Experiment: UNSW-NB15 dataset performance

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import os, random, math
import numpy as np, pandas as pd
import torch
import torch.nn as nn
import torch.nn.functional as F
from sklearn.impute import SimpleImputer
from sklearn.preprocessing import OneHotEncoder, StandardScaler
from sklearn.metrics import accuracy_score, f1_score, roc_auc_score
from torch.utils.data import DataLoader, TensorDataset

# ── hyperparameters ──────────────────────────────────────────────
DATA_DIR     = "./data"
K            = 5
ROUNDS       = 100
DIRICHLET_A  = 0.5
WARMUP_FR    = 0.05
BASE_LR      = 1e-3
LAM0         = 1e-2       # initial entropy penalty
LOCAL_EPOCHS = 1
BATCH_SIZE   = 64
SEEDS        = list(range(1, 51))   # 50 runs: seeds 1–50

device = torch.device("cuda" if torch.cuda.is_available() else "cpu")

# ── MLP definition ──────────────────────────────────────────────
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class MLP(nn.Module):
    def __init__(self, in_dim, hidden=64, num_classes=2):
        super().__init__()
        self.net = nn.Sequential(
            nn.Linear(in_dim, hidden), nn.ReLU(),
            nn.Linear(hidden, hidden), nn.ReLU(),
            nn.Linear(hidden, num_classes),
        )
    def forward(self, x): return self.net(x)

# —— load & preprocess UNSW-NB15 ——————————————————————————
def load_unsw():
    tr = pd.read_csv(os.path.join(DATA_DIR, "UNSW_NB15_training-set.csv"))
    te = pd.read_csv(os.path.join(DATA_DIR, "UNSW_NB15_testing-set.csv"))

    num_cols = tr.select_dtypes(include="number").columns.drop(["id","label"])
    cat_cols = [c for c in tr.columns if tr[c].dtype=="object" and c!="attack_cat"]

    impN = SimpleImputer(strategy="median")
    impC = SimpleImputer(strategy="most_frequent")
    tr[num_cols], te[num_cols] = impN.fit_transform(tr[num_cols]),
impN.transform(te[num_cols])
    tr[cat_cols], te[cat_cols] = impC.fit_transform(tr[cat_cols]), impC.transform(te[cat_cols])

    # ← fix: use sparse_output instead of deprecated sparse
    enc = OneHotEncoder(sparse_output=False, handle_unknown="ignore")
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    trC, teC = enc.fit_transform(tr[cat_cols]), enc.transform(te[cat_cols])
    scl = StandardScaler()
    trN, teN = scl.fit_transform(tr[num_cols]), scl.transform(te[num_cols])

    Xtr = np.hstack([trN, trC]).astype(np.float32)
    Xte = np.hstack([teN, teC]).astype(np.float32)
    ytr = tr.label.values.astype(int)
    yte = te.label.values.astype(int)
    return Xtr, ytr, Xte, yte

Xtr, ytr, Xte, yte = load_unsw()
IN_DIM, NUM_CLASSES = Xtr.shape[1], len(np.unique(ytr))

# —— entropy gradient helper ————————————————————————
def entropy_grad(model, w0):
    with torch.no_grad():
        delta = torch.cat([
            (p.data - w0i).abs().flatten()
            for p, w0i in zip(model.parameters(), w0)
        ])
        Z = delta.sum().clamp_min(1e-12)
        p_j = delta / Z
        hbar = (p_j * p_j.log()).sum()

        grads, idx = [], 0
        for p, w0i in zip(model.parameters(), w0):
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            n = p.numel()
            pj = p_j[idx:idx+n].view_as(p)
            gH = ((hbar - pj.log())/Z) * (p.data - w0i).sign()
            grads.append(gH.clone())
            idx += n
    return grads

# —— local training with entropy regularization ——————————
def local_train(w0, indices, lam, lr, epochs, scheduler=None):
    m = MLP(IN_DIM, num_classes=NUM_CLASSES).to(device)
    for p, w0i in zip(m.parameters(), w0):
        p.data.copy_(w0i)
    opt = torch.optim.Adam(m.parameters(), lr=lr)
    sched = scheduler(opt) if scheduler else None

    ds     = TensorDataset(torch.from_numpy(Xtr[indices]), torch.from_numpy(ytr[indices]))
    loader = DataLoader(ds, batch_size=BATCH_SIZE, shuffle=True)

    for _ in range(epochs):
        gH = entropy_grad(m, w0)
        for xb, yb in loader:
            xb, yb = xb.to(device), yb.to(device)
            opt.zero_grad()
            out  = m(xb)
            loss = F.cross_entropy(out, yb)
            for p, gh in zip(m.parameters(), gH):
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            if p.grad is not None:
                p.grad.data += lam * gh.to(device)
        loss.backward()
        torch.nn.utils.clip_grad_norm_(m.parameters(), 1.0)
        opt.step()
        if sched: sched.step()

    return [p.data - w0i for p, w0i in zip(m.parameters(), w0)]

# —— one ERFO run, returns arrays ————————————————————————
def run_erfo(seed):
    random.seed(seed); np.random.seed(seed)
    torch.manual_seed(seed); torch.cuda.manual_seed_all(seed)
    torch.backends.cudnn.deterministic = True
    torch.backends.cudnn.benchmark     = False

    # 1) IID warm-up
    n_warm = int(WARMUP_FR * len(Xtr))
    idx0   = np.random.choice(len(Xtr), n_warm, replace=False)
    warm   = MLP(IN_DIM, num_classes=NUM_CLASSES).to(device)
    opt0   = torch.optim.Adam(warm.parameters(), lr=BASE_LR)
    loader0= DataLoader(TensorDataset(torch.from_numpy(Xtr[idx0]),
torch.from_numpy(ytr[idx0])),
                        batch_size=128, shuffle=True)
    warm.train()
    for xb, yb in loader0:
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    xb, yb = xb.to(device), yb.to(device)
    opt0.zero_grad()
    F.cross_entropy(warm(xb), yb).backward()
    opt0.step()
global_w = [p.data.clone() for p in warm.parameters()]

# 2) Dirichlet split
clients = {i: [] for i in range(K)}
for c in np.unique(ytr):
    idxs  = np.where(ytr==c)[0]
    props = np.random.dirichlet([DIRICHLET_A]*K)
    cuts  = (np.cumsum(props)*len(idxs)).astype(int)
    s = 0
    for i, e in enumerate(cuts):
        clients[i].extend(idxs[s:e].tolist()); s = e

accs = np.zeros(ROUNDS)
f1s  = np.zeros(ROUNDS)
aucs = np.zeros(ROUNDS)

# 3) federated rounds
for r in range(ROUNDS):
    lam_t = LAM0 * (1 - r/ROUNDS)
    deltas, sizes = [], []

    for cid in range(K):
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        d = local_train(global_w, clients[cid], lam_t, BASE_LR, LOCAL_EPOCHS,
                        scheduler=lambda opt: torch.optim.lr_scheduler.LambdaLR(
                            opt, lambda step: (step+1)/10 if step<10 else 1.0))
        deltas.append(d)
        sizes.append(len(clients[cid]))

    total = sum(sizes)
    with torch.no_grad():
        for p, *dlist in zip(global_w, *deltas):
            update = sum(sz*di for sz, di in zip(sizes, dlist)) / total
            p.data += update

    # evaluate
    eval_m = MLP(IN_DIM, num_classes=NUM_CLASSES).to(device).eval()
    with torch.no_grad():
        for p, w in zip(eval_m.parameters(), global_w):
            p.data.copy_(w)
        out_logits = eval_m(torch.from_numpy(Xte).to(device))
        probs      = F.softmax(out_logits, dim=1).cpu().numpy()
        preds      = probs.argmax(axis=1)

    accs[r] = accuracy_score(yte, preds)*100
    f1s[r]  = f1_score(yte, preds, average="macro")
    aucs[r] = roc_auc_score(yte, probs[:,1])

return accs, f1s, aucs
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# ── run all seeds and collect ──────────────────────────────────────
n_runs = len(SEEDS)
all_acc = np.zeros((n_runs, ROUNDS))
all_f1  = np.zeros((n_runs, ROUNDS))
all_auc = np.zeros((n_runs, ROUNDS))

for i, sd in enumerate(SEEDS):
    a, f, u = run_erfo(sd)
    all_acc[i], all_f1[i], all_auc[i] = a, f, u

# ── print mean ± std (95% CI) per round ────────────────────────────
for r in range(ROUNDS):
    mu_acc, sd_acc = all_acc[:,r].mean(), all_acc[:,r].std(ddof=1)
    ci_acc = 1.96 * sd_acc / math.sqrt(n_runs)
    mu_f1,  sd_f1  = all_f1[:,r].mean(),  all_f1[:,r].std(ddof=1)
    ci_f1  = 1.96 * sd_f1  / math.sqrt(n_runs)
    mu_auc, sd_auc = all_auc[:,r].mean(), all_auc[:,r].std(ddof=1)
    ci_auc = 1.96 * sd_auc / math.sqrt(n_runs)

    print(
        f"Round {r+1:3d} → "
        f"Acc={mu_acc:6.2f}% ±{sd_acc:5.2f}% (95% CI ±{ci_acc:4.2f})   "
        f"Macro-F1={mu_f1:5.3f} ±{sd_f1:5.3f} (95% CI ±{ci_f1:5.3f})   "
        f"ROC-AUC={mu_auc:5.3f} ±{sd_auc:5.3f} (95% CI ±{ci_auc:5.3f})"
    )
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Experiment 1 Results

Round 1 → Acc= 75.90% ± 3.06% (95% CI ±0.85) Macro-F1=0.726 ±0.046 (95% CI ±0.013) ROC-AUC=0.920 ±0.021 (95% CI ±0.006)

Round 2 → Acc= 76.05% ± 3.57% (95% CI ±0.99) Macro-F1=0.728 ±0.054 (95% CI ±0.015) ROC-AUC=0.926 ±0.024 (95% CI ±0.007)

Round 3 → Acc= 76.22% ± 3.64% (95% CI ±1.01) Macro-F1=0.730 ±0.054 (95% CI ±0.015) ROC-AUC=0.926 ±0.028 (95% CI ±0.008)

Round 4 → Acc= 76.56% ± 3.58% (95% CI ±0.99) Macro-F1=0.734 ±0.053 (95% CI ±0.015) ROC-AUC=0.928 ±0.027 (95% CI ±0.008)

Round 5 → Acc= 76.78% ± 3.28% (95% CI ±0.91) Macro-F1=0.738 ±0.047 (95% CI ±0.013) ROC-AUC=0.929 ±0.029 (95% CI ±0.008)

Round 6 → Acc= 77.08% ± 3.28% (95% CI ±0.91) Macro-F1=0.742 ±0.046 (95% CI ±0.013) ROC-AUC=0.930 ±0.029 (95% CI ±0.008)

Round 7 → Acc= 77.27% ± 3.10% (95% CI ±0.86) Macro-F1=0.745 ±0.043 (95% CI ±0.012) ROC-AUC=0.931 ±0.027 (95% CI ±0.007)

Round 8 → Acc= 77.40% ± 3.05% (95% CI ±0.85) Macro-F1=0.746 ±0.042 (95% CI ±0.012) ROC-AUC=0.932 ±0.027 (95% CI ±0.008)

Round 9 → Acc= 77.55% ± 2.97% (95% CI ±0.82) Macro-F1=0.748 ±0.041 (95% CI ±0.011) ROC-AUC=0.933 ±0.026 (95% CI ±0.007)

Round 10 → Acc= 77.78% ± 2.98% (95% CI ±0.83) Macro-F1=0.751 ±0.041 (95% CI ±0.011) ROC-AUC=0.934 ±0.027 (95% CI ±0.007)

Round 11 → Acc= 77.77% ± 2.92% (95% CI ±0.81) Macro-F1=0.751 ±0.039 (95% CI ±0.011) ROC-AUC=0.935 ±0.026 (95% CI ±0.007)

Round 12 → Acc= 77.82% ± 2.91% (95% CI ±0.81) Macro-F1=0.752 ±0.039 (95% CI ±0.011) ROC-AUC=0.935 ±0.026 (95% CI ±0.007)

Round 13 → Acc= 77.99% ± 2.88% (95% CI ±0.80) Macro-F1=0.754 ±0.038 (95% CI ±0.011) ROC-AUC=0.935 ±0.027 (95% CI ±0.007)

Round 14 → Acc= 77.95% ± 2.72% (95% CI ±0.76) Macro-F1=0.754 ±0.036 (95% CI ±0.010) ROC-AUC=0.937 ±0.025 (95% CI ±0.007)

Round 15 → Acc= 78.02% ± 2.70% (95% CI ±0.75) Macro-F1=0.755 ±0.036 (95% CI ±0.010) ROC-AUC=0.937 ±0.026 (95% CI ±0.007)

Round 16 → Acc= 78.01% ± 2.88% (95% CI ±0.80) Macro-F1=0.754 ±0.038 (95% CI ±0.011) ROC-AUC=0.937 ±0.026 (95% CI ±0.007)

Round 17 → Acc= 78.11% ± 2.76% (95% CI ±0.76) Macro-F1=0.756 ±0.037 (95% CI ±0.010) ROC-AUC=0.938 ±0.025 (95% CI ±0.007)

Round 18 → Acc= 78.08% ± 2.80% (95% CI ±0.78) Macro-F1=0.756 ±0.037 (95% CI ±0.010) ROC-AUC=0.939 ±0.024 (95% CI ±0.007)

Round 19 → Acc= 78.31% ± 2.65% (95% CI ±0.73) Macro-F1=0.759 ±0.034 (95% CI ±0.010) ROC-AUC=0.940 ±0.023 (95% CI ±0.006)

Round 20 → Acc= 78.36% ± 2.56% (95% CI ±0.71) Macro-F1=0.759 ±0.033 (95% CI ±0.009) ROC-AUC=0.939 ±0.024 (95% CI ±0.007)

Round 21 → Acc= 78.43% ± 2.61% (95% CI ±0.72) Macro-F1=0.760 ±0.034 (95% CI ±0.009) ROC-AUC=0.940 ±0.023 (95% CI ±0.006)

Round 22 → Acc= 78.42% ± 2.56% (95% CI ±0.71) Macro-F1=0.760 ±0.033 (95% CI ±0.009) ROC-AUC=0.940 ±0.023 (95% CI ±0.007)

Round 23 → Acc= 78.39% ± 2.48% (95% CI ±0.69) Macro-F1=0.760 ±0.032 (95% CI ±0.009) ROC-AUC=0.941 ±0.023 (95% CI ±0.006)

Round 24 → Acc= 78.45% ± 2.55% (95% CI ±0.71) Macro-F1=0.760 ±0.033 (95% CI ±0.009) ROC-AUC=0.941 ±0.022 (95% CI ±0.006)

Round 25 → Acc= 78.56% ± 2.50% (95% CI ±0.69) Macro-F1=0.762 ±0.032 (95% CI ±0.009) ROC-AUC=0.941 ±0.021 (95% CI ±0.006)

Round 26 → Acc= 78.67% ± 2.38% (95% CI ±0.66) Macro-F1=0.763 ±0.031 (95% CI ±0.008) ROC-AUC=0.942 ±0.021 (95% CI ±0.006)

Round 27 → Acc= 78.73% ± 2.50% (95% CI ±0.69) Macro-F1=0.764 ±0.032 (95% CI ±0.009) ROC-AUC=0.942 ±0.023 (95% CI ±0.006)

Round 28 → Acc= 78.72% ± 2.48% (95% CI ±0.69) Macro-F1=0.764 ±0.032 (95% CI ±0.009) ROC-AUC=0.942 ±0.023 (95% CI ±0.006)

Round 29 → Acc= 78.75% ± 2.49% (95% CI ±0.69) Macro-F1=0.764 ±0.032 (95% CI ±0.009) ROC-AUC=0.942 ±0.022 (95% CI ±0.006)

Round 30 → Acc= 78.85% ± 2.35% (95% CI ±0.65) Macro-F1=0.766 ±0.030 (95% CI ±0.008) ROC-AUC=0.943 ±0.022 (95% CI ±0.006)

Round 31 → Acc= 78.81% ± 2.38% (95% CI ±0.66) Macro-F1=0.765 ±0.031 (95% CI ±0.008) ROC-AUC=0.943 ±0.022 (95% CI ±0.006)

Round 32 → Acc= 78.89% ± 2.37% (95% CI ±0.66) Macro-F1=0.766 ±0.030 (95% CI ±0.008) ROC-AUC=0.943 ±0.022 (95% CI ±0.006)

Round 33 → Acc= 78.96% ± 2.47% (95% CI ±0.68) Macro-F1=0.767 ±0.032 (95% CI ±0.009) ROC-AUC=0.944 ±0.022 (95% CI ±0.006)

Round 34 → Acc= 79.14% ± 2.51% (95% CI ±0.70) Macro-F1=0.769 ±0.032 (95% CI ±0.009) ROC-AUC=0.944 ±0.021 (95% CI ±0.006)

Round 35 → Acc= 79.06% ± 2.41% (95% CI ±0.67) Macro-F1=0.768 ±0.031 (95% CI ±0.009) ROC-AUC=0.944 ±0.022 (95% CI ±0.006)

Round 36 → Acc= 79.07% ± 2.45% (95% CI ±0.68) Macro-F1=0.769 ±0.031 (95% CI ±0.009) ROC-AUC=0.944 ±0.022 (95% CI ±0.006)

Round 37 → Acc= 79.13% ± 2.33% (95% CI ±0.65) Macro-F1=0.769 ±0.030 (95% CI ±0.008) ROC-AUC=0.944 ±0.022 (95% CI ±0.006)

Round 38 → Acc= 79.21% ± 2.42% (95% CI ±0.67) Macro-F1=0.770 ±0.031 (95% CI ±0.009) ROC-AUC=0.945 ±0.021 (95% CI ±0.006)

Round 39 → Acc= 79.12% ± 2.50% (95% CI ±0.69) Macro-F1=0.769 ±0.032 (95% CI ±0.009) ROC-AUC=0.944 ±0.022 (95% CI ±0.006)

Round 40 → Acc= 79.26% ± 2.51% (95% CI ±0.70) Macro-F1=0.771 ±0.032 (95% CI ±0.009) ROC-AUC=0.944 ±0.022 (95% CI ±0.006)

Round 41 → Acc= 79.29% ± 2.44% (95% CI ±0.68) Macro-F1=0.771 ±0.031 (95% CI ±0.009) ROC-AUC=0.945 ±0.021 (95% CI ±0.006)

Round 42 → Acc= 79.47% ± 2.40% (95% CI ±0.66) Macro-F1=0.774 ±0.030 (95% CI ±0.008) ROC-AUC=0.945 ±0.022 (95% CI ±0.006)

Round 43 → Acc= 79.40% ± 2.48% (95% CI ±0.69) Macro-F1=0.773 ±0.031 (95% CI ±0.009) ROC-AUC=0.945 ±0.021 (95% CI ±0.006)

Round 44 → Acc= 79.44% ± 2.45% (95% CI ±0.68) Macro-F1=0.773 ±0.031 (95% CI ±0.009) ROC-AUC=0.945 ±0.022 (95% CI ±0.006)

Round 45 → Acc= 79.33% ± 2.50% (95% CI ±0.69) Macro-F1=0.772 ±0.032 (95% CI ±0.009) ROC-AUC=0.945 ±0.023 (95% CI ±0.006)

Round 46 → Acc= 79.52% ± 2.17% (95% CI ±0.60) Macro-F1=0.774 ±0.027 (95% CI ±0.008) ROC-AUC=0.946 ±0.021 (95% CI ±0.006)

Round 47 → Acc= 79.53% ± 2.41% (95% CI ±0.67) Macro-F1=0.774 ±0.030 (95% CI ±0.008) ROC-AUC=0.946 ±0.022 (95% CI ±0.006)

Round 48 → Acc= 79.55% ± 2.51% (95% CI ±0.70) Macro-F1=0.775 ±0.032 (95% CI ±0.009) ROC-AUC=0.945 ±0.022 (95% CI ±0.006)

Round 49 → Acc= 79.69% ± 2.46% (95% CI ±0.68) Macro-F1=0.776 ±0.031 (95% CI ±0.009) ROC-AUC=0.945 ±0.022 (95% CI ±0.006)

Round 50 → Acc= 79.57% ± 2.38% (95% CI ±0.66) Macro-F1=0.775 ±0.030 (95% CI ±0.008) ROC-AUC=0.946 ±0.022 (95% CI ±0.006)

Round 51 → Acc= 79.59% ± 2.52% (95% CI ±0.70) Macro-F1=0.775 ±0.032 (95% CI ±0.009) ROC-AUC=0.945 ±0.022 (95% CI ±0.006)

Round 52 → Acc= 79.64% ± 2.54% (95% CI ±0.70) Macro-F1=0.776 ±0.032 (95% CI ±0.009) ROC-AUC=0.946 ±0.022 (95% CI ±0.006)

Round 53 → Acc= 79.97% ± 2.45% (95% CI ±0.68) Macro-F1=0.780 ±0.031 (95% CI ±0.009) ROC-AUC=0.947 ±0.021 (95% CI ±0.006)

Round 54 → Acc= 79.80% ± 2.31% (95% CI ±0.64) Macro-F1=0.778 ±0.029 (95% CI ±0.008) ROC-AUC=0.946 ±0.021 (95% CI ±0.006)

Round 55 → Acc= 79.97% ± 2.35% (95% CI ±0.65) Macro-F1=0.780 ±0.029 (95% CI ±0.008) ROC-AUC=0.947 ±0.020 (95% CI ±0.006)

Round 56 → Acc= 79.88% ± 2.57% (95% CI ±0.71) Macro-F1=0.779 ±0.033 (95% CI ±0.009) ROC-AUC=0.945 ±0.023 (95% CI ±0.006)

Round 57 → Acc= 79.77% ± 2.47% (95% CI ±0.68) Macro-F1=0.777 ±0.031 (95% CI ±0.009) ROC-AUC=0.945 ±0.023 (95% CI ±0.006)

Round 58 → Acc= 79.87% ± 2.49% (95% CI ±0.69) Macro-F1=0.779 ±0.032 (95% CI ±0.009) ROC-AUC=0.946 ±0.023 (95% CI ±0.006)

Round 59 → Acc= 79.99% ± 2.34% (95% CI ±0.65) Macro-F1=0.780 ±0.029 (95% CI ±0.008) ROC-AUC=0.947 ±0.022 (95% CI ±0.006)

Round 60 → Acc= 79.84% ± 2.43% (95% CI ±0.67) Macro-F1=0.778 ±0.031 (95% CI ±0.008) ROC-AUC=0.946 ±0.023 (95% CI ±0.006)

Round 61 → Acc= 79.90% ± 2.38% (95% CI ±0.66) Macro-F1=0.779 ±0.030 (95% CI ±0.008) ROC-AUC=0.946 ±0.022 (95% CI ±0.006)

Round 62 → Acc= 79.88% ± 2.40% (95% CI ±0.67) Macro-F1=0.779 ±0.030 (95% CI ±0.008) ROC-AUC=0.946 ±0.022 (95% CI ±0.006)

Round 63 → Acc= 80.01% ± 2.31% (95% CI ±0.64) Macro-F1=0.781 ±0.029 (95% CI ±0.008) ROC-AUC=0.946 ±0.021 (95% CI ±0.006)

Round 64 → Acc= 79.87% ± 2.42% (95% CI ±0.67) Macro-F1=0.779 ±0.030 (95% CI ±0.008) ROC-AUC=0.946 ±0.022 (95% CI ±0.006)

Round 65 → Acc= 79.93% ± 2.48% (95% CI ±0.69) Macro-F1=0.779 ±0.031 (95% CI ±0.009) ROC-AUC=0.946 ±0.022 (95% CI ±0.006)

Round 66 → Acc= 79.94% ± 2.40% (95% CI ±0.67) Macro-F1=0.780 ±0.030 (95% CI ±0.008) ROC-AUC=0.946 ±0.022 (95% CI ±0.006)

Round 67 → Acc= 80.10% ± 2.23% (95% CI ±0.62) Macro-F1=0.782 ±0.028 (95% CI ±0.008) ROC-AUC=0.946 ±0.021 (95% CI ±0.006)

Round 68 → Acc= 80.05% ± 2.38% (95% CI ±0.66) Macro-F1=0.781 ±0.030 (95% CI ±0.008) ROC-AUC=0.946 ±0.022 (95% CI ±0.006)

Round 69 → Acc= 79.99% ± 2.29% (95% CI ±0.63) Macro-F1=0.780 ±0.029 (95% CI ±0.008) ROC-AUC=0.946 ±0.022 (95% CI ±0.006)

Round 70 → Acc= 79.93% ± 2.16% (95% CI ±0.60) Macro-F1=0.779 ±0.027 (95% CI ±0.008) ROC-AUC=0.946 ±0.022 (95% CI ±0.006)

Round 71 → Acc= 80.12% ± 2.30% (95% CI ±0.64) Macro-F1=0.782 ±0.029 (95% CI ±0.008) ROC-AUC=0.946 ±0.022 (95% CI ±0.006)

Round 72 → Acc= 80.14% ± 2.37% (95% CI ±0.66) Macro-F1=0.782 ±0.030 (95% CI ±0.008) ROC-AUC=0.946 ±0.022 (95% CI ±0.006)

Round 73 → Acc= 80.13% ± 2.12% (95% CI ±0.59) Macro-F1=0.782 ±0.027 (95% CI ±0.007) ROC-AUC=0.946 ±0.022 (95% CI ±0.006)

Round 74 → Acc= 80.16% ± 2.18% (95% CI ±0.60) Macro-F1=0.782 ±0.027 (95% CI ±0.008) ROC-AUC=0.946 ±0.021 (95% CI ±0.006)

Round 75 → Acc= 80.22% ± 2.18% (95% CI ±0.61) Macro-F1=0.783 ±0.027 (95% CI ±0.008) ROC-AUC=0.946 ±0.022 (95% CI ±0.006)

Round 76 → Acc= 80.09% ± 2.19% (95% CI ±0.61) Macro-F1=0.782 ±0.028 (95% CI ±0.008) ROC-AUC=0.945 ±0.022 (95% CI ±0.006)

Round 77 → Acc= 80.05% ± 2.39% (95% CI ±0.66) Macro-F1=0.781 ±0.030 (95% CI ±0.008) ROC-AUC=0.945 ±0.023 (95% CI ±0.006)

Round 78 → Acc= 80.06% ± 2.43% (95% CI ±0.67) Macro-F1=0.781 ±0.031 (95% CI ±0.009) ROC-AUC=0.945 ±0.023 (95% CI ±0.006)

Round 79 → Acc= 80.26% ± 2.19% (95% CI ±0.61) Macro-F1=0.784 ±0.028 (95% CI ±0.008) ROC-AUC=0.946 ±0.023 (95% CI ±0.006)

Round 80 → Acc= 80.34% ± 2.22% (95% CI ±0.62) Macro-F1=0.785 ±0.028 (95% CI ±0.008) ROC-AUC=0.946 ±0.022 (95% CI ±0.006)

Round 81 → Acc= 80.21% ± 2.33% (95% CI ±0.65) Macro-F1=0.783 ±0.029 (95% CI ±0.008) ROC-AUC=0.945 ±0.023 (95% CI ±0.006)

Round 82 → Acc= 80.04% ± 2.40% (95% CI ±0.67) Macro-F1=0.781 ±0.031 (95% CI ±0.009) ROC-AUC=0.943 ±0.026 (95% CI ±0.007)

Round 83 → Acc= 80.18% ± 2.37% (95% CI ±0.66) Macro-F1=0.783 ±0.030 (95% CI ±0.008) ROC-AUC=0.945 ±0.023 (95% CI ±0.006)

Round 84 → Acc= 80.22% ± 2.22% (95% CI ±0.61) Macro-F1=0.783 ±0.028 (95% CI ±0.008) ROC-AUC=0.944 ±0.023 (95% CI ±0.006)

Round 85 → Acc= 80.11% ± 2.63% (95% CI ±0.73) Macro-F1=0.782 ±0.033 (95% CI ±0.009) ROC-AUC=0.943 ±0.027 (95% CI ±0.008)

Round 86 → Acc= 80.26% ± 2.24% (95% CI ±0.62) Macro-F1=0.784 ±0.028 (95% CI ±0.008) ROC-AUC=0.944 ±0.024 (95% CI ±0.007)

Round 87 → Acc= 80.19% ± 2.19% (95% CI ±0.61) Macro-F1=0.783 ±0.027 (95% CI ±0.008) ROC-AUC=0.945 ±0.023 (95% CI ±0.006)

Round 88 → Acc= 80.22% ± 2.29% (95% CI ±0.63) Macro-F1=0.783 ±0.029 (95% CI ±0.008) ROC-AUC=0.944 ±0.023 (95% CI ±0.006)

Round 89 → Acc= 80.09% ± 2.46% (95% CI ±0.68) Macro-F1=0.781 ±0.031 (95% CI ±0.009) ROC-AUC=0.943 ±0.027 (95% CI ±0.007)

Round 90 → Acc= 80.23% ± 2.41% (95% CI ±0.67) Macro-F1=0.783 ±0.030 (95% CI ±0.008) ROC-AUC=0.944 ±0.024 (95% CI ±0.007)

Round 91 → Acc= 80.13% ± 2.27% (95% CI ±0.63)   Macro-F1=0.782 ±0.029 (95% CI ±0.008)
ROC-AUC=0.943 ±0.025 (95% CI ±0.007)

Round 92 → Acc= 80.22% ± 2.31% (95% CI ±0.64)   Macro-F1=0.783 ±0.029 (95% CI ±0.008)
ROC-AUC=0.944 ±0.025 (95% CI ±0.007)

Round 93 → Acc= 80.16% ± 2.21% (95% CI ±0.61)   Macro-F1=0.783 ±0.028 (95% CI ±0.008)
ROC-AUC=0.944 ±0.025 (95% CI ±0.007)

Round 94 → Acc= 80.34% ± 2.21% (95% CI ±0.61)   Macro-F1=0.785 ±0.028 (95% CI ±0.008)
ROC-AUC=0.944 ±0.025 (95% CI ±0.007)

Round 95 → Acc= 80.17% ± 2.20% (95% CI ±0.61)   Macro-F1=0.783 ±0.028 (95% CI ±0.008)
ROC-AUC=0.943 ±0.025 (95% CI ±0.007)

Round 96 → Acc= 80.20% ± 2.31% (95% CI ±0.64)   Macro-F1=0.783 ±0.029 (95% CI ±0.008)
ROC-AUC=0.943 ±0.025 (95% CI ±0.007)

Round 97 → Acc= 80.31% ± 2.14% (95% CI ±0.59)   Macro-F1=0.784 ±0.027 (95% CI ±0.007)
ROC-AUC=0.944 ±0.024 (95% CI ±0.007)

Round 98 → Acc= 80.37% ± 2.17% (95% CI ±0.60)   Macro-F1=0.785 ±0.027 (95% CI ±0.008)
ROC-AUC=0.944 ±0.023 (95% CI ±0.006)

Round 99 → Acc= 80.36% ± 2.07% (95% CI ±0.58)   Macro-F1=0.785 ±0.026 (95% CI ±0.007)
ROC-AUC=0.945 ±0.023 (95% CI ±0.006)

Round 100 → Acc= 80.41% ± 2.15% (95% CI ±0.60)   Macro-F1=0.786 ±0.027 (95% CI ±0.007)
ROC-AUC=0.945 ±0.023 (95% CI ±0.007)