yolo11s_finetuned_20251201 Hyperparameter Tuning Report

Generated: 2025-12-01 06:42:36

1. Optimization Overview

Property	Value
Model	yolo11s_finetuned_20251201
Dataset	bdd100k_yolo_tiny
Total Trials	50
Completed Trials	50
Failed Trials	0
Best Trial	16
Best mAP@0.5	0.5523
Optimization Duration	1:11:43.933828

2. Optimization Configuration

Parameter	Value
Total Trials	50
Epochs per Trial	10
Batch Size	96
Startup Trials (TPE)	10
Device	cuda
Number of Classes	10
Train Images	570
Val Images	375

2.5 Executive Summary & Key Findings

Metric	Value
■ Best Performance	Trial #16: mAP@0.5 = 0.5523
■ Performance Range	0.4256 to 0.5523 (29.8% improvement)
■ Mean Performance	0.5319 across 50 trials
■ Best Optimizer	SGD (mean: 0.5477)
■■ Optimal Image Size	768px (1.64% better)
■■ Optimization Time	1:11:43.933828
■ Success Rate	50/50 trials (100.0%)

Key Insights:
• The optimization process successfully explored 50 trials, achieving a 29.8% performance improvement from worst to best.
• **SGD** optimizer demonstrated superior performance with mean mAP@0.5 of 0.5477.
• Image size of **768px** provided optimal accuracy-efficiency tradeoff.
• High consistency achieved: mean performance (0.5319) close to best (0.5523), indicating robust hyperparameter space.

3. Best Hyperparameters

Parameter	Value	Description
imgsz	768	
optimizer	SGD	Optimization algorithm
lr0	0.001427	Initial learning rate
momentum	0.969458	SGD momentum / Adam beta1
weight_decay	0.000541	Weight decay (L2 penalty)
warmup_epochs	3	Warmup epochs
warmup_momentum	0.895637	Warmup momentum
warmup_bias_lr	0.060526	
mosaic	0.879214	Mosaic augmentation
mixup	0.068396	Mixup augmentation

4. Top 20 Trials Performance

#	mAP@0.5	ImgSz	Opt	lr0	mom	mixup	mosaic
1	0.5523	768	SGD	0.0014	0.969	0.07	0.88
2	0.5515	768	SGD	0.0030	0.936	0.10	0.85
3	0.5514	768	SGD	0.0016	0.961	0.08	0.91
4	0.5513	768	SGD	0.0023	0.948	0.03	0.77
5	0.5511	768	SGD	0.0025	0.965	0.10	0.72
6	0.5510	768	SGD	0.0026	0.966	0.04	0.80
7	0.5510	768	SGD	0.0024	0.961	0.04	0.65
8	0.5509	768	SGD	0.0003	0.939	0.06	0.96
9	0.5506	768	SGD	0.0016	0.962	0.06	0.92
10	0.5499	768	SGD	0.0001	0.956	0.10	0.89
11	0.5498	768	SGD	0.0002	0.893	0.14	0.92
12	0.5496	768	Adam	0.0002	0.858	0.14	0.55
13	0.5494	768	SGD	0.0032	0.956	0.11	0.90
14	0.5494	768	SGD	0.0002	0.895	0.10	0.98
15	0.5493	768	SGD	0.0001	0.968	0.02	1.00
16	0.5491	768	SGD	0.0002	0.947	0.04	0.86
17	0.5490	768	SGD	0.0019	0.966	0.08	0.92
18	0.5489	768	SGD	0.0033	0.952	0.06	0.69
19	0.5489	768	SGD	0.0022	0.954	0.13	0.57
20	0.5485	768	SGD	0.0042	0.938	0.07	0.66

4.1 Detailed Hyperparameters - Top 5 Trials

Rank 1: Trial 16 (mAP@0.5: 0.5523)
imgsz=768, lr0=0.001427, mixup=0.068396, momentum=0.969458, mosaic=0.879214, optimizer=SGD, warmup_bias_lr=0.060526, warmup_epochs=3, warmup_momentum=0.895637, weight_decay=0.000541

Rank 2: Trial 48 (mAP@0.5: 0.5515)
imgsz=768, lr0=0.003011, mixup=0.097906, momentum=0.935534, mosaic=0.847726, optimizer=SGD, warmup_bias_lr=0.055336, warmup_epochs=2, warmup_momentum=0.794918, weight_decay=0.000057

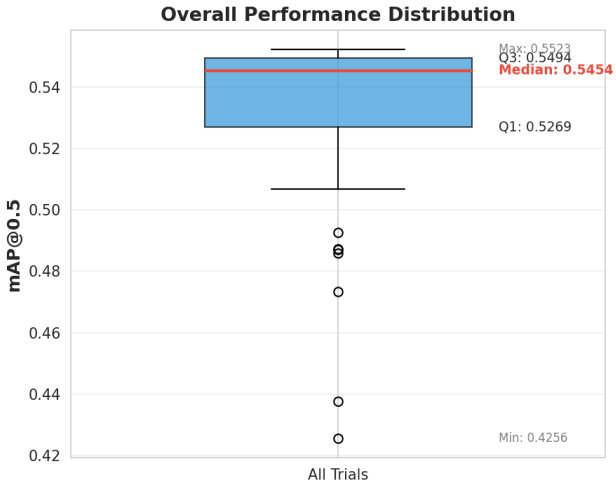
Rank 3: Trial 21 (mAP@0.5: 0.5514)
imgsz=768, lr0=0.001615, mixup=0.084481, momentum=0.960522, mosaic=0.914846, optimizer=SGD, warmup_bias_lr=0.078371, warmup_epochs=2, warmup_momentum=0.931693, weight_decay=0.000478

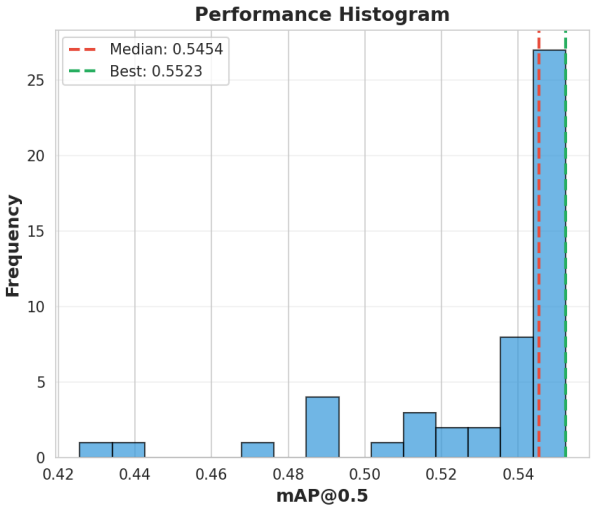
Rank 4: Trial 45 (mAP@0.5: 0.5513)
imgsz=768, lr0=0.002296, mixup=0.028200, momentum=0.948473, mosaic=0.771222, optimizer=SGD, warmup_bias_lr=0.061112, warmup_epochs=2, warmup_momentum=0.758181, weight_decay=0.000068

Rank 5: Trial 36 (mAP@0.5: 0.5511)
imgsz=768, lr0=0.002514, mixup=0.096114, momentum=0.965286, mosaic=0.716754, optimizer=SGD, warmup_bias_lr=0.080543, warmup_epochs=3, warmup_momentum=0.820053, weight_decay=0.000448

5. Optimization Visualizations & Analysis

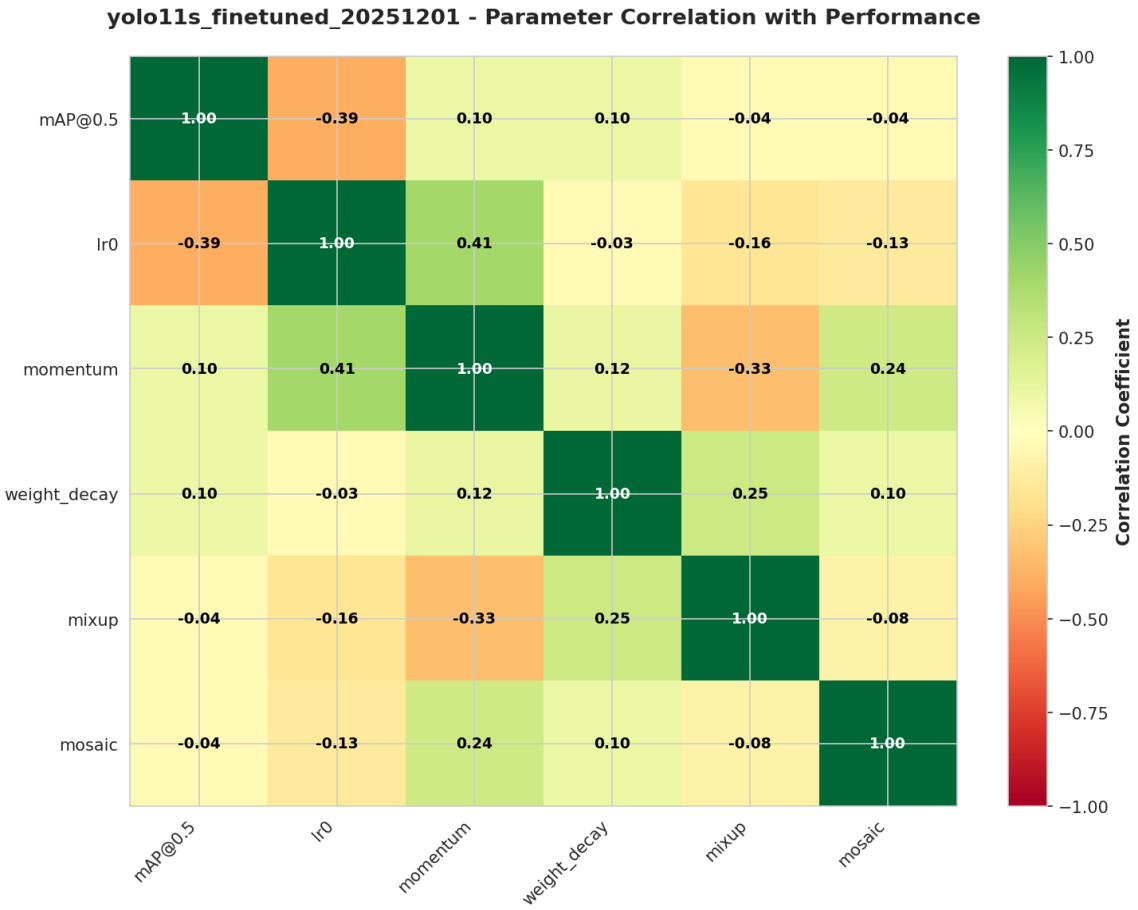
5.0 Performance Distribution Analysis





Statistic	Value
Mean	0.5319
Median	0.5454
Std Dev	0.0291
IQR (Q3-Q1)	0.0225
Range	0.1267

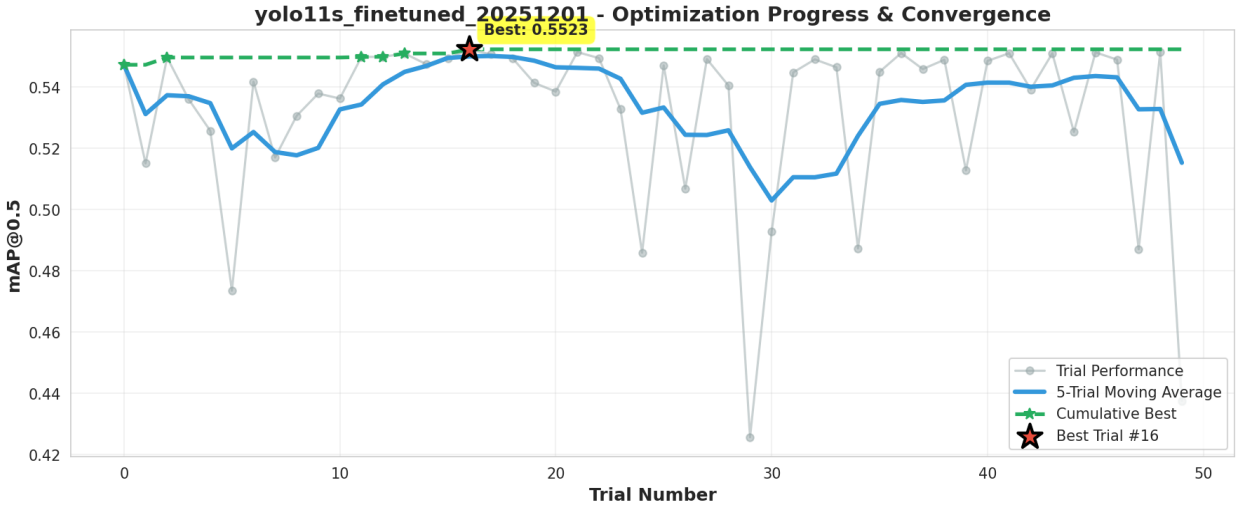
5.1 Parameter Correlation Analysis



Correlation Insights:

• Strongest positive correlation: **momentum** (0.101) - Higher values tend to improve performance.
• Strongest negative correlation: **lr0** (-0.392) - Higher values tend to decrease performance.
• Green cells indicate positive correlation, red cells indicate negative correlation.

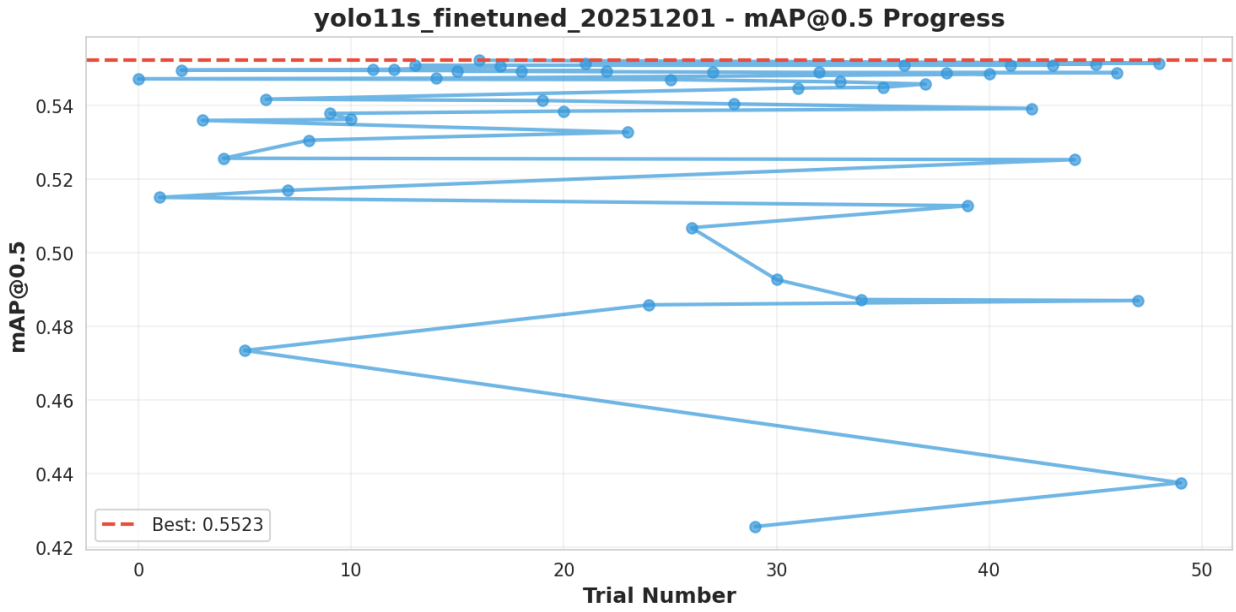
5.2 Optimization Timeline & Convergence



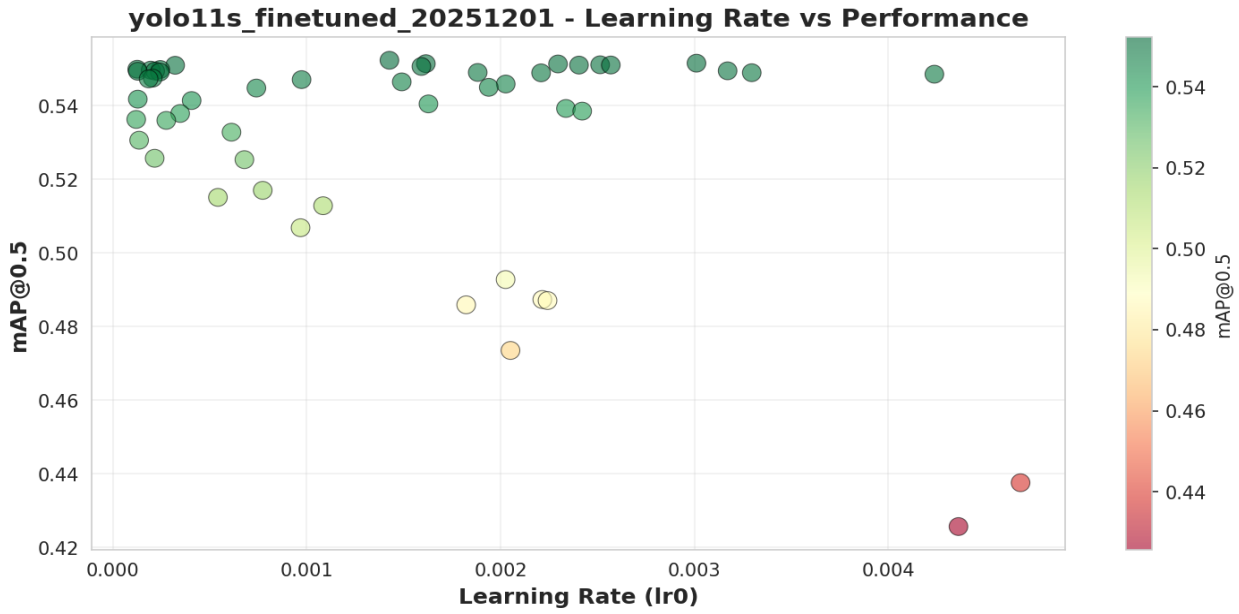
Convergence Analysis:

• Best solution found at trial **#16** (32.0% through optimization).
• Moving average shows rapid early convergence pattern.
• Cumulative best curve indicates efficient exploration of hyperparameter space.

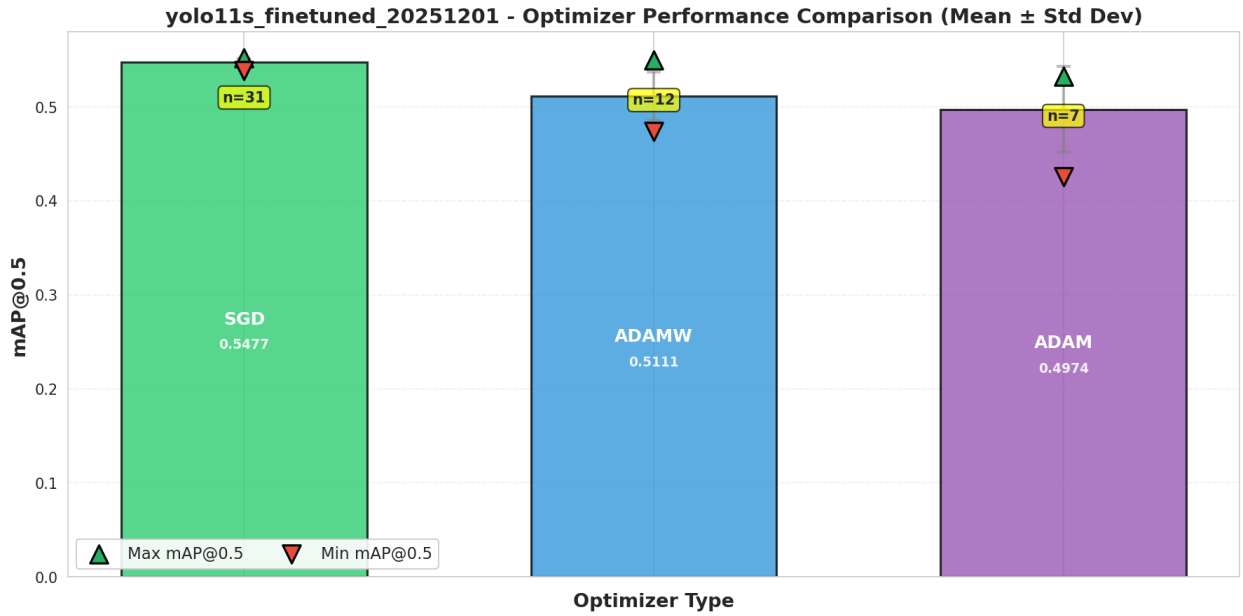
5.3 mAP@0.5 Progress Over Trials



5.4 Learning Rate Impact on Performance



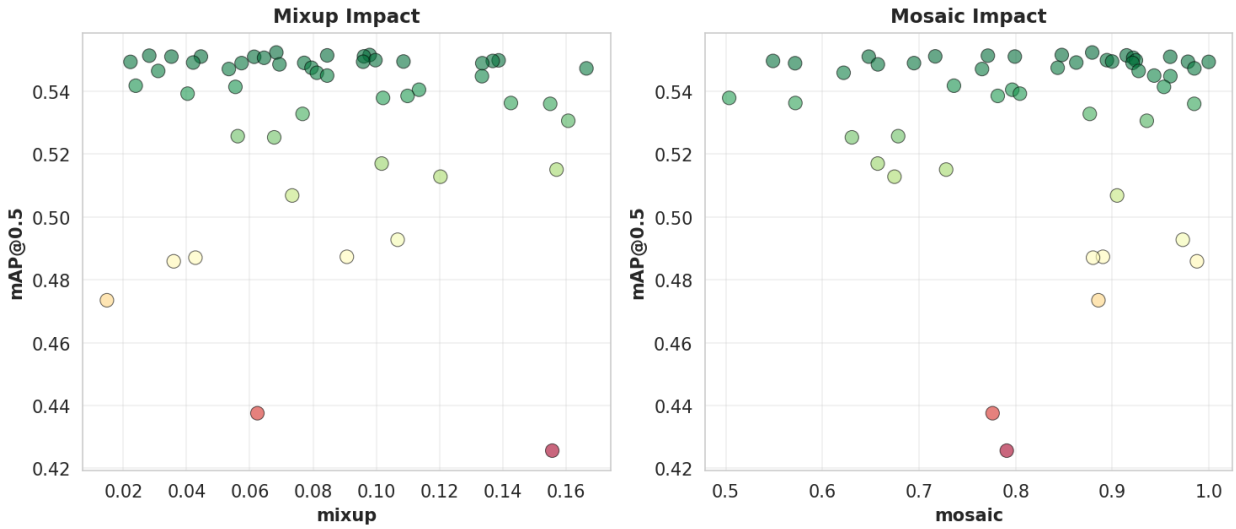
5.5 Optimizer Performance Comparison



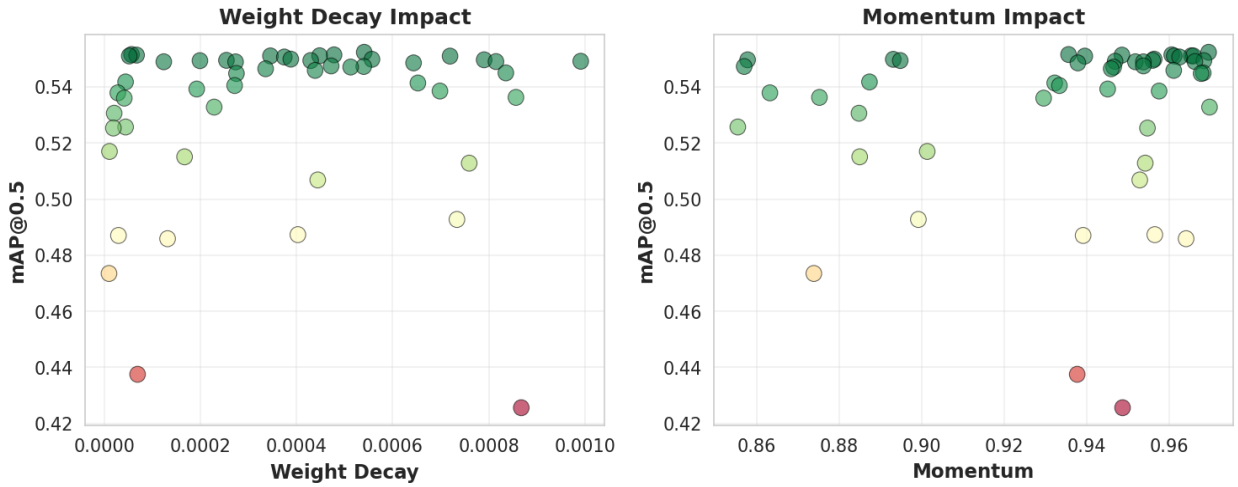
Optimizer	Mean	Max	Min	Std Dev	Trials
SGD	0.5477	0.5523	0.5385	0.0039	31
ADAMW	0.5111	0.5496	0.4735	0.0256	12
ADAM	0.4974	0.5328	0.4256	0.0457	7

Analysis: SGD achieved the highest mean performance (0.5477) across 31 trials. The error bars show the standard deviation, indicating performance consistency.

5.6 Augmentation Parameters Impact



5.7 Regularization Parameters Impact



5.8 Image Size Impact on Performance

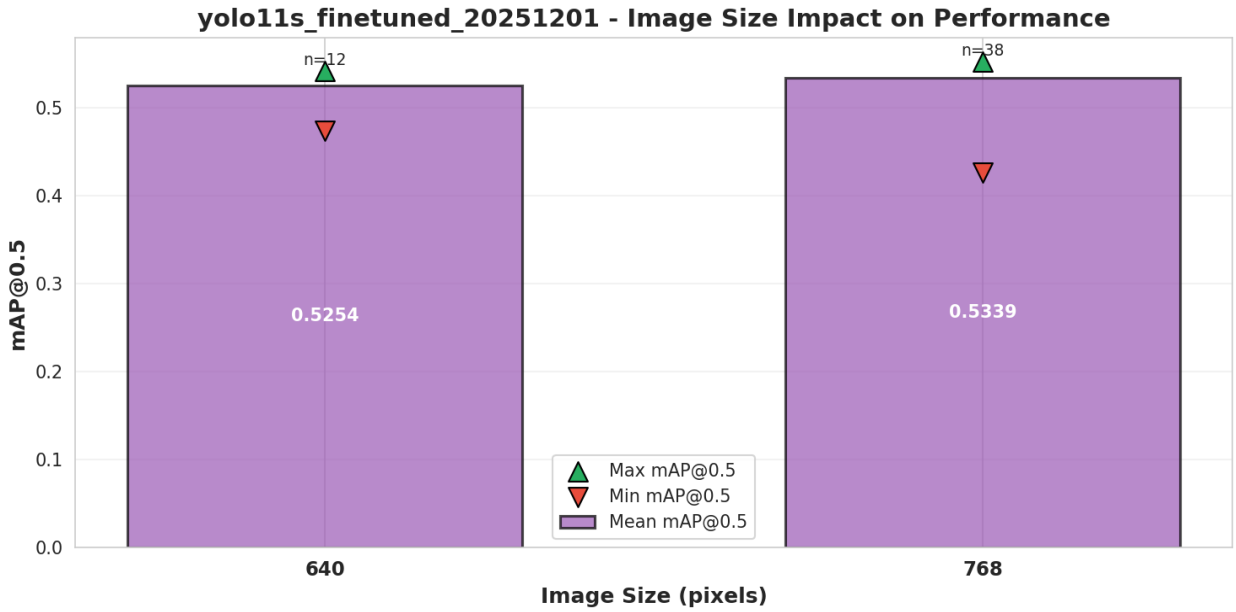


Image Size	Mean mAP@0.5	Max mAP@0.5	Min mAP@0.5	Trials
640	0.5254	0.5417	0.4735	12
768	0.5339	0.5523	0.4256	38

5.9 Key Insights & Production Recommendations

■ Optimal Configuration for Production Deployment:

1. Image Processing:
• Use **768px** input resolution for optimal accuracy
• Expected performance: **mAP@0.5 = 0.5523**
• Tradeoff: Higher resolution improves accuracy but increases inference time

2. Optimizer Configuration:
• Algorithm: **SGD**
• Learning rate (lr0): **0.001427**
• Momentum: **0.9695**
• Weight decay: **0.000541**

3. Training Warmup:
• Warmup epochs: **3**
• Warmup momentum: **0.8956**
• Warmup bias lr: **0.060526**

4. Data Augmentation:
• Mosaic augmentation: **0.8792** (strong augmentation for robustness)
• Mixup augmentation: **0.0684** (light augmentation)
• Recommendation: Use these exact values for similar datasets

5. Performance Metrics:
• Best trial found at **#16** out of 50 trials
• Performance improvement: **29.8%** over worst trial
• Consistency: Mean mAP@0.5 = 0.5319 (Std = 0.0291)

6. Deployment Recommendations:
• **SGD** optimizer demonstrated best performance (mean: 0.5477)
• **SGD** outperformed Adam by 10.1%
• For maximum accuracy, use 768px images
• For faster inference with slight accuracy trade-off, consider 640px (mAP: 0.5254)

7. Next Steps:
• Train full model with these hyperparameters
• Monitor validation metrics for overfitting
• Consider ensemble methods for further improvement

■ Confidence Level:
• Based on 50 successful trials
• Optimization converged early (best at 32.0% through search)
• Standard deviation (0.0291) indicates moderate consistency

Metric	Best Trial	Mean Performance	Worst Trial
mAP@0.5	0.5523	0.5319	0.4256
Trial #	#16	-	#29
Learning Rate	0.001427	0.001467	0.004363
Momentum	0.9695	0.9338	0.9486

6. All Trials Summary

Metric	Value
Completed Trials	50
Best mAP@0.5	0.5523
Worst mAP@0.5	0.4256
Mean mAP@0.5	0.5319
Std Dev mAP@0.5	0.0291
Median mAP@0.5	0.5454