Vehicle Detection in Diverse Weather Conditions: YOLOv8 with Optuna Optimization

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Methodology:
• Model: YOLOv8x pre-trained, fine-tuned on AVD-Dataset
• Dataset: 3,200 images (2,600 training, 200 validation)
• Hyperparameter Optimization: Optuna framework
  - Optimized: epochs, batch size, learning rate, image size
  - Objective: Maximize mAP50-95

Optimal Hyperparameters:
• Epochs: 8
• Batch size: 8
• Learning rate: 2.65e-05
• Image size: 720 x 720 pixels

Performance Metrics:
• mAP50-95 (B): 29.24%
• mAP50 (B): 56.08%
• Precision (B): 59.81%
• Recall (B): 50.20%
• Fitness score: 0.3192

Key Findings:
1. Strong performance on common vehicles (taxi, bike, car, bus)
2. Lower accuracy on smaller or less common vehicles (cycle, van)
3. Potential for real-time application with ~38 FPS processing speed
4. Room for improvement in precise localization (mAP50-95 vs mAP50)

Conclusion:
The YOLOv8-based approach with Optuna optimization shows promise for vehicle detection across diverse weather conditions. The model achieves a good balance between accuracy and speed, making it suitable for real-time applications. While performance is strong for common vehicle types, there's room for improvement, particularly for less frequent or smaller vehicles. This lays a solid foundation for further research and practical deployment in traffic monitoring and management scenarios.