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YOLO11-l TRAINING - VinDr-SpineXR (MEMORY OPTIMIZED)

Target: Beat 33.15% mAP@0.5 baseline

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Configuration:

- Model: YOLO11-l (25M parameters)
- 35 epochs (~6-8 hours on RTX 3050)
- Image size: 640px
- Batch size: 12 (safe for 8GB GPU)
- Expected: 32-36% mAP@0.5

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Dataset Analysis Applied:

- Class imbalance: 46.9:1 ratio
- Small objects: 8812-9745 px2
- Minority classes: 268-446 samples

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Configuration:

Model: YOLO11-l (25M parameters)

Epochs: 35

Batch Size: 12

Image Size: 640

Device: CUDA

Dataset Characteristics:

Total training images: 8,389

Class imbalance: 46.9:1

Hardest classes: Other lesions (446), Vertebral collapse (268)

Small objects: Osteophytes (8812px^2), Foraminal stenosis (9745px^2)

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Loading YOLO11-l model...

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✓ YOLO11-l loaded successfully

Model Architecture: YOLO11-l

Parameters: ~25M (vs 65M for YOLO11-x)

GPU Memory: ~6GB (vs 13.3GB for YOLO11-x)

Key features:

- C2PSA (Partial Self-Attention) for small objects

- P3-P7 feature pyramid (5 scales)

- Improved focal loss for class imbalance

- 2-3x faster than YOLO11-x

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Starting training with dataset-optimized configuration...

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optimizer: AdamW(lr=0.0001, momentum=0.937) with parameter groups 167 weight(decay=0.0), 174 weight(decay=0.00046875), 173 bias(decay=0.0)

Image sizes 640 train, 640 val

Using 4 dataloader workers

Logging results to C:\Users\prosenjit19\Desktop\Spine\runs\detect\runs\yolo11\vindr_l_final

Starting training for 35 epochs...

35 epochs completed in 13.255 hours.

YOLO Validation Results

Class	Images	Instances	Precision (P)	Recall (R)	mAP50	mAP50-95
All	**2077**	**3638**	**0.484**	**0.394**	**0.401**	**0.193**
Osteophytes	878	2961	0.478	0.407	0.406	0.145
Surgical implant	64	107	0.601	0.757	0.741	0.471
Spondylolysthesis	62	69	0.470	0.377	0.377	0.164
Foraminal stenosis	60	94	0.688	0.305	0.414	0.157
Disc space narrowing	148	230	0.390	0.296	0.299	0.132
Vertebral collapse	52	69	0.564	0.580	0.538	0.272
Other lesions	80	108	0.196	0.037	0.029	0.011

Speed: 0.2ms preprocess, 9.8ms inference, 0.0ms loss, 1.1ms postprocess per image

Results saved to C:\Users\prosenjit19\Desktop\Spine\runs\detect\runs\yolo11\vindr_l_final

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TRAINING COMPLETED

Final Metrics:

mAP@0.5: 0.4005 (40.05%)

✅ SUCCESS! Beat 33.15% baseline!

mAP@0.5:0.95: 0.1932 (19.32%)