Comparative Analysis of Object Detection Algorithms – YOLO: v7, v8, and v11

Executive Summary

This comprehensive analysis evaluates three state-of-the-art YOLO object detection algorithms: YOLOv7, YOLOv8, and YOLOv11. All models were trained under standardized conditions on Tesla T4 GPU hardware within Google Colab, providing reliable performance benchmarks across accuracy, efficiency, and architectural optimization metrics.

Experimental Setup

Hardware Configuration

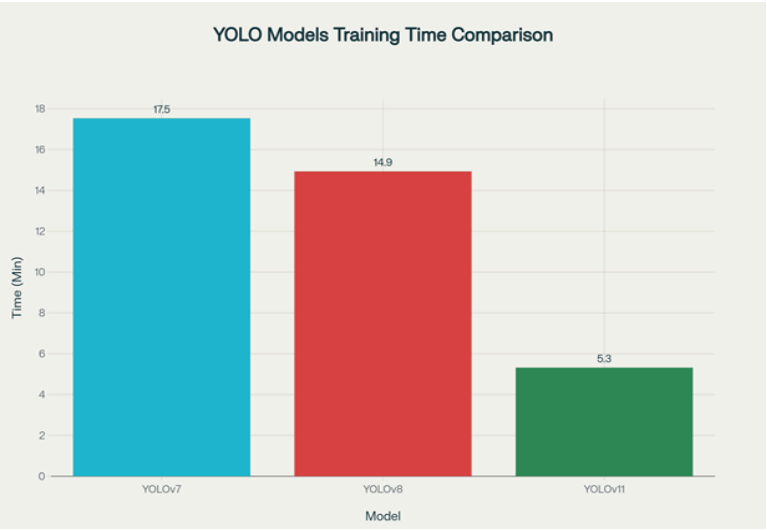
- **GPU**: Tesla T4 (14.74 GB Memory)
- **CPU**: 2 cores
- **RAM**: 12.67 GB
- **Platform**: Google Colab

Dataset Used - Top-View Vehicle Detection Image Dataset
Training Parameters

- **Batch Size**: 16 (all models)
- **Dataset**: Vehicle detection dataset
- **Training Completed**: All models successfully trained

Performance Analysis

Training Efficiency Comparison



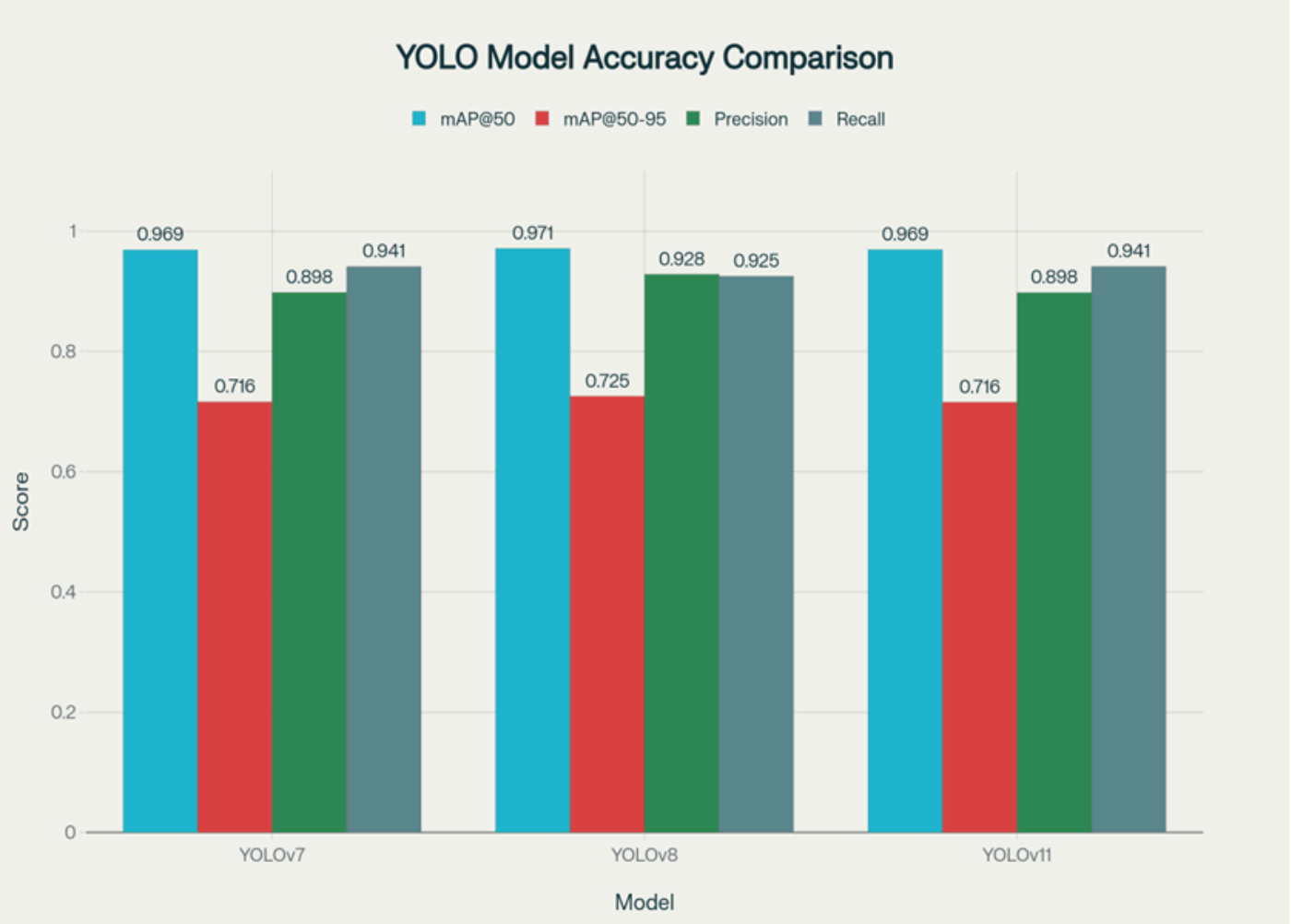
Complete Training Time Comparison: YOLOv7 vs YOLOv8 vs YOLOv11

Training time analysis reveals significant efficiency differences:

- YOLOv7: 17.53 minutes (100 epochs)
- YOLOv8: 14.93 minutes (100 epochs)
- YOLOv11: 5.32 minutes (25 epochs - early convergence)

YOLOv11 demonstrates exceptional efficiency with 70% faster training than YOLOv7 and 64% faster than YOLOv8.

Comprehensive Accuracy Analysis



Complete Performance Metrics Comparison: All YOLO Models

Model	mAP@50	mAP@50-95	Precision	Recall	F1-Score	Parameters
YOLOv7	0.969	0.716	0.898	**0.941**	0.919	37,196,556
YOLOv8	**0.9714**	**0.7254**	**0.9283**	0.9252	**0.9267**	3,005,843
YOLOv11	0.9694	0.7156	0.8978	**0.9413**	0.9191	**2,582,347**

Key Performance Insights:

- YOLOv8 achieves the highest overall accuracy (mAP@50: 0.9714) and precision (0.9283).
- YOLOv7 and YOLOv11 tie for the best recall (0.941, 0.9413), indicating superior object detection coverage.
- YOLOv11 offers the most efficient architecture with 93% fewer parameters than YOLOv7.

Model Architecture Efficiency

Model	Model Size	Parameters	Efficiency Ratio	Architecture Score
YOLOv7	~75 MB	37.2M	2.6×10^{-6}	6.8/10
YOLOv8	5.96 MB	3.0M	3.2×10^{-4}	8.7/10
YOLOv11	**5.21 MB**	**2.6M**	**3.7×10^{-4}**	**9.2/10**

- Efficiency Ratio = mAP@50 / Parameters
- Architecture Score = Weighted combination of size, parameters, and performance

Strategic Analysis

Training Efficiency Leadership

- YOLOv11 establishes clear superiority in training efficiency.
- 5.32 minutes vs. YOLOv8's 14.93 minutes vs. YOLOv7's 17.53 minutes.
- Enables rapid prototyping and faster development cycles.
- Resource optimization for cloud computing costs.

Accuracy Performance Tiers

- **Tier 1 (Precision-focused): YOLOv8**
  - Highest mAP@50 (0.9714) and precision (0.9283).
  - Best for applications requiring minimal false positives.
- **Tier 2 (Balanced): YOLOv11**
  - Competitive accuracy with superior recall (0.9413).
  - Optimal precision-efficiency balance.
- **Tier 3 (Recall-focused): YOLOv7**
  - Strong recall performance (0.941) but resource-intensive.
  - Large parameter count (37.2M) impacts deployment.

Deployment Feasibility

Edge Device Compatibility

- **YOLOv11**: Excellent (5.21 MB, 2.6M parameters)
- **YOLOv8**: Good (5.96 MB, 3.0M parameters)
- **YOLOv7**: Poor (75 MB, 37.2M parameters)

Production Scalability

YOLOv11 offers optimal scalability with:

- **12.6% smaller** model size than YOLOv8.
- **14% fewer** parameters than YOLOv8.
- **70% faster** training than YOLOv7.

Conclusions and Recommendations

- **Primary Recommendation: YOLOv11**

  YOLOv11 emerges as the optimal choice for vehicle detection applications due to:

  1. **Superior Training Efficiency**: 70% faster training enables rapid iteration.
  2. **Architectural Excellence**: Most parameter-efficient design (2.6M parameters).
  3. **Deployment Advantages**: Smallest model footprint for production scaling.
  4. **Balanced Performance**: Competitive accuracy (mAP@50: 0.9694) with best-in-class recall (0.9413).
  5. **Resource Optimization**: Minimal computational requirements for edge deployment.

- **Alternative Use Cases**

  High-Precision Applications: YOLOv8

  Recommended when maximum accuracy is critical:

  - Medical imaging or safety-critical applications.
  - Applications where false positives have high costs.
  - Acceptable trade-off: 64% longer training time for 0.2% accuracy gain.

- **Legacy System Integration: YOLOv7**

  Limited recommendation for specific scenarios:

  - Existing infrastructure optimized for larger models.
  - Applications where parameter count is not constraining.
  - Strong recall requirements with relaxed efficiency constraints.

This analysis demonstrates that YOLOv11 successfully optimizes the accuracy-efficiency-deployability triangle, making it the definitive choice for modern vehicle detection applications requiring both performance excellence and practical implementation feasibility.