

Supplementary Algorithm 1: Pseudo-codes for calculating 3D mAP and recall.

Algorithm 1: Calculating per-frame mAP and recall

Inputs: H estimated bounding boxes $D_{boxs_{est}} = \{(x_i^e, y_i^e, z_i^e, w_i^e, l_i^e, h_i^e, \theta_i^e, c_i^e, s_i^e) | i = 1, 2, \dots, H\}$, G ground truth bounding boxes $D_{boxs_{gt}} = \{(x_j^{gt}, y_j^{gt}, z_j^{gt}, w_j^{gt}, l_j^{gt}, h_j^{gt}, \theta_j^{gt}, c_j^{gt}) | j = 1, 2, \dots, G\}$, where $\forall c_i^{pre}$ (c_j^{gt}) $\in \{0, 1, \dots, n\}$ represents the class label (0 for car in this study. n is determined by classification).

Outputs: mAP and $recall$.

1: Set $mAP = 0$, $recall = 0$ and the threshold of intersection over union (IOU) $iou_{th} = 0.5$.

2: **For** c in $\{0, \dots, n + 1\}$

3: Obtain estimated and ground truth bounding boxes with the class labels equal to c , i.e., $D_{est} = \{(x_i^e, y_i^e, z_i^e, w_i^e, l_i^e, h_i^e, \theta_i^e, c_i^e, s_i^e) | c_i^e = c, i = 1, 2, \dots, H\}$ and $D_{gt} = \{(x_j^{gt}, y_j^{gt}, z_j^{gt}, w_j^{gt}, l_j^{gt}, h_j^{gt}, \theta_j^{gt}, c_j^{gt}) | c_j^{gt} = c, j = 1, 2, \dots, G\}$.

4: Sort D_{est} in a descending order according to s_i^e , i.e., $s_1^e \geq s_2^e \geq \dots \geq s_{|D_{est}|}^e$, set the total number of true positives $count = 0$.

5: Define five sets, i.e., $TP = [tp_1, tp_2, \dots, tp_{|D_{est}|}]$, $FP = [fp_1, fp_2, \dots, fp_{|D_{est}|}]$, $Pr = [pr_1, pr_2, \dots, pr_{|D_{est}|}]$, $Re = [re_1, re_2, \dots, re_{|D_{est}|}]$ and $Flag = [f_1, f_2, \dots, f_{|D_{est}|}]$. Initialize all elements in these five sets as 0.

6: **For** $k = 1$ to $|D_{est}|$ **do**

7: Parameter recover: $iou_{max} = -1$, $j_{max} = 0$.

8: **For** $l = 1$ to $|D_{gt}|$ **do**

9: Calculate the IOU between the k -th bounding box in D_{est} and l -th bounding box in D_{gt} .

10: **If** IOU $> iou_{max}$ **then**

11: $iou_{max} = \text{IOU}$, $j_{max} = l$.

12: **End If**

13: **End For**

14: **If** $iou_{max} > iou_{th}$ **then**

15: **If** $f_{j_{max}} = 0$ **then**

16: $tp_k = 1$, $f_{j_{max}} = 1$.

17: **Else**

18: $fp_k = 1$.

19: **End If**

20: **End If**

21: **End For**

22: **For** $k = 1$ to $|D_{est}|$ **do**

23: $count = count + tp_k$.

24: $pr_k = count/k$, $re_k = count/|D_{gt}|$.

25: **End For**

26: $AP = pr_1 * re_1 + \sum_{k=2}^{|D_{est}|} pr_k * (re_k - re_{k-1})$, $recall' = re_{|D_{est}|}$.

27: $mAP = mAP + AP/n + 1$, $recall = recall + recall'$.

28: **End For**

29: **Return** mAP , $recall$