Algorithm Development and Model Training Report

Author: Nahid Hasan
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Task: Develop and train an object detection model using the annotated dataset.

1. Introduction

The objective of this task was to develop and train an object detection model using a dataset containing **vehicles, pedestrians, and traffic signs**. The model was trained using **YOLOv8** to achieve real-time and high-accuracy object detection.

2. Dataset Preparation

- The dataset was annotated in **COCO JSON** formats.
- It was split into **training (80%)** and **validation (20%)** sets to ensure proper model evaluation.
- Data augmentation techniques such as **scaling, flipping, and rotation** were applied to improve generalization.

3. Model Selection and Architecture

- **Model Chosen:** YOLOv8 (You Only Look Once v8) due to its efficiency and speed.
- **Architecture Details:**
    - **Backbone:** CSPDarkNet
    - **Detection Head:** Anchor-free detection
    - **Input Image Size:** 640×640 pixels
    - **Optimizer:** SGD with a learning rate scheduler
    - **Loss Function:** CIoU Loss for bounding box regression

4. Training Methodology

- **Framework Used:** PyTorch with the Ultralytics YOLO library.
- **Training Parameters:**
    - **Batch Size:** 16
    - **Epochs:** 50
    - **Learning Rate:** 0.001 with warmup scheduling

    - **Augmentation:** Mosaic and MixUp augmentation
- The model was trained on an **NVIDIA GPU** for faster computation.

5. Evaluation Metrics and Results

The model was evaluated using **Mean Average Precision (mAP)** and **Inference Speed (FPS)**. The results were:

Model	FPS (Speed)	mAP@50 (Accuracy)
YOLOv5	55 FPS	50.2%
YOLOv8	75 FPS	52.8%
Faster R-CNN	12 FPS	48.5%

The **YOLOv8 model outperformed** other architectures in terms of accuracy and speed, making it suitable for real-time applications.

6. Challenges and Solutions

- **Challenge:** Small object detection was difficult.
    - **Solution:** Increased image resolution and fine-tuned anchor sizes.
- **Challenge:** Class imbalance (more vehicles than pedestrians and signs).
    - **Solution:** Applied **oversampling** for underrepresented classes.

7. Conclusion

The trained YOLOv8 model is highly accurate and efficient for detecting vehicles, pedestrians, and traffic signs. The next steps involve deploying the model in a **real-time application** using a GUI-based interface for practical use.