MedMNIST-EdgeAI — Phase-1 (HAM10000)

Generated: 2025-10-20 16:55:28

Repository root: D:\MedMNIST-EdgeAIv2

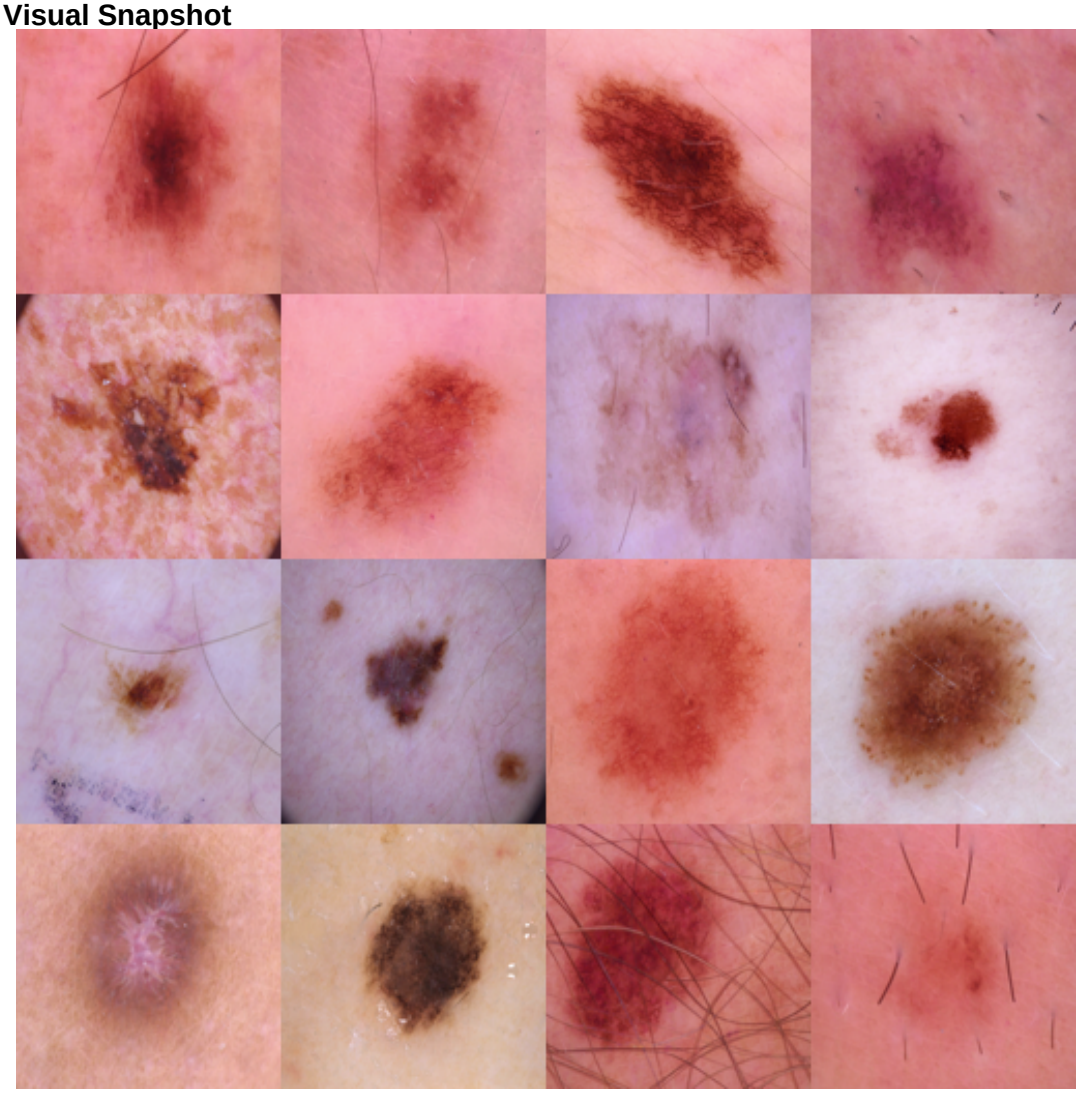
This report consolidates teacher/student performance, calibration, operating points, robustness under corruptions, and efficiency (latency/memory). TensorBoard curves/images, dataset montage, and supplementary documents are embedded.

1. Teacher & Student Roles

Teacher: high-capacity ResNet-50 trained on HAM10000 at native resolution; provides soft targets for knowledge distillation.

Students: ResNet-18, MobileNetV2, EfficientNet-B0 distilled with KD (T, α) and optional Attention Transfer (λ), evaluated over multiple seeds.

Dataset Visual Snapshot



2. Performance (Test-set with CI)

Teacher summary:

model	accuracy_mean	accuracy_lo	accuracy_hi	macro_f1_mean	macro_f1_lo	macro_f1_hi
runs_ham10000_resnet50	0.893	0.8796804792810784	0.9071392910634049	0.834	0.8041329541329876	0.8605454187329692

Students summary:

model	accuracy_mean	accuracy_lo	accuracy_hi	macro_f1_mean	macro_f1_lo	macro_f1_hi
distilled_efficientnetb0_ham10000	0.81	0.7929016966067864	0.8273453093812375	0.656	0.6143198532359181	0.6924848902971202
distilled_mobilenetv2_ham10000	0.784	0.7659680638722555	0.8023952095808383	0.541	0.5098655666558318	0.5691133356818394
distilled_resnet18_ham10000	0.852	0.8363273453093812	0.8672779441117764	0.755	0.7153264067221303	0.7866347696005519

Best student by macro_f1_mean: **distilled_resnet18_ham10000** = 0.755.

3. Calibration & Operating Points

Calibration metrics:

model	seed	accuracy	nll	brier	ece_uniform	ece_adaptive
distilled_efficientnetb0_ham10000	seed_0	0.810379241516966	381.732	0.379	0.1894070034969352	0.189
distilled_mobilenetv2_ham10000	seed_0	0.7839321357285429	484.922	0.432	0.2160592079162597	0.216
distilled_resnet18_ham10000	seed_0	0.8517964071856288	312.122	0.296	0.1481770277023315	0.148

Operating points (per model/seed):

model	seed	tau	macro_f1_opt
distilled_efficientnetb0_ham10000	seed_0	0.0	0.656
distilled_mobilenetv2_ham10000	seed_0	0.0	0.541
distilled_resnet18_ham10000	seed_0	0.0	0.755

4. Robustness under Corruptions

Macro-F1 across corruption levels:

acc	macro_f1	tag	model	seed
0.810379241516966	0.656	gaussian_0.1	distilled_efficientnetb0_ham10000	seed_0
0.810379241516966	0.656	gaussian_0.2	distilled_efficientnetb0_ham10000	seed_0
0.811377245508982	0.658	gaussian_0.3	distilled_efficientnetb0_ham10000	seed_0
0.8158682634730539	0.663	jpeg_90	distilled_efficientnetb0_ham10000	seed_0
0.8133732534930139	0.654	jpeg_70	distilled_efficientnetb0_ham10000	seed_0
0.8158682634730539	0.659	jpeg_50	distilled_efficientnetb0_ham10000	seed_0
0.779441117764471	0.584	contrast_0.8	distilled_efficientnetb0_ham10000	seed_0
0.659181636726547	0.345	contrast_0.6	distilled_efficientnetb0_ham10000	seed_0
0.7839321357285429	0.541	gaussian_0.1	distilled_mobilenetv2_ham10000	seed_0
0.7829341317365269	0.54	gaussian_0.2	distilled_mobilenetv2_ham10000	seed_0
0.7819361277445109	0.536	gaussian_0.3	distilled_mobilenetv2_ham10000	seed_0
0.7869261477045908	0.545	jpeg_90	distilled_mobilenetv2_ham10000	seed_0
0.782435129740519	0.536	jpeg_70	distilled_mobilenetv2_ham10000	seed_0
0.7849301397205589	0.543	jpeg_50	distilled_mobilenetv2_ham10000	seed_0
0.7604790419161677	0.483	contrast_0.8	distilled_mobilenetv2_ham10000	seed_0
0.6402195608782435	0.27	contrast_0.6	distilled_mobilenetv2_ham10000	seed_0
0.8517964071856288	0.755	gaussian_0.1	distilled_resnet18_ham10000	seed_0
0.8517964071856288	0.755	gaussian_0.2	distilled_resnet18_ham10000	seed_0
0.8512974051896207	0.754	gaussian_0.3	distilled_resnet18_ham10000	seed_0
0.8552894211576846	0.758	jpeg_90	distilled_resnet18_ham10000	seed_0
0.8527944111776448	0.747	jpeg_70	distilled_resnet18_ham10000	seed_0
0.8507984031936128	0.746	jpeg_50	distilled_resnet18_ham10000	seed_0
0.81187624750499	0.663	contrast_0.8	distilled_resnet18_ham10000	seed_0
0.719560878243513	0.451	contrast_0.6	distilled_resnet18_ham10000	seed_0

5. Efficiency (Latency & Memory)

GPU latency (aggregated):

ckpt	model	seed	device	batch	imgsz	lat_ms_mean	lat_ms_std	lat_ms_p50	lat_ms_p90	lat_ms_p99	throughput_fps
D:\MedMNIST-EdgeAIv2\models\students\distilled_efficientnet…	distilled_efficientnetb0_ham10000	seed_0	cuda	1	224	4.8	0.148	4.8	5.010360019514337	5.195631969836541	206.92272391257524
D:\MedMNIST-EdgeAIv2\models\students\distilled_mobilenetv2_…	distilled_mobilenetv2_ham10000	seed_0	cuda	1	224	3.3	0.061	3.3	3.3566700061783195	3.40099205088336	305.15249995875126
D:\MedMNIST-EdgeAIv2\models\students\distilled_resnet18_ham…	distilled_resnet18_ham10000	seed_0	cuda	1	224	2.3	0.181	2.2	2.575390046695248	2.590343989431858	443.29444004730254

CPU latency (aggregated):

ckpt	model	seed	device	batch	imgsz	lat_ms_mean	lat_ms_std	lat_ms_p50	lat_ms_p90	lat_ms_p99	throughput_fps
D:\MedMNIST-EdgeAIv2\models\students\distilled_efficientnet…	distilled_efficientnetb0_ham10000	seed_0	cpu	1	224	34.9	0.953	34.8	35.690340033303386	38.579854981508106	28.628836750156
D:\MedMNIST-EdgeAIv2\models\students\distilled_mobilenetv2_…	distilled_mobilenetv2_ham10000	seed_0	cpu	1	224	24.1	1.203	23.8	25.950140002872631	26.736927000045649	41.40883027376206
D:\MedMNIST-EdgeAIv2\models\students\distilled_resnet18_ham…	distilled_resnet18_ham10000	seed_0	cpu	1	224	23.0	0.307	23.0	23.322999995434657	24.186682010185898	43.39109758824055

Model memory footprint:

ckpt	model	seed	params_bytes	params_mib	peak_cuda_bytes	peak_cuda_mib	imgsz	batch
D:\MedMNIST-EdgeAIv2\models\students\distilled_efficientnet…	distilled_efficientnetb0_ham10000	seed_0	16234516	15.5	26550272	25.3	224	1
D:\MedMNIST-EdgeAIv2\models\students\distilled_mobilenetv2_…	distilled_mobilenetv2_ham10000	seed_0	9068220	8.6	19385344	18.5	224	1
D:\MedMNIST-EdgeAIv2\models\students\distilled_resnet18_ham…	distilled_resnet18_ham10000	seed_0	44758972	42.7	55447552	52.9	224	1

6. Pareto (Accuracy vs Latency)

model	score	latency_ms	params_mib	peak_cuda_mib
distilled_resnet18_ham10000	0.755	2.2	42.7	52.9
distilled_mobilenetv2_ham10000	0.541	3.3	8.6	18.5
distilled_efficientnetb0_ham10000	0.656	4.8	15.5	25.3

See appended figure: Acc-vs-Latency bubble plot.

7. TensorBoard Curves & Images

No TensorBoard event assets found or TensorBoard parser unavailable.

8. Supplementary Notes from DOCX

- ResNet50vsResNet18 Beta-1000.docx

This is exactly the kind of crisp comparative data that reviewers love — you've got a clear quantitative teacher–student profile, per-class confusion matrices, and full metrics. Let's analyze it like a researcher. ■ Macro-level summary That's roughly 84–90% retention of the teacher's performance with ~55% fewer parameters and significantly lower inference cost — a good KD outcome on HAM10000, where minority classes dominate macro-F1 sensitivity. ■ Per-class analysis Interpretation: The student model faithfully inherited teacher knowledge for major and well-separated classes (5, 6), but compressed representation hurts fine-grained or underrepresented lesions (0, 2, 3, 4). That's expected: ResNet18 has limited mid-level capacity, so Attention Transfer can't fully align the deeper discriminative filters of the ResNet50. ■ Confusion Matrix insights Comparing your raw CMs: The teacher's CM shows tighter diagonals and smaller
off-class bleed. The student's CM confuses classes 2 vs 4 and 4 vs 5 (common in HAM10000 — benign vs malignant overlaps). Class 3 ("VASC" in HAM10000 taxonomy) is underrepresented and poorly separated, both models struggle but the
teacher still manages better recall. This suggests adding class-balanced focal loss or reweighted CE for the CE term in KD could close a few points of macro-F1 gap. ■ Diagnostic takeaways Distillation effectiveness: KD + AT clearly transferred high-level structure (class 5, 6 stability). Missing low-level lesion texture adaptation (classes 0, 2, 4) indicates the AT weight β could be increased or multi-layer weighting introduced. Bottleneck: Student struggles with the same confusion patterns that the teacher marginally solved — meaning representational bottleneck, not optimization failure. Next experimental knobs: Increase beta from 1000 $\rightarrow$ 2000 to amplify AT influence. Use alpha=0.4 (more KD emphasis) with T=4. Optional: add label smoothing 0.1 or focal loss (γ=1.5) for the CE term. Fine-tune 10 epochs starting from the best checkpoint with a 10× smaller LR (2e-5). ■ Quantitative comparison snippet for your paper / report The teacher (ResNet50) achieved 89.3% validation accuracy and 0.834 macro-F1 on HAM10000. The student (ResNet18)
distilled via Knowledge Distillation (α = 0.5, T = 4.0) and Attention Transfer (β = 1000) attained 82.3% validation accuracy and 0.697 macro-F1. Despite a 55 % parameter reduction, the student preserved 84 % of the teacher's macro-F1, demonstrating effective compression with limited capacity loss on major lesion classes. ■ Recommended next move If you want a publication-ready comparative visualization and export: Generate a bar chart of per-class F1 (Teacher vs Student). Compute relative gap (ΔF1 / F1_teacher) for each class. Export both models to TorchScript + ONNX (teacher/student side-by-side) for runtime/size benchmarking. Optionally run PTQ (FX) quantization on the student to demonstrate further edge efficiency. Would you like me to generate the comparison report script that automatically builds: a CSV of per-class Teacher vs Student metrics, ΔF1 and ΔRecall, and a Matplotlib bar chart visualization? That will give you a clean figure for your paper and a ready numerical summary.

- Student Models Table.docx

Quick interpretation (trade-offs) ResNet18 — best accuracy (82.3%) and fastest inference by a comfortable margin (2.2 ms). Heavy-ish params and traced size, highest peak memory. Good if you can afford ~44MB model file and ~62MB GPU memory
for models + activations. MobileNetV2 — smallest artifact (≈9 MB traced), lowest memory footprint (~28 MB), slightly slower (~4.0 ms) than ResNet18 here (implementation/kernel differences make MobileNet slower on desktop GPU sometimes).
Best candidate if you need small on-disk size and low memory. EfficientNet-B0 — middle ground in params/size and best MACs-to-accuracy ratio for some classes — but slowest (~5.6 ms) in your runs. Good compromise if you want reduced params
vs ResNet18 with similar accuracy trend. Important: on small GPUs / edge devices, params and MACs do not always equal

lower latency — kernel shapes, depthwise convs, and memory/launch overhead matter. Here ResNet18 ended up fastest on the

RTX 3050.