Learning Modulated Loss for Rotated Object Detection

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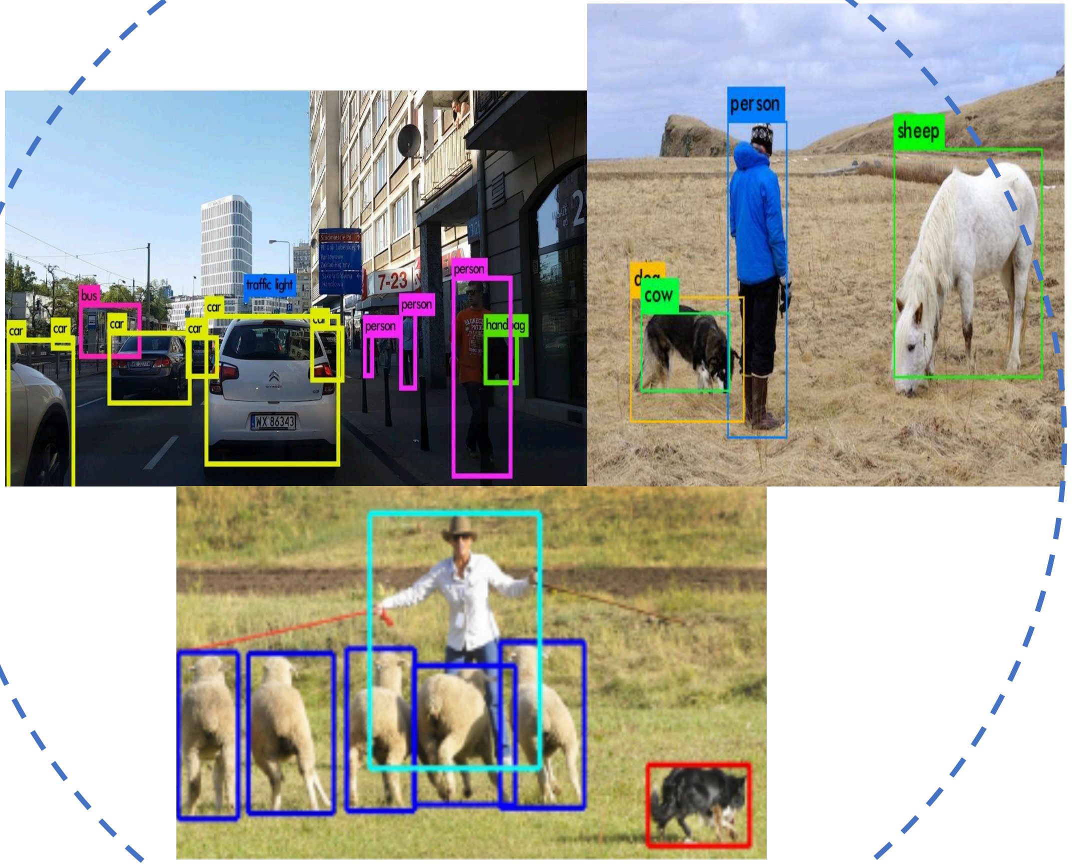
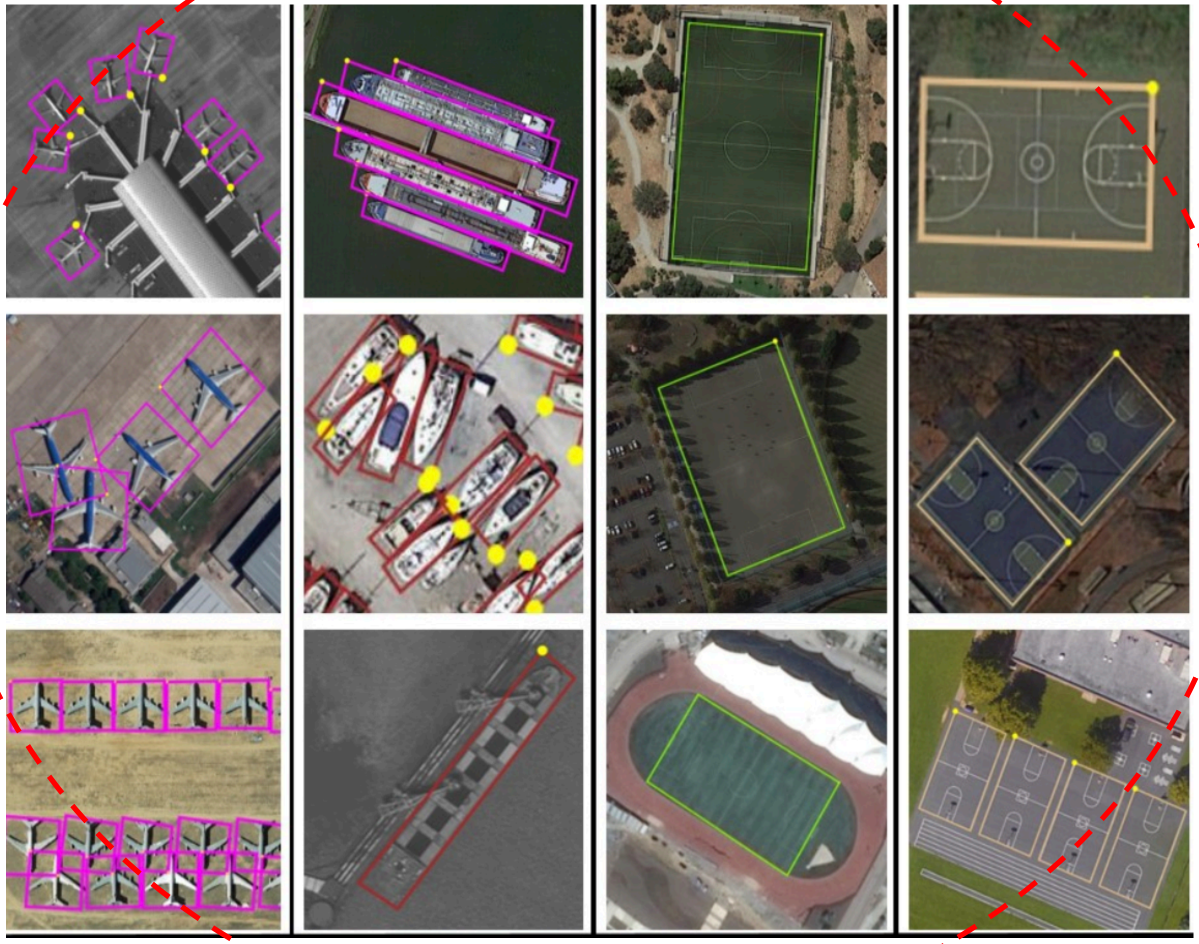
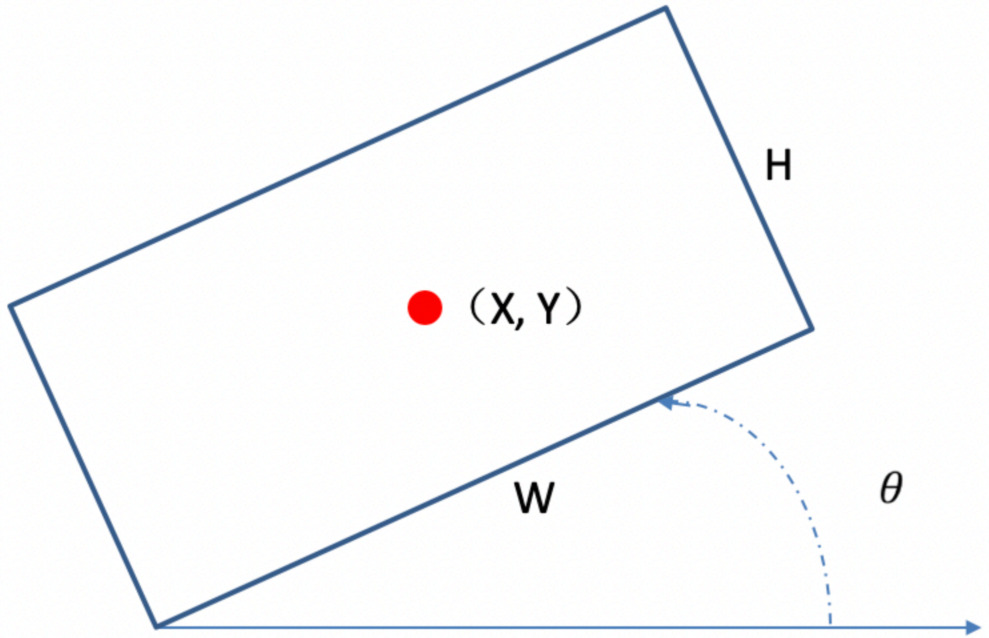
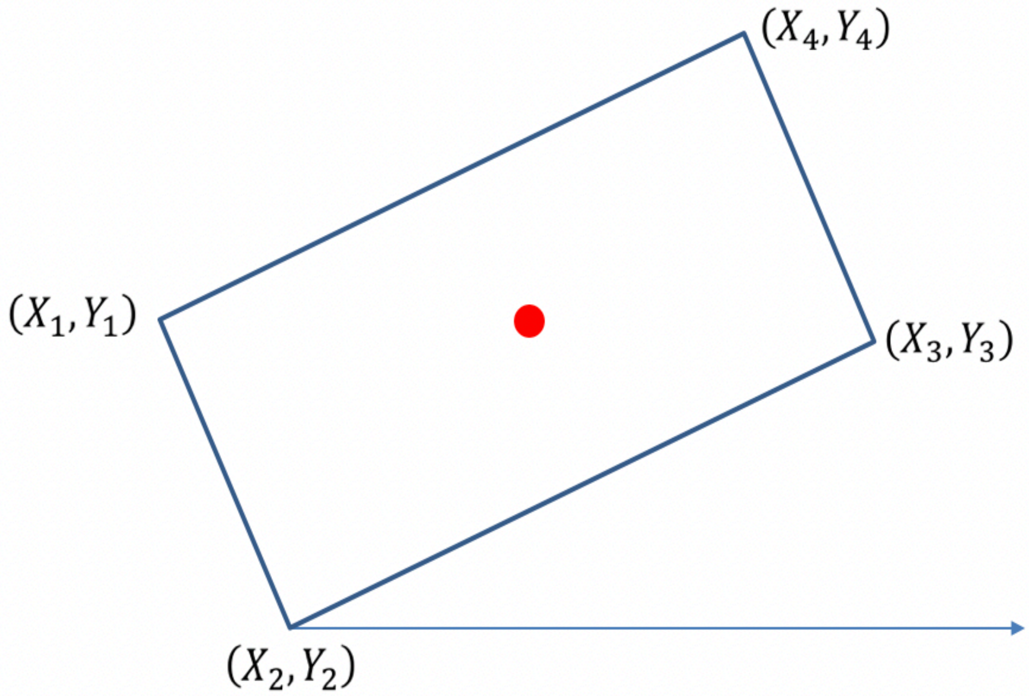
Horizontal object detection and Rotated object detection



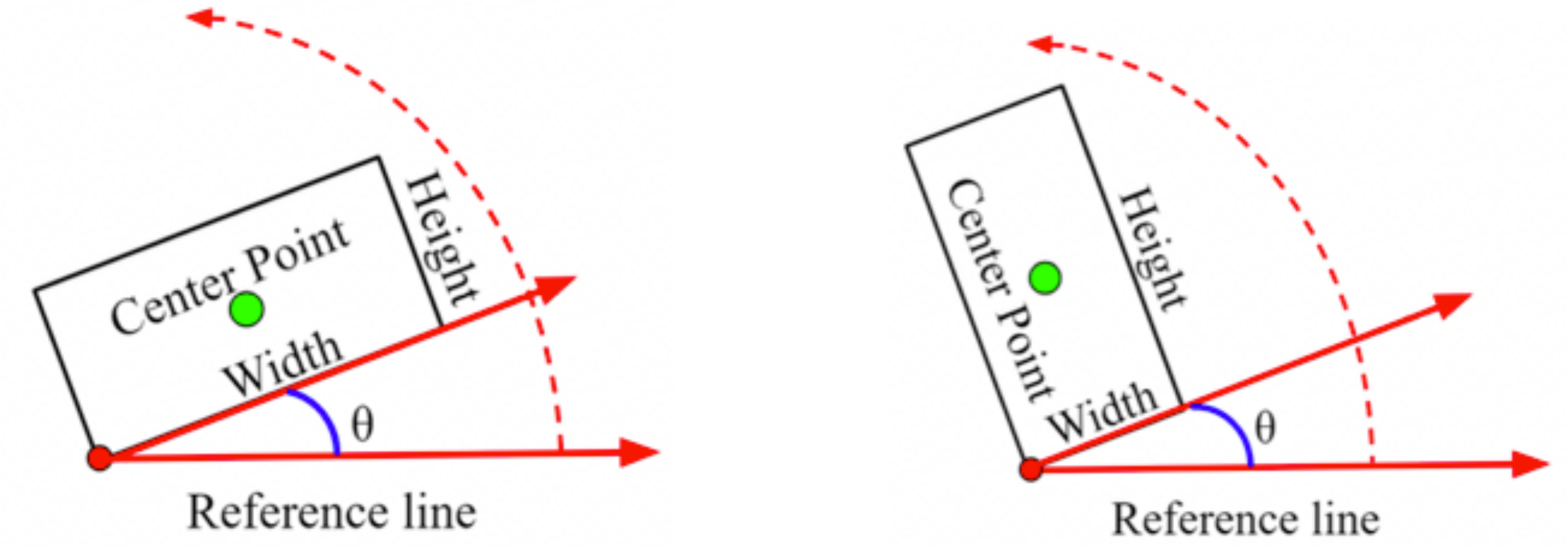


Traditional Definitions of rotated bounding box





The discontinuity of loss in five-parameter methods



(a) Width is longer than height. (b) Height is longer than width.

The discontinuity of loss in five-parameter methods

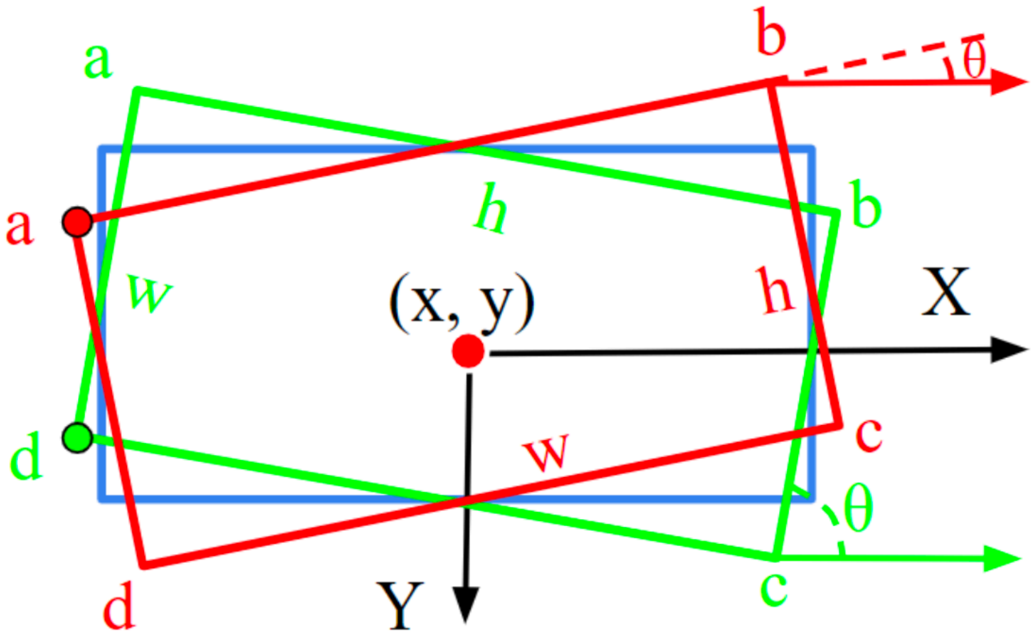
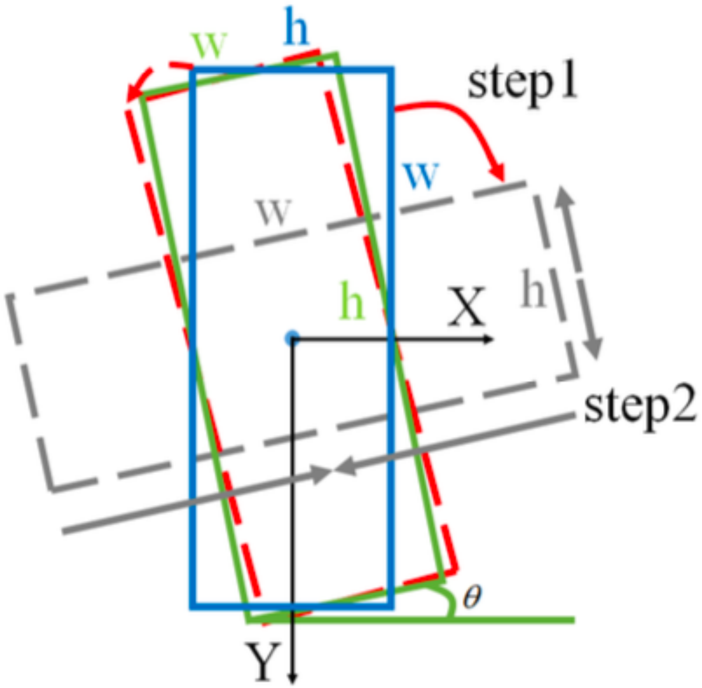
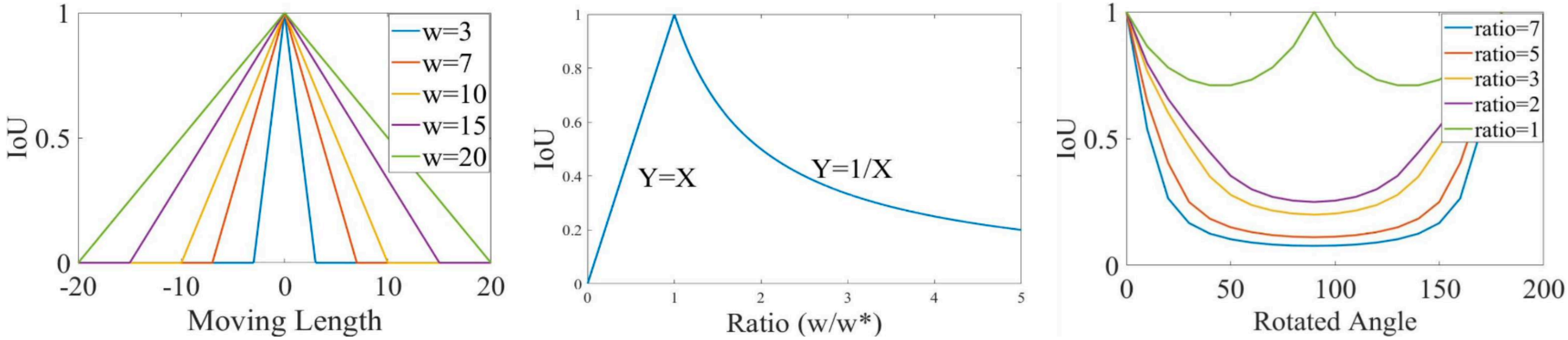


Figure 2: Loss discontinuity: rectangles in blue, red, and green respectively denote reference box, ground truth, and prediction. Here the reference box is rotated one degree clockwise to get the ground truth and is rotated similarly counterclockwise to obtain the prediction. Then the three boxes are described with five parameters: reference (0, 0, 10, 25, -90°), ground truth (0, 0, 25, 10, -1°), and prediction (0, 0, 10, 25, -89°). Here ℓ_1 loss is far more than 0.

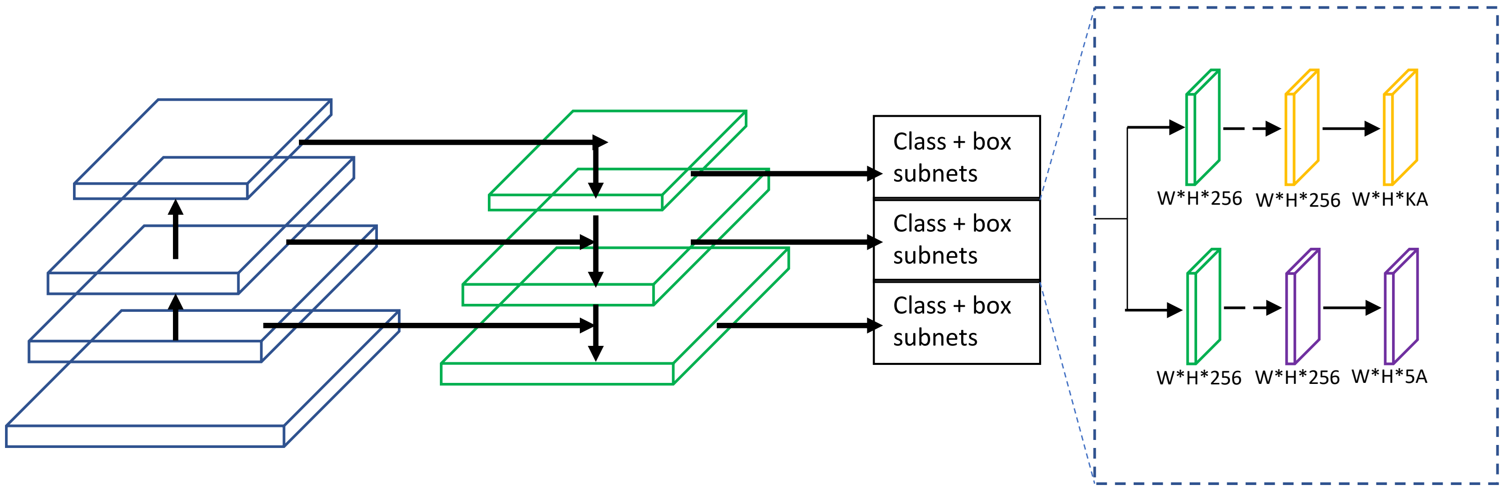
The discontinuity of loss in five-parameter methods



The discontinuity of loss in five-parameter methods



(a) Relation between center point and IoU (b) Relation between width and IoU (c) Relation between angle and IoU



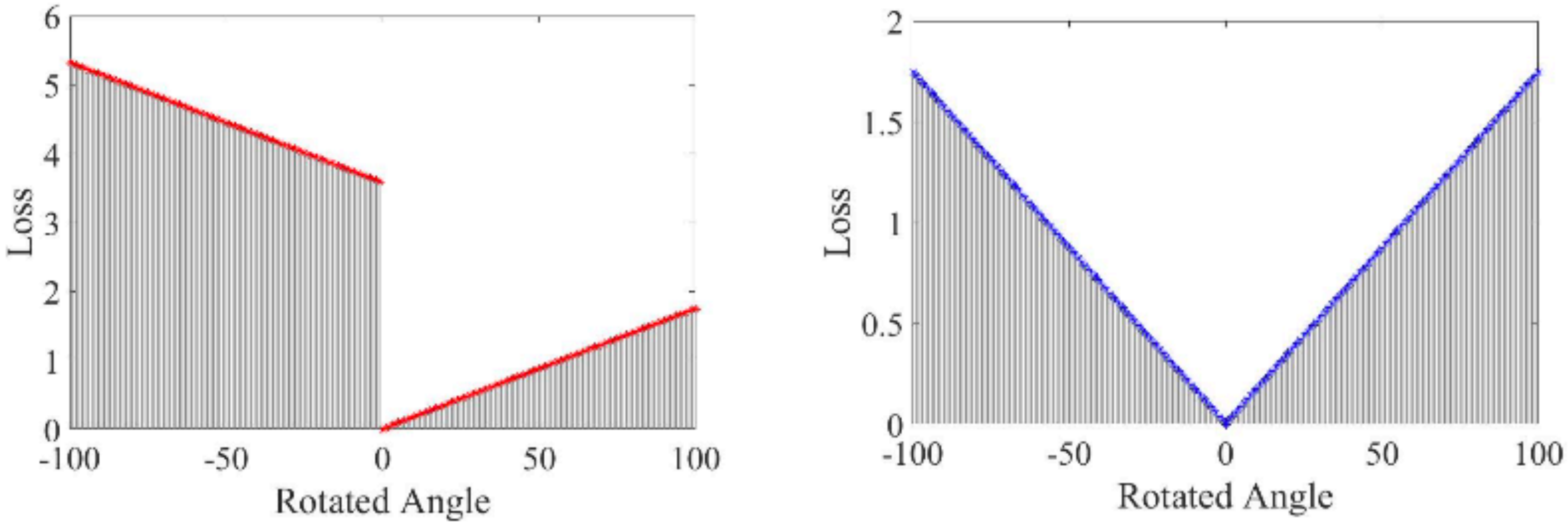
$$t_x = \frac{x - x_a}{w_a} \qquad t_y = \frac{y - y_a}{h_a} \qquad t_w = \log\left(\frac{w}{w_a}\right)$$

$$t_h = \log\left(\frac{h}{h_a}\right) \qquad t_\theta = \frac{\theta\,\pi}{180}$$

The discontinuity of loss in five-parameter methods

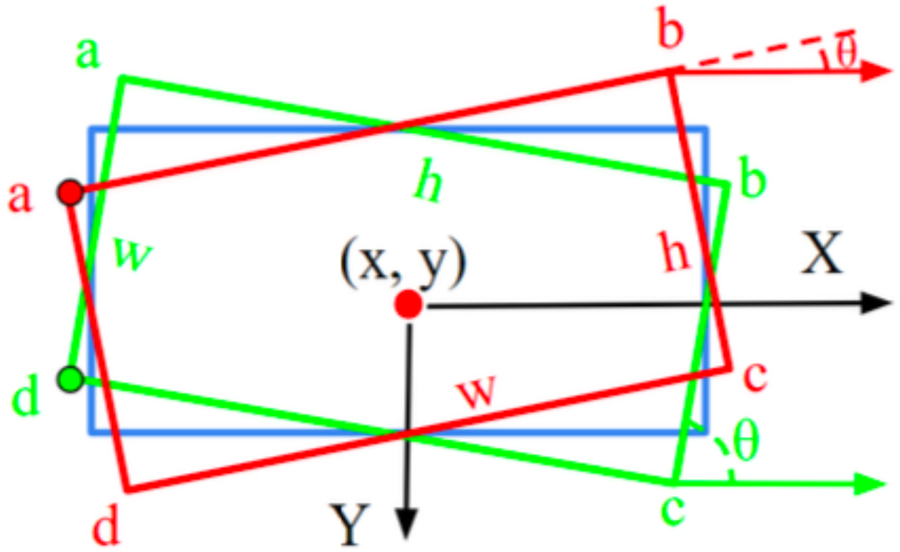
$$\ell_{cp} = |x_1 - x_2| + |y_1 - y_2|, \tag{2}$$

$$\ell_{mr}^{5p} = \min \begin{cases} \ell_{cp} + |w_1 - w_2| + |h_1 - h_2| + |\theta_1 - \theta_2| \\ \ell_{cp} + |w_1 - h_2| + |h_1 - w_2| \\ \quad + |90 - |\theta_1 - \theta_2||, \end{cases} \tag{3}$$



(a) Discontinuous ℓ_1-loss (b) Continuous ℓ_{mr}^{5p}

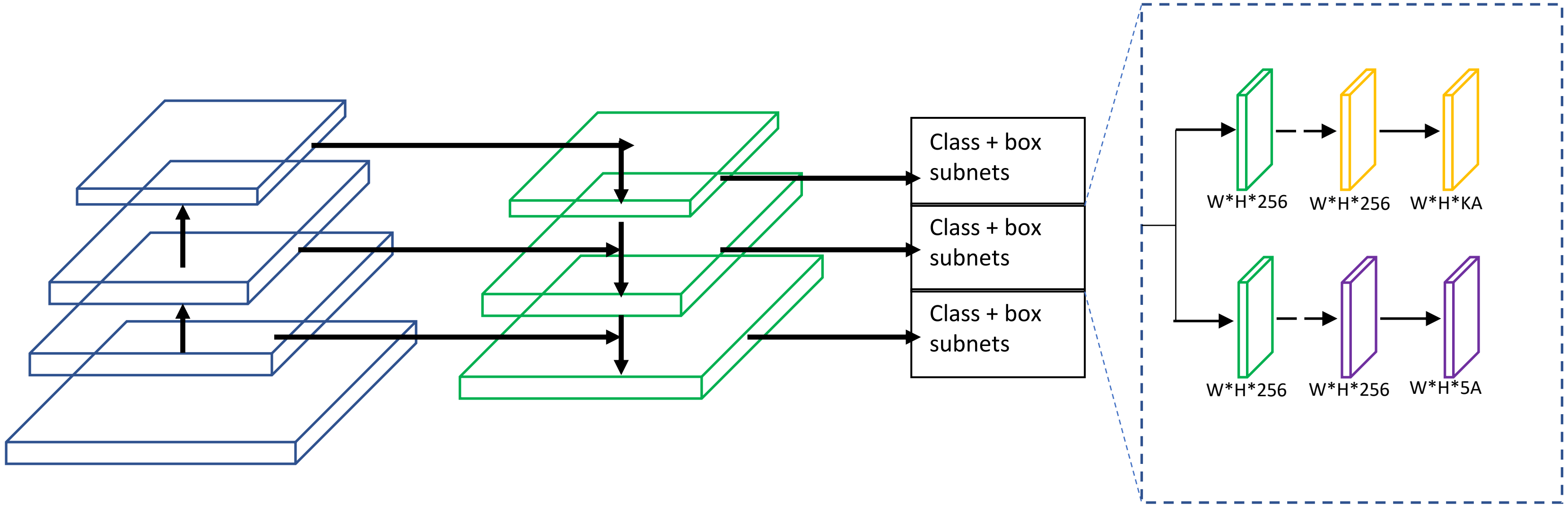
The discontinuity of loss in eight-parameter methods



The discontinuity of loss in eight-parameter methods

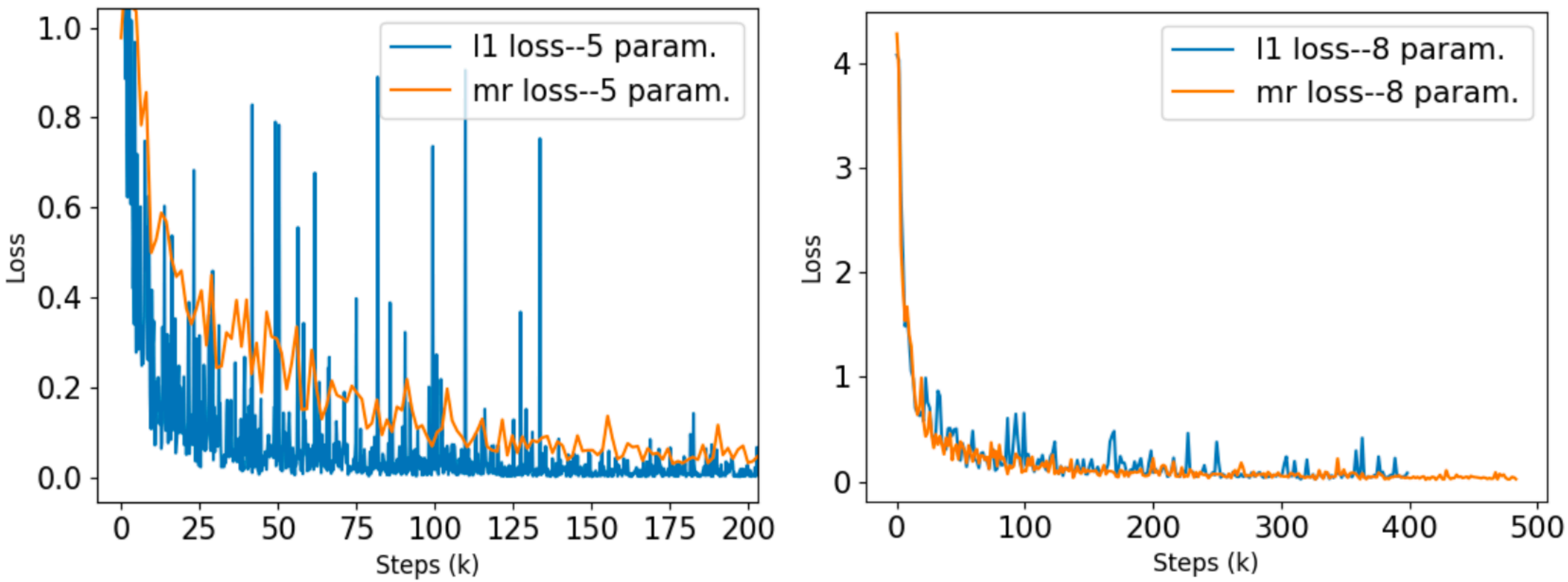
$$\ell_{mr}^{8p} = \min \begin{cases} \sum_{i=0}^{3} \left(\frac{|x_{(i+3)\%4} - x_i^*|}{w_a} + \frac{|y_{(i+3)\%4} - y_i^*|}{h_a} \right) \\ \sum_{i=0}^{3} \left(\frac{|x_i - x_i^*|}{w_a} + \frac{|y_i - y_i^*|}{h_a} \right) \\ \sum_{i=0}^{3} \left(\frac{|x_{(i+1)\%4} - x_i^*|}{w_a} + \frac{|y_{(i+1)\%4} - y_i^*|}{h_a} \right) \end{cases} \tag{6}$$

The discontinuity of loss in eight-parameter methods



$$t_x = \frac{x - x_a}{w_a} \qquad t_y = \frac{y - y_a}{h_a} \qquad t_w = \log\left(\frac{w}{w_a}\right)$$

$$t_h = \log\left(\frac{h}{h_a}\right) \qquad t_\theta = \frac{\theta\,\pi}{180}$$



(a) Loss curves (five-param.) (b) Loss curves (eight-param.)

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large-vehic
large-vehic
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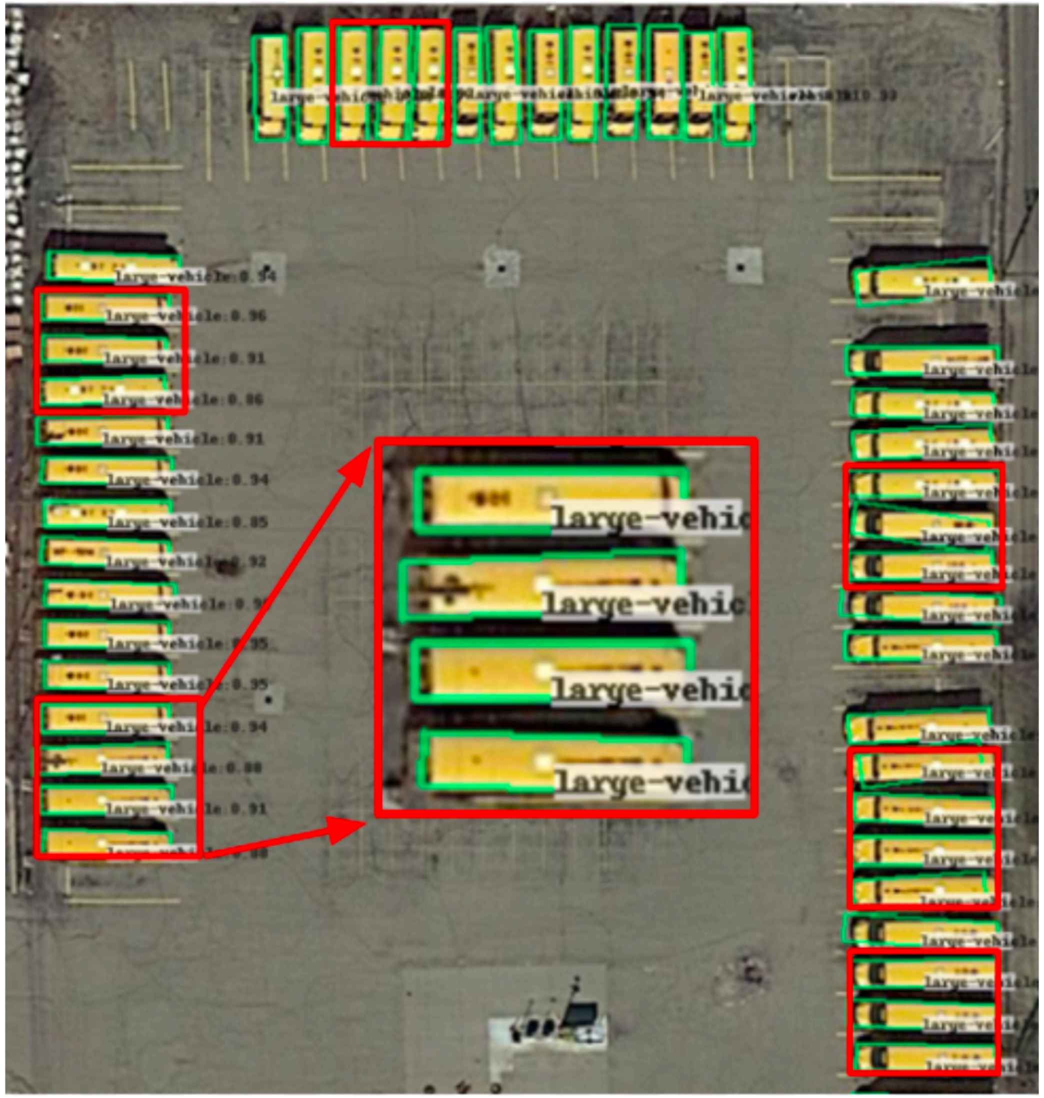
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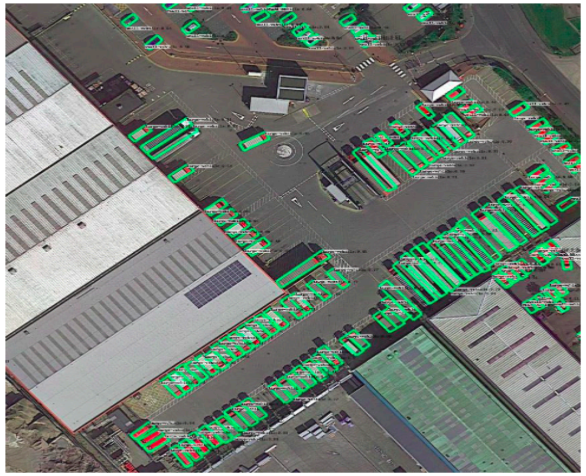
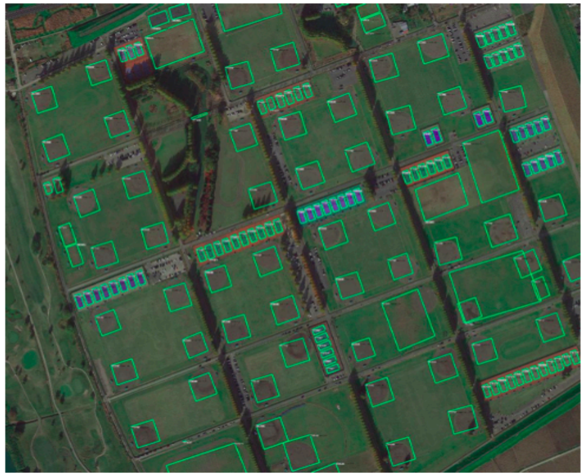


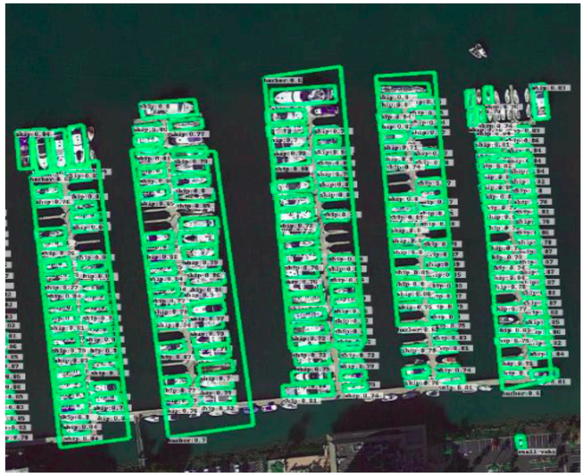
(a) Vehicles



(b) Tennis field

(c) Text in signs

(d) Storage tank



(e) Harbor and ship

(f) Text in elevator

THANKS