Object Detection Questions

1. What are the key differences between Faster R-CNN and YOLO in terms of architecture and performance?

2. How does Non-Maximum Suppression (NMS) work, and why is it important in object detection?

3. Explain the concept of Focal Loss in object detection and its significance in handling class imbalance.

4. What is the role of augmentation techniques like flipping, cropping, and scaling in object detection?

5. How would you handle detecting objects in an image where the lighting conditions are poor?

SOLUTIONS

1. **Faster R-CNN vs YOLO (Architecture & Performance)**
   * **Faster R-CNN** is a two-stage detector that first generates region proposals using a Region Proposal Network (RPN) and then classifies and refines bounding boxes.
   * **YOLO** (You Only Look Once) is a single-stage detector that directly predicts bounding boxes and class probabilities in a single pass.
   * **Performance Comparison**:
     + Faster R-CNN is **more accurate but slower** due to two-stage processing.
     + YOLO is **faster but less accurate**, making it better for real-time applications.
2. **How Non-Maximum Suppression (NMS) Works & Importance**
   * **Purpose**: NMS is used to remove redundant overlapping bounding boxes by selecting the most confident detection.
   * **Steps**:
     + 1. Sort all detected boxes by confidence score.
       2. Select the highest-confidence box.
       3. Remove all overlapping boxes with an **IoU (Intersection over Union)** greater than a threshold.
       4. Repeat until only non-overlapping boxes remain.
   * **Importance**: Prevents multiple detections of the same object, improving detection accuracy.
3. **Focal Loss & Class Imbalance**
   * Focal Loss is an improved loss function designed for object detection models (e.g., RetinaNet).
   * **Why needed?**:
     + In object detection, the background (negative class) dominates, leading to class imbalance.
   * **How it works?**:
     + It applies a scaling factor to down-weight easy examples and focus more on hard-to-classify objects.
4. **Role of Augmentation in Object Detection**
   * **Flipping**: Helps generalize for different viewing angles.
   * **Cropping**: Forces the model to focus on parts of objects.
   * **Scaling & Resizing**: Helps in learning multi-scale features.
   * **Brightness & Contrast Adjustments**: Helps in handling different lighting conditions.
   * **Rotation & Perspective Transformations**: Helps in improving robustness to distortions.
5. **Handling Poor Lighting in Object Detection**
   * **Preprocessing Techniques**:
     + Histogram Equalization to enhance contrast.
     + CLAHE (Contrast Limited Adaptive Histogram Equalization).
   * **Data Augmentation**:
     + Train on darkened versions of images.
   * **Infrared Cameras**:
     + For extreme low-light conditions.
   * **Use of Advanced Models**:
     + Transformer-based models like **DETR** or **YOLOv8** perform better in challenging conditions.