

Using CUDA GPU: NVIDIA GeForce RTX 3050

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Training densenet121 for Chest X-Ray Classification

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Loading data...

Loading data from:

Train: data/raw/chest_xray/train

Val: data/raw/chest_xray/val

Test: data/raw/chest_xray/test

/home/user/miniconda3/envs/dl_env/lib/python3.10/site-packages/albumenations/core/validation.py:114: UserWarning: ShiftScaleRotate is a special case of Affine transform. Please use Affine transform instead.

original_init(self, **validated_kwargs)

Train samples: 5216

Validation samples: 16

Test samples: 624

Train distribution - Normal: 1341, Pneumonia: 3875

Imbalance ratio: 2.89:1

Creating densenet121 model...

model.safetensors: 100% [██████████] 32.3M/32.3M [00:11<00:00, 2.76MB/s]

Model parameters: 7,479,682

Trainable parameters: 7,479,682

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STAGE 1: Baseline Training (Frozen Backbone)

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Trainable parameters: 525,826

Training stage: baseline

Epochs: 15, Learning rate: 0.001

Epoch 1/15

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Training: 100%|██████████| 163/163

[00:28<00:00, 5.63it/s, loss=0.35]

Evaluating:

100%|██████████| 1/1

[00:00<00:00, 2.28it/s]

Train Loss: 0.2965, Train Acc: 0.8825

Val Loss: 1.8861, Val Acc: 0.5625, Val AUC: 0.9531

Epoch 2/15

Training: 100%|██████████| 163/163 [00:29<00:00,

5.58it/s, loss=0.836]

Evaluating:

100%|██████████| 1/1

[00:00<00:00, 2.52it/s]

Train Loss: 0.2258, Train Acc: 0.9087

Val Loss: 3.1116, Val Acc: 0.5625, Val AUC: 0.9375

Epoch 3/15

Training: 100%|██████████| 163/163 [00:29<00:00,

5.47it/s, loss=0.0657]

Evaluating:

100%|██████████| 1/1

[00:00<00:00, 2.74it/s]

Train Loss: 0.2113, Train Acc: 0.9170

Val Loss: 3.1900, Val Acc: 0.5625, Val AUC: 1.0000

Epoch 4/15

Training: 100%|██████████| 163/163 [00:29<00:00,

5.46it/s, loss=0.151]

Evaluating:

100%|██████████| 1/1

[00:00<00:00, 2.43it/s]

Train Loss: 0.2033, Train Acc: 0.9197

Val Loss: 2.3505, Val Acc: 0.6250, Val AUC: 0.9688

Epoch 5/15

Training: 100%|██████████| 163/163 [00:31<00:00,

5.20it/s, loss=0.167]

Evaluating:

100%|██████████| 1/1

[00:00<00:00, 2.34it/s]

Train Loss: 0.2093, Train Acc: 0.9151

Val Loss: 2.5430, Val Acc: 0.5625, Val AUC: 0.9844

Epoch 6/15

Training: 100%|██████████| 163/163 [00:30<00:00,
5.28it/s, loss=0.306]

Evaluating:

100%|██████████| 1/1

[00:00<00:00, 2.49it/s]

Train Loss: 0.1960, Train Acc: 0.9248

Val Loss: 2.2536, Val Acc: 0.6250, Val AUC: 0.9531

Early stopping triggered at epoch 6

Best Validation AUC: 1.0000

Baseline model saved to models/densenet121_baseline.pth

STAGE 2: Progressive Unfreezing - Stage 1

Unfrozen last 20 layers

Trainable parameters: 1,013,634

Training stage: stage_1

Epochs: 15, Learning rate: 0.0001

Epoch 1/15

Training: 100%|██████████| 163/163 [00:29<00:00,
5.49it/s, loss=0.085]

Evaluating:

100%|██████████| 1/1

[00:00<00:00, 2.40it/s]

Train Loss: 0.1802, Train Acc: 0.9312

Val Loss: 2.3592, Val Acc: 0.6250, Val AUC: 0.9688

Epoch 2/15

Training: 100% | ████████████████████████████████████ | 163/163 [00:29<00:00, 5.55it/s, loss=0.283]

Evaluating:

100% | ████████████████████████████████████ | 1/1
[00:00<00:00, 2.42it/s]

Train Loss: 0.1710, Train Acc: 0.9317

Val Loss: 2.6327, Val Acc: 0.5625, Val AUC: 0.9688

Epoch 3/15

Training: 100% | ████████████████████████████████████ | 163/163
[00:30<00:00, 5.34it/s, loss=0.11]

Evaluating:

100% | ████████████████████████████████████ | 1/1
[00:00<00:00, 2.28it/s]

Train Loss: 0.1661, Train Acc: 0.9350

Val Loss: 2.4690, Val Acc: 0.6250, Val AUC: 0.9688

Epoch 4/15

Training: 100% | ████████████████████████████████████ | 163/163 [00:31<00:00, 5.13it/s, loss=0.155]

Evaluating:

100% | ████████████████████████████████████ | 1/1
[00:00<00:00, 2.38it/s]

Train Loss: 0.1699, Train Acc: 0.9340

Val Loss: 2.2253, Val Acc: 0.5625, Val AUC: 0.9688

Epoch 5/15

Training: 100% | ████████████████████████████████████ | 163/163 [00:30<00:00, 5.33it/s, loss=0.221]

Evaluating:

100% | ████████████████████████████████████ | 1/1
[00:00<00:00, 2.34it/s]

Train Loss: 0.1598, Train Acc: 0.9394

Val Loss: 2.2037, Val Acc: 0.5625, Val AUC: 0.9688

Epoch 6/15

Training: 100% | ████████████████████████████████████ | 163/163 [00:31<00:00, 5.23it/s, loss=0.148]

Evaluating:

100%|██████████| 1/1

[00:00<00:00, 2.35it/s]

Train Loss: 0.1460, Train Acc: 0.9398

Val Loss: 2.3404, Val Acc: 0.5625, Val AUC: 0.9688

Epoch 7/15

Training: 100%|██████████| 163/163 [00:30<00:00,
5.30it/s, loss=0.0874]

Evaluating:

100%|██████████| 1/1

[00:00<00:00, 2.32it/s]

Train Loss: 0.1345, Train Acc: 0.9484

Val Loss: 2.5943, Val Acc: 0.5625, Val AUC: 0.9688

Epoch 8/15

Training: 100%|██████████| 163/163 [00:30<00:00,
5.40it/s, loss=0.177]

Evaluating:

100%|██████████| 1/1

[00:00<00:00, 2.39it/s]

Train Loss: 0.1332, Train Acc: 0.9523

Val Loss: 2.3083, Val Acc: 0.6250, Val AUC: 0.9688

Epoch 9/15

Training: 100%|██████████| 163/163 [00:30<00:00,
5.33it/s, loss=0.0917]

Evaluating:

100%|██████████| 1/1

[00:00<00:00, 2.39it/s]

Train Loss: 0.1260, Train Acc: 0.9515

Val Loss: 2.1330, Val Acc: 0.6250, Val AUC: 0.9531

Epoch 10/15

Training: 100%|██████████| 163/163 [00:30<00:00,
5.33it/s, loss=0.0519]

Evaluating:

100%|██████████| 1/1

[00:00<00:00, 2.37it/s]

Train Loss: 0.1167, Train Acc: 0.9584
Val Loss: 2.2643, Val Acc: 0.5625, Val AUC: 0.9688

Epoch 11/15

Training: 100%|██████████| 163/163 [00:30<00:00,
5.32it/s, loss=0.0572]
Evaluating:
100%|██████████| 1/1
[00:00<00:00, 2.37it/s]

Train Loss: 0.1164, Train Acc: 0.9551
Val Loss: 2.3268, Val Acc: 0.5625, Val AUC: 0.9531

Epoch 12/15

Training: 100%|██████████| 163/163 [00:30<00:00,
5.33it/s, loss=0.216]
Evaluating:
100%|██████████| 1/1
[00:00<00:00, 2.29it/s]

Train Loss: 0.1073, Train Acc: 0.9599
Val Loss: 2.1736, Val Acc: 0.5625, Val AUC: 0.9375

Epoch 13/15

Training: 100%|██████████| 163/163
[00:30<00:00, 5.32it/s, loss=0.4]
Evaluating:
100%|██████████| 1/1
[00:00<00:00, 2.38it/s]

Train Loss: 0.1050, Train Acc: 0.9628
Val Loss: 2.3306, Val Acc: 0.6250, Val AUC: 0.9688

Epoch 14/15

Training: 100%|██████████| 163/163 [00:31<00:00,
5.22it/s, loss=0.0575]
Evaluating:
100%|██████████| 1/1
[00:00<00:00, 2.26it/s]

Train Loss: 0.1014, Train Acc: 0.9615
Val Loss: 2.3581, Val Acc: 0.6250, Val AUC: 0.9688
Early stopping triggered at epoch 14

Best Validation AUC: 0.9688

Stage 1 model saved to models/densenet121_stage1.pth

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STAGE 3: Progressive Unfreezing - Stage 2

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Unfrozen last 50 layers

Trainable parameters: 1,740,034

Training stage: stage_2

Epochs: 15, Learning rate: 1e-05

Epoch 1/15

Training: 100%|██████████| 163/163 [00:29<00:00,
5.56it/s, loss=0.0844]

Evaluating:

100%|██████████| 1/1
[00:00<00:00, 2.44it/s]

Train Loss: 0.0912, Train Acc: 0.9653

Val Loss: 2.2020, Val Acc: 0.6250, Val AUC: 0.9688

Epoch 2/15

Training: 100%|██████████| 163/163 [00:29<00:00,
5.56it/s, loss=0.0761]

Evaluating:

100%|██████████| 1/1
[00:00<00:00, 2.46it/s]

Train Loss: 0.0922, Train Acc: 0.9678

Val Loss: 2.2629, Val Acc: 0.5625, Val AUC: 0.9688

Epoch 3/15

Training: 100%|██████████| 163/163 [00:29<00:00,
5.59it/s, loss=0.00834]

Evaluating:

100%|██████████| 1/1
[00:00<00:00, 2.44it/s]

Train Loss: 0.1059, Train Acc: 0.9636
Val Loss: 2.1903, Val Acc: 0.6250, Val AUC: 0.9531

Epoch 4/15

Training: 100%|██████████| 163/163 [00:29<00:00,
5.61it/s, loss=0.138]

Evaluating:

100%|██████████| 1/1
[00:00<00:00, 2.44it/s]

Train Loss: 0.0934, Train Acc: 0.9653

Val Loss: 2.2168, Val Acc: 0.5625, Val AUC: 0.9531

Epoch 5/15

Training: 100%|██████████| 163/163 [00:28<00:00,
5.63it/s, loss=0.0849]

Evaluating:

100%|██████████| 1/1
[00:00<00:00, 2.45it/s]

Train Loss: 0.1039, Train Acc: 0.9649

Val Loss: 2.1461, Val Acc: 0.5625, Val AUC: 0.9688

Epoch 6/15

Training: 100%|██████████| 163/163 [00:28<00:00,
5.63it/s, loss=0.0454]

Evaluating:

100%|██████████| 1/1
[00:00<00:00, 2.43it/s]

Train Loss: 0.0931, Train Acc: 0.9670

Val Loss: 2.4156, Val Acc: 0.5625, Val AUC: 0.9688

Epoch 7/15

Training: 100%|██████████| 163/163 [00:29<00:00,
5.54it/s, loss=0.0911]

Evaluating:

100%|██████████| 1/1
[00:00<00:00, 2.44it/s]

Train Loss: 0.0904, Train Acc: 0.9689

Val Loss: 2.2264, Val Acc: 0.5625, Val AUC: 0.9531

Epoch 8/15

Training: 100%|██████████| 163/163 [00:29<00:00,
5.58it/s, loss=0.0283]

Evaluating:

100%|██████████| 1/1
[00:00<00:00, 2.44it/s]

Train Loss: 0.0811, Train Acc: 0.9686

Val Loss: 2.2792, Val Acc: 0.5625, Val AUC: 0.9688

Epoch 9/15

Training: 100%|██████████| 163/163 [00:29<00:00,
5.59it/s, loss=0.0308]

Evaluating:

100%|██████████| 1/1
[00:00<00:00, 2.41it/s]

Train Loss: 0.0876, Train Acc: 0.9688

Val Loss: 2.1008, Val Acc: 0.5625, Val AUC: 0.9531

Epoch 10/15

Training: 100%|██████████| 163/163 [00:29<00:00,
5.55it/s, loss=0.0955]

Evaluating:

100%|██████████| 1/1
[00:00<00:00, 2.45it/s]

Train Loss: 0.0843, Train Acc: 0.9672

Val Loss: 2.2950, Val Acc: 0.5625, Val AUC: 0.9688

Epoch 11/15

Training: 100%|██████████| 163/163 [00:28<00:00,
5.63it/s, loss=0.0625]

Evaluating:

100%|██████████| 1/1
[00:00<00:00, 2.45it/s]

Train Loss: 0.0862, Train Acc: 0.9718

Val Loss: 2.2309, Val Acc: 0.5625, Val AUC: 0.9531

Epoch 12/15

Training: 100%|██████████| 163/163 [00:30<00:00,
5.40it/s, loss=0.0459]

Evaluating:

100%|██████████| 1/1
[00:00<00:00, 2.39it/s]

Train Loss: 0.0836, Train Acc: 0.9686

Val Loss: 2.1856, Val Acc: 0.5625, Val AUC: 0.9688

Epoch 13/15

Training: 100%|██████████| 163/163 [00:30<00:00,
5.33it/s, loss=0.0686]

Evaluating:

100%|██████████| 1/1
[00:00<00:00, 2.40it/s]

Train Loss: 0.0770, Train Acc: 0.9737

Val Loss: 2.2560, Val Acc: 0.5625, Val AUC: 0.9688

Epoch 14/15

Training: 100%|██████████| 163/163 [00:30<00:00,
5.28it/s, loss=0.0683]

Evaluating:

100%|██████████| 1/1
[00:00<00:00, 2.39it/s]

Train Loss: 0.0783, Train Acc: 0.9718

Val Loss: 2.5098, Val Acc: 0.5625, Val AUC: 0.9688

Early stopping triggered at epoch 14

Best Validation AUC: 0.9688

Final model saved to models/densenet121_final.pth

FINAL EVALUATION ON TEST SET

Evaluating: 100%|██████████|
20/20 [00:04<00:00, 4.98it/s]

Test Metrics:

loss: 1.1631

accuracy: 0.6891
auc: 0.9505
f1_score: 0.8008
precision: 0.6678
recall: 1.0000
sensitivity: 1.0000
specificity: 0.1709

Results saved to results/densenet121_test_results.txt

Training completed successfully!