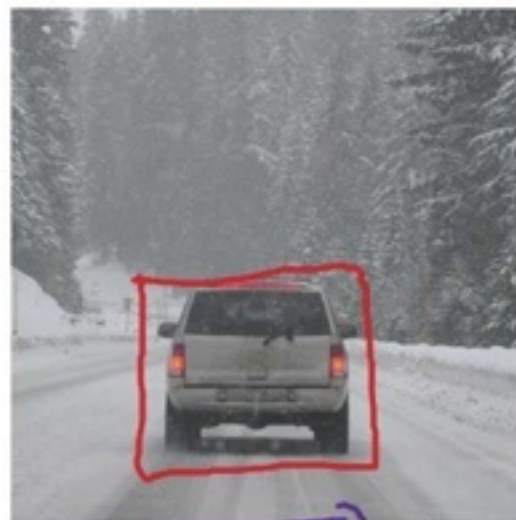
$$\begin{bmatrix} 0 \\ ? \\ ? \\ ? \\ ? \\ ? \\ ? \\ ? \end{bmatrix}$$

← "don't care"

Defining the target label y

- 1 - pedestrian
- 2 - car ←
- 3 - motorcycle
- 4 - background ←

Need to output b_x, b_y, b_h, b_w , class label (1-4)



$x =$

$$\mathcal{L}(\hat{y}, y) = \begin{cases} (\hat{y}_1 - y_1)^2 + (\hat{y}_2 - y_2)^2 + \dots + (\hat{y}_8 - y_8)^2 & \text{if } \underline{y_1 = 1} \\ (\hat{y}_1 - y_1)^2 & \text{if } \underline{y_1 = 0} \end{cases}$$

$$y = \begin{bmatrix} p_c \\ b_x \\ b_y \\ b_h \\ b_w \\ c_1 \\ c_2 \\ c_3 \end{bmatrix} \quad \begin{matrix} \text{? is there any} \\ \text{object?} \end{matrix}$$

(x, y)

$$\begin{bmatrix} 1 \\ b_x \\ b_y \\ b_h \\ b_w \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$\begin{bmatrix} 0 \\ ? \\ ? \\ ? \\ ? \\ ? \\ ? \\ ? \end{bmatrix} \quad \begin{matrix} p_c \\ \leftarrow \text{"don't care"} \end{matrix}$$