

filmGuru

December 11, 2025

0.1 Data Overview

```
[1]: from pathlib import Path
import pandas as pd

CSV_PATH = Path("../labels.csv")

df = pd.read_csv(CSV_PATH)
print(df["film_type"].value_counts())
```

```
film_type
hp5          507
e100         240
portra160    239
5219         101
5207          72
800t          71
400tmax      70
portra800    70
portra400    65
delta400     61
velvia50     39
400tx         37
delta          36
delta100      35
phoenix200   33
delta3200     32
pan100        31
400           30
5222          29
100tmax       26
100           17
Name: count, dtype: int64
```

I plan to classify the photos bases on the famous film types and the one I uses most. So the final class is: - Ilford hp5 - Kodak E100 - Kodak Portra Seires - Other Colors - Other B&Ws

So each class has above 200 samples.

```
[2]: from sklearn.model_selection import train_test_split

LABEL = Path("../labels_film.csv")

def film_label(film_type):
    t = film_type.strip().lower()

    ## Ilford hp5
    if t == "hp5":
        return "hp5"

    ## Kodak E100
    elif t == "e100":
        return "e100"

    ## Kodak Portra Series
    elif t in ["portra160", "portra400", "portra800"]:
        return "portra"

    ## Other B&W films
    elif t in [
        "400tmax", "delta400", "400tx", "delta", "delta100", "delta3200", "pan100", "5222", "100tmax"
    ]:
        return "other_bw"

    ## Other Color films
    else:
        return "other_color"

df["film_label"] = df["film_type"].apply(film_label)

print("\nCounting film_label:")
print(df["film_label"].value_counts())

df.to_csv(LABEL, index=False)
print(f"\nSaved to: {LABEL.resolve()}"
```

```
Counting film_label:
film_label
hp5          507
portra       374
other_color   363
other_bw      357
e100         240
Name: count, dtype: int64
```

```
Saved to: /home/longwei/CS441/final/labels_film.csv
```

```
Splitted into train/test/val
```

```
[3]: df_train, df_temp = train_test_split(  
      df,  
      test_size=0.30,  
      stratify=df["film_label"],  
      )  
  
df_val, df_test = train_test_split(  
      df_temp,  
      test_size=0.50,  
      stratify=df_temp["film_label"],  
      random_state=42  
      )  
  
df_train = df_train.copy()  
df_val = df_val.copy()  
df_test = df_test.copy()  
  
df_train["split"] = "train"  
df_val["split"] = "val"  
df_test["split"] = "test"  
  
df_all = pd.concat([df_train, df_val, df_test], axis=0, ignore_index=True)  
  
df_all.to_csv(LABEL, index=False)  
  
print("Saved to:", LABEL.resolve())  
print(df_all["split"].value_counts())
```

```
Saved to: /home/longwei/CS441/final/labels_film.csv
```

```
split
```

```
train    1288  
test     277  
val      276  
Name: count, dtype: int64
```

0.2 Baseline

Resize the photo to a small size.

Use global mean and std of RGB/HSV do a logistic regression.

0.2.1 Data Processing

Train:Val:Test = 75:15:15

```
[4]: from pathlib import Path
from typing import Tuple

import numpy as np
import pandas as pd
from PIL import Image
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import classification_report, confusion_matrix
from sklearn.preprocessing import StandardScaler

# ===== Configuration =====

CSV = Path("../labels.csv")
RAW = Path("../raw_photos")

# ===== Data processing =====

def load_image_rgb(path: Path,
                    size: Tuple[int, int] = (256, 256)) -> np.ndarray:
    """Load an image and convert to RGB format."""
    img = Image.open(path).convert("RGB")
    img = img.resize(size)
    arr = np.asarray(img, dtype=np.float32) / 255.0
    return arr

def rgb_to_hsv(image: np.ndarray) -> np.ndarray:
    """Convert an RGB image to HSV format."""
    img = Image.fromarray((image * 255).astype(np.uint8), mode="RGB")
    hsv_img = img.convert("HSV")
    hsv_array = np.asarray(hsv_img, dtype=np.float32) / 255.0
    return hsv_array

def extract_features_rgb_hsv(path: Path) -> np.ndarray:
    """Extract RGB + HSV features from an image."""
    rgb = load_image_rgb(path) # (H, W, 3)
    hsv = rgb_to_hsv(rgb) # (H, W, 3)

    r = rgb[:, :, 0].ravel()
    g = rgb[:, :, 1].ravel()
    b = rgb[:, :, 2].ravel()

    h = hsv[:, :, 0].ravel()
    s = hsv[:, :, 1].ravel()
    v = hsv[:, :, 2].ravel()

    feats = [
        r.mean(), g.mean(), b.mean(),
        h.mean(), s.mean(), v.mean(),
        np.std(r), np.std(g), np.std(b),
        np.std(h), np.std(s), np.std(v),
        np.min(r), np.max(r), np.min(g),
        np.max(g), np.min(b), np.max(b),
        np.min(h), np.max(h), np.min(s),
        np.max(s), np.min(v), np.max(v)
    ]
    return np.array(feats)
```

```

        h.mean(), s.mean(), v.mean(),
        r.std(), g.std(), b.std(),
        h.std(), s.std(), v.std(),
    ]
    return np.array(feats, dtype=np.float32)

def build_dataset(df: pd.DataFrame,
                  img_root: Path) -> tuple[np.ndarray, np.ndarray]:
    """Build dataset from dataframe and image root."""
    xs = []
    ys = []

    for _, row in df.iterrows():
        fname = row["filename"]
        label = row["film_label"]

        img_path = img_root / fname
        if not img_path.is_file():
            print(f"[WARN] Image not found, skip: {img_path}")
            continue

        vec = extract_features_rgb_hsv(img_path)
        xs.append(vec)
        ys.append(label)

    X = np.stack(xs, axis=0)
    y = np.array(ys)
    return X, y

df = pd.read_csv(LABEL)
df_train = df[df["split"] == "train"].reset_index(drop=True)
df_val = df[df["split"] == "val"].reset_index(drop=True)
df_test = df[df["split"] == "test"].reset_index(drop=True)

print("Building train set features...")
X_train, y_train = build_dataset(df_train, RAW)

print("Building val set features...")
X_val, y_val = build_dataset(df_val, RAW)

print("Building test set features...")
X_test, y_test = build_dataset(df_test, RAW)

print(f"Feature dim: {X_train.shape[1]}")

```

```
Building train set features...
Building val set features...
Building test set features...
Feature dim: 12
```

0.2.2 Logistic Regression

```
[5]: from sklearn.metrics import (
    classification_report,
    confusion_matrix,
    f1_score
)
import matplotlib.pyplot as plt

scaler = StandardScaler(with_mean=True, with_std=True)
X_train_scaled = scaler.fit_transform(X_train)
X_val_scaled = scaler.transform(X_val)
X_test_scaled = scaler.transform(X_test)

C = [0.01, 0.1, 1.0, 10.0, 100.0, 1000.0, 10000.0, 100000.0, 1000000.0]
macro_f1_list = []
acc_list = []

for c in C:
    print(f"\nTraining Logistic Regression with C={c}...")

    clf = LogisticRegression(
        solver="lbfgs",
        max_iter=1000,
        n_jobs=-1,
        C=c,
    )

    clf.fit(X_train_scaled, y_train)
    y_val_pred = clf.predict(X_val_scaled)
    macro_f1 = f1_score(y_val, y_val_pred, average="macro")
    macro_f1_list.append(macro_f1)
    print(f"Validation Macro F1: {macro_f1:.4f}")

    acc = clf.score(X_val_scaled, y_val)
    acc_list.append(acc)
    print(f"Validation Accuracy: {acc:.4f}")

# ----- Plot -----
plt.figure(figsize=(8, 5))

plt.plot(C, macro_f1_list, marker='o', label="Macro F1", linewidth=2)
```

```

plt.plot(C, acc_list, marker='s', label="Accuracy", linewidth=2)

plt.xscale("log")

plt.xlabel("C (log scale)")
plt.ylabel("Score")
plt.title("Logistic Regression C Tuning\n(Macro-F1 & Accuracy)")
plt.grid(True, linestyle="--", alpha=0.6)
plt.legend()

plt.tight_layout()
plt.show()

best_clf = LogisticRegression(
    solver="lbfgs",
    max_iter=1000,
    n_jobs=-1,
    C=C[np.argmax(macro_f1_list)],
)
best_clf.fit(X_train_scaled, y_train)

print("\n==== Test set performance ===")
y_test_pred = best_clf.predict(X_test_scaled)
print(classification_report(y_test, y_test_pred))
print("Confusion matrix (test):")
print(confusion_matrix(y_test, y_test_pred))

```

Training Logistic Regression with C=0.01...

Validation Macro F1: 0.4638

Validation Accuracy: 0.5399

Training Logistic Regression with C=0.1...

Validation Macro F1: 0.5217

Validation Accuracy: 0.5761

Training Logistic Regression with C=1.0...

Validation Macro F1: 0.5599

Validation Accuracy: 0.6014

Training Logistic Regression with C=10.0...

Validation Macro F1: 0.6151

Validation Accuracy: 0.6522

Training Logistic Regression with C=100.0...

Validation Macro F1: 0.6145

Validation Accuracy: 0.6522

```
Training Logistic Regression with C=1000.0...
```

```
Validation Macro F1: 0.6173
```

```
Validation Accuracy: 0.6558
```

```
Training Logistic Regression with C=10000.0...
```

```
Validation Macro F1: 0.6173
```

```
Validation Accuracy: 0.6558
```

```
Training Logistic Regression with C=100000.0...
```

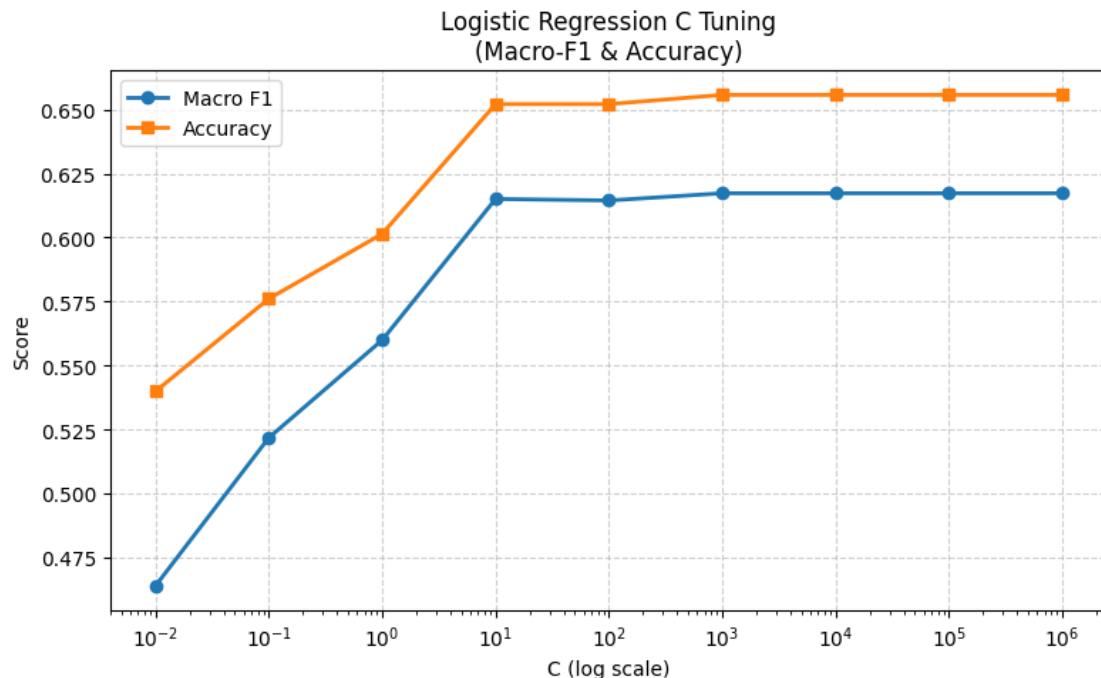
```
Validation Macro F1: 0.6173
```

```
Validation Accuracy: 0.6558
```

```
Training Logistic Regression with C=1000000.0...
```

```
Validation Macro F1: 0.6173
```

```
Validation Accuracy: 0.6558
```



```
==== Test set performance ====
```

	precision	recall	f1-score	support
--	-----------	--------	----------	---------

e100	0.48	0.33	0.39	36
hp5	0.71	0.86	0.77	76
other_bw	0.71	0.51	0.59	53
other_color	0.67	0.75	0.71	55

portra	0.56	0.60	0.58	57
accuracy			0.65	277
macro avg	0.63	0.61	0.61	277
weighted avg	0.64	0.65	0.64	277

Confusion matrix (test):

```
[[12  0  0  8 16]
 [ 0 65 11  0  0]
 [ 0 26 27  0  0]
 [ 3  0  0 41 11]
 [10  1  0 12 34]]
```

0.3 CLIP

Use Pre-trained CLIP-Vit-B-32 to embed a photo

Use logistic regression to classify the photo

0.3.1 CLIP

```
[6]: from pathlib import Path
from typing import Tuple
import torch
from torch.utils.data import Dataset, DataLoader
from PIL import Image
import pandas as pd
import numpy as np
import open_clip

# ===== Configuration =====
RAW = Path("../raw_photos")
LABEL = Path("../labels_film.csv")
OUT_DIR = Path("../clip_features")
OUT_DIR.mkdir(parents=True, exist_ok=True)

# ===== Dataset =====
class FilmDataset(Dataset):
    def __init__(self,
                 df: pd.DataFrame,
                 img_root: Path,
                 preprocess) -> None:
        self.df = df
        self.img_root = img_root
        self.preprocess = preprocess

    def __len__(self) -> int:
        return len(self.df)
```

```

def __getitem__(self, index: int) -> Tuple[torch.Tensor, str]:
    row = self.df.iloc[index]
    fname = row["filename"]
    label = row["film_label"]
    img_path = self.img_root / fname
    img = Image.open(img_path).convert("RGB")
    img_tensor = self.preprocess(img)

    return img_tensor, label


def extract_clip_features(split: str,
                          model: torch.nn.Module,
                          preprocess,
                          device: torch.device,
                          batch_size: int = 32) -> Tuple[np.ndarray, np.
                                         ndarray]:
    """Extract CLIP features from dataloader using the given model."""
    df_split = df[df[["split"]] == split].reset_index(drop=True)

    dataset = FilmDataset(df_split, RAW, preprocess)
    loader = DataLoader(dataset, batch_size=batch_size, shuffle=False, u
    ↪num_workers=4)
    all_feats = []
    all_labels = []

    model.eval()
    with torch.no_grad():
        for batch_imgs, batch_labels in loader:
            batch_imgs = batch_imgs.to(device)
            image_features = model.encode_image(batch_imgs)
            image_features = image_features / image_features.norm(dim=-1, u
            ↪keepdim=True)

            feats_np = image_features.cpu().numpy()
            all_feats.append(feats_np)
            all_labels.extend(batch_labels)

    X = np.concatenate(all_feats, axis=0)
    y = np.array(all_labels)
    print(f"Features shape: {X.shape}, labels shape: {y.shape}")
    return X, y

# ===== Model =====
device = torch.device("cuda" if torch.cuda.is_available() else "cpu")
print("Using device:", device)

```

```

model, _, preprocess = open_clip.create_model_and_transforms(
    "ViT-B-32",
    pretrained="laion2b_s34b_b79k"
)
model.to(device)
model.eval()

features = {}
df = pd.read_csv(LABEL)
for split in ["test", "val", "train"]:
    print(f"\nExtracting features for split: {split}...")
    X, y = extract_clip_features(split, model, preprocess, device)
    features[split] = (X, y)
    np.savez(OUT_DIR / f"clip_{split}.npz", X=X, y=y)

print("\n All splits extracted and saved to:", OUT_DIR)

```

```

/home/longwei/CS441/final/.venv/lib/python3.10/site-packages/tqdm/auto.py:21:
TqdmWarning: IProgress not found. Please update jupyter and ipywidgets. See
https://ipywidgets.readthedocs.io/en/stable/user_install.html
    from .autonotebook import tqdm as notebook_tqdm

```

Using device: cuda

```

Extracting features for split: test...
Features shape: (277, 512), labels shape: (277,)

```

```

Extracting features for split: val...
Features shape: (276, 512), labels shape: (276,)

```

```

Extracting features for split: train...
Features shape: (1288, 512), labels shape: (1288,)

```

All splits extracted and saved to: ./clip_features

0.3.2 Linear Probe

```

[ ]: FEATURE = Path("../clip_features")

def load_split(name: str):
    data = np.load(FEATURE/ f"clip_{name}.npz", allow_pickle=True)
    X = data["X"]
    y = data["y"]
    return X, y

X_train, y_train = load_split("train")
X_val, y_val = load_split("val")
X_test, y_test = load_split("test")

```

```

scaler = StandardScaler(with_mean=True, with_std=True)
X_train_sc = scaler.fit_transform(X_train)
X_val_sc = scaler.transform(X_val)
X_test_sc = scaler.transform(X_test)

Cs = [0.001, 0.01, 0.1, 1, 10, 100]
best_C = None
best_macro_f1 = -1

for C in Cs:
    clf = LogisticRegression(
        C=C,
        max_iter=2000,
        solver="lbfgs",
        n_jobs=-1,
    )
    clf.fit(X_train_sc, y_train)
    y_val_pred = clf.predict(X_val_sc)

    macro_f1 = f1_score(y_val, y_val_pred, average="macro")
    acc = clf.score(X_val_sc, y_val)
    print(f"C={C}: val_acc={acc:.4f}, macro_F1={macro_f1:.4f}")

    if macro_f1 > best_macro_f1:
        best_macro_f1 = macro_f1
        best_C = C

print(f"\nBest C on val (by Macro-F1): {best_C}, Macro-F1={best_macro_f1:.4f}")

X_trainval = np.concatenate([X_train_sc, X_val_sc], axis=0)
y_trainval = np.concatenate([y_train, y_val], axis=0)

final_clf = LogisticRegression(
    C=best_C,
    max_iter=2000,
    solver="lbfgs",
    n_jobs=-1,
)
final_clf.fit(X_trainval, y_trainval)

y_test_pred = final_clf.predict(X_test_sc)

print("\n==== Test set performance (CLIP + LR) ====")
print(classification_report(y_test, y_test_pred))

```

```

print("Confusion matrix (test):")
print(confusion_matrix(y_test, y_test_pred))

macro_f1_test = f1_score(y_test, y_test_pred, average="macro")
print("Macro F1 (test):", macro_f1_test)

```

C=0.001: val_acc=0.7609, macro_F1=0.7490
C= 0.01: val_acc=0.7935, macro_F1=0.7890
C= 0.1: val_acc=0.7717, macro_F1=0.7645
C= 1: val_acc=0.7609, macro_F1=0.7553
C= 10: val_acc=0.7681, macro_F1=0.7612
C= 100: val_acc=0.7500, macro_F1=0.7456

Best C on val (by Macro-F1): 0.01, Macro-F1=0.7890

==== Test set performance (CLIP + LR) ====

	precision	recall	f1-score	support
e100	0.82	0.78	0.80	36
hp5	0.82	0.87	0.85	76
other_bw	0.78	0.75	0.77	53
other_color	0.82	0.82	0.82	55
portra	0.79	0.79	0.79	57
accuracy			0.81	277
macro avg	0.81	0.80	0.80	277
weighted avg	0.81	0.81	0.81	277

Confusion matrix (test):
[[28 0 0 3 5]
 [0 66 10 0 0]
 [0 13 40 0 0]
 [2 1 0 45 7]
 [4 0 1 7 45]]
Macro F1 (test): 0.804608023555392

0.3.3 MLP Probe

```
[38]: from pathlib import Path
import numpy as np
import torch
import torch.nn as nn
from torch.utils.data import Dataset, DataLoader

from sklearn.preprocessing import StandardScaler, LabelEncoder
from sklearn.metrics import classification_report, confusion_matrix, f1_score, accuracy_score
```

```

class NpDataset(Dataset):
    def __init__(self, X: np.ndarray, y: np.ndarray):
        self.X = torch.tensor(X, dtype=torch.float32)
        self.y = torch.tensor(y, dtype=torch.long)

    def __len__(self):
        return self.X.shape[0]

    def __getitem__(self, idx):
        return self.X[idx], self.y[idx]


class MLPProbe(nn.Module):
    def __init__(self, in_dim=512, hidden_dim=256, num_classes=5, dropout=0.2):
        super().__init__()
        self.net = nn.Sequential(
            nn.Linear(in_dim, hidden_dim),
            nn.ReLU(inplace=True),
            nn.Dropout(dropout),
            nn.Linear(hidden_dim, num_classes),
        )

    def forward(self, x):
        return self.net(x)


@torch.no_grad()
def eval_model(model, loader, device):
    model.eval()
    ys, preds = [], []
    for Xb, yb in loader:
        Xb = Xb.to(device)
        logits = model(Xb)
        pb = torch.argmax(logits, dim=1).cpu().numpy()
        preds.append(pb)
        ys.append(yb.numpy())
    y_true = np.concatenate(ys)
    y_pred = np.concatenate(preds)
    return y_true, y_pred


def train_one_lr(lr: float, epochs: int = 35, hidden_dim: int = 256, dropout: float = 0.2):
    model = MLPProbe(X_train_sc.shape[1], hidden_dim, len(le.classes_), dropout).to(device)

```

```

opt = torch.optim.AdamW(model.parameters(), lr=lr, weight_decay=1e-4)
crit = nn.CrossEntropyLoss()

best_val = -1.0
best_state = None

for ep in range(1, epochs + 1):
    model.train()
    for xb, yb in train_loader:
        xb, yb = xb.to(device), yb.to(device)
        opt.zero_grad()
        loss = crit(model(xb), yb)
        loss.backward()
        opt.step()

    yv_true, yv_pred = eval_model(model, val_loader, device)
    val_macro = f1_score(yv_true, yv_pred, average="macro")
    acc = accuracy_score(yv_true, yv_pred)

    if val_macro > best_val:
        best_val = val_macro
        best_state = {k: v.detach().cpu().clone() for k, v in model.
        state_dict().items()}
        acc = accuracy_score(yv_true, yv_pred)

return best_val, acc

le = LabelEncoder()
le.fit(np.concatenate([y_train, y_val, y_test]))
y_train_i = le.transform(y_train)
y_val_i = le.transform(y_val)
y_test_i = le.transform(y_test)

scaler = StandardScaler(with_mean=True, with_std=True)
X_train_sc = scaler.fit_transform(X_train)
X_val_sc = scaler.transform(X_val)
X_test_sc = scaler.transform(X_test)

batch_size = 64
train_loader = DataLoader(NpDataset(X_train_sc, y_train_i), u
    ↪batch_size=batch_size, shuffle=True)
val_loader = DataLoader(NpDataset(X_val_sc, y_val_i), batch_size=batch_size, u
    ↪shuffle=False)

```

```

test_loader = DataLoader(NpDataset(X_test_sc, y_test_i),  

    batch_size=batch_size, shuffle=False)

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

print("Device:", device)

lrs = [1e-4, 3e-4, 1e-3, 3e-3, 1e-2, 3e-2, 1e-1, 1, 10, 100]  

f1_list = []  

acc_list = []  

best_lr = None  

best_f1 = -1

for lr in lrs:  

    best_val, acc = train_one_lr(lr=lr, epochs=50)  

    f1_list.append(best_val)  

    acc_list.append(acc)  

    print(f"lr={lr:.0e} best_val_macroF1={best_val:.4f} val_acc={acc:.4f}")  

    if best_val > best_f1:  

        best_f1 = best_val  

        best_lr = lr

plt.figure(figsize=(7,4))  

plt.plot(lrs, f1_list, marker="o", label="Val Macro-F1")  

plt.plot(lrs, acc_list, marker="s", label="Val Accuracy")  

plt.xscale("log")  

plt.xlabel("Learning rate (log scale)")  

plt.ylabel("Macro-F1")  

plt.title("CLIP + 2-layer MLP: LR sweep")  

plt.grid(True, linestyle="--", alpha=0.6)  

plt.legend()  

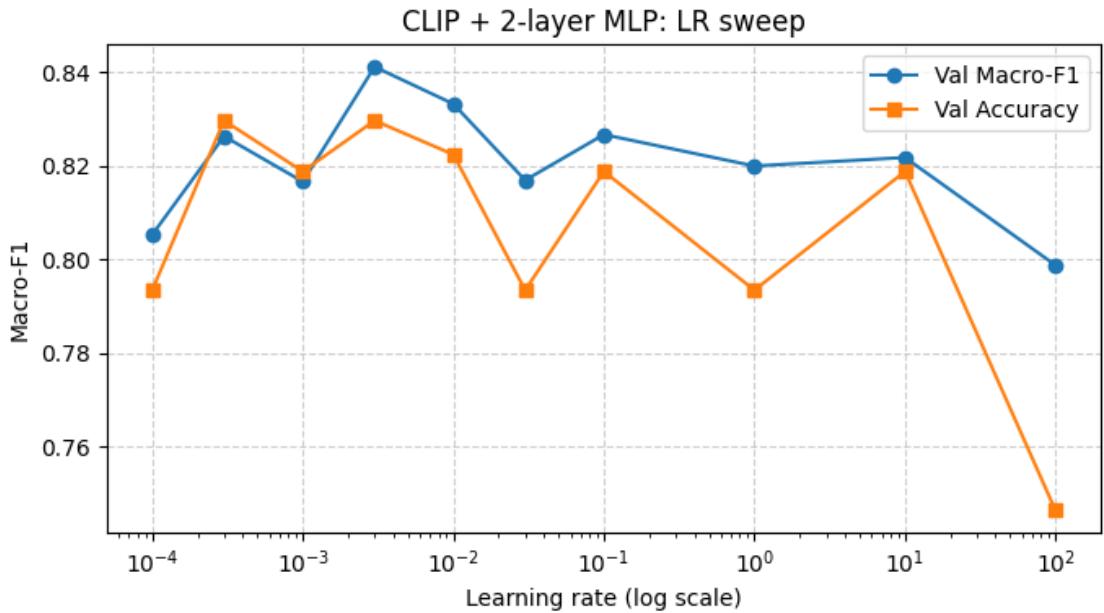
plt.tight_layout()  

plt.show()

```

Device: cuda

lr=1e-04	best_val_macroF1=0.8053	val_acc=0.7935
lr=3e-04	best_val_macroF1=0.8264	val_acc=0.8297
lr=1e-03	best_val_macroF1=0.8167	val_acc=0.8188
lr=3e-03	best_val_macroF1=0.8412	val_acc=0.8297
lr=1e-02	best_val_macroF1=0.8333	val_acc=0.8225
lr=3e-02	best_val_macroF1=0.8170	val_acc=0.7935
lr=1e-01	best_val_macroF1=0.8267	val_acc=0.8188
lr=1e+00	best_val_macroF1=0.8200	val_acc=0.7935
lr=1e+01	best_val_macroF1=0.8218	val_acc=0.8188
lr=1e+02	best_val_macroF1=0.7988	val_acc=0.7464



```
[39]: print("\nBest lr =", best_lr, "best val macroF1 =", best_f1)

final_model = MLPProbe(
    in_dim=X_train_sc.shape[1],
    hidden_dim=256,
    num_classes=len(le.classes_),
    dropout=0.2
).to(device)

opt = torch.optim.AdamW(final_model.parameters(), lr=best_lr, weight_decay=1e-4)
crit = nn.CrossEntropyLoss()

final_model.train()
for ep in range(50):
    for xb, yb in train_loader:
        xb, yb = xb.to(device), yb.to(device)
        opt.zero_grad()
        loss = crit(final_model(xb), yb)
        loss.backward()
        opt.step()

yt_true, yt_pred = eval_model(final_model, test_loader, device)

print("\n==== Test set performance (CLIP + MLP, best lr) ===")
print(classification_report(yt_true, yt_pred, target_names=list(le.classes_)))
print("Confusion matrix (test):")
```

```

print(confusion_matrix(yt_true, yt_pred))
print("Macro F1 (test):", f1_score(yt_true, yt_pred, average="macro"))
print("Accuracy (test):", accuracy_score(yt_true, yt_pred))

```

Best lr = 0.003 best val macroF1 = 0.841196634974955

```

==== Test set performance (CLIP + MLP, best lr) ====
      precision    recall   f1-score   support

       e100        0.83     0.83     0.83      36
        hp5        0.83     0.84     0.84      76
other_bw        0.78     0.79     0.79      53
other_color      0.83     0.78     0.80      55
      portra       0.81     0.82     0.82      57

  accuracy           0.82      --      277
macro avg         0.82     0.81     0.82      277
weighted avg      0.82     0.82     0.82      277

```

Confusion matrix (test):

```

[[30  0  0  3  3]
 [ 0 64 12  0  0]
 [ 0 11 42  0  0]
 [ 3  1  0 43  8]
 [ 3  1  0  6 47]]

```

Macro F1 (test): 0.8152221983199347

Accuracy (test): 0.8158844765342961

0.3.4 Misclassified Photos

```

[42]: import pandas as pd
import numpy as np
from pathlib import Path
import shutil

df = pd.read_csv("../labels_film.csv")
df_test = df[df["split"] == "test"].reset_index(drop=True)

mis_idx = np.where(yt_true != yt_pred)[0]
print(f"Misclassified: {len(mis_idx)} / {len(yt_true)}")

df_mis = df_test.loc[mis_idx, ["filename"]].copy()
df_mis["y_true"] = le.inverse_transform(yt_true[mis_idx])
df_mis["y_pred"] = le.inverse_transform(yt_pred[mis_idx])

df_mis.to_csv("../misclassified_images.csv", index=False)

```

```
print("Saved misclassified_images.csv")

IMG_ROOT = Path("../raw_photos")

OUT_DIR = Path("../misclassified_images")
OUT_DIR.mkdir(parents=True, exist_ok=True)

for fname in df_mis["filename"]:
    src = IMG_ROOT / fname
    if not src.is_file():
        print(f"[WARN] missing file: {src}")
        continue
    shutil.copy2(src, OUT_DIR / fname)

print(f"Copied {len(df_mis)} misclassified images to {OUT_DIR}")
```

```
Misclassified: 51 / 277
Saved misclassified_images.csv
Copied 51 misclassified images to ../misclassified_images
```