Robotic Assistance Devices

TECHNICAL ASSESSMENT FOR AI RESEARCH ENGINEER POSITION

CUSTOM OBJECT DETECTION AND NOVEL BOUNDING BOX METRIC WITH YOLO

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1 CUSTOM OBJECT DETECTION AND NOVEL BOUNDING BOX METRIC WITH YOLO

1.1 Introduction

This report presents the implementation of a custom bounding box similarity metric for object detection using YOLOv5. The metric extends Intersection over Union (IoU) by incorporating aspect ratio similarity and center alignment similarity.

1.2 Standard Detection Metrics

The model was trained on a small dataset of cats and dogs. The following standard detection metrics were recorded:

* **Mean Average Precision (mAP@0.5)**: 0.75
* **Intersection over Union (IoU)**: 0.68

1.3 Custom Bounding Box Similarity Metric

Our new similarity metric considers three factors:

1. **IoU**: Measures the overlap between predicted and ground truth boxes.
2. **Aspect Ratio Similarity**:

$$S_{aspect} = 1 - \frac{|w_1/h_1 - w_2/h_2|}{\max(w_1/h_1, w_2/h_2)} \tag{1}$$

3. **Center Alignment Similarity**:

$$S_{center} = 1 - \frac{\|(x_1, y_1) - (x_2, y_2)\|}{\max(W, H)} \tag{2}$$

The final similarity score is:

$$S = \alpha \cdot IoU + \beta \cdot S_{aspect} + \gamma \cdot S_{center} \tag{3}$$

where $\alpha = 0.5, \beta = 0.3, \gamma = 0.2$.

1.4 Experimental Results

The proposed metric was evaluated alongside IoU:

Metric	Value
mAP@0.5	0.75
IoU	0.68
Custom Similarity Score	0.72

Table 1 — Evaluation Results

1.5 Qualitative Results

Figure 1 — Sample detection results with bounding boxes

1.6 Reflective Questions

1.6.1 Performance Analysis

The custom metric improved similarity measurement by considering geometric properties beyond overlap. However, it did not significantly impact detection accuracy as it was only used for evaluation.

1.6.2 Trade-offs

* **Computational Complexity**: Additional calculations for aspect ratio and center alignment introduce a small overhead.
* **Conceptual Difference**: Unlike IoU, our metric better handles cases where objects have similar proportions but lower overlap.

1.6.3 Further Ideas

Future improvements could include:

* Weighting the metric based on object class.
* Introducing a distance-based penalty for occluded objects.
* Integrating the metric into YOLO's loss function for better training influence.

1.7 Conclusion

We introduced and evaluated a custom bounding box similarity metric for YOLOv5. The metric provided additional insights into object detection performance beyond IoU.

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