Skin Cancer Detection using CLIP

Name : Andi Analta Dwiyanto Palalangan Tunru
ID : 2024962230

The notebook includes the code for both augmented dataset and non-augmented dataset runs. Please check section 2 of the notebook and choose one of the subsections

1. Imports

```
!pip install datasets
```

```
Requirement already satisfied: datasets in /usr/local/lib/python3.10/dist-packages (3.1.0)
Requirement already satisfied: filelock in /usr/local/lib/python3.10/dist-packages (from datasets) (3.16.1)
Requirement already satisfied: numpy>=1.17 in /usr/local/lib/python3.10/dist-packages (from datasets) (1.26.4)
Requirement already satisfied: pyarrow>=15.0.0 in /usr/local/lib/python3.10/dist-packages (from datasets) (17.0.0)
Requirement already satisfied: dill<0.3.9,>=0.3.0 in /usr/local/lib/python3.10/dist-packages (from datasets) (0.3.8)
Requirement already satisfied: pandas in /usr/local/lib/python3.10/dist-packages (from datasets) (2.2.2)
Requirement already satisfied: requests>=2.32.2 in /usr/local/lib/python3.10/dist-packages (from datasets) (2.32.3)
Requirement already satisfied: tqdm>=4.66.3 in /usr/local/lib/python3.10/dist-packages (from datasets) (4.66.6)
Requirement already satisfied: xxhash in /usr/local/lib/python3.10/dist-packages (from datasets) (3.5.0)
Requirement already satisfied: multiprocess<0.70.17 in /usr/local/lib/python3.10/dist-packages (from datasets) (0.70.16)
Requirement already satisfied: fsspec<=2024.9.0,>=2023.1.0 in /usr/local/lib/python3.10/dist-packages (from fsspec[http]<=2024.9.0,>
Requirement already satisfied: aiohttp in /usr/local/lib/python3.10/dist-packages (from datasets) (3.11.9)
Requirement already satisfied: huggingface-hub>=0.23.0 in /usr/local/lib/python3.10/dist-packages (from datasets) (0.26.3)
Requirement already satisfied: packaging in /usr/local/lib/python3.10/dist-packages (from datasets) (24.2)
Requirement already satisfied: pyyaml>=5.1 in /usr/local/lib/python3.10/dist-packages (from datasets) (6.0.2)
Requirement already satisfied: aiohappyeyeballs>=2.3.0 in /usr/local/lib/python3.10/dist-packages (from aiohttp->datasets) (2.4.4)
Requirement already satisfied: aiosignal>=1.1.2 in /usr/local/lib/python3.10/dist-packages (from aiohttp->datasets) (1.3.1)
Requirement already satisfied: async-timeout<6.0,>=4.0 in /usr/local/lib/python3.10/dist-packages (from aiohttp->datasets) (4.0.3)
Requirement already satisfied: attrs>=17.3.0 in /usr/local/lib/python3.10/dist-packages (from aiohttp->datasets) (24.2.0)
Requirement already satisfied: frozenlist>=1.1.1 in /usr/local/lib/python3.10/dist-packages (from aiohttp->datasets) (1.5.0)
Requirement already satisfied: multidict<7.0,>=4.5 in /usr/local/lib/python3.10/dist-packages (from aiohttp->datasets) (6.1.0)
Requirement already satisfied: propcache>=0.2.0 in /usr/local/lib/python3.10/dist-packages (from aiohttp->datasets) (0.2.1)
Requirement already satisfied: yarl<2.0,>=1.17.0 in /usr/local/lib/python3.10/dist-packages (from aiohttp->datasets) (1.18.3)
Requirement already satisfied: typing-extensions>=3.7.4.3 in /usr/local/lib/python3.10/dist-packages (from huggingface-hub>=0.23.0->
Requirement already satisfied: charset-normalizer<4,>=2 in /usr/local/lib/python3.10/dist-packages (from requests>=2.32.2->datasets
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.10/dist-packages (from requests>=2.32.2->datasets) (3.10)
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.10/dist-packages (from requests>=2.32.2->datasets) (2.2
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.10/dist-packages (from requests>=2.32.2->datasets) (2024
Requirement already satisfied: python-dateutil>=2.8.2 in /usr/local/lib/python3.10/dist-packages (from pandas->datasets) (2.8.2)
Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.10/dist-packages (from pandas->datasets) (2024.2)
Requirement already satisfied: tzdata>=2022.7 in /usr/local/lib/python3.10/dist-packages (from pandas->datasets) (2024.2)
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.10/dist-packages (from python-dateutil>=2.8.2->pandas->datasets)
```

```
from datasets import load_dataset
dataset = load_dataset("marmal88/skin_cancer")
```

```
dataset
```

```
DatasetDict({
    train: Dataset({
        features: ['image', 'image_id', 'lesion_id', 'dx', 'dx_type', 'age', 'sex', 'localization'],
        num_rows: 9577
    })
    validation: Dataset({
        features: ['image', 'image_id', 'lesion_id', 'dx', 'dx_type', 'age', 'sex', 'localization'],
        num_rows: 2492
    })
    test: Dataset({
        features: ['image', 'image_id', 'lesion_id', 'dx', 'dx_type', 'age', 'sex', 'localization'],
        num_rows: 1285
    })
})
```

```
dataset["train"][0]
```

```
{'image': <PIL.JpegImagePlugin.JpegImageFile image mode=RGB size=600x450>,
 'image_id': 'ISIC_0024329',
 'lesion_id': 'HAM_0002954',
 'dx': 'actinic_keratoses',
 'dx_type': 'histo',
 'age': 75.0,
 'sex': 'female',
 'localization': 'lower extremity'}
```

```
def collate_fn(batch):
    pixel_values = torch.stack([example["pixel_values"] for example in batch])
```

```
    labels = torch.tensor([example["labels"] for example in batch])
    return {"pixel_values": pixel_values, "labels": labels}
```

2. Data Preparation

```
import torch
from transformers import CLIPProcessor
from torch.utils.data import DataLoader

processor = CLIPProcessor.from_pretrained("openai/clip-vit-base-patch32")

labels = dataset["train"].unique("dx")
label_to_id = {label: idx for idx, label in enumerate(labels)}

processor = CLIPProcessor.from_pretrained("openai/clip-vit-base-patch32")


# Set seed value
seed_value = 42

# Seed all random sources
torch.manual_seed(seed_value)
np.random.seed(seed_value)

# For CUDA (if used)
torch.cuda.manual_seed(seed_value)
torch.cuda.manual_seed_all(seed_value)  # For multi-GPU
torch.backends.cudnn.deterministic = True
torch.backends.cudnn.benchmark = False
```

2.1 Augmented Data

```
from torchvision.transforms import Compose, RandomHorizontalFlip, RandomCrop, ColorJitter, Resize, ToTensor

# Augmentations
train_augmentations = Compose([
    Resize((256, 256)),
    RandomCrop((224, 224)),
    RandomHorizontalFlip(p=0.5),
    ToTensor(),
])

val_augmentations = Compose([
    Resize((224, 224)),
    ToTensor(),
])



from datasets import concatenate_datasets

# Duplicate the training dataset
duplicated_train_dataset = concatenate_datasets([dataset["train"], dataset["train"]])


def preprocess_train(examples):
    num_samples = len(examples["image"])
    half = num_samples // 2

    # Original images (first half)
    original_images = [Resize((224, 224))(img) if not isinstance(img, torch.Tensor) else img for img in examples["image"][:half]]
    original_labels = [label_to_id[label] for label in examples["dx"][:half]]
    original_texts = [f"The lesion shows signs of {label}" for label in examples["dx"][:half]]

    # Augmented images (second half)
    augmented_images = [train_augmentations(img) if not isinstance(img, torch.Tensor) else img for img in examples["image"][half:]]
    augmented_labels = [label_to_id[label] for label in examples["dx"][half:]]
    augmented_texts = [f"The lesion shows signs of {label}" for label in examples["dx"][half:]]

    # Combine images, labels, and texts
    combined_images = original_images + augmented_images
    combined_labels = original_labels + augmented_labels
    combined_texts = original_texts + augmented_texts

    text_inputs = processor(
        text=combined_texts,
        return_tensors="pt",
```

```
        padding="max_length",
        truncation=True,
        max_length=77,
    )

    processed = {
        "pixel_values": torch.stack([img if isinstance(img, torch.Tensor) else ToTensor()(img) for img in combined_images]),
        "input_ids": text_inputs.input_ids,
        "attention_mask": text_inputs.attention_mask,
        "labels": torch.tensor(combined_labels),
    }
    return processed


def preprocess_val(examples):
    resized_images = [val_augmentations(img) for img in examples["image"]]

    text_inputs = processor(
        text=[f"The lesion shows signs of {label}" for label in examples["dx"]],
        return_tensors="pt",
        padding="max_length",
        truncation=True,
        max_length=77,
    )

    processed = {
        "pixel_values": torch.stack(resized_images),
        "input_ids": text_inputs.input_ids,
        "attention_mask": text_inputs.attention_mask,
        "labels": torch.tensor([label_to_id[label] for label in examples["dx"]]),
    }
    return processed


train_dataset = duplicated_train_dataset.with_transform(preprocess_train)
val_dataset = dataset["validation"].with_transform(preprocess_val)

print(train_dataset[0])
print(val_dataset[0])
```

```
{'pixel_values': tensor([[[0.7216, 0.7255, 0.7255,  ..., 0.7725, 0.7725, 0.7725],
          [0.7216, 0.7255, 0.7255,  ..., 0.7647, 0.7725, 0.7686],
          [0.7294, 0.7294, 0.7216,  ..., 0.7647, 0.7725, 0.7725],
          ...,
          [0.6706, 0.6784, 0.6863,  ..., 0.7098, 0.6941, 0.6863],
          [0.6706, 0.6706, 0.6784,  ..., 0.7059, 0.6941, 0.6863],
          [0.6745, 0.6745, 0.6784,  ..., 0.6980, 0.6941, 0.6902]],

         [[0.6235, 0.6157, 0.6078,  ..., 0.6392, 0.6431, 0.6392],
          [0.6235, 0.6157, 0.6078,  ..., 0.6353, 0.6392, 0.6392],
          [0.6196, 0.6157, 0.6078,  ..., 0.6353, 0.6392, 0.6392],
          ...,
          [0.5608, 0.5647, 0.5725,  ..., 0.5922, 0.5843, 0.5686],
          [0.5569, 0.5608, 0.5647,  ..., 0.5882, 0.5804, 0.5725],
          [0.5608, 0.5647, 0.5608,  ..., 0.5843, 0.5804, 0.5765]],

         [[0.5765, 0.5725, 0.5647,  ..., 0.6314, 0.6314, 0.6314],
          [0.5765, 0.5725, 0.5647,  ..., 0.6235, 0.6314, 0.6275],
          [0.5843, 0.5804, 0.5686,  ..., 0.6275, 0.6314, 0.6314],
          ...,
          [0.5059, 0.5137, 0.5137,  ..., 0.5961, 0.5843, 0.5843],
          [0.5098, 0.5137, 0.5176,  ..., 0.5961, 0.5882, 0.5843],
          [0.5137, 0.5176, 0.5137,  ..., 0.5882, 0.5882, 0.5843]]]), 'input_ids': tensor([49406,   518,   534,  1015,  2665,  4659,
           318,  2352,  7987,  1386, 49407, 49407, 49407, 49407, 49407, 49407,
         49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407,
         49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407,
         49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407,
         49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407,
         49407, 49407, 49407, 49407, 49407, 49407, 49407]), 'attention_mask': tensor([1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1,
         0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
         0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
         0, 0, 0, 0, 0]), 'labels': tensor(0)}
 {'pixel_values': tensor([[[0.2745, 0.3137, 0.3569,  ..., 0.0549, 0.0627, 0.0706],
          [0.3059, 0.3412, 0.3843,  ..., 0.0471, 0.0510, 0.0627],
          [0.3255, 0.3608, 0.4078,  ..., 0.0471, 0.0510, 0.0627],
          ...,
          [0.3882, 0.4275, 0.4627,  ..., 0.0118, 0.0157, 0.0196],
          [0.3608, 0.4039, 0.4392,  ..., 0.0157, 0.0157, 0.0235],
          [0.3373, 0.3765, 0.4196,  ..., 0.0157, 0.0196, 0.0196]],

         [[0.1490, 0.1843, 0.2314,  ..., 0.0353, 0.0431, 0.0392],
          [0.1686, 0.2118, 0.2549,  ..., 0.0314, 0.0392, 0.0392],
          [0.1922, 0.2353, 0.2784,  ..., 0.0314, 0.0353, 0.0431],
          ...,
          [0.2471, 0.2784, 0.3098,  ..., 0.0118, 0.0118, 0.0078],
```

```
             [0.2275, 0.2549, 0.2863,  ..., 0.0118, 0.0118, 0.0118],
             [0.2039, 0.2314, 0.2667,  ..., 0.0118, 0.0157, 0.0078]],

            [[0.1569, 0.2000, 0.2392,  ..., 0.0392, 0.0471, 0.0392],
             [0.1804, 0.2196, 0.2588,  ..., 0.0275, 0.0431, 0.0431],
             [0.2039, 0.2353, 0.2784,  ..., 0.0314, 0.0392, 0.0471],
             ...,
             [0.2549, 0.2902, 0.3216,  ..., 0.0039, 0.0039, 0.0039],
             [0.2314, 0.2627, 0.2980,  ..., 0.0039, 0.0039, 0.0078],
             [0.2039, 0.2431, 0.2824,  ..., 0.0039, 0.0078, 0.0039]]]), 'input_ids': tensor([49406,   518,   534,  1015,  2665,  4659,
              318,  2352,  7987,  1386, 49407, 49407, 49407, 49407, 49407, 49407,
```

```
train_dataset
```

```
Dataset({
    features: ['image', 'image_id', 'lesion_id', 'dx', 'dx_type', 'age', 'sex', 'localization'],
    num_rows: 19154
})
```

2.2 Data Without Augmentation

```
def preprocess(examples):
    text_inputs = processor(
        text=[f"This is {label}" for label in examples["dx"]],
        return_tensors="pt",
        padding="max_length",
        truncation=True,
        max_length=77,
    )

    image_inputs = processor(
        images=examples["image"],
        return_tensors="pt",
        padding=True,
        truncation=True,
    )

    processed = {
        "pixel_values": image_inputs.pixel_values,
        "input_ids": text_inputs.input_ids,
        "attention_mask": text_inputs.attention_mask,
        "labels": torch.tensor([label_to_id[label] for label in examples["dx"]])
    }
    return processed


train_dataset = dataset["train"].with_transform(preprocess)
val_dataset = dataset["test"].with_transform(preprocess)


train_dataset[0]
```

```
{'pixel_values': tensor([[[0.7917, 0.7917, 0.8209,  ..., 1.1712, 1.1274, 1.0982],
              [0.8209, 0.8063, 0.7917,  ..., 1.1566, 1.1566, 1.1420],
              [0.8355, 0.8209, 0.7917,  ..., 1.1420, 1.1420, 1.1566],
              ...,
              [0.7333, 0.7479, 0.7479,  ..., 0.9376, 0.9522, 0.8501],
              [0.7479, 0.7479, 0.7479,  ..., 0.8792, 0.8647, 0.8209],
              [0.7771, 0.7771, 0.7625,  ..., 0.8938, 0.8938, 0.8938]],

             [[0.4691, 0.4691, 0.4991,  ..., 0.7242, 0.6792, 0.6642],
              [0.4991, 0.4991, 0.4691,  ..., 0.7242, 0.7092, 0.6792],
              [0.5141, 0.5141, 0.4841,  ..., 0.7542, 0.7392, 0.7242],
              ...,
              [0.4090, 0.4240, 0.4240,  ..., 0.6191, 0.6191, 0.5291],
              [0.4390, 0.4390, 0.4390,  ..., 0.5741, 0.5441, 0.4841],
              [0.4691, 0.4691, 0.4540,  ..., 0.5291, 0.5291, 0.4991]],

             [[0.5532, 0.5248, 0.5532,  ..., 0.8234, 0.7808, 0.7666],
              [0.5675, 0.5675, 0.5532,  ..., 0.8234, 0.8092, 0.7950],
              [0.5959, 0.5959, 0.5675,  ..., 0.7808, 0.8092, 0.8377],
              ...,
              [0.3968, 0.4110, 0.4253,  ..., 0.7097, 0.7239, 0.6386],
              [0.4395, 0.4395, 0.4395,  ..., 0.6386, 0.6528, 0.5959],
              [0.4679, 0.4679, 0.4537,  ..., 0.5817, 0.5959, 0.5959]]]),
  'input_ids': tensor([49406,   589,   533,   546,  1310,  1029,   318,  2352,  7987,  1386,
         49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407,
         49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407,
         49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407,
         49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407,
         49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407, 49407,
         49407, 49407, 49407, 49407, 49407, 49407, 49407]),
```

```
  'attention_mask': tensor([1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
         0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
         0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
         0, 0, 0, 0, 0]),
  'labels': tensor(0)}
```

3. Training

```
from torch.utils.data import DataLoader

train_dataloader = DataLoader(train_dataset, batch_size=32, shuffle=True)
val_dataloader = DataLoader(val_dataset, batch_size=32)


from transformers import CLIPModel
from torch import nn, optim
from torch.optim.lr_scheduler import StepLR

model = CLIPModel.from_pretrained("openai/clip-vit-base-patch32")

num_labels = len(labels)
classifier = nn.Linear(model.config.projection_dim, num_labels)

criterion = nn.CrossEntropyLoss()
optimizer = optim.AdamW(model.parameters(), lr=5e-5)
device = torch.device("cuda" if torch.cuda.is_available() else "cpu")
model.to(device)
classifier.to(device)

scheduler = StepLR(optimizer, step_size=5, gamma=0.1)

epochs = 20
for epoch in range(epochs):
    model.train()
    total_loss = 0
    correct_train = 0
    total_train = 0

    for batch in train_dataloader:
        images = batch["pixel_values"].to(device)
        texts = batch["input_ids"].to(device)
        attention_masks = batch["attention_mask"].to(device)
        labels = batch["labels"].to(device)

        outputs = model(pixel_values=images, input_ids=texts, attention_mask=attention_masks, return_dict=True)
        image_embeddings = outputs.image_embeds

        logits = classifier(image_embeddings)

        loss = criterion(logits, labels)

        # Backward pass
        optimizer.zero_grad()
        loss.backward()
        optimizer.step()

        total_loss += loss.item()

        # Training accuracy
        preds = logits.argmax(dim=-1)
        correct_train += (preds == labels).sum().item()
        total_train += labels.size(0)

    # Training metrics
    train_accuracy = correct_train / total_train
    print(f"Epoch {epoch + 1}/{epochs}, Loss: {total_loss / len(train_dataloader):.4f}, Train Accuracy: {train_accuracy:.4f}, LR: {schedu

    scheduler.step()
```

```
Epoch 1/20, Loss: 1.6356, Train Accuracy: 0.6675, LR: [5e-05]
Epoch 2/20, Loss: 1.6263, Train Accuracy: 0.6728, LR: [5e-05]
Epoch 3/20, Loss: 1.6145, Train Accuracy: 0.6863, LR: [5e-05]
Epoch 4/20, Loss: 1.6080, Train Accuracy: 0.6969, LR: [5e-05]
Epoch 5/20, Loss: 1.6037, Train Accuracy: 0.7067, LR: [5e-05]
Epoch 6/20, Loss: 1.5867, Train Accuracy: 0.7343, LR: [5e-06]
Epoch 7/20, Loss: 1.5775, Train Accuracy: 0.7529, LR: [5e-06]
Epoch 8/20, Loss: 1.5747, Train Accuracy: 0.7574, LR: [5e-06]
Epoch 9/20, Loss: 1.5702, Train Accuracy: 0.7646, LR: [5e-06]
Epoch 10/20, Loss: 1.5679, Train Accuracy: 0.7678, LR: [5e-06]
Epoch 11/20, Loss: 1.5625, Train Accuracy: 0.7795, LR: [5.000000000000001e-07]
Epoch 12/20, Loss: 1.5612, Train Accuracy: 0.7824, LR: [5.000000000000001e-07]
```

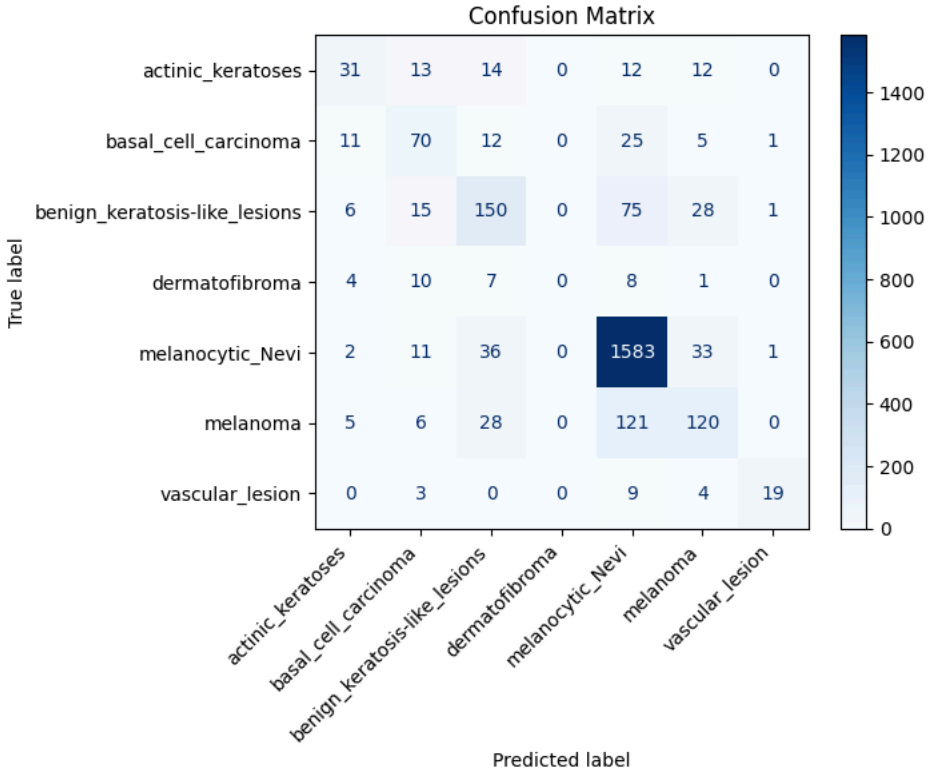
```
Epoch 13/20, Loss: 1.5608, Train Accuracy: 0.7832, LR: [5.000000000000001e-07]
Epoch 14/20, Loss: 1.5602, Train Accuracy: 0.7844, LR: [5.000000000000001e-07]
Epoch 15/20, Loss: 1.5596, Train Accuracy: 0.7860, LR: [5.000000000000001e-07]
Epoch 16/20, Loss: 1.5595, Train Accuracy: 0.7878, LR: [5.000000000000001e-08]
Epoch 17/20, Loss: 1.5586, Train Accuracy: 0.7894, LR: [5.000000000000001e-08]
Epoch 18/20, Loss: 1.5590, Train Accuracy: 0.7878, LR: [5.000000000000001e-08]
Epoch 19/20, Loss: 1.5581, Train Accuracy: 0.7910, LR: [5.000000000000001e-08]
Epoch 20/20, Loss: 1.5588, Train Accuracy: 0.7889, LR: [5.000000000000001e-08]
```

```
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay
import matplotlib.pyplot as plt
import numpy as np

# Validation loop with confusion matrix integration
model.eval()
correct_val = 0
total_val = 0

all_preds = []
all_labels = []

for batch in val_dataloader:
    images = batch["pixel_values"].to(device)
    labels = batch["labels"].to(device)
    texts = [f"The lesion shows signs of {label}" for label in batch["labels"]]

    # Preprocess validation text
    text_inputs = processor(
        text=texts,
        return_tensors="pt",
        padding="max_length",
        truncation=True,
        max_length=77,
    )
    input_ids = text_inputs["input_ids"].to(device)
    attention_mask = text_inputs["attention_mask"].to(device)

    with torch.no_grad():
        outputs = model(
            pixel_values=images,
            input_ids=input_ids,
            attention_mask=attention_mask,
            return_dict=True
        )
        image_embeddings = outputs.image_embeds

        logits = classifier(image_embeddings)
        preds = logits.argmax(dim=-1)

    # Collect predictions and labels for confusion matrix
    all_preds.extend(preds.cpu().numpy())
    all_labels.extend(labels.cpu().numpy())

    # Accuracy calculation
    correct_val += (preds == labels).sum().item()
    total_val += labels.size(0)

# Compute validation accuracy
validation_accuracy = correct_val / total_val
print(f"Validation Accuracy: {validation_accuracy:.4f}")
```

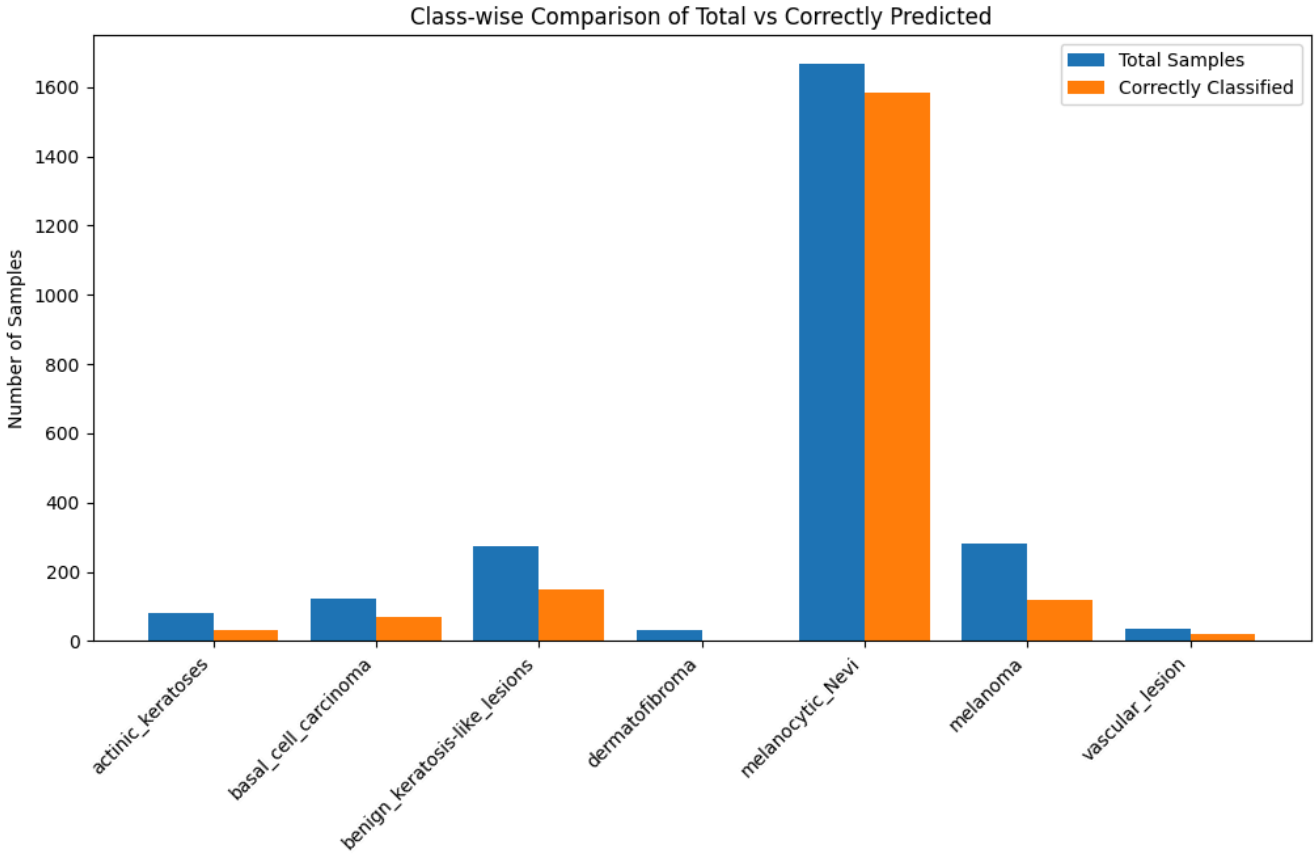
```
Validation Accuracy: 0.7917
```

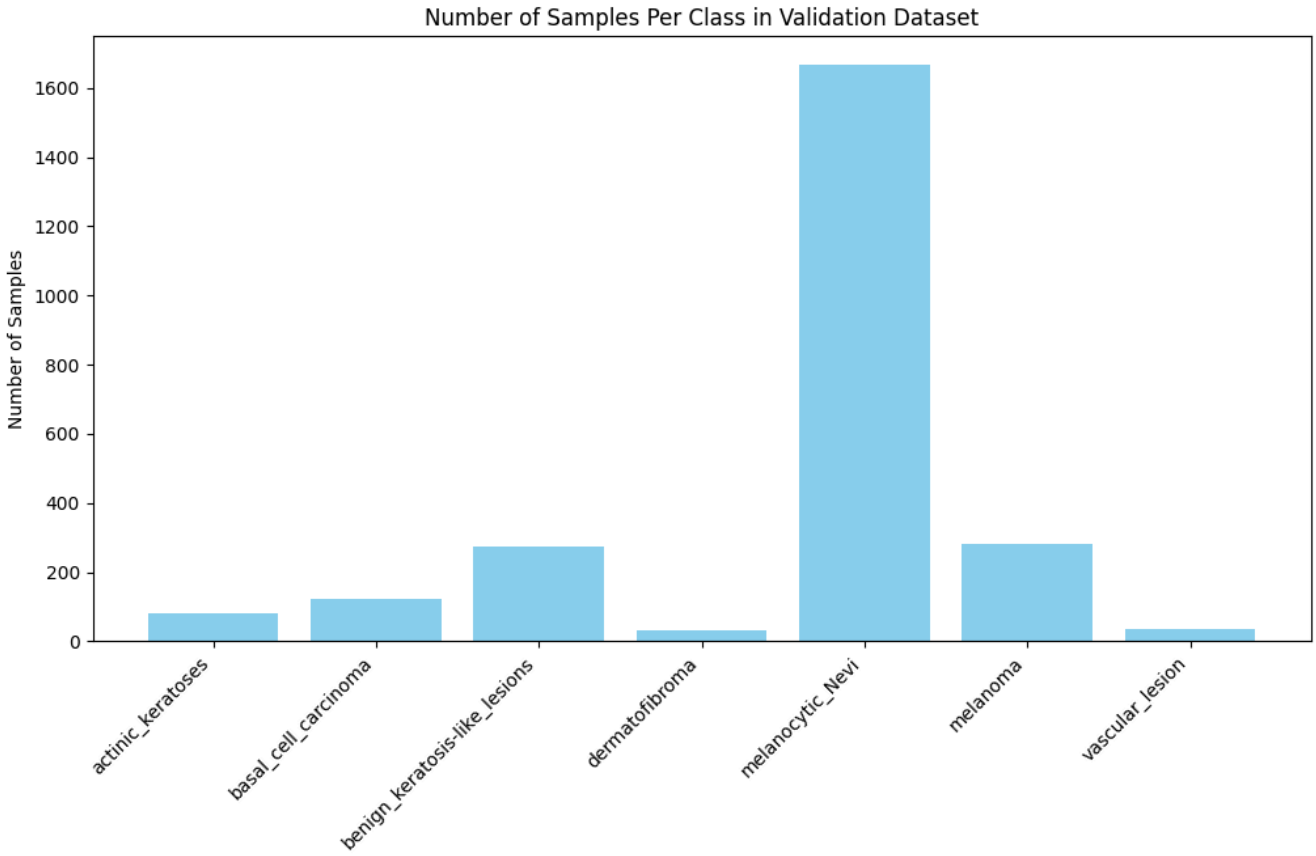
```
# Compute confusion matrix
class_names = ['actinic_keratoses',
 'basal_cell_carcinoma',
 'benign_keratosis-like_lesions',
 'dermatofibroma',
 'melanocytic_Nevi',
 'melanoma',
 'vascular_lesion']  # Replace with actual class names
cm = confusion_matrix(all_labels, all_preds)

# Plot confusion matrix
plt.figure(figsize=(21, 7))
disp = ConfusionMatrixDisplay(confusion_matrix=cm, display_labels=class_names)
disp.plot(cmap=plt.cm.Blues, values_format="d")
plt.xticks(rotation=45, ha="right")
plt.title("Confusion Matrix")
plt.show()
```

<Figure size 2100x700 with 0 Axes>




```
# Plot class-wise comparison
correct_per_class = np.diag(cm)  # Correct predictions per class
total_per_class = cm.sum(axis=1)  # Total samples per class
class_accuracy = correct_per_class / total_per_class

plt.figure(figsize=(12, 6))
bar_width = 0.4
x = np.arange(len(class_names))

plt.bar(x - bar_width / 2, total_per_class, width=bar_width, label="Total Samples")
plt.bar(x + bar_width / 2, correct_per_class, width=bar_width, label="Correctly Classified")
plt.xticks(x, class_names)
plt.xticks(rotation=45, ha="right")
plt.ylabel("Number of Samples")
plt.title("Class-wise Comparison of Total vs Correctly Predicted")
plt.legend()
plt.show()

# Plot amount of data for each class in the validation dataset
plt.figure(figsize=(12, 6))
plt.bar(class_names, total_per_class, color='skyblue')
plt.xticks(rotation=45, ha="right")
plt.ylabel("Number of Samples")
plt.title("Number of Samples Per Class in Validation Dataset")
plt.show()
```



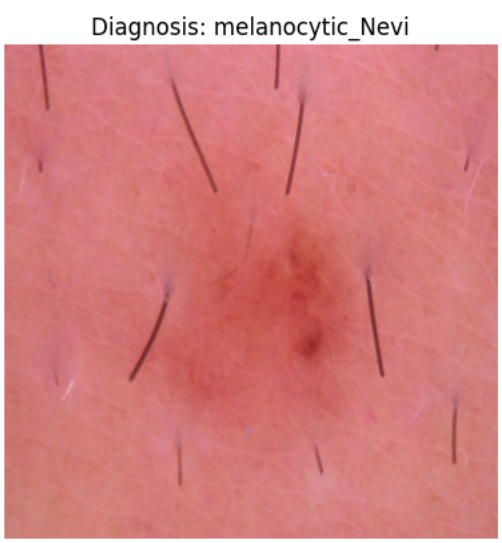



```
import matplotlib.pyplot as plt
from PIL import Image

# Filter the dataset based on diagnosis
filtered_dataset = dataset["train"].filter(lambda example: example["dx"] in ["dermatofibroma", "melanoma", "benign_keratosis-like_lesion
```

```
Filter:  100%                                    9577/9577  [01:01<00:00,  158.22  examples/s]
```

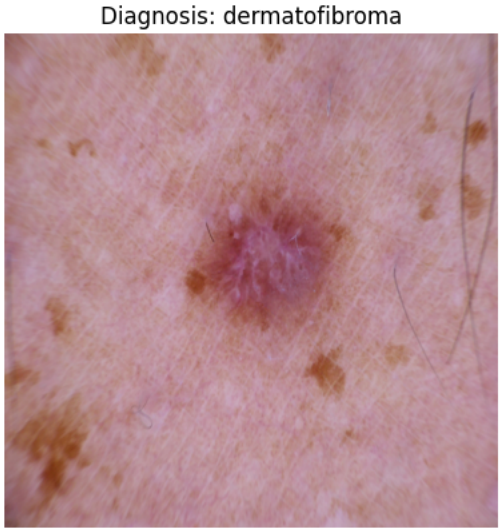
```
melano_dataset = filtered_dataset.filter(lambda example: example["dx"] == "melanocytic_Nevi")
```

```
image = melano_dataset[10]["image"]  # example["image"] is already a PIL Image

# Resize the image before displaying using Image.resize
image = image.resize((1024, 1024)) # Resize to a smaller size, maintaining aspect ratio


plt.imshow(image)
plt.title(f"Diagnosis: {melano_dataset[0]['dx']}")  # Set title with diagnosis, accessing the first element
plt.axis("off")  # Hide axes
plt.show()
```



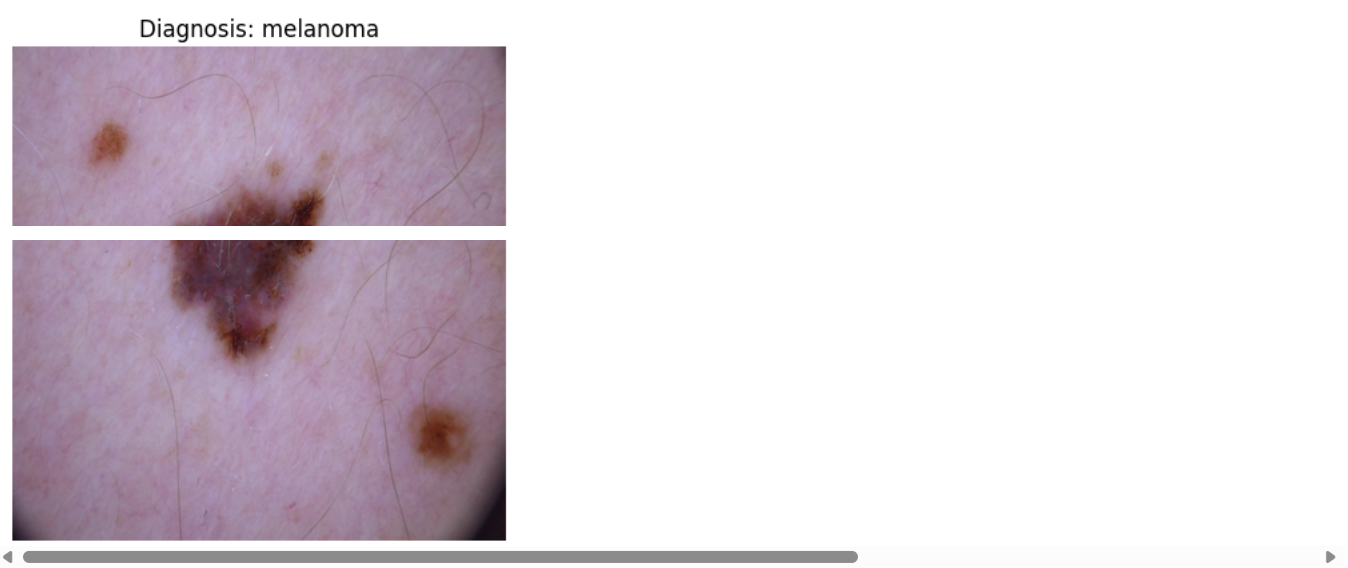

```
dermatofibroma_dataset = filtered_dataset.filter(lambda example: example["dx"] == "dermatofibroma")

image = dermatofibroma_dataset[20]["image"]  # example["image"] is already a PIL Image

# Resize the image before displaying using Image.resize
image = image.resize((1024, 1024)) # Resize to a smaller size, maintaining aspect ratio


plt.imshow(image)
plt.title(f"Diagnosis: {dermatofibroma_dataset[0]['dx']}")  # Set title with diagnosis, accessing the first element
plt.axis("off")  # Hide axes
plt.show()
```

Filter: 100% 2234/2234 [00:16<00:00, 131.53 examples/s]




```
melanoma_dataset = filtered_dataset.filter(lambda example: example["dx"] == "melanoma")

image = melanoma_dataset[2]["image"]  # example["image"] is already a PIL Image
# Resize the image before displaying using Image.resize
image = image.resize((1024, 1024)) # Resize to a smaller size, maintaining aspect ratio


plt.imshow(image)
plt.title(f"Diagnosis: {melanoma_dataset[0]['dx']}")  # Set title with diagnosis, accessing the first elemen
```

```
plt.axis("off")  # Hide axes
```




```
benign_dataset = filtered_dataset.filter(lambda example: example["dx"] == "benign_keratosis-like_lesions")

image = benign_dataset[5]["image"]  # example["image"] is already a PIL Image
# Resize the image before displaying using Image.resize
image = image.resize((1024, 1024)) # Resize to a smaller size, maintaining aspect ratio


plt.imshow(image)
plt.title(f"Diagnosis: {benign_dataset[0]['dx']}")  # Set title with diagnosis, accessing the first element
plt.axis("off")  # Hide axes
plt.show()
```

Filter: 100% 2234/2234 [00:17<00:00, 126.42 examples/s]

- Base Results (Batch Size = 16, Initial Learning Rate = 5e-5)
  - Training Accuracy : 0.835
  - Validation Accuracy : 0.818
    Indicating that the model isn't experiencing overfitting hence there is no need to implement dropout
- With Regularization (Weight-Decay = 0.01)
  - Training Accuracy : 0.812
  - Validation Accuracy : 0.804