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Institute of Exact Sciences
Department of Computer Science
$2^{ed} Master$:
Artificial Intelligence and Data Science
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— Exam :Pattern Recognition—

Duration : 1 :30 hour :

Section A : Multiple Choice Questions (MCQs) 7 pts

1. What is the primary difference between image classification and object detection ?
   (a) Image classification predicts bounding boxes, object detection does not.
   (b) Image classification identifies one object per image, while object detection identifies and localizes multiple objects.
   (c) Object detection uses RNNs, while image classification uses CNNs.
   (d) Object detection is less complex than image classification.
2. Which of the following models uses a Region Proposal Network (RPN) ?
   (a) YOLO
   (b) SSD
   (c) Faster R-CNN
   (d) AlexNet
3. In YOLO, what does the objectness score represent ?
   (a) The confidence of class prediction.
   (b) The likelihood that a grid cell contains an object.
   (c) The size of the bounding box.
   (d) The overlap of the predicted box with other boxes.
4. What is the main advantage of SSD compared to R-CNN models ?
   (a) Higher accuracy on small objects.
   (b) Simplified single-stage architecture for real-time applications.
   (c) Use of Selective Search for proposals.
   (d) Improved precision-recall performance.
5. Non-Maximum Suppression (NMS) is used to :
   (a) Generate region proposals.
   (b) Normalize input images.
   (c) Eliminate redundant bounding boxes for the same object.
   (d) Improve feature extraction.

Section B : Short Answer Questions 7pts

1. Define the term "Bounding Box Regression" in the context of object detection.
2. List and explain two evaluation metrics commonly used for object detection models.
3. Describe the role of anchors in Faster R-CNN. How do they help in object detection ?
4. What are the main contributions of YOLO to the field of object detection ?
5. Explain how the "IoU" (Intersection over Union) metric is calculated. Why is it important ?

Section C : 6 pts

1. **Feature Map Understanding** An SSD model uses feature maps at multiple scales for object detection. Given an input image of size 300×300, if the feature map size is reduced to 10×10 at a specific layer :
   (a) How many cells does this feature map contain ?
   (b) If each cell is responsible for 5 default boxes, how many bounding boxes will be considered in total ?
2. **YOLO Grid Division** In YOLOv3, an input image is divided into a grid of $S \times S$ cells. Assume $S = 7$, and each cell predicts 3 bounding boxes.
   (a) How many bounding boxes are predicted in total ?
   (b) What information is included in the prediction for each bounding box ?
3. **Comparison of Object Detection Techniques** Compare the advantages and disadvantages of R-CNN, SSD, and YOLO in terms of speed, accuracy, and complexity. Provide a table summarizing your answer.

Good luck !

Section A : Multiple Choice Questions (MCQs)

1. **What is the primary difference between image classification and object detection ? Answer :** b. Image classification identifies one object per image, while object detection identifies and localizes multiple objects.
2. **Which of the following models uses a Region Proposal Network (RPN) ? Answer :** c. Faster R-CNN
3. **In YOLO, what does the objectness score represent ? Answer :** b. The likelihood that a grid cell contains an object.
4. **What is the main advantage of SSD compared to R-CNN models ? Answer :** b. Simplified single-stage architecture for real-time applications.
5. **Non-Maximum Suppression (NMS) is used to : Answer :** c. Eliminate redundant bounding boxes for the same object.

Section B : Short Answer Questions

1. **Define the term "Bounding Box Regression" in the context of object detection. Answer :** Bounding box regression refers to the process of predicting the coordinates of a bounding box that tightly encloses an object in an image. The model outputs four parameters : (x, y, w, h), which represent the center coordinates, width, and height of the box.
2. **List and explain two evaluation metrics commonly used for object detection models. Answer :**
   - **Mean Average Precision (mAP) :** Measures the model's accuracy across all object classes, combining precision and recall for bounding box predictions.
   - **Intersection over Union (IoU) :** Evaluates the overlap between the predicted bounding box and the ground-truth box, determining the quality of localization.
3. **Describe the role of anchors in Faster R-CNN. How do they help in object detection ? Answer :** Anchors are predefined bounding boxes of various sizes and aspect ratios placed at each location on the feature map. They serve as starting points for the model to refine bounding box predictions, enabling detection of objects of different sizes and shapes.
4. **What are the main contributions of YOLO to the field of object detection ? Answer :** YOLO introduced a unified architecture that combines object localization and classification in a single network pass, enabling real-time performance. Its grid-based approach and elimination of the region proposal stage simplified the detection pipeline.
5. **Explain how the "IoU" (Intersection over Union) metric is calculated. Why is it important ? Answer :** IoU $= \frac{\text{Area of Overlap}}{\text{Area of Union}}$ It measures the overlap between the predicted bounding box and the ground-truth box. A higher IoU indicates better accuracy in localizing objects.

Section C :

1. **Feature Map Understanding** An SSD model uses feature maps at multiple scales for object detection. Given an input image of size 300×300, if the feature map size is reduced to 10×10 at a specific layer :
   (a) **How many cells does this feature map contain ? Answer :** $10 \times 10 = 100$ cells.
   (b) **If each cell is responsible for 5 default boxes, how many bounding boxes will be considered in total ? Answer :** $100 \times 5 = 500$ bounding boxes.
2. **YOLO Grid Division** In YOLOv3, an input image is divided into a grid of $S \times S$ cells. Assume $S = 7$, and each cell predicts 3 bounding boxes.
   (a) **How many bounding boxes are predicted in total ? Answer :** $7 \times 7 \times 3 = 147$ bounding boxes.
   (b) **What information is included in the prediction for each bounding box ? Answer :** Each bounding box prediction includes :
      — Four coordinates (b_x, b_y, b_w, b_h) for the box.
      — An objectness score.
      — Class probabilities.
3. **Comparison of Object Detection Techniques**
   Answer :

Aspect	**R-CNN**	**SSD**	**YOLO**
Speed	Slow (multi-stage)	Fast (real-time)	Very fast (real-time)
Accuracy	High	Moderate	Moderate
Complexity	High	Simple	Simple