

# Assignment -10

**Title:** Python program to implement CNN object detection. Discuss numerous performance evaluations

**Aim:** Write Python program to implement CNN object detection. Discuss numerous performance evaluation metrics for evaluating the object detecting algorithms performance.

**Theory:** Object detection is a computer vision technique for locating instances of objects in images or videos. Object detection algorithms typically leverage machine learning or deep learning to produce meaningful results. When humans look at images or video, we can recognize and locate objects of interest within a matter of moments. The goal of object detection is to replicate this intelligence using a computer. Average Precision (AP) and mean Average Precision (mAP) are the most popular metrics used to evaluate object detection models, such as Faster R-CNN, Mask R-CNN, and YOLO, among others.

## Definition of terms:

- **True Positive (TP)** - Correct detection made by the model.
- **False Positive (FP)** - Incorrect detection made by the detector.
- **False Negative (FN)** - A Ground-truth missed (not detected) by the object detector.
- **True Negative (TN)** - This is the background region correctly not detected by the model. This metric is not used in object detection because such regions are not explicitly annotated when preparing the annotations.

## Object Detection metrics:

### Intersection over Union (IoU):

IoU metric in object detection evaluates the degree of overlap between the ground(gt) truth and prediction(pd). The ground truth and the prediction can be of any shape-rectangular box, circle, or irregular shape). It is calculated as follows:

$$IoU = \frac{\text{area}(gt \cap pd)}{\text{area}(gt \cup pd)}$$

Diagrammatically, IoU is defined as follows (the area of the intersection divided by the area of union between ground-truth and predicted box).


$$IoU = \frac{\text{area of overlap}}{\text{area of union}}$$

IoU ranges between 0 and 1, where 0 shows no overlap, and 1 means perfect overlap between *gt* and *pd*. IoU metric is useful through thresholding; that is, we need a threshold (a, say) to determine whether detection is correct.

### Precision and Recall

**Precision** is the degree of exactness of the model in identifying only relevant objects. It is the ratio of TPs over all detections made by the model.

**Recall** measures the ability of the model to detect all ground truths- proportion of TPs among all ground truths.

$$P = \frac{TP}{TP + FP} = \frac{TP}{\text{all detections}}$$

$$R = \frac{TP}{TP + FN} = \frac{TP}{\text{all ground-truths}}$$

A model is said to be good if it has high precision and high recall. A perfect model has zero FNs and zero FPs (precision=1 and recall=1). Often, attaining a perfect model is not feasible.

### Average Precision

AP@ $\alpha$  is Area Under the Precision-Recall Curve(AUC-PR) evaluated at a IoU threshold. Formally, it is defined as follows.

$$AP@{\alpha} = \int_0^1 p(r) dr$$

**Notation:** AP@ $\alpha$  or AP $\alpha$  means that AP precision is evaluated at  $\alpha$  IoU threshold. If you see metrics like AP50 and A75, they mean AP calculated at IoU=0.5 and IoU=0.75, respectively.

Mean Average Precision (mAP)

**Remark (AP and the number of classes):** AP is calculated individually for each class. This means that there are as many AP values as the number of classes (loosely). These AP values are averaged to obtain the **mean Average Precision (mAP)** metric.

**Definition:** The mean Average Precision (mAP) is the average of AP values over all classes.

$$mAP@{\alpha} = \frac{1}{n} \sum_{i=1}^n AP_i \quad \text{for } n \text{ classes.}$$

### Conclusion:

We have successfully implemented CNN object detection. Discuss numerous performance evaluation metrics for evaluating the object detecting algorithms' performance.

### Questions:

1. Explain Training & testing on different distributions.
2. Explain Bias & Variance with mismatched data distributions.
3. Explain Transfer learning.
4. Explain Multi task learning
5. Explain end to end learning