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Setup the environment

In [ ]:
```
from pathlib import Path
import sys

if 'google.colab' in str(get_ipython()):
    from google.colab import drive  # Import Google Drive mounting uti
lity
    drive.mount('/content/drive')  # Mount Google Drive

    # REPLACE WITH YOUR FOLDER

    base_folder = Path('/content/drive/MyDrive/Colab_Notebooks/BUAN_63
82_Applied_DeepLearning')

    data_folder =  Path('/content')

    !pip install pytorch-lightning==2.0.9 -qq
    !pip install torchmetrics -U -qq
    !pip install fastdownload -U -qq
    !pip install fastai -U -qq
    !pip install wandb -U -qq
    !pip install torchinfo -U -qq

else:
    # Set base folder path for storing files on local machine
    # REPLACE WITH YOUR FOLDER
    # FILL THIS ONLY IF YOU ARE RUNNING ON A LOCAL MACHINE
    print('Path is /Users/harikrishnadev/Library/CloudStorage/GoogleDr
ive-harikrish0607@gmail.com/My Drive/Colab_Notebooks/BUAN_6382_Applied
_DeepLearning/Data')

    base_folder = Path('/Users/harikrishnadev/Library/CloudStorage/Goo
gleDrive-harikrish0607@gmail.com/My Drive/Colab_Notebooks/BUAN_6382_Ap
plied_DeepLearning')
    data_folder = Path('/Users/harikrishnadev/Library/CloudStorage/Goo
gleDrive-harikrish0607@gmail.com/My Drive/Colab_Notebooks/BUAN_6382_Ap
plied_DeepLearning/Data')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remoun
t, call drive.mount("/content/drive", force_remount=True).
```

```
In [ ]: from pathlib import Path
import sys

# Determine the storage location based on the execution environment
# If running on Google Colab, use Google Drive as storage
if 'google.colab' in str(get_ipython()):
    custom_function_folder = Path('/content/drive/MyDrive/Colab_Notebo
oks/BUAN_6382_Applied_DeepLearning/Custom_files') # Your Google Drive

    sys.path.append(str(custom_function_folder))
    model_folder = Path('/content/drive/MyDrive/Colab_Notebooks/BUAN_6
382_Applied_DeepLearning/Data') # Google drive folder where you want t
o save model and logs
    model_folder.mkdir(parents=True, exist_ok=True)
    project_folder = model_folder
    # project_folder = Path('/content/drive/MyDrive/Colab_Notebooks/BU
AN_6382_Applied_DeepLearning/Class/Class - 6/Imagenette_project')
    kaggle_api_folder = base_folder/'data/.kaggle'

# If running locally, specify a different path
else:
    # Set base folder path for storing files on local machine
    # REPLACE WITH YOUR FOLDER
    # FILL THIS ONLY IF YOU ARE RUNNING ON A LOCAL MACHINE
    print('Path is /Users/harikrishnadev/Library/CloudStorage/GoogleDr
ive-harikrish0607@gmail.com/My Drive/Colab_Notebooks/BUAN_6382_Applied
_DeepLearning/Custom_files')
    custom_function_folder = Path('/Users/harikrishnadev/Library/Cloud
Storage/GoogleDrive-harikrish0607@gmail.com/My Drive/Colab_Notebooks/B
UAN_6382_Applied_DeepLearning/Custom_files') # Your Google Drive

    sys.path.append(str(custom_function_folder))
    model_folder = Path('/Users/harikrishnadev/Library/CloudStorage/Go
ogleDrive-harikrish0607@gmail.com/My Drive/Colab_Notebooks/BUAN_6382_A
pplied_DeepLearning/Data') # Google drive folder where you want to sav
e model and logs
    model_folder.mkdir(parents=True, exist_ok=True)
    # project_folder = Path('/Users/harikrishnadev/Library/CloudStorag
e/GoogleDrive-harikrish0607@gmail.com/My Drive/Colab_Notebooks/BUAN_63
82_Applied_DeepLearning/Class/Class - 6/Imagenette_project')
    kaggle_api_folder = base_folder/'data/.kaggle'
    # project_folder = Path('/Users/harikrishnadev/Library/CloudStorag
e/GoogleDrive-harikrish0607@gmail.com/My Drive/Colab_Notebooks/BUAN_63
82_Applied_DeepLearning/Data')
```

Required libraries

In [ ]:
```
# import Libraries
import yaml

import torch
import torch.nn as nn
import torchmetrics
from torchvision import transforms
import pytorch_lightning as pl
from pytorch_lightning import seed_everything
from pytorch_lightning.tuner import Tuner
from pytorch_lightning.callbacks import ModelCheckpoint, EarlyStoppin
g, LearningRateMonitor
from pytorch_lightning.loggers import CSVLogger, WandbLogger
import wandb
import gc


from multiclass_lightning_module_v0 import MultiClassLightningModule
from shared_utils import  plot_losses_acc
```

Task 1 (2.5 Points): Data Preparation and Augmentation for CIFAR-10

- Load the CIFAR-10 dataset, dividing it into three subsets: train, validation, and test.
- Create a Lightning DataModule for the dataset.

In [ ]:
```
from torchvision import datasets
from torch.utils.data import Dataset, DataLoader
import torch
import random
from collections import defaultdict
import pytorch_lightning as pl


class TransformedSubset(Dataset):
    """
    A Dataset wrapper that applies a transform to a subset of a datase
t.

    Attributes:
    subset (Dataset): The subset of data to which the transform will b
e applied.
    transform (callable, optional): A function/transform to apply to t
he images.
    """

    def __init__(self, subset, transform=None):
        self.subset = subset  # The original data subset
        self.transform = transform  # The transform function to apply
on the data

    def __getitem__(self, index):
        """
        Retrieve and optionally transform the item (image, label) at t
he given index.

        Parameters:
        index (int): Index of the item to retrieve.

        Returns:
        tuple: Transformed image and label pair.
        """
        # Retrieve original data
        x, y = self.subset[index]
        if self.transform:
            x = self.transform(x)
        return x, y

    def __len__(self):
        return len(self.subset)


class CIFAR10MNISTDataModule(pl.LightningDataModule):
    def __init__(self, data_dir="./cifar10", train_transform=transform
s.ToTensor(), test_transform=transforms.ToTensor(),
                 batch_size=64, seed=42, fraction_train=0.8):
        super().__init__()
        self.data_dir = data_dir
        self.batch_size = batch_size
        self.train_transform = train_transform
        self.test_transform = test_transform
        self.seed = seed
        self.fraction_train = fraction_train
    def split_dataset(self, base_dataset):
        split_a_size = int(self.fraction_train * len(base_dataset))
        split_b_size = len(base_dataset) - split_a_size

        return torch.utils.data.random_split(
            base_dataset,
            [split_a_size, split_b_size],
            generator=torch.Generator().manual_seed(self.seed)
        )

    def prepare_data(self):
        # download
        datasets.CIFAR10(self.data_dir, train=True, download=True)
        datasets.CIFAR10(self.data_dir, train=False, download=True)

    def setup(self, stage: str):
        self.testset = datasets.CIFAR10(
            self.data_dir, transform=self.test_transform, train=False
, download=True
        )
        self.predictset = datasets.CIFAR10(
            self.data_dir, transform=self.test_transform, train=False,
download=True
        )
        self.train_val_set = datasets.CIFAR10(
            self.data_dir, train=True , download=True
        )
        self.trainset, self.validset = self.split_dataset(self.train_v
al_set)
        self.trainset_transformed = TransformedSubset(self.trainset, s
elf.train_transform)
        self.validset_transformed = TransformedSubset(self.validset, s
elf.test_transform)
        self.testset_transformed = TransformedSubset(self.testset, sel
f.test_transform)

    def train_dataloader(self):
        return DataLoader(
            self.trainset_transformed, batch_size=self.batch_size, shu
ffle=True, drop_last=True
        )

    def val_dataloader(self):
        return DataLoader(self.validset_transformed, batch_size=self.b
atch_size, shuffle=False)

    def test_dataloader(self):
        return DataLoader(self.testset_transformed, batch_size=self.ba
tch_size, shuffle=False)

    def predict_dataloader(self):
        return DataLoader(self.predictset, batch_size=self.batch_size,
shuffle=False)


def get_stratified_subset(dataset, num_samples, seed=None):
    if seed is not None:
        random.seed(seed)

    # Step 1: Identify label distribution
    label_to_indices = defaultdict(list)
    for idx, (_, label) in enumerate(dataset):
        label_to_indices[label].append(idx)

    # Step 2: Calculate proportions and initialize subset indices list
    proportions = {label: len(indices) / len(dataset) for label, indic
es in label_to_indices.items()}
    subset_indices = []

    # Step 3: Sample according to proportion
    for label, indices in label_to_indices.items():
        num_samples_for_label = round(proportions[label] * num_sample
s)
        subset_indices += random.sample(indices, num_samples_for_labe
l)

    # Step 4: Combine samples
    return torch.utils.data.Subset(dataset, subset_indices)
```

Task 2 (2.5 Points): Fine-Tuning Classifier Layers of VGG16

- Load the pre-trained VGG16 model.
- Adjust and refine the classifier layers of the pre-trained model to tailor it for the CIFAR-10 dataset. Determine the optimal number of classifier layers to unfreeze based on your model's performance requirements.
- OneCycleLR policy for efficient and effective fine-tuning. Implement data augmentation and preprocessing techniques. Justify each transformation in terms of how it improves model training or generalization. For instance, normalization standardizes pixel values to aid in faster convergence, while random flips or rotations can make the model more robust to variations in input data.
- Present results on the test set, ensuring that this set was excluded from the fine-tuning process.

In [ ]:
```
dm = CIFAR10MNISTDataModule(data_dir=data_folder)
dm.prepare_data()
```

```
Downloading https://www.cs.toronto.edu/~kriz/cifar-10-python.tar.gz to
/content/cifar-10-python.tar.gz

100%|██████████| 170498071/170498071 [00:05<00:00, 29300377.24it/s]

Extracting /content/cifar-10-python.tar.gz to /content
Files already downloaded and verified
```

```
In [ ]: dm.setup('fit')
```

```
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified
```

```
In [ ]: dm.train_dataloader()
```

```
Out[ ]: <torch.utils.data.dataloader.DataLoader at 0x7cb89cf95090>
```

```
In [ ]: data = dm.trainset.dataset.data/255

        print(data.mean(axis=(0,1,2)))
        print(data.std(axis=(0,1,2)))
        print(data.var(axis=(0,1,2)))
```

```
[0.49139968 0.48215841 0.44653091]
[0.24703223 0.24348513 0.26158784]
[0.06102492 0.05928501 0.0684282 ]
```

```
In [ ]: normalize = transforms.Normalize(mean=(0.49139968, 0.48215841, 0.44653
091), std=(0.24703223, 0.24348513, 0.26158784) )
train_transform = transforms.Compose([
    transforms.RandomCrop(32, padding=4),
    transforms.ToTensor(),
    transforms.Resize(size=(224, 224)),
    transforms.RandomHorizontalFlip(),
    # transforms.RandomCrop([45,45]),
    # transforms.Resize(size=(224, 224)),
    # transforms.RandomHorizontalFlip(),
    # transforms.RandomCrop([50,50]),
    # transforms.RandomRotation(degrees=45),
    # transforms.ColorJitter(brightness=0.1, contrast=0.1, saturation=
0.1, hue=0.1),
    normalize,
])

test_transform = transforms.Compose([
    transforms.Resize(size=(224, 224)),
    transforms.ToTensor(),
    # transforms.Resize(size=(224, 224)),
    # transforms.CenterCrop([50,50]),
    normalize,
])
```

In [ ]:
```
import torchvision.models as models
def load_model(config):
    model = models.vgg16(weights="DEFAULT")

    for param in model.parameters():
        param.requires_grad = False

    if config['f'] != 30:
        for i in range(config['f'],30):
            for param in model.features[i].parameters():
                param.requires_grad = True

    for i in range(config['c'],6):
        for param in model.classifier[i].parameters():
            param.requires_grad = True

    model.classifier[6] = nn.Linear(model.classifier[6].in_features, o
ut_features=config['out_features'],bias=True)
    return model
```

In [ ]:
```
def load_datamodule(config,data_folder):
    # Fetch the correct transform function based on config and pass th
e appropriate arguments
    dm = CIFAR10MNISTDataModule(
        data_dir=data_folder,
        train_transform=train_transform,
        test_transform=test_transform,
        **config['data_module']
    )
    return dm
```

In [ ]:
```
def load_lightning_module(config, model):
    optimizer_cls = eval(config['optimizer_cls'])
    loss_fn = eval(config['loss_fn'])()  # directly instantiate the lo
ss function
    metric_cls = eval(config['metric_cls'])

    # If scheduler is defined, convert its string to class as well
    if config.get('scheduler_cls'):
        scheduler_cls = eval(config['scheduler_cls'])
        scheduler_options = config['scheduler_options']
        scheduler_params =   config['scheduler_params']
    else:
        scheduler_cls = None

    lightning_module = MultiClassLightningModule(model=model,
                                                 optimizer_cls=optimiz
er_cls,
                                                 loss_fn=loss_fn,
                                                 metric_cls=metric_cl
s,
                                                 scheduler_cls=schedul
er_cls,
                                                 scheduler_options=sch
eduler_options,
                                                 scheduler_params=sche
duler_params,
                                                 **config['others']
)
    return lightning_module
```

In [ ]:
```python
def load_trainer(model, trainer_config, cl_config, batch_size, model_folder,  logging=False, checkpointing=True, early_stopping=False):

    lr_monitor = LearningRateMonitor(**cl_config['lr_monitor'])
    callbacks = [lr_monitor]
    if checkpointing:
        model_checkpoint_callback = ModelCheckpoint(dirpath=model_folder/cl_config['log_dir'],
                                                **cl_config['model_checkpoint'])
        callbacks.append(model_checkpoint_callback)

    if early_stopping:
        early_stop_callback = EarlyStopping(**cl_config['early_stopping'] )
        callbacks.append(early_stop_callback)

    if logging:
        # For WandB logger:
        wandb_logger = WandbLogger(project=cl_config['wandb']['project'], name=cl_config['wandb']['name'], save_dir=model_folder/cl_config['log_dir'])
        wandb_logger.experiment.config.update({'batch_size': batch_size, 'epochs': trainer_config['max_epochs']})
        wandb_logger.watch(model)

        # For CSV logger:
        csv_logger = CSVLogger(save_dir=model_folder/cl_config['log_dir'], name=cl_config['csv']['name'])
        csv_logger.log_hyperparams(params={'batch_size': batch_size, 'epochs': trainer_config['max_epochs']})

        trainer = pl.Trainer(callbacks=callbacks,
                            logger=[csv_logger, wandb_logger],
                            **trainer_config)
    else:
        trainer = pl.Trainer(callbacks=callbacks,
                            **trainer_config
                )
    return trainer
```

In [ ]:
```
def load_components(model_config, data_module_config, lightning_module
_config, data_folder, trainer_config,
cl_config, batch_size,logging=False, checkpointing=True, early_stoppin
g=False):

    # Load the model
    model = load_model(model_config)

    # Load the data module
    dm = load_datamodule(data_module_config, data_folder)

    # Load the lightning module
    lightning_module = load_lightning_module(lightning_module_config,
model)

    # Load the trainer
    trainer = load_trainer(model, trainer_config, cl_config, batch_siz
e, model_folder,  logging=logging,
                           checkpointing=checkpointing, early_stopping
=early_stopping)

    return model, dm, lightning_module, trainer
```

In [ ]:
```
def load_yaml(filepath):
    with open(filepath, 'r') as file:
        return yaml.safe_load(file)
```

In [ ]:
```
project_folder = custom_function_folder
```

In [ ]:
```
# Load configurations from YAML files
def load_all_configs():
    model_config = load_yaml(project_folder/'model_config_cifar10.yam
l')
    data_module_config = load_yaml(project_folder/'data_module_cifar1
0.yaml')
    lightning_module_config = load_yaml(project_folder/'lightning_modu
le_config.yaml')
    cl_config = load_yaml(project_folder/'callbacks_loggers_config_fmi
nst.yaml')
    trainer_config = load_yaml(project_folder/'trainer_config.yaml')
    return model_config, data_module_config, lightning_module_config,
cl_config, trainer_config
```

In [ ]:
```
def free_memory():
    """
    Attempts to free up memory by deleting variables and running Pytho
n's garbage collector.
    """
    gc.collect()
    for device_id in range(torch.cuda.device_count()):
        torch.cuda.set_device(device_id)
        torch.cuda.empty_cache()
    gc.collect()
```

```
In [ ]: model_config, data_module_config, lightning_module_config, cl_config,
        trainer_config = load_all_configs()
        model_config
```

```
Out[ ]: {'model_name': 'vgg16',
         'pretrained': True,
         'out_features': 10,
         'c': 0,
         'f': 30}
```

```
In [ ]: data_module_config
```

```
Out[ ]: {'data_module': {'batch_size': 64, 'seed': 42}}
```

```
In [ ]: def count_parameters(model):
          """
          Function to count the number of trainable parameters in the model
          Input: model
          Output: Number of trainable parameters in the input model
          """
          return sum(p.numel() for p in model.parameters() if p.requires_grad)
```

```
In [ ]: def print_requires_grad(model):
            for name, param in model.named_parameters():
                print(f'{name}: requires_grad={param.requires_grad}')
```

```
In [ ]: print_requires_grad(model = load_model(model_config))
```

```
Downloading: "https://download.pytorch.org/models/vgg16-397923af.pth"
to /root/.cache/torch/hub/checkpoints/vgg16-397923af.pth
100%|██████████| 528M/528M [00:05<00:00, 92.9MB/s]

features.0.weight: requires_grad=False
features.0.bias: requires_grad=False
features.2.weight: requires_grad=False
features.2.bias: requires_grad=False
features.5.weight: requires_grad=False
features.5.bias: requires_grad=False
features.7.weight: requires_grad=False
features.7.bias: requires_grad=False
features.10.weight: requires_grad=False
features.10.bias: requires_grad=False
features.12.weight: requires_grad=False
features.12.bias: requires_grad=False
features.14.weight: requires_grad=False
features.14.bias: requires_grad=False
features.17.weight: requires_grad=False
features.17.bias: requires_grad=False
features.19.weight: requires_grad=False
features.19.bias: requires_grad=False
features.21.weight: requires_grad=False
features.21.bias: requires_grad=False
features.24.weight: requires_grad=False
features.24.bias: requires_grad=False
features.26.weight: requires_grad=False
features.26.bias: requires_grad=False
features.28.weight: requires_grad=False
features.28.bias: requires_grad=False
classifier.0.weight: requires_grad=True
classifier.0.bias: requires_grad=True
classifier.3.weight: requires_grad=True
classifier.3.bias: requires_grad=True
classifier.6.weight: requires_grad=True
classifier.6.bias: requires_grad=True
```

In [ ]:
```
load_model(model_config)
```

Out[ ]:
```
VGG(
  (features): Sequential(
    (0): Conv2d(3, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1,
1))
    (1): ReLU(inplace=True)
    (2): Conv2d(64, 64, kernel_size=(3, 3), stride=(1, 1), padding=(1,
1))
    (3): ReLU(inplace=True)
    (4): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, cei
l_mode=False)
    (5): Conv2d(64, 128, kernel_size=(3, 3), stride=(1, 1), padding=
(1, 1))
    (6): ReLU(inplace=True)
    (7): Conv2d(128, 128, kernel_size=(3, 3), stride=(1, 1), padding=
(1, 1))
    (8): ReLU(inplace=True)
    (9): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, cei
l_mode=False)
    (10): Conv2d(128, 256, kernel_size=(3, 3), stride=(1, 1), padding=
(1, 1))
    (11): ReLU(inplace=True)
    (12): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=
(1, 1))
    (13): ReLU(inplace=True)
    (14): Conv2d(256, 256, kernel_size=(3, 3), stride=(1, 1), padding=
(1, 1))
    (15): ReLU(inplace=True)
    (16): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ce
il_mode=False)
    (17): Conv2d(256, 512, kernel_size=(3, 3), stride=(1, 1), padding=
(1, 1))
    (18): ReLU(inplace=True)
    (19): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=
(1, 1))
    (20): ReLU(inplace=True)
    (21): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=
(1, 1))
    (22): ReLU(inplace=True)
    (23): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ce
il_mode=False)
    (24): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=
(1, 1))
    (25): ReLU(inplace=True)
    (26): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=
(1, 1))
    (27): ReLU(inplace=True)
    (28): Conv2d(512, 512, kernel_size=(3, 3), stride=(1, 1), padding=
(1, 1))
    (29): ReLU(inplace=True)
    (30): MaxPool2d(kernel_size=2, stride=2, padding=0, dilation=1, ce
il_mode=False)
  )
  (avgpool): AdaptiveAvgPool2d(output_size=(7, 7))
  (classifier): Sequential(
    (0): Linear(in_features=25088, out_features=4096, bias=True)
    (1): ReLU(inplace=True)
    (2): Dropout(p=0.5, inplace=False)
    (3): Linear(in_features=4096, out_features=4096, bias=True)
    (4): ReLU(inplace=True)
    (5): Dropout(p=0.5, inplace=False)
    (6): Linear(in_features=4096, out_features=10, bias=True)
  )
)
```

Running for one Epoch to check for errors

In [ ]:
```
# Load components
free_memory()
seed_everything(42)
model_config, data_module_config, lightning_module_config, cl_config,
trainer_config = load_all_configs()
# override default values
trainer_config['fast_dev_run']=True
model, dm, lightning_module, trainer = load_components(model_config, d
ata_module_config,
                                                       lightning_modul
e_config, data_folder, trainer_config,
                                                        cl_config, bat
ch_size=data_module_config['data_module']['batch_size'],
                                                        logging=False,
checkpointing=False, early_stopping=False)
dm.setup('fit')
trainer.fit(lightning_module, dm)
```

```
INFO:lightning_fabric.utilities.seed:Global seed set to 42
INFO:pytorch_lightning.utilities.rank_zero:GPU available: True (cuda),
used: True
INFO:pytorch_lightning.utilities.rank_zero:TPU available: False, usin
g: 0 TPU cores
INFO:pytorch_lightning.utilities.rank_zero:IPU available: False, usin
g: 0 IPUs
INFO:pytorch_lightning.utilities.rank_zero:HPU available: False, usin
g: 0 HPUs
INFO:pytorch_lightning.utilities.rank_zero:Running in `fast_dev_run` m
ode: will run the requested loop using 1 batch(es). Logging and checkp
ointing is suppressed.

Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified

INFO:pytorch_lightning.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_
DEVICES: [0]
INFO:pytorch_lightning.callbacks.model_summary:
  | Name         | Type               | Params
----------------------------------------------------
0 | model        | VGG                | 134 M
1 | loss_fn      | CrossEntropyLoss   | 0
2 | train_metric | MulticlassAccuracy | 0
3 | val_metric   | MulticlassAccuracy | 0
4 | test_metric  | MulticlassAccuracy | 0
----------------------------------------------------
119 M     Trainable params
14.7 M    Non-trainable params
134 M     Total params
537.206   Total estimated model params size (MB)


/usr/local/lib/python3.10/dist-packages/torchvision/transforms/functio
nal.py:1603: UserWarning: The default value of the antialias parameter
of all the resizing transforms (Resize(), RandomResizedCrop(), etc.) w
ill change from None to True in v0.17, in order to be consistent acros
s the PIL and Tensor backends. To suppress this warning, directly pass
antialias=True (recommended, future default), antialias=None (current
default, which means False for Tensors and True for PIL), or antialias
=False (only works on Tensors - PIL will still use antialiasing). This
also applies if you are using the inference transforms from the models
weights: update the call to weights.transforms(antialias=True).
  warnings.warn(


Epoch 1: Val_Loss: 2.30, Val_Metric: 0.14 |

INFO:pytorch_lightning.utilities.rank_zero:`Trainer.fit` stopped: `max
_steps=1` reached.

Train_Loss: 2.35, Train_Metric: 0.14
```

Learning rate finder

In [ ]:
```
# Load components
from pytorch_lightning.tuner import Tuner
free_memory()
seed_everything(42)
model_config, data_module_config, lightning_module_config, cl_config,
trainer_config = load_all_configs()
# override default values
trainer_config['max_epochs']=5
data_module_config['data_module']['batch_size']=128

model, dm, lightning_module, trainer = load_components(model_config, d
ata_module_config,
                                                       lightning_modul
e_config, data_folder, trainer_config,
                                                        cl_config,batc
h_size=data_module_config['data_module']['batch_size'],
                                                        logging=False,
checkpointing=False, early_stopping=False)
dm.setup('fit')
tuner = Tuner(trainer)
lr_finder = tuner.lr_find(lightning_module, datamodule=dm, min_lr=1e-
5, max_lr=1, num_training=30, mode='exponential')
fig = lr_finder.plot(suggest=True)
new_lr = lr_finder.suggestion()
print(new_lr)
```

```
INFO:lightning_fabric.utilities.seed:Global seed set to 42
INFO:pytorch_lightning.utilities.rank_zero:GPU available: True (cuda),
used: True
INFO:pytorch_lightning.utilities.rank_zero:TPU available: False, usin
g: 0 TPU cores
INFO:pytorch_lightning.utilities.rank_zero:IPU available: False, usin
g: 0 IPUs
INFO:pytorch_lightning.utilities.rank_zero:HPU available: False, usin
g: 0 HPUs
INFO:pytorch_lightning.utilities.rank_zero:`Trainer(limit_train_batche
s=1.0)` was configured so 100% of the batches per epoch will be used..
INFO:pytorch_lightning.utilities.rank_zero:`Trainer(limit_val_batches=
1.0)` was configured so 100% of the batches will be used..
INFO:pytorch_lightning.utilities.rank_zero:`Trainer(limit_test_batches
=1.0)` was configured so 100% of the batches will be used..

Files already downloaded and verified
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Files already downloaded and verified

WARNING:pytorch_lightning.loggers.tensorboard:Missing logger folder: /
content/lightning_logs

Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified

INFO:pytorch_lightning.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_
DEVICES: [0]

Epoch 1: Val_Loss: 2.34, Val_Metric: 0.09 |


Epoch 1: Val_Loss: 67.99, Val_Metric: 0.10 |

INFO:pytorch_lightning.tuner.lr_finder:LR finder stopped early after 2
0 steps due to diverging loss.
INFO:pytorch_lightning.tuner.lr_finder:Learning rate set to 0.00068129
20690579612
INFO:pytorch_lightning.utilities.rank_zero:Restoring states from the c
heckpoint path at /content/.lr_find_8a8b85db-3d84-4ddd-b78b-48f9c1df3d
37.ckpt

Train_Loss: 5.66, Train_Metric: 0.31

INFO:pytorch_lightning.utilities.rank_zero:Restored all states from th
e checkpoint at /content/.lr_find_8a8b85db-3d84-4ddd-b78b-48f9c1df3d3
7.ckpt

0.0006812920690579612
```

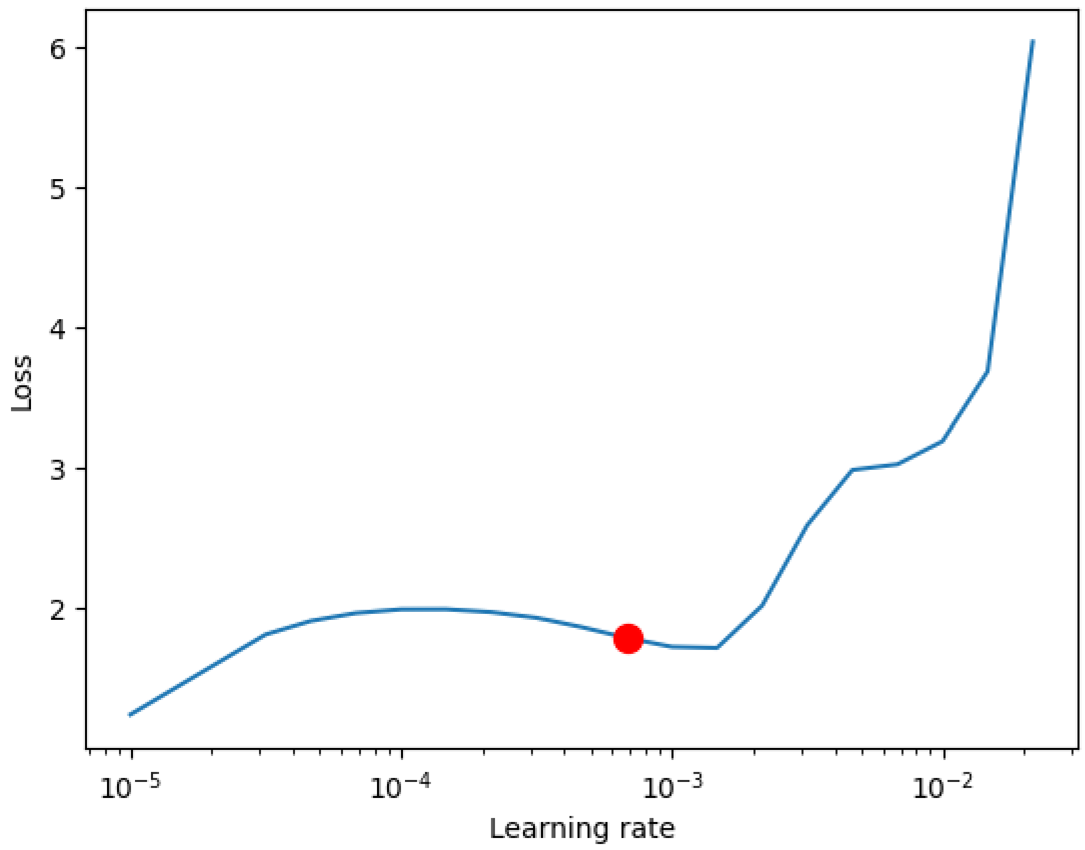

I had tried the below code block by changing the value is `c` in the `model_config` file. I got the best result as expected by unfreezing the entire classifier

```
In [ ]: # Load components

        free_memory()
        seed_everything(42)
        model_config, data_module_config, lightning_module_config, cl_config,
        trainer_config = load_all_configs()

        # override default values

        trainer_config['max_epochs']=5
        trainer_config['gradient_clip_val']=1
        trainer_config['log_every_n_steps']=100

        # lightning module config
        lightning_module_config['others']['optimizer_params']['weight_decay']=
        1
        lightning_module_config['others']['learning_rate']=0.001

        # Setting the scheduler class
        lightning_module_config['scheduler_cls'] = 'torch.optim.lr_scheduler.O
        neCycleLR'

        # Parameters for the OneCycleLR
        # Note: 'max_lr' is a required parameter for OneCycleLR; you'll need t
        o specify it based on your needs
        lightning_module_config['scheduler_params'] = {'max_lr':1e-3,'steps_pe
        r_epoch':75, 'final_div_factor': 1e4, 'div_factor': 25.0, 'pct_start':
        0.3, 'anneal_strategy':'cos','epochs':4}

        # Options related to the monitoring of the scheduler (if needed)
        lightning_module_config['scheduler_options'] = {'monitor': 'val_loss',
        'interval': 'epoch', 'frequency': 1}

        # logging
        cl_config['lr_monitor']['logging_interval']='epoch'
        cl_config['wandb']['project']='cifar10_multiclass_CNN'
        cl_config['wandb']['name']='cifar10_exp1'

        # Data Module
        data_module_config['data_module']['batch_size']=128
        model, dm, lightning_module, trainer = load_components(model_config, d
        ata_module_config,
                                                               lightning_modul
        e_config, data_folder, trainer_config,
                                                                cl_config, bat
        ch_size=data_module_config['data_module']['batch_size'],
                                                                logging=True,
        checkpointing=False, early_stopping=False)
        dm.setup('fit')
        print_requires_grad(model=model)
        trainer.fit(lightning_module, dm)
        file = f"{trainer.logger.log_dir}/metrics.csv"
        plot_losses_acc(file)
        ckpt_path = trainer.checkpoint_callback.best_model_path
        train_acc = trainer.validate(dataloaders=dm.train_dataloader(), ckpt_p
        ath=ckpt_path, verbose=False)
        valid_acc = trainer.validate(dataloaders=dm.val_dataloader(), ckpt_pat
        h=ckpt_path, verbose=False)
        test_acc = trainer.validate(dataloaders=dm.predict_dataloader(), ckpt_
        path=ckpt_path, verbose=False)
        print(f"Train Accuracy: {train_acc[0]['val_metric']*100:0.2f}")
        print(f"Validation Accuracy: {valid_acc[0]['val_metric']*100:0.2f}")
        print(f"Test Accuracy: {test_acc[0]['val_metric']*100:0.2f}")
        wandb.finish()
```

```
INFO:lightning_fabric.utilities.seed:Global seed set to 42
```

```
wandb: Logging into wandb.ai. (Learn how to deploy a W&B server locall
y: https://wandb.me/wandb-server)
wandb: You can find your API key in your browser here: https://wandb.a
i/authorize
wandb: Paste an API key from your profile and hit enter, or press ctrl
+c to quit:
```

```
 ..........
```

```
wandb: Appending key for api.wandb.ai to your netrc file: /root/.netrc
```

Tracking run with wandb version 0.16.0

Run data is saved locally in
`/content/drive/MyDrive/Colab_Notebooks/BUAN_6382_Applied_DeepLearning/D`
`20231117_013737-q4mg05hq`

Syncing run **cifar10_exp1 (https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/q4mg05hq)** to Weights & Biases (https://wandb.ai/harikrishnad/cifar10_multiclass_CNN) (docs (https://wandb.me/run))

View project at https://wandb.ai/harikrishnad/cifar10_multiclass_CNN (https://wandb.ai/harikrishnad/cifar10_multiclass_CNN)

View run at https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/q4mg05hq (https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/q4mg05hq)

```
wandb: logging graph, to disable use `wandb.watch(log_graph=False)`
INFO:pytorch_lightning.utilities.rank_zero:GPU available: True (cuda),
used: True
INFO:pytorch_lightning.utilities.rank_zero:TPU available: False, usin
g: 0 TPU cores
INFO:pytorch_lightning.utilities.rank_zero:IPU available: False, usin
g: 0 IPUs
INFO:pytorch_lightning.utilities.rank_zero:HPU available: False, usin
g: 0 HPUs
INFO:pytorch_lightning.utilities.rank_zero:`Trainer(limit_train_batche
s=1.0)` was configured so 100% of the batches per epoch will be used..
INFO:pytorch_lightning.utilities.rank_zero:`Trainer(limit_val_batches=
1.0)` was configured so 100% of the batches will be used..
INFO:pytorch_lightning.utilities.rank_zero:`Trainer(limit_test_batches
=1.0)` was configured so 100% of the batches will be used..
```

```
Files already downloaded and verified
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Files already downloaded and verified
features.0.weight: requires_grad=False
features.0.bias: requires_grad=False
features.2.weight: requires_grad=False
features.2.bias: requires_grad=False
features.5.weight: requires_grad=False
features.5.bias: requires_grad=False
features.7.weight: requires_grad=False
features.7.bias: requires_grad=False
features.10.weight: requires_grad=False
features.10.bias: requires_grad=False
features.12.weight: requires_grad=False
features.12.bias: requires_grad=False
features.14.weight: requires_grad=False
features.14.bias: requires_grad=False
features.17.weight: requires_grad=False
features.17.bias: requires_grad=False
features.19.weight: requires_grad=False
features.19.bias: requires_grad=False
features.21.weight: requires_grad=False
features.21.bias: requires_grad=False
features.24.weight: requires_grad=False
features.24.bias: requires_grad=False
features.26.weight: requires_grad=False
features.26.bias: requires_grad=False
features.28.weight: requires_grad=False
features.28.bias: requires_grad=False
classifier.0.weight: requires_grad=True
classifier.0.bias: requires_grad=True
classifier.3.weight: requires_grad=True
classifier.3.bias: requires_grad=True
classifier.6.weight: requires_grad=True
classifier.6.bias: requires_grad=True
Files already downloaded and verified
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Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified
```
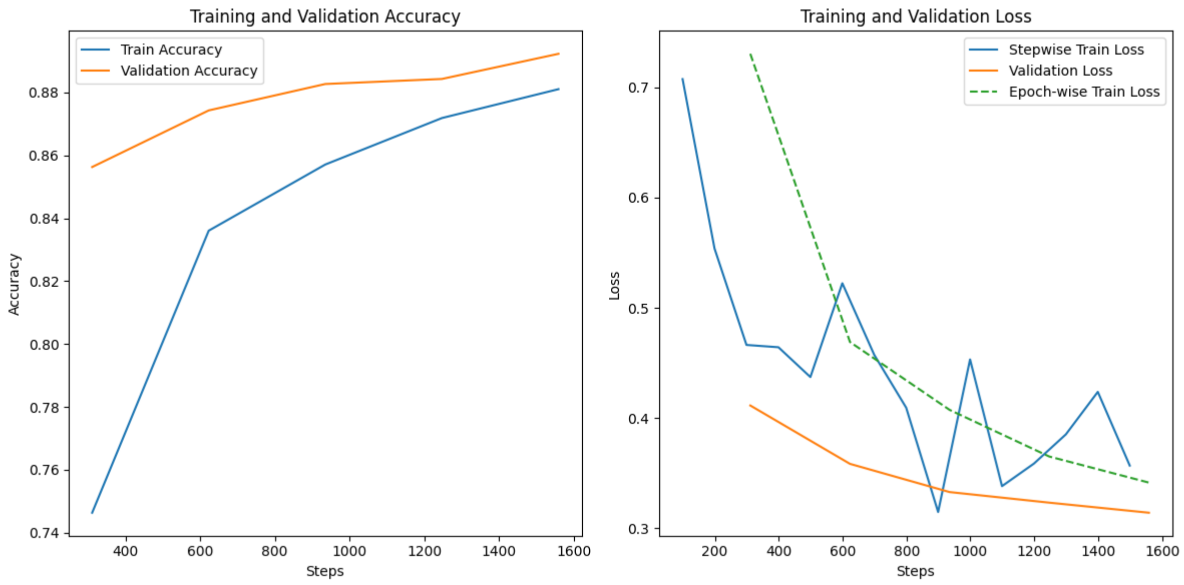

```
INFO:pytorch_lightning.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_
DEVICES: [0]
/usr/local/lib/python3.10/dist-packages/pytorch_lightning/core/optimiz
er.py:289: RuntimeWarning: A `OneCycleLR` scheduler is using 'interva
l': 'epoch'. Are you sure you didn't mean 'interval': 'step'?
  rank_zero_warn(
INFO:pytorch_lightning.callbacks.model_summary:
  | Name         | Type               | Params
----------------------------------------------------
0 | model        | VGG                | 134 M
1 | loss_fn      | CrossEntropyLoss   | 0
2 | train_metric | MulticlassAccuracy | 0
3 | val_metric   | MulticlassAccuracy | 0
4 | test_metric  | MulticlassAccuracy | 0
----------------------------------------------------
119 M     Trainable params
14.7 M    Non-trainable params
134 M     Total params
537.206   Total estimated model params size (MB)

Epoch 1: Val_Loss: 2.34, Val_Metric: 0.12 |


/usr/local/lib/python3.10/dist-packages/torchvision/transforms/functio
nal.py:1603: UserWarning: The default value of the antialias parameter
of all the resizing transforms (Resize(), RandomResizedCrop(), etc.) w
ill change from None to True in v0.17, in order to be consistent acros
s the PIL and Tensor backends. To suppress this warning, directly pass
antialias=True (recommended, future default), antialias=None (current
default, which means False for Tensors and True for PIL), or antialias
=False (only works on Tensors - PIL will still use antialiasing). This
also applies if you are using the inference transforms from the models
weights: update the call to weights.transforms(antialias=True).
  warnings.warn(


Epoch 1: Val_Loss: 0.41, Val_Metric: 0.86 | Train_Loss: 0.73, Train_Me
tric: 0.75


Epoch 2: Val_Loss: 0.36, Val_Metric: 0.87 | Train_Loss: 0.47, Train_Me
tric: 0.84


Epoch 3: Val_Loss: 0.33, Val_Metric: 0.88 | Train_Loss: 0.41, Train_Me
tric: 0.86


Epoch 4: Val_Loss: 0.32, Val_Metric: 0.88 | Train_Loss: 0.37, Train_Me
tric: 0.87


Epoch 5: Val_Loss: 0.31, Val_Metric: 0.89 | Train_Loss: 0.34, Train_Me
tric: 0.88

INFO:pytorch_lightning.utilities.rank_zero:`Trainer.fit` stopped: `max
_epochs=5` reached.
```



```
Files already downloaded and verified
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Files already downloaded and verified

INFO:pytorch_lightning.utilities.rank_zero:Restoring states from the c
heckpoint path at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_App
lied_DeepLearning/Data/logs/csvlogger/version_100/checkpoints/epoch=4-
step=1560.ckpt
INFO:pytorch_lightning.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_
DEVICES: [0]
INFO:pytorch_lightning.utilities.rank_zero:Loaded model weights from t
he checkpoint at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_Appl
ied_DeepLearning/Data/logs/csvlogger/version_100/checkpoints/epoch=4-s
tep=1560.ckpt
/usr/local/lib/python3.10/dist-packages/pytorch_lightning/trainer/conn
ectors/data_connector.py:490: PossibleUserWarning: Your `val_dataloade
r`'s sampler has shuffling enabled, it is strongly recommended that yo
u turn shuffling off for val/test dataloaders.
  rank_zero_warn(


/usr/local/lib/python3.10/dist-packages/torchvision/transforms/functio
nal.py:1603: UserWarning: The default value of the antialias parameter
of all the resizing transforms (Resize(), RandomResizedCrop(), etc.) w
ill change from None to True in v0.17, in order to be consistent acros
s the PIL and Tensor backends. To suppress this warning, directly pass
antialias=True (recommended, future default), antialias=None (current
default, which means False for Tensors and True for PIL), or antialias
=False (only works on Tensors - PIL will still use antialiasing). This
also applies if you are using the inference transforms from the models
weights: update the call to weights.transforms(antialias=True).
  warnings.warn(
Epoch 6: Val_Loss: 0.28, Val_Metric: 0.90 | Files already downloaded a
nd verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified

INFO:pytorch_lightning.utilities.rank_zero:Restoring states from the c
heckpoint path at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_App
lied_DeepLearning/Data/logs/csvlogger/version_100/checkpoints/epoch=4-
step=1560.ckpt
INFO:pytorch_lightning.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_
DEVICES: [0]
INFO:pytorch_lightning.utilities.rank_zero:Loaded model weights from t
he checkpoint at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_Appl
ied_DeepLearning/Data/logs/csvlogger/version_100/checkpoints/epoch=4-s
tep=1560.ckpt


Epoch 6: Val_Loss: 0.31, Val_Metric: 0.89 | Files already downloaded a
nd verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified

INFO:pytorch_lightning.utilities.rank_zero:Restoring states from the c
heckpoint path at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_App
lied_DeepLearning/Data/logs/csvlogger/version_100/checkpoints/epoch=4-
step=1560.ckpt
INFO:pytorch_lightning.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_
DEVICES: [0]
INFO:pytorch_lightning.utilities.rank_zero:Loaded model weights from t
he checkpoint at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_Appl
ied_DeepLearning/Data/logs/csvlogger/version_100/checkpoints/epoch=4-s
tep=1560.ckpt


Epoch 6: Val_Loss: 0.34, Val_Metric: 0.88 | Train Accuracy: 90.41
Validation Accuracy: 89.23
Test Accuracy: 88.40
```

Run history:

epoch	
lr-AdamW	
train_loss_epoch	
train_loss_step	
train_metric	
trainer/global_step	
val_loss	
val_metric	

Run summary:

epoch	5
lr-AdamW	4e-05
train_loss_epoch	0.34156
train_loss_step	0.35698
train_metric	0.88106
trainer/global_step	1560
val_loss	0.34148
val_metric	0.884

View run **cifar10_exp1** at:
https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/q4mg05hq
(https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/q4mg05hq)
Synced 5 W&B file(s), 1 media file(s), 0 artifact file(s) and 0 other file(s)

Find logs at:
```
./drive/MyDrive/Colab_Notebooks/BUAN_6382_Applied_DeepLearning/Data/log
20231117_013737-q4mg05hq/logs
```

Task 3 (2.5 Points): Fine-Tuning from the Last CNN Block in VGG16

- Modify VGG16 by unfreezing from the last CNN block (i.e., features [24] onwards).
- Train the model and report its performance on the test dataset, confirming the absence of test data in training

```
In [ ]: # Load components

        free_memory()
        seed_everything(42)
        model_config, data_module_config, lightning_module_config, cl_config,
        trainer_config = load_all_configs()

        # override default values

        trainer_config['max_epochs']=5
        trainer_config['gradient_clip_val']=1
        trainer_config['log_every_n_steps']=100

        # lightning module config
        lightning_module_config['others']['optimizer_params']['weight_decay']=
        1
        lightning_module_config['others']['learning_rate']=0.001

        # Setting the scheduler class
        lightning_module_config['scheduler_cls'] = 'torch.optim.lr_scheduler.O
        neCycleLR'

        # Parameters for the OneCycleLR
        # Note: 'max_lr' is a required parameter for OneCycleLR; you'll need t
        o specify it based on your needs
        lightning_module_config['scheduler_params'] = {'max_lr':1e-3,'steps_pe
        r_epoch':75, 'final_div_factor': 1e4, 'div_factor': 25.0, 'pct_start':
        0.3, 'anneal_strategy':'cos','epochs':4}

        # Options related to the monitoring of the scheduler (if needed)
        lightning_module_config['scheduler_options'] = {'monitor': 'val_loss',
        'interval': 'epoch', 'frequency': 1}

        # logging
        cl_config['lr_monitor']['logging_interval']='epoch'
        cl_config['wandb']['project']='cifar10_multiclass_CNN'
        cl_config['wandb']['name']='cifar10_exp2'

        # Data Module
        data_module_config['data_module']['batch_size']=128

        # Model config
        model_config['f'] = 24

        model, dm, lightning_module, trainer = load_components(model_config, d
        ata_module_config,
                                                                      lightning_modul
        e_config, data_folder, trainer_config,
                                                                       cl_config, bat
        ch_size=data_module_config['data_module']['batch_size'],
                                                                       logging=True,
        checkpointing=False, early_stopping=False)
        dm.setup('fit')
        print_requires_grad(model=model)
        trainer.fit(lightning_module, dm)
        file = f"{trainer.logger.log_dir}/metrics.csv"
        plot_losses_acc(file)
```

```
ckpt_path = trainer.checkpoint_callback.best_model_path
train_acc = trainer.validate(dataloaders=dm.train_dataloader(), ckpt_p
ath=ckpt_path, verbose=False)
valid_acc = trainer.validate(dataloaders=dm.val_dataloader(), ckpt_pat
h=ckpt_path, verbose=False)
test_acc = trainer.validate(dataloaders=dm.predict_dataloader(), ckpt_
path=ckpt_path, verbose=False)
print(f"Train Accuracy: {train_acc[0]['val_metric']*100:0.2f}")
print(f"Validation Accuracy: {valid_acc[0]['val_metric']*100:0.2f}")
print(f"Test Accuracy: {test_acc[0]['val_metric']*100:0.2f}")
wandb.finish()
```

```
INFO:lightning_fabric.utilities.seed:Global seed set to 42
wandb: Currently logged in as: harikrish0607 (harikrishnad). Use `wand
b login --relogin` to force relogin
```

Tracking run with wandb version 0.16.0

Run data is saved locally in
`/content/drive/MyDrive/Colab_Notebooks/BUAN_6382_Applied_DeepLearning/D`
`20231117_020214-h0rlyyo9`

Syncing run **cifar10_exp2 (https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/h0rlyyo9)** to Weights & Biases (https://wandb.ai/harikrishnad/cifar10_multiclass_CNN) (docs (https://wandb.me/run))

View project at https://wandb.ai/harikrishnad/cifar10_multiclass_CNN (https://wandb.ai/harikrishnad/cifar10_multiclass_CNN)

View run at https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/h0rlyyo9 (https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/h0rlyyo9)

```
wandb: logging graph, to disable use `wandb.watch(log_graph=False)`
INFO:pytorch_lightning.utilities.rank_zero:GPU available: True (cuda),
used: True
INFO:pytorch_lightning.utilities.rank_zero:TPU available: False, usin
g: 0 TPU cores
INFO:pytorch_lightning.utilities.rank_zero:IPU available: False, usin
g: 0 IPUs
INFO:pytorch_lightning.utilities.rank_zero:HPU available: False, usin
g: 0 HPUs
INFO:pytorch_lightning.utilities.rank_zero:`Trainer(limit_train_batche
s=1.0)` was configured so 100% of the batches per epoch will be used..
INFO:pytorch_lightning.utilities.rank_zero:`Trainer(limit_val_batches=
1.0)` was configured so 100% of the batches will be used..
INFO:pytorch_lightning.utilities.rank_zero:`Trainer(limit_test_batches
=1.0)` was configured so 100% of the batches will be used..
```

```
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified
features.0.weight: requires_grad=False
features.0.bias: requires_grad=False
features.2.weight: requires_grad=False
features.2.bias: requires_grad=False
features.5.weight: requires_grad=False
features.5.bias: requires_grad=False
features.7.weight: requires_grad=False
features.7.bias: requires_grad=False
features.10.weight: requires_grad=False
features.10.bias: requires_grad=False
features.12.weight: requires_grad=False
features.12.bias: requires_grad=False
features.14.weight: requires_grad=False
features.14.bias: requires_grad=False
features.17.weight: requires_grad=False
features.17.bias: requires_grad=False
features.19.weight: requires_grad=False
features.19.bias: requires_grad=False
features.21.weight: requires_grad=False
features.21.bias: requires_grad=False
features.24.weight: requires_grad=True
features.24.bias: requires_grad=True
features.26.weight: requires_grad=True
features.26.bias: requires_grad=True
features.28.weight: requires_grad=True
features.28.bias: requires_grad=True
classifier.0.weight: requires_grad=True
classifier.0.bias: requires_grad=True
classifier.3.weight: requires_grad=True
classifier.3.bias: requires_grad=True
classifier.6.weight: requires_grad=True
classifier.6.bias: requires_grad=True
Files already downloaded and verified
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Files already downloaded and verified
Files already downloaded and verified
```
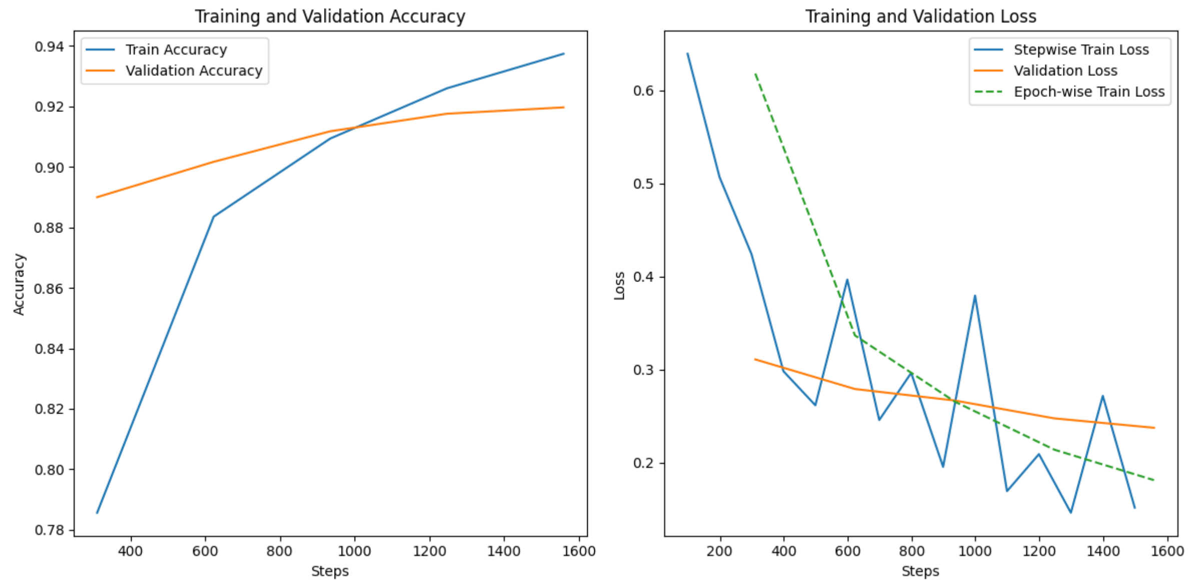

```
INFO:pytorch_lightning.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_
DEVICES: [0]
/usr/local/lib/python3.10/dist-packages/pytorch_lightning/core/optimiz
er.py:289: RuntimeWarning: A `OneCycleLR` scheduler is using 'interva
l': 'epoch'. Are you sure you didn't mean 'interval': 'step'?
  rank_zero_warn(
INFO:pytorch_lightning.callbacks.model_summary:
  | Name         | Type               | Params
----------------------------------------------------
0 | model        | VGG                | 134 M
1 | loss_fn      | CrossEntropyLoss   | 0
2 | train_metric | MulticlassAccuracy | 0
3 | val_metric   | MulticlassAccuracy | 0
4 | test_metric  | MulticlassAccuracy | 0
----------------------------------------------------
126 M     Trainable params
7.6 M     Non-trainable params
134 M     Total params
537.206   Total estimated model params size (MB)

Epoch 1: Val_Loss: 2.34, Val_Metric: 0.12 |


Epoch 1: Val_Loss: 0.31, Val_Metric: 0.89 | Train_Loss: 0.62, Train_Me
tric: 0.79


Epoch 2: Val_Loss: 0.28, Val_Metric: 0.90 | Train_Loss: 0.34, Train_Me
tric: 0.88


Epoch 3: Val_Loss: 0.27, Val_Metric: 0.91 | Train_Loss: 0.27, Train_Me
tric: 0.91


Epoch 4: Val_Loss: 0.25, Val_Metric: 0.92 | Train_Loss: 0.21, Train_Me
tric: 0.93


Epoch 5: Val_Loss: 0.24, Val_Metric: 0.92 | Train_Loss: 0.18, Train_Me
tric: 0.94

INFO:pytorch_lightning.utilities.rank_zero:`Trainer.fit` stopped: `max
_epochs=5` reached.
```



```
Files already downloaded and verified
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Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified

INFO:pytorch_lightning.utilities.rank_zero:Restoring states from the c
heckpoint path at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_App
lied_DeepLearning/Data/logs/csvlogger/version_101/checkpoints/epoch=4-
step=1560.ckpt
INFO:pytorch_lightning.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_
DEVICES: [0]
INFO:pytorch_lightning.utilities.rank_zero:Loaded model weights from t
he checkpoint at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_Appl
ied_DeepLearning/Data/logs/csvlogger/version_101/checkpoints/epoch=4-s
tep=1560.ckpt
/usr/local/lib/python3.10/dist-packages/pytorch_lightning/trainer/conn
ectors/data_connector.py:490: PossibleUserWarning: Your `val_dataloade
r`'s sampler has shuffling enabled, it is strongly recommended that yo
u turn shuffling off for val/test dataloaders.
  rank_zero_warn(


/usr/local/lib/python3.10/dist-packages/torchvision/transforms/functio
nal.py:1603: UserWarning: The default value of the antialias parameter
of all the resizing transforms (Resize(), RandomResizedCrop(), etc.) w
ill change from None to True in v0.17, in order to be consistent acros
s the PIL and Tensor backends. To suppress this warning, directly pass
antialias=True (recommended, future default), antialias=None (current
default, which means False for Tensors and True for PIL), or antialias
=False (only works on Tensors - PIL will still use antialiasing). This
also applies if you are using the inference transforms from the models
weights: update the call to weights.transforms(antialias=True).
  warnings.warn(
Epoch 6: Val_Loss: 0.13, Val_Metric: 0.96 | Files already downloaded a
nd verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified

INFO:pytorch_lightning.utilities.rank_zero:Restoring states from the c
heckpoint path at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_App
lied_DeepLearning/Data/logs/csvlogger/version_101/checkpoints/epoch=4-
step=1560.ckpt
INFO:pytorch_lightning.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_
DEVICES: [0]
INFO:pytorch_lightning.utilities.rank_zero:Loaded model weights from t
he checkpoint at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_Appl
ied_DeepLearning/Data/logs/csvlogger/version_101/checkpoints/epoch=4-s
tep=1560.ckpt


Epoch 6: Val_Loss: 0.24, Val_Metric: 0.92 | Files already downloaded a
nd verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified

INFO:pytorch_lightning.utilities.rank_zero:Restoring states from the c
heckpoint path at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_App
lied_DeepLearning/Data/logs/csvlogger/version_101/checkpoints/epoch=4-
step=1560.ckpt
INFO:pytorch_lightning.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_
DEVICES: [0]
INFO:pytorch_lightning.utilities.rank_zero:Loaded model weights from t
he checkpoint at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_Appl
ied_DeepLearning/Data/logs/csvlogger/version_101/checkpoints/epoch=4-s
tep=1560.ckpt


Epoch 6: Val_Loss: 0.26, Val_Metric: 0.92 | Train Accuracy: 95.94
Validation Accuracy: 91.97
Test Accuracy: 91.74
```
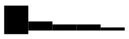
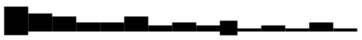
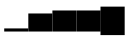
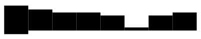
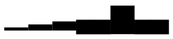

Run history:

epoch	
lr-AdamW	
train_loss_epoch	
train_loss_step	
train_metric	
trainer/global_step	
val_loss	
val_metric	

Run summary:

epoch	5
lr-AdamW	4e-05
train_loss_epoch	0.18093
train_loss_step	0.15133
train_metric	0.93742
trainer/global_step	1560
val_loss	0.2577
val_metric	0.9174

View run **cifar10_exp2** at: https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/h0rlyyo9 (https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/h0rlyyo9)
Synced 5 W&B file(s), 1 media file(s), 0 artifact file(s) and 0 other file(s)

Find logs at:
```
./drive/MyDrive/Colab_Notebooks/BUAN_6382_Applied_DeepLearning/Data/log
20231117_020214-h0rlyyo9/logs
```

Task 4 (2.5 Points): Fine-Tuning from the Last Two CNN Blocks in VGG16

- Adjust the VGG16 model to unfreeze from the last two CNN blocks (i.e., features [17] onwards).
- Evaluate and compare the test set results with those from Tasks 2 and 3 to determine the most effective strategy.
- Aim for at least 90% accuracy across tasks 2,3 and 4 i.e. at least one of the task should have 90% accuracy

In [ ]:
```
# Load components

free_memory()
seed_everything(42)
model_config, data_module_config, lightning_module_config, cl_config,
trainer_config = load_all_configs()

# override default values

trainer_config['max_epochs']=5
trainer_config['gradient_clip_val']=1
trainer_config['log_every_n_steps']=100

# lightning module config
lightning_module_config['others']['optimizer_params']['weight_decay']=
1
lightning_module_config['others']['learning_rate']=0.001

# Setting the scheduler class
lightning_module_config['scheduler_cls'] = 'torch.optim.lr_scheduler.O
neCycleLR'

# Parameters for the OneCycleLR
# Note: 'max_lr' is a required parameter for OneCycleLR; you'll need t
o specify it based on your needs
lightning_module_config['scheduler_params'] = {'max_lr':1e-3,'steps_pe
r_epoch':75, 'final_div_factor': 1e4, 'div_factor': 25.0, 'pct_start':
0.3, 'anneal_strategy':'cos','epochs':4}

# Options related to the monitoring of the scheduler (if needed)
lightning_module_config['scheduler_options'] = {'monitor': 'val_loss',
'interval': 'epoch', 'frequency': 1}

# logging
cl_config['lr_monitor']['logging_interval']='epoch'
cl_config['wandb']['project']='cifar10_multiclass_CNN'
cl_config['wandb']['name']='cifar10_exp3'

# Data Module
data_module_config['data_module']['batch_size']=128

# Model config
model_config['f'] = 17

model, dm, lightning_module, trainer = load_components(model_config, d
ata_module_config,
                                                       lightning_modul
e_config, data_folder, trainer_config,
                                                        cl_config, bat
ch_size=data_module_config['data_module']['batch_size'],
                                                        logging=True,
checkpointing=False, early_stopping=False)
dm.setup('fit')
print_requires_grad(model=model)
trainer.fit(lightning_module, dm)
file = f"{trainer.logger.log_dir}/metrics.csv"
plot_losses_acc(file)
```

```
ckpt_path = trainer.checkpoint_callback.best_model_path
train_acc = trainer.validate(dataloaders=dm.train_dataloader(), ckpt_p
ath=ckpt_path, verbose=False)
valid_acc = trainer.validate(dataloaders=dm.val_dataloader(), ckpt_pat
h=ckpt_path, verbose=False)
test_acc = trainer.validate(dataloaders=dm.predict_dataloader(), ckpt_
path=ckpt_path, verbose=False)
print(f"Train Accuracy: {train_acc[0]['val_metric']*100:0.2f}")
print(f"Validation Accuracy: {valid_acc[0]['val_metric']*100:0.2f}")
print(f"Test Accuracy: {test_acc[0]['val_metric']*100:0.2f}")
wandb.finish()
```

```
INFO:lightning_fabric.utilities.seed:Global seed set to 42
```

Tracking run with wandb version 0.16.0

Run data is saved locally in
`/content/drive/MyDrive/Colab_Notebooks/BUAN_6382_Applied_DeepLearning/D
20231117_022556-dtvdwwx2`

Syncing run **cifar10_exp3 (https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/dtvdwwx2)** to Weights & Biases (https://wandb.ai/harikrishnad/cifar10_multiclass_CNN) (docs (https://wandb.me/run))

View project at https://wandb.ai/harikrishnad/cifar10_multiclass_CNN (https://wandb.ai/harikrishnad/cifar10_multiclass_CNN)

View run at https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/dtvdwwx2 (https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/dtvdwwx2)

```
wandb: logging graph, to disable use `wandb.watch(log_graph=False)`
INFO:pytorch_lightning.utilities.rank_zero:GPU available: True (cuda),
used: True
INFO:pytorch_lightning.utilities.rank_zero:TPU available: False, usin
g: 0 TPU cores
INFO:pytorch_lightning.utilities.rank_zero:IPU available: False, usin
g: 0 IPUs
INFO:pytorch_lightning.utilities.rank_zero:HPU available: False, usin
g: 0 HPUs
INFO:pytorch_lightning.utilities.rank_zero:`Trainer(limit_train_batche
s=1.0)` was configured so 100% of the batches per epoch will be used..
INFO:pytorch_lightning.utilities.rank_zero:`Trainer(limit_val_batches=
1.0)` was configured so 100% of the batches will be used..
INFO:pytorch_lightning.utilities.rank_zero:`Trainer(limit_test_batches
=1.0)` was configured so 100% of the batches will be used..
```

```
Files already downloaded and verified
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Files already downloaded and verified
features.0.weight: requires_grad=False
features.0.bias: requires_grad=False
features.2.weight: requires_grad=False
features.2.bias: requires_grad=False
features.5.weight: requires_grad=False
features.5.bias: requires_grad=False
features.7.weight: requires_grad=False
features.7.bias: requires_grad=False
features.10.weight: requires_grad=False
features.10.bias: requires_grad=False
features.12.weight: requires_grad=False
features.12.bias: requires_grad=False
features.14.weight: requires_grad=False
features.14.bias: requires_grad=False
features.17.weight: requires_grad=True
features.17.bias: requires_grad=True
features.19.weight: requires_grad=True
features.19.bias: requires_grad=True
features.21.weight: requires_grad=True
features.21.bias: requires_grad=True
features.24.weight: requires_grad=True
features.24.bias: requires_grad=True
features.26.weight: requires_grad=True
features.26.bias: requires_grad=True
features.28.weight: requires_grad=True
features.28.bias: requires_grad=True
classifier.0.weight: requires_grad=True
classifier.0.bias: requires_grad=True
classifier.3.weight: requires_grad=True
classifier.3.bias: requires_grad=True
classifier.6.weight: requires_grad=True
classifier.6.bias: requires_grad=True
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified
```
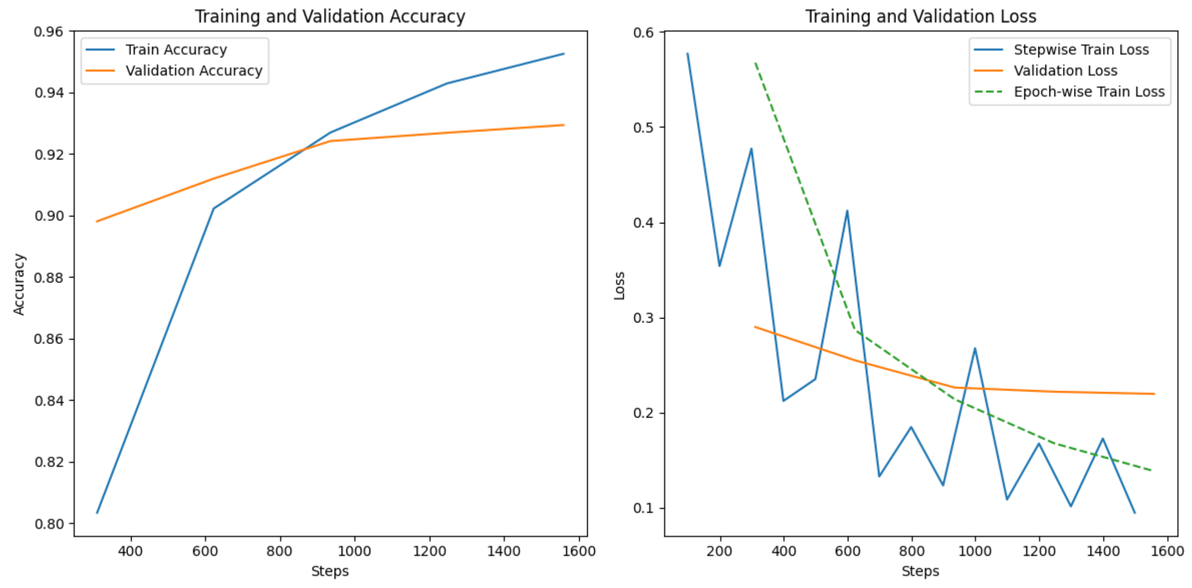

```
INFO:pytorch_lightning.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_
DEVICES: [0]
/usr/local/lib/python3.10/dist-packages/pytorch_lightning/core/optimiz
er.py:289: RuntimeWarning: A `OneCycleLR` scheduler is using 'interva
l': 'epoch'. Are you sure you didn't mean 'interval': 'step'?
  rank_zero_warn(
INFO:pytorch_lightning.callbacks.model_summary:
  | Name         | Type               | Params
----------------------------------------------------
0 | model        | VGG                | 134 M
1 | loss_fn      | CrossEntropyLoss   | 0
2 | train_metric | MulticlassAccuracy | 0
3 | val_metric   | MulticlassAccuracy | 0
4 | test_metric  | MulticlassAccuracy | 0
----------------------------------------------------
132 M     Trainable params
1.7 M     Non-trainable params
134 M     Total params
537.206   Total estimated model params size (MB)

Epoch 1: Val_Loss: 2.34, Val_Metric: 0.12 |


Epoch 1: Val_Loss: 0.29, Val_Metric: 0.90 | Train_Loss: 0.57, Train_Me
tric: 0.80


Epoch 2: Val_Loss: 0.25, Val_Metric: 0.91 | Train_Loss: 0.29, Train_Me
tric: 0.90


Epoch 3: Val_Loss: 0.23, Val_Metric: 0.92 | Train_Loss: 0.21, Train_Me
tric: 0.93


Epoch 4: Val_Loss: 0.22, Val_Metric: 0.93 | Train_Loss: 0.17, Train_Me
tric: 0.94


Epoch 5: Val_Loss: 0.22, Val_Metric: 0.93 | Train_Loss: 0.14, Train_Me
tric: 0.95

INFO:pytorch_lightning.utilities.rank_zero:`Trainer.fit` stopped: `max
_epochs=5` reached.
```



```
Files already downloaded and verified
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Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified

INFO:pytorch_lightning.utilities.rank_zero:Restoring states from the c
heckpoint path at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_App
lied_DeepLearning/Data/logs/csvlogger/version_102/checkpoints/epoch=4-
step=1560.ckpt
INFO:pytorch_lightning.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_
DEVICES: [0]
INFO:pytorch_lightning.utilities.rank_zero:Loaded model weights from t
he checkpoint at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_Appl
ied_DeepLearning/Data/logs/csvlogger/version_102/checkpoints/epoch=4-s
tep=1560.ckpt
/usr/local/lib/python3.10/dist-packages/pytorch_lightning/trainer/conn
ectors/data_connector.py:490: PossibleUserWarning: Your `val_dataloade
r`'s sampler has shuffling enabled, it is strongly recommended that yo
u turn shuffling off for val/test dataloaders.
  rank_zero_warn(


/usr/local/lib/python3.10/dist-packages/torchvision/transforms/functio
nal.py:1603: UserWarning: The default value of the antialias parameter
of all the resizing transforms (Resize(), RandomResizedCrop(), etc.) w
ill change from None to True in v0.17, in order to be consistent acros
s the PIL and Tensor backends. To suppress this warning, directly pass
antialias=True (recommended, future default), antialias=None (current
default, which means False for Tensors and True for PIL), or antialias
=False (only works on Tensors - PIL will still use antialiasing). This
also applies if you are using the inference transforms from the models
weights: update the call to weights.transforms(antialias=True).
  warnings.warn(
Epoch 6: Val_Loss: 0.10, Val_Metric: 0.97 | Files already downloaded a
nd verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified

INFO:pytorch_lightning.utilities.rank_zero:Restoring states from the c
heckpoint path at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_App
lied_DeepLearning/Data/logs/csvlogger/version_102/checkpoints/epoch=4-
step=1560.ckpt
INFO:pytorch_lightning.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_
DEVICES: [0]
INFO:pytorch_lightning.utilities.rank_zero:Loaded model weights from t
he checkpoint at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_Appl
ied_DeepLearning/Data/logs/csvlogger/version_102/checkpoints/epoch=4-s
tep=1560.ckpt


Epoch 6: Val_Loss: 0.22, Val_Metric: 0.93 | Files already downloaded a
nd verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified

INFO:pytorch_lightning.utilities.rank_zero:Restoring states from the c
heckpoint path at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_App
lied_DeepLearning/Data/logs/csvlogger/version_102/checkpoints/epoch=4-
step=1560.ckpt
INFO:pytorch_lightning.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_
DEVICES: [0]
INFO:pytorch_lightning.utilities.rank_zero:Loaded model weights from t
he checkpoint at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_Appl
ied_DeepLearning/Data/logs/csvlogger/version_102/checkpoints/epoch=4-s
tep=1560.ckpt


Epoch 6: Val_Loss: 0.23, Val_Metric: 0.93 | Train Accuracy: 96.62
Validation Accuracy: 92.94
Test Accuracy: 92.54
```
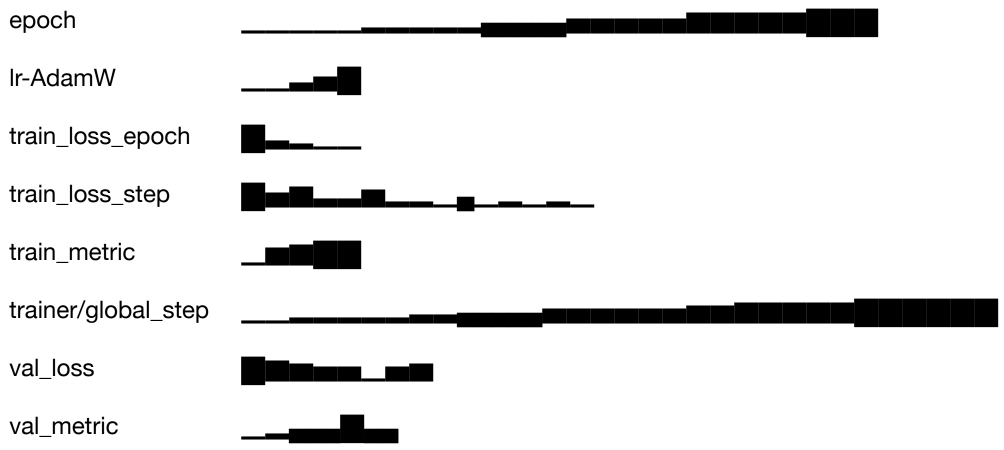

Run history:



Run summary:

epoch	5
lr-AdamW	4e-05
train_loss_epoch	0.13857
train_loss_step	0.09484
train_metric	0.95257
trainer/global_step	1560
val_loss	0.2348
val_metric	0.9254

View run **cifar10_exp3** at:
https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/dtvdwwx2
(https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/dtvdwwx2)
Synced 5 W&B file(s), 1 media file(s), 0 artifact file(s) and 0 other file(s)

Find logs at:
```
 ./drive/MyDrive/Colab_Notebooks/BUAN_6382_Applied_DeepLearning/Data/log
20231117_022556-dtvdwwx2/logs
```

Task 5 (5 Points): Dynamic Learning Rate Adjustment

- Experiment with different learning rates for various layers during each epoch. Refer to the provided tutorial for implementation strategies. This advanced technique can lead to more nuanced and effective model training. (See the link here : https://github.com/Paperspace/PyTorch-101-Tutorial-Series/blob/master/PyTorch%20101%20Part%203%20-%20Advance%20PyTorch%20Usage.ipynb (https://github.com/Paperspace/PyTorch-101-Tutorial-Series/blob/master/PyTorch%20101%20Part%203%20-%20Advance%20PyTorch%20Usage.ipynb))

In [ ]:
```
# Load components

free_memory()
seed_everything(42)
model_config, data_module_config, lightning_module_config, cl_config,
trainer_config = load_all_configs()

# override default values

trainer_config['max_epochs']=5
trainer_config['gradient_clip_val']=1
trainer_config['log_every_n_steps']=100

# lightning module config
lightning_module_config['others']['optimizer_params']['weight_decay']=
1
lightning_module_config['others']['learning_rate']= 0.001

# Setting the scheduler class
lightning_module_config['scheduler_cls'] = 'torch.optim.lr_scheduler.O
neCycleLR'

# Parameters for the OneCycleLR
# Note: 'max_lr' is a required parameter for OneCycleLR; you'll need t
o specify it based on your needs
lightning_module_config['scheduler_params'] = {'max_lr':1e-3,'steps_pe
r_epoch':75, 'final_div_factor': 1e4, 'div_factor': 25.0, 'pct_start':
0.3, 'anneal_strategy':'cos','epochs':4}

# Options related to the monitoring of the scheduler (if needed)
lightning_module_config['scheduler_options'] = {'monitor': 'val_loss',
'interval': 'epoch', 'frequency': 1}


# logging
cl_config['lr_monitor']['logging_interval']='epoch'
cl_config['wandb']['project']='cifar10_multiclass_CNN'
cl_config['wandb']['name']='cifar10_exp4'

# Data Module
data_module_config['data_module']['batch_size']=128

# Model config
model_config['f'] = 17

model, dm, lightning_module, trainer = load_components(model_config, d
ata_module_config,
                                                       lightning_modul
e_config, data_folder, trainer_config,
                                                        cl_config, bat
ch_size=data_module_config['data_module']['batch_size'],
                                                        logging=True,
checkpointing=False, early_stopping=False)
dm.setup('fit')
print_requires_grad(model)
```

```
INFO:lightning_fabric.utilities.seed:Global seed set to 42
```

Tracking run with wandb version 0.16.0

Run data is saved locally in
`/content/drive/MyDrive/Colab_Notebooks/BUAN_6382_Applied_DeepLearning/D`
`20231117_025026-8rxjoya0`

Syncing run **cifar10_exp4 (https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/8rxjoya0)** to Weights & Biases (https://wandb.ai/harikrishnad/cifar10_multiclass_CNN) (docs (https://wandb.me/run))

View project at https://wandb.ai/harikrishnad/cifar10_multiclass_CNN (https://wandb.ai/harikrishnad/cifar10_multiclass_CNN)

View run at https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/8rxjoya0 (https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/8rxjoya0)

```
wandb: logging graph, to disable use `wandb.watch(log_graph=False)`
INFO:pytorch_lightning.utilities.rank_zero:GPU available: True (cuda),
used: True
INFO:pytorch_lightning.utilities.rank_zero:TPU available: False, usin
g: 0 TPU cores
INFO:pytorch_lightning.utilities.rank_zero:IPU available: False, usin
g: 0 IPUs
INFO:pytorch_lightning.utilities.rank_zero:HPU available: False, usin
g: 0 HPUs
INFO:pytorch_lightning.utilities.rank_zero:`Trainer(limit_train_batche
s=1.0)` was configured so 100% of the batches per epoch will be used..
INFO:pytorch_lightning.utilities.rank_zero:`Trainer(limit_val_batches=
1.0)` was configured so 100% of the batches will be used..
INFO:pytorch_lightning.utilities.rank_zero:`Trainer(limit_test_batches
=1.0)` was configured so 100% of the batches will be used..
```

```
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified
features.0.weight: requires_grad=False
features.0.bias: requires_grad=False
features.2.weight: requires_grad=False
features.2.bias: requires_grad=False
features.5.weight: requires_grad=False
features.5.bias: requires_grad=False
features.7.weight: requires_grad=False
features.7.bias: requires_grad=False
features.10.weight: requires_grad=False
features.10.bias: requires_grad=False
features.12.weight: requires_grad=False
features.12.bias: requires_grad=False
features.14.weight: requires_grad=False
features.14.bias: requires_grad=False
features.17.weight: requires_grad=True
features.17.bias: requires_grad=True
features.19.weight: requires_grad=True
features.19.bias: requires_grad=True
features.21.weight: requires_grad=True
features.21.bias: requires_grad=True
features.24.weight: requires_grad=True
features.24.bias: requires_grad=True
features.26.weight: requires_grad=True
features.26.bias: requires_grad=True
features.28.weight: requires_grad=True
features.28.bias: requires_grad=True
classifier.0.weight: requires_grad=True
classifier.0.bias: requires_grad=True
classifier.3.weight: requires_grad=True
classifier.3.bias: requires_grad=True
classifier.6.weight: requires_grad=True
classifier.6.bias: requires_grad=True
```

In [ ]:
```
layer_names = []
for idx, (name, param) in enumerate(model.named_parameters()):
    layer_names.append(name)
    print(f'{idx}: {name}')
```

```
0: features.0.weight
1: features.0.bias
2: features.2.weight
3: features.2.bias
4: features.5.weight
5: features.5.bias
6: features.7.weight
7: features.7.bias
8: features.10.weight
9: features.10.bias
10: features.12.weight
11: features.12.bias
12: features.14.weight
13: features.14.bias
14: features.17.weight
15: features.17.bias
16: features.19.weight
17: features.19.bias
18: features.21.weight
19: features.21.bias
20: features.24.weight
21: features.24.bias
22: features.26.weight
23: features.26.bias
24: features.28.weight
25: features.28.bias
26: classifier.0.weight
27: classifier.0.bias
28: classifier.3.weight
29: classifier.3.bias
30: classifier.6.weight
31: classifier.6.bias
```

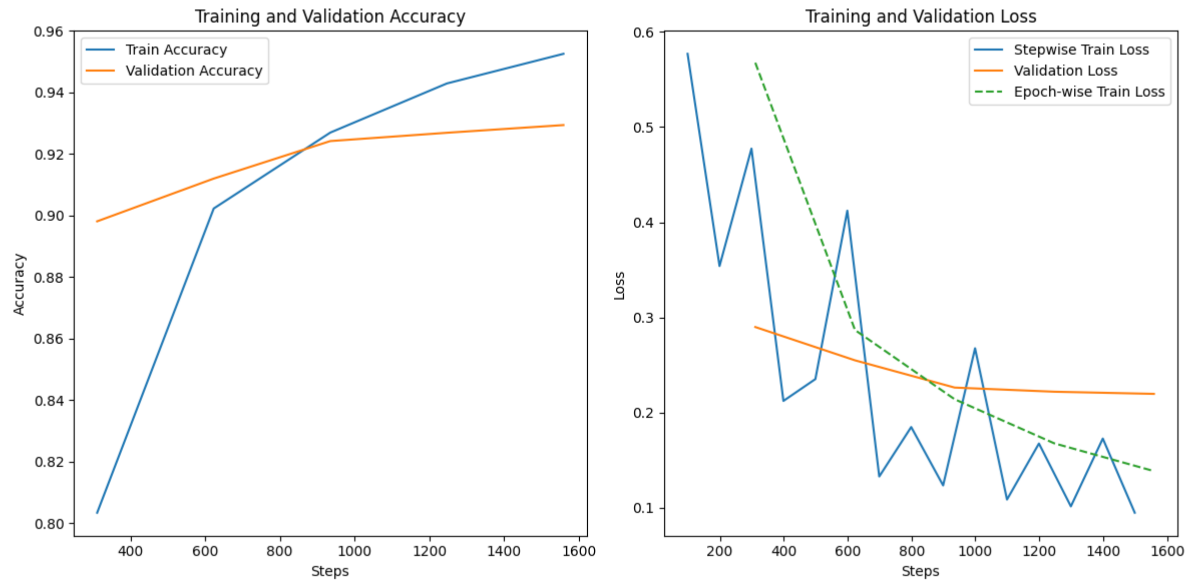
In [ ]:
```
lr      = 1e-3
lr_mult = 0.9

# placeholder
parameters = []

c=0

# store params & learning rates
for idx, name in enumerate(layer_names):

    if c < model_config['c']:

      lr = lr

      c+=1

    else:

      # append layer parameters
      parameters += [{'params': [p for n, p in model.named_parameters
() if n == name and p.requires_grad],
                      'lr':     lr}]
      lr /= lr_mult

      # update learning rate
      c+=1

      # display info
      print(f'{idx}: lr = {lr:.6f}, {name}')
```

```
0: lr = 0.001111, features.0.weight
1: lr = 0.001235, features.0.bias
2: lr = 0.001372, features.2.weight
3: lr = 0.001524, features.2.bias
4: lr = 0.001694, features.5.weight
5: lr = 0.001882, features.5.bias
6: lr = 0.002091, features.7.weight
7: lr = 0.002323, features.7.bias
8: lr = 0.002581, features.10.weight
9: lr = 0.002868, features.10.bias
10: lr = 0.003187, features.12.weight
11: lr = 0.003541, features.12.bias
12: lr = 0.003934, features.14.weight
13: lr = 0.004371, features.14.bias
14: lr = 0.004857, features.17.weight
15: lr = 0.005397, features.17.bias
16: lr = 0.005996, features.19.weight
17: lr = 0.006662, features.19.bias
18: lr = 0.007403, features.21.weight
19: lr = 0.008225, features.21.bias
20: lr = 0.009139, features.24.weight
21: lr = 0.010155, features.24.bias
22: lr = 0.011283, features.26.weight
23: lr = 0.012537, features.26.bias
24: lr = 0.013930, features.28.weight
25: lr = 0.015477, features.28.bias
26: lr = 0.017197, classifier.0.weight
27: lr = 0.019108, classifier.0.bias
28: lr = 0.021231, classifier.3.weight
29: lr = 0.023590, classifier.3.bias
30: lr = 0.026211, classifier.6.weight
31: lr = 0.029123, classifier.6.bias
```

In [ ]:
```
lightning_module_config['others']['optimizer_params'] = parameters
```

In [34]:
```
trainer.fit(lightning_module, dm)
file = f"{trainer.logger.log_dir}/metrics.csv"
plot_losses_acc(file)
ckpt_path = trainer.checkpoint_callback.best_model_path
# train_acc = trainer.validate(dataloaders=dm.train_dataloader(), ckpt
_path=ckpt_path, verbose=False)
valid_acc = trainer.validate(dataloaders=dm.val_dataloader(), ckpt_pat
h=ckpt_path, verbose=False)
test_acc = trainer.validate(dataloaders=dm.predict_dataloader(), ckpt_
path=ckpt_path, verbose=False)
# print(f"Train Accuracy: {train_acc[0]['val_metric']*100:0.2f}")
print(f"Validation Accuracy: {valid_acc[0]['val_metric']*100:0.2f}")
print(f"Test Accuracy: {test_acc[0]['val_metric']*100:0.2f}")
wandb.finish()
```

```
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified

INFO:pytorch_lightning.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_
DEVICES: [0]
/usr/local/lib/python3.10/dist-packages/pytorch_lightning/core/optimiz
er.py:289: RuntimeWarning: A `OneCycleLR` scheduler is using 'interva
l': 'epoch'. Are you sure you didn't mean 'interval': 'step'?
  rank_zero_warn(
INFO:pytorch_lightning.callbacks.model_summary:
  | Name         | Type               | Params
----------------------------------------------------
0 | model        | VGG                | 134 M
1 | loss_fn      | CrossEntropyLoss   | 0
2 | train_metric | MulticlassAccuracy | 0
3 | val_metric   | MulticlassAccuracy | 0
4 | test_metric  | MulticlassAccuracy | 0
----------------------------------------------------
132 M     Trainable params
1.7 M     Non-trainable params
134 M     Total params
537.206   Total estimated model params size (MB)

Epoch 1: Val_Loss: 2.34, Val_Metric: 0.12 |


Epoch 1: Val_Loss: 0.29, Val_Metric: 0.90 | Train_Loss: 0.57, Train_Me
tric: 0.80


Epoch 2: Val_Loss: 0.25, Val_Metric: 0.91 | Train_Loss: 0.29, Train_Me
tric: 0.90


Epoch 3: Val_Loss: 0.23, Val_Metric: 0.92 | Train_Loss: 0.21, Train_Me
tric: 0.93


Epoch 4: Val_Loss: 0.22, Val_Metric: 0.93 | Train_Loss: 0.17, Train_Me
tric: 0.94


Epoch 5: Val_Loss: 0.22, Val_Metric: 0.93 | Train_Loss: 0.14, Train_Me
tric: 0.95

INFO:pytorch_lightning.utilities.rank_zero:`Trainer.fit` stopped: `max
_epochs=5` reached.
```



```
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Files already downloaded and verified
Files already downloaded and verified

INFO:pytorch_lightning.utilities.rank_zero:Restoring states from the c
heckpoint path at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_App
lied_DeepLearning/Data/logs/csvlogger/version_103/checkpoints/epoch=4-
step=1560.ckpt
INFO:pytorch_lightning.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_
DEVICES: [0]
INFO:pytorch_lightning.utilities.rank_zero:Loaded model weights from t
he checkpoint at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_Appl
ied_DeepLearning/Data/logs/csvlogger/version_103/checkpoints/epoch=4-s
tep=1560.ckpt


Epoch 6: Val_Loss: 0.22, Val_Metric: 0.93 | Files already downloaded a
nd verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified

INFO:pytorch_lightning.utilities.rank_zero:Restoring states from the c
heckpoint path at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_App
lied_DeepLearning/Data/logs/csvlogger/version_103/checkpoints/epoch=4-
step=1560.ckpt
INFO:pytorch_lightning.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_
DEVICES: [0]
INFO:pytorch_lightning.utilities.rank_zero:Loaded model weights from t
he checkpoint at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_Appl
ied_DeepLearning/Data/logs/csvlogger/version_103/checkpoints/epoch=4-s
tep=1560.ckpt


Epoch 6: Val_Loss: 0.23, Val_Metric: 0.93 | Validation Accuracy: 92.94
Test Accuracy: 92.54
```

Run history:

epoch	
lr-AdamW	
train_loss_epoch	
train_loss_step	
train_metric	
trainer/global_step	
val_loss	
val_metric	

Run summary:

epoch	5
lr-AdamW	4e-05
train_loss_epoch	0.13857
train_loss_step	0.09484
train_metric	0.95257
trainer/global_step	1560
val_loss	0.2348
val_metric	0.9254

View run **cifar10_exp4** at: https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/8rxjoya0 (https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/8rxjoya0)
Synced 5 W&B file(s), 1 media file(s), 0 artifact file(s) and 0 other file(s)

Find logs at:
```
./drive/MyDrive/Colab_Notebooks/BUAN_6382_Applied_DeepLearning/Data/log
20231117_025026-8rxjoya0/logs
```

Task 6 (5 Points): Experimenting with a Different Pre-Trained Model

- Choose a different pre-trained model and adapt it for CIFAR-10.
  - Try atleast one model from convnext family
  - Try atleast one model from Resnet family
- Aim for a minimum accuracy of 94% on the test set. This task encourages exploration of different architectures and their suitability for the CIFAR-10 dataset.

Resnet model

In [35]:
```
import torchvision.models as models
def load_model(config):
    model = models.resnet34(weights='DEFAULT')

    for param in model.parameters():
        param.requires_grad = False

    # for i, requires_grad in enumerate(config['classifier']):
    #     if requires_grad:
    #         model.classifier[i].requires_grad_(True)
    for param in model.layer3.parameters():
        param.requires_grad = True

    for param in model.layer4.parameters():
        param.requires_grad = True

    # if i > 0:
    #   c = 0
    #   for param in model.parameters():
    #     c+=1
    #     if c>i:
    #         param.requires_grad = True
    model.fc = nn.Linear(512, config['output_size'],bias=True)
    return model
```

In [36]:
```
# Load components

free_memory()
seed_everything(42)
_, data_module_config, lightning_module_config, cl_config, trainer_con
fig = load_all_configs()

# override default values

trainer_config['max_epochs']=5
trainer_config['gradient_clip_val']=1
trainer_config['log_every_n_steps']=100

# lightning module config
lightning_module_config['others']['optimizer_params']['weight_decay']=
1
lightning_module_config['others']['learning_rate']=0.001

# Setting the scheduler class
lightning_module_config['scheduler_cls'] = 'torch.optim.lr_scheduler.O
neCycleLR'

# Parameters for the OneCycleLR
# Note: 'max_lr' is a required parameter for OneCycleLR; you'll need t
o specify it based on your needs
lightning_module_config['scheduler_params'] = {'max_lr':1e-3,'steps_pe
r_epoch':75, 'final_div_factor': 1e4, 'div_factor': 25.0, 'pct_start':
0.3, 'anneal_strategy':'cos','epochs':4}

# Options related to the monitoring of the scheduler (if needed)
lightning_module_config['scheduler_options'] = {'monitor': 'val_loss',
'interval': 'epoch', 'frequency': 1}

# logging
cl_config['lr_monitor']['logging_interval']='epoch'
cl_config['wandb']['project']='cifar10_multiclass_CNN'
cl_config['wandb']['name']='cifar10_exp5'

# Data Module
data_module_config['data_module']['batch_size']=128

# Model config
model_config = {'output_size': 10}

model, dm, lightning_module, trainer = load_components(model_config, d
ata_module_config,
                                                        lightning_modul
e_config, data_folder, trainer_config,
                                                         cl_config, bat
ch_size=data_module_config['data_module']['batch_size'],
                                                         logging=True,
checkpointing=False, early_stopping=False)
dm.setup('fit')
print_requires_grad(model=model)
trainer.fit(lightning_module, dm)
file = f"{trainer.logger.log_dir}/metrics.csv"
plot_losses_acc(file)
```

```
ckpt_path = trainer.checkpoint_callback.best_model_path
# train_acc = trainer.validate(dataloaders=dm.train_dataloader(), ckpt
_path=ckpt_path, verbose=False)
valid_acc = trainer.validate(dataloaders=dm.val_dataloader(), ckpt_pat
h=ckpt_path, verbose=False)
test_acc = trainer.validate(dataloaders=dm.predict_dataloader(), ckpt_
path=ckpt_path, verbose=False)
# print(f"Train Accuracy: {train_acc[0]['val_metric']*100:0.2f}")
print(f"Validation Accuracy: {valid_acc[0]['val_metric']*100:0.2f}")
print(f"Test Accuracy: {test_acc[0]['val_metric']*100:0.2f}")
wandb.finish()
```

```
INFO:lightning_fabric.utilities.seed:Global seed set to 42
Downloading: "https://download.pytorch.org/models/resnet34-b627a593.pt
h" to /root/.cache/torch/hub/checkpoints/resnet34-b627a593.pth
100%|██████████| 83.3M/83.3M [00:00<00:00, 150MB/s]
```

Tracking run with wandb version 0.16.0

Run data is saved locally in
`/content/drive/MyDrive/Colab_Notebooks/BUAN_6382_Applied_DeepLearning/D`
`20231117_031220-nlw21c5v`

Syncing run **cifar10_exp5 (https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/nlw21c5v)** to Weights & Biases (https://wandb.ai/harikrishnad/cifar10_multiclass_CNN) (docs (https://wandb.me/run))

View project at https://wandb.ai/harikrishnad/cifar10_multiclass_CNN (https://wandb.ai/harikrishnad/cifar10_multiclass_CNN)

View run at https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/nlw21c5v (https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/nlw21c5v)

```
wandb: logging graph, to disable use `wandb.watch(log_graph=False)`
INFO:pytorch_lightning.utilities.rank_zero:GPU available: True (cuda),
used: True
INFO:pytorch_lightning.utilities.rank_zero:TPU available: False, usin
g: 0 TPU cores
INFO:pytorch_lightning.utilities.rank_zero:IPU available: False, usin
g: 0 IPUs
INFO:pytorch_lightning.utilities.rank_zero:HPU available: False, usin
g: 0 HPUs
INFO:pytorch_lightning.utilities.rank_zero:`Trainer(limit_train_batche
s=1.0)` was configured so 100% of the batches per epoch will be used..
INFO:pytorch_lightning.utilities.rank_zero:`Trainer(limit_val_batches=
1.0)` was configured so 100% of the batches will be used..
INFO:pytorch_lightning.utilities.rank_zero:`Trainer(limit_test_batches
=1.0)` was configured so 100% of the batches will be used..
```

```
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified
conv1.weight: requires_grad=False
bn1.weight: requires_grad=False
bn1.bias: requires_grad=False
layer1.0.conv1.weight: requires_grad=False
layer1.0.bn1.weight: requires_grad=False
layer1.0.bn1.bias: requires_grad=False
layer1.0.conv2.weight: requires_grad=False
layer1.0.bn2.weight: requires_grad=False
layer1.0.bn2.bias: requires_grad=False
layer1.1.conv1.weight: requires_grad=False
layer1.1.bn1.weight: requires_grad=False
layer1.1.bn1.bias: requires_grad=False
layer1.1.conv2.weight: requires_grad=False
layer1.1.bn2.weight: requires_grad=False
layer1.1.bn2.bias: requires_grad=False
layer1.2.conv1.weight: requires_grad=False
layer1.2.bn1.weight: requires_grad=False
layer1.2.bn1.bias: requires_grad=False
layer1.2.conv2.weight: requires_grad=False
layer1.2.bn2.weight: requires_grad=False
layer1.2.bn2.bias: requires_grad=False
layer2.0.conv1.weight: requires_grad=False
layer2.0.bn1.weight: requires_grad=False
layer2.0.bn1.bias: requires_grad=False
layer2.0.conv2.weight: requires_grad=False
layer2.0.bn2.weight: requires_grad=False
layer2.0.bn2.bias: requires_grad=False
layer2.0.downsample.0.weight: requires_grad=False
layer2.0.downsample.1.weight: requires_grad=False
layer2.0.downsample.1.bias: requires_grad=False
layer2.1.conv1.weight: requires_grad=False
layer2.1.bn1.weight: requires_grad=False
layer2.1.bn1.bias: requires_grad=False
layer2.1.conv2.weight: requires_grad=False
layer2.1.bn2.weight: requires_grad=False
layer2.1.bn2.bias: requires_grad=False
layer2.2.conv1.weight: requires_grad=False
layer2.2.bn1.weight: requires_grad=False
layer2.2.bn1.bias: requires_grad=False
layer2.2.conv2.weight: requires_grad=False
layer2.2.bn2.weight: requires_grad=False
layer2.2.bn2.bias: requires_grad=False
layer2.3.conv1.weight: requires_grad=False
layer2.3.bn1.weight: requires_grad=False
layer2.3.bn1.bias: requires_grad=False
layer2.3.conv2.weight: requires_grad=False
layer2.3.bn2.weight: requires_grad=False
layer2.3.bn2.bias: requires_grad=False
layer3.0.conv1.weight: requires_grad=True
layer3.0.bn1.weight: requires_grad=True
layer3.0.bn1.bias: requires_grad=True
layer3.0.conv2.weight: requires_grad=True
layer3.0.bn2.weight: requires_grad=True
layer3.0.bn2.bias: requires_grad=True
```

```
layer3.0.downsample.0.weight: requires_grad=True
layer3.0.downsample.1.weight: requires_grad=True
layer3.0.downsample.1.bias: requires_grad=True
layer3.1.conv1.weight: requires_grad=True
layer3.1.bn1.weight: requires_grad=True
layer3.1.bn1.bias: requires_grad=True
layer3.1.conv2.weight: requires_grad=True
layer3.1.bn2.weight: requires_grad=True
layer3.1.bn2.bias: requires_grad=True
layer3.2.conv1.weight: requires_grad=True
layer3.2.bn1.weight: requires_grad=True
layer3.2.bn1.bias: requires_grad=True
layer3.2.conv2.weight: requires_grad=True
layer3.2.bn2.weight: requires_grad=True
layer3.2.bn2.bias: requires_grad=True
layer3.3.conv1.weight: requires_grad=True
layer3.3.bn1.weight: requires_grad=True
layer3.3.bn1.bias: requires_grad=True
layer3.3.conv2.weight: requires_grad=True
layer3.3.bn2.weight: requires_grad=True
layer3.3.bn2.bias: requires_grad=True
layer3.4.conv1.weight: requires_grad=True
layer3.4.bn1.weight: requires_grad=True
layer3.4.bn1.bias: requires_grad=True
layer3.4.conv2.weight: requires_grad=True
layer3.4.bn2.weight: requires_grad=True
layer3.4.bn2.bias: requires_grad=True
layer3.5.conv1.weight: requires_grad=True
layer3.5.bn1.weight: requires_grad=True
layer3.5.bn1.bias: requires_grad=True
layer3.5.conv2.weight: requires_grad=True
layer3.5.bn2.weight: requires_grad=True
layer3.5.bn2.bias: requires_grad=True
layer4.0.conv1.weight: requires_grad=True
layer4.0.bn1.weight: requires_grad=True
layer4.0.bn1.bias: requires_grad=True
layer4.0.conv2.weight: requires_grad=True
layer4.0.bn2.weight: requires_grad=True
layer4.0.bn2.bias: requires_grad=True
layer4.0.downsample.0.weight: requires_grad=True
layer4.0.downsample.1.weight: requires_grad=True
layer4.0.downsample.1.bias: requires_grad=True
layer4.1.conv1.weight: requires_grad=True
layer4.1.bn1.weight: requires_grad=True
layer4.1.bn1.bias: requires_grad=True
layer4.1.conv2.weight: requires_grad=True
layer4.1.bn2.weight: requires_grad=True
layer4.1.bn2.bias: requires_grad=True
layer4.2.conv1.weight: requires_grad=True
layer4.2.bn1.weight: requires_grad=True
layer4.2.bn1.bias: requires_grad=True
layer4.2.conv2.weight: requires_grad=True
layer4.2.bn2.weight: requires_grad=True
layer4.2.bn2.bias: requires_grad=True
fc.weight: requires_grad=True
fc.bias: requires_grad=True
Files already downloaded and verified
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Files already downloaded and verified
Files already downloaded and verified

INFO:pytorch_lightning.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_
DEVICES: [0]
/usr/local/lib/python3.10/dist-packages/pytorch_lightning/core/optimiz
er.py:289: RuntimeWarning: A `OneCycleLR` scheduler is using 'interva
l': 'epoch'. Are you sure you didn't mean 'interval': 'step'?
  rank_zero_warn(
INFO:pytorch_lightning.callbacks.model_summary:
  | Name         | Type               | Params
----------------------------------------------------
0 | model        | ResNet             | 21.3 M
1 | loss_fn      | CrossEntropyLoss   | 0
2 | train_metric | MulticlassAccuracy | 0
3 | val_metric   | MulticlassAccuracy | 0
4 | test_metric  | MulticlassAccuracy | 0
----------------------------------------------------
19.9 M    Trainable params
1.3 M     Non-trainable params
21.3 M    Total params
85.159    Total estimated model params size (MB)


Epoch 1: Val_Loss: 2.76, Val_Metric: 0.09 |


/usr/local/lib/python3.10/dist-packages/torchvision/transforms/functio
nal.py:1603: UserWarning: The default value of the antialias parameter
of all the resizing transforms (Resize(), RandomResizedCrop(), etc.) w
ill change from None to True in v0.17, in order to be consistent acros
s the PIL and Tensor backends. To suppress this warning, directly pass
antialias=True (recommended, future default), antialias=None (current
default, which means False for Tensors and True for PIL), or antialias
=False (only works on Tensors - PIL will still use antialiasing). This
also applies if you are using the inference transforms from the models
weights: update the call to weights.transforms(antialias=True).
  warnings.warn(


Epoch 1: Val_Loss: 0.20, Val_Metric: 0.93 | Train_Loss: 0.47, Train_Me
tric: 0.85


Epoch 2: Val_Loss: 0.17, Val_Metric: 0.94 | Train_Loss: 0.18, Train_Me
tric: 0.94


Epoch 3: Val_Loss: 0.15, Val_Metric: 0.95 | Train_Loss: 0.12, Train_Me
tric: 0.96


Epoch 4: Val_Loss: 0.15, Val_Metric: 0.95 | Train_Loss: 0.09, Train_Me
tric: 0.97


Epoch 5: Val_Loss: 0.16, Val_Metric: 0.95 | Train_Loss: 0.07, Train_Me
tric: 0.98
```
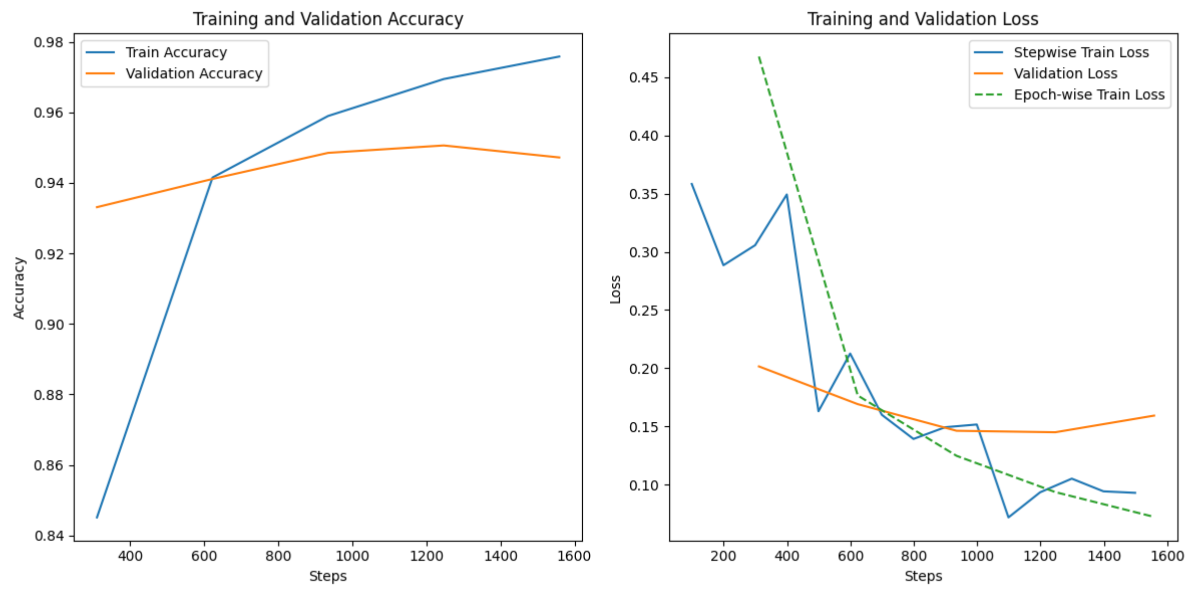

```
INFO:pytorch_lightning.utilities.rank_zero:`Trainer.fit` stopped: `max
_epochs=5` reached.
```



```
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified

INFO:pytorch_lightning.utilities.rank_zero:Restoring states from the c
heckpoint path at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_App
lied_DeepLearning/Data/logs/csvlogger/version_104/checkpoints/epoch=4-
step=1560.ckpt
INFO:pytorch_lightning.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_
DEVICES: [0]
INFO:pytorch_lightning.utilities.rank_zero:Loaded model weights from t
he checkpoint at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_Appl
ied_DeepLearning/Data/logs/csvlogger/version_104/checkpoints/epoch=4-s
tep=1560.ckpt


Epoch 6: Val_Loss: 0.16, Val_Metric: 0.95 | Files already downloaded a
nd verified
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Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified

INFO:pytorch_lightning.utilities.rank_zero:Restoring states from the c
heckpoint path at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_App
lied_DeepLearning/Data/logs/csvlogger/version_104/checkpoints/epoch=4-
step=1560.ckpt
INFO:pytorch_lightning.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_
DEVICES: [0]
INFO:pytorch_lightning.utilities.rank_zero:Loaded model weights from t
he checkpoint at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_Appl
ied_DeepLearning/Data/logs/csvlogger/version_104/checkpoints/epoch=4-s
tep=1560.ckpt
```
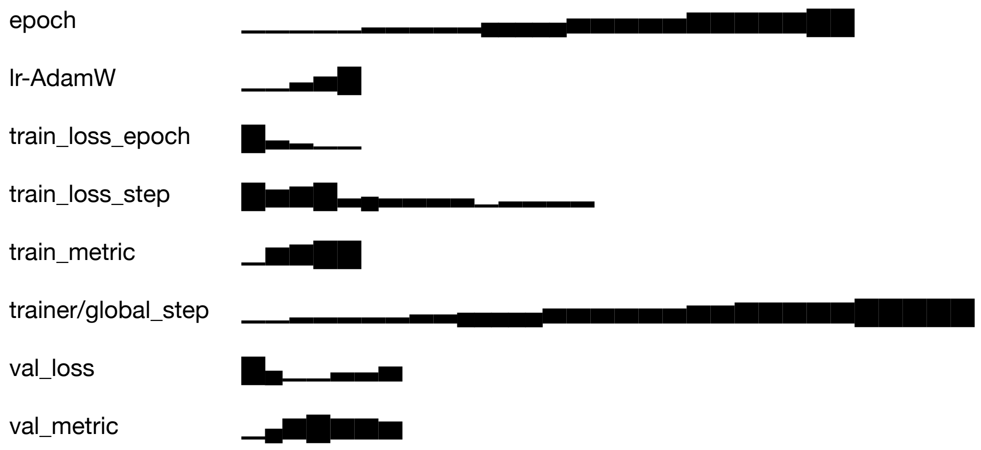

```
Epoch 6: Val_Loss: 0.18, Val_Metric: 0.95 | Validation Accuracy: 94.72
Test Accuracy: 94.57
```

Run history:



Run summary:

epoch	5
lr-AdamW	4e-05
train_loss_epoch	0.07245
train_loss_step	0.09311
train_metric	0.97581
trainer/global_step	1560
val_loss	0.17923
val_metric	0.9457

View run **cifar10_exp5** at:
https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/nlw21c5v
(https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/nlw21c5v)
Synced 5 W&B file(s), 1 media file(s), 0 artifact file(s) and 0 other file(s)

Find logs at:
```
./drive/MyDrive/Colab_Notebooks/BUAN_6382_Applied_DeepLearning/Data/log
20231117_031220-nlw21c5v/logs
```

Convnext model

```
In [39]: import torchvision.models as models
         def load_model(config):
             model = models.convnext_tiny(weights='DEFAULT')

             for param in model.parameters():
                 param.requires_grad = False

             # for i, requires_grad in enumerate(config['classifier']):
             #     if requires_grad:
             #         model.classifier[i].requires_grad_(True)
             for param in model.features[7].parameters():
                 param.requires_grad = True

             for param in model.classifier.parameters():
                 param.requires_grad = True

             # if i > 0:
             #   c = 0
             #   for param in model.parameters():
             #     c+=1
             #     if c>i:
             #         param.requires_grad = True
             model.classifier[2] = nn.Linear(768, config['output_size'],bias=Tr
         ue)
             return model
```

```
In [40]: # Load components

         free_memory()
         seed_everything(42)
         _, data_module_config, lightning_module_config, cl_config, trainer_con
         fig = load_all_configs()

         # override default values

         trainer_config['max_epochs']=5
         trainer_config['gradient_clip_val']=1
         trainer_config['log_every_n_steps']=100

         # lightning module config
         lightning_module_config['others']['optimizer_params']['weight_decay']=
         1
         lightning_module_config['others']['learning_rate']=0.001

         # Setting the scheduler class
         lightning_module_config['scheduler_cls'] = 'torch.optim.lr_scheduler.O
         neCycleLR'

         # Parameters for the OneCycleLR
         # Note: 'max_lr' is a required parameter for OneCycleLR; you'll need t
         o specify it based on your needs
         lightning_module_config['scheduler_params'] = {'max_lr':1e-3,'steps_pe
         r_epoch':75, 'final_div_factor': 1e4, 'div_factor': 25.0, 'pct_start':
         0.3, 'anneal_strategy':'cos','epochs':4}

         # Options related to the monitoring of the scheduler (if needed)
         lightning_module_config['scheduler_options'] = {'monitor': 'val_loss',
         'interval': 'epoch', 'frequency': 1}

         # logging
         cl_config['lr_monitor']['logging_interval']='epoch'
         cl_config['wandb']['project']='cifar10_multiclass_CNN'
         cl_config['wandb']['name']='cifar10_exp6'

         # Data Module
         data_module_config['data_module']['batch_size']=128

         # Model config
         model_config = {'output_size': 10}

         model, dm, lightning_module, trainer = load_components(model_config, d
         ata_module_config,
                                                                lightning_modul
         e_config, data_folder, trainer_config,
                                                                 cl_config, bat
         ch_size=data_module_config['data_module']['batch_size'],
                                                                 logging=True,
         checkpointing=False, early_stopping=False)
         dm.setup('fit')
         print_requires_grad(model=model)
         trainer.fit(lightning_module, dm)
         file = f"{trainer.logger.log_dir}/metrics.csv"
         plot_losses_acc(file)
```

```python
ckpt_path = trainer.checkpoint_callback.best_model_path
# train_acc = trainer.validate(dataloaders=dm.train_dataloader(), ckpt
_path=ckpt_path, verbose=False)
valid_acc = trainer.validate(dataloaders=dm.val_dataloader(), ckpt_pat
h=ckpt_path, verbose=False)
test_acc = trainer.validate(dataloaders=dm.predict_dataloader(), ckpt_
path=ckpt_path, verbose=False)
# print(f"Train Accuracy: {train_acc[0]['val_metric']*100:0.2f}")
print(f"Validation Accuracy: {valid_acc[0]['val_metric']*100:0.2f}")
print(f"Test Accuracy: {test_acc[0]['val_metric']*100:0.2f}")
wandb.finish()
```

```
INFO:lightning_fabric.utilities.seed:Global seed set to 42
```

Tracking run with wandb version 0.16.0

Run data is saved locally in
`/content/drive/MyDrive/Colab_Notebooks/BUAN_6382_Applied_DeepLearning/D`
`20231117_071635-t3m0jx6z`

Syncing run **cifar10_exp6 (https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/t3m0jx6z)** to Weights & Biases (https://wandb.ai/harikrishnad/cifar10_multiclass_CNN) (docs (https://wandb.me/run))

View project at https://wandb.ai/harikrishnad/cifar10_multiclass_CNN (https://wandb.ai/harikrishnad/cifar10_multiclass_CNN)

View run at https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/t3m0jx6z (https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/t3m0jx6z)

```
wandb: logging graph, to disable use `wandb.watch(log_graph=False)`
INFO:pytorch_lightning.utilities.rank_zero:GPU available: True (cuda),
used: True
INFO:pytorch_lightning.utilities.rank_zero:TPU available: False, usin
g: 0 TPU cores
INFO:pytorch_lightning.utilities.rank_zero:IPU available: False, usin
g: 0 IPUs
INFO:pytorch_lightning.utilities.rank_zero:HPU available: False, usin
g: 0 HPUs
INFO:pytorch_lightning.utilities.rank_zero:`Trainer(limit_train_batche
s=1.0)` was configured so 100% of the batches per epoch will be used..
INFO:pytorch_lightning.utilities.rank_zero:`Trainer(limit_val_batches=
1.0)` was configured so 100% of the batches will be used..
INFO:pytorch_lightning.utilities.rank_zero:`Trainer(limit_test_batches
=1.0)` was configured so 100% of the batches will be used..
```

```
Files already downloaded and verified
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Files already downloaded and verified
features.0.0.weight: requires_grad=False
features.0.0.bias: requires_grad=False
features.0.1.weight: requires_grad=False
features.0.1.bias: requires_grad=False
features.1.0.layer_scale: requires_grad=False
features.1.0.block.0.weight: requires_grad=False
features.1.0.block.0.bias: requires_grad=False
features.1.0.block.2.weight: requires_grad=False
features.1.0.block.2.bias: requires_grad=False
features.1.0.block.3.weight: requires_grad=False
features.1.0.block.3.bias: requires_grad=False
features.1.0.block.5.weight: requires_grad=False
features.1.0.block.5.bias: requires_grad=False
features.1.1.layer_scale: requires_grad=False
features.1.1.block.0.weight: requires_grad=False
features.1.1.block.0.bias: requires_grad=False
features.1.1.block.2.weight: requires_grad=False
features.1.1.block.2.bias: requires_grad=False
features.1.1.block.3.weight: requires_grad=False
features.1.1.block.3.bias: requires_grad=False
features.1.1.block.5.weight: requires_grad=False
features.1.1.block.5.bias: requires_grad=False
features.1.2.layer_scale: requires_grad=False
features.1.2.block.0.weight: requires_grad=False
features.1.2.block.0.bias: requires_grad=False
features.1.2.block.2.weight: requires_grad=False
features.1.2.block.2.bias: requires_grad=False
features.1.2.block.3.weight: requires_grad=False
features.1.2.block.3.bias: requires_grad=False
features.1.2.block.5.weight: requires_grad=False
features.1.2.block.5.bias: requires_grad=False
features.2.0.weight: requires_grad=False
features.2.0.bias: requires_grad=False
features.2.1.weight: requires_grad=False
features.2.1.bias: requires_grad=False
features.3.0.layer_scale: requires_grad=False
features.3.0.block.0.weight: requires_grad=False
features.3.0.block.0.bias: requires_grad=False
features.3.0.block.2.weight: requires_grad=False
features.3.0.block.2.bias: requires_grad=False
features.3.0.block.3.weight: requires_grad=False
features.3.0.block.3.bias: requires_grad=False
features.3.0.block.5.weight: requires_grad=False
features.3.0.block.5.bias: requires_grad=False
features.3.1.layer_scale: requires_grad=False
features.3.1.block.0.weight: requires_grad=False
features.3.1.block.0.bias: requires_grad=False
features.3.1.block.2.weight: requires_grad=False
features.3.1.block.2.bias: requires_grad=False
features.3.1.block.3.weight: requires_grad=False
features.3.1.block.3.bias: requires_grad=False
features.3.1.block.5.weight: requires_grad=False
features.3.1.block.5.bias: requires_grad=False
features.3.2.layer_scale: requires_grad=False
features.3.2.block.0.weight: requires_grad=False
features.3.2.block.0.bias: requires_grad=False
features.3.2.block.2.weight: requires_grad=False
features.3.2.block.2.bias: requires_grad=False
features.3.2.block.3.weight: requires_grad=False
features.3.2.block.3.bias: requires_grad=False
features.3.2.block.5.weight: requires_grad=False
features.3.2.block.5.bias: requires_grad=False
features.4.0.weight: requires_grad=False
features.4.0.bias: requires_grad=False
features.4.1.weight: requires_grad=False
features.4.1.bias: requires_grad=False
features.5.0.layer_scale: requires_grad=False
features.5.0.block.0.weight: requires_grad=False
features.5.0.block.0.bias: requires_grad=False
features.5.0.block.2.weight: requires_grad=False
features.5.0.block.2.bias: requires_grad=False
features.5.0.block.3.weight: requires_grad=False
features.5.0.block.3.bias: requires_grad=False
features.5.0.block.5.weight: requires_grad=False
features.5.0.block.5.bias: requires_grad=False
features.5.1.layer_scale: requires_grad=False
features.5.1.block.0.weight: requires_grad=False
features.5.1.block.0.bias: requires_grad=False
features.5.1.block.2.weight: requires_grad=False
features.5.1.block.2.bias: requires_grad=False
features.5.1.block.3.weight: requires_grad=False
features.5.1.block.3.bias: requires_grad=False
features.5.1.block.5.weight: requires_grad=False
features.5.1.block.5.bias: requires_grad=False
features.5.2.layer_scale: requires_grad=False
features.5.2.block.0.weight: requires_grad=False
features.5.2.block.0.bias: requires_grad=False
features.5.2.block.2.weight: requires_grad=False
features.5.2.block.2.bias: requires_grad=False
features.5.2.block.3.weight: requires_grad=False
features.5.2.block.3.bias: requires_grad=False
features.5.2.block.5.weight: requires_grad=False
features.5.2.block.5.bias: requires_grad=False
features.5.3.layer_scale: requires_grad=False
features.5.3.block.0.weight: requires_grad=False
features.5.3.block.0.bias: requires_grad=False
features.5.3.block.2.weight: requires_grad=False
features.5.3.block.2.bias: requires_grad=False
features.5.3.block.3.weight: requires_grad=False
features.5.3.block.3.bias: requires_grad=False
features.5.3.block.5.weight: requires_grad=False
features.5.3.block.5.bias: requires_grad=False
features.5.4.layer_scale: requires_grad=False
features.5.4.block.0.weight: requires_grad=False
features.5.4.block.0.bias: requires_grad=False
features.5.4.block.2.weight: requires_grad=False
features.5.4.block.2.bias: requires_grad=False
features.5.4.block.3.weight: requires_grad=False
features.5.4.block.3.bias: requires_grad=False
features.5.4.block.5.weight: requires_grad=False
features.5.4.block.5.bias: requires_grad=False
features.5.5.layer_scale: requires_grad=False
features.5.5.block.0.weight: requires_grad=False
features.5.5.block.0.bias: requires_grad=False
features.5.5.block.2.weight: requires_grad=False
features.5.5.block.2.bias: requires_grad=False
features.5.5.block.3.weight: requires_grad=False
features.5.5.block.3.bias: requires_grad=False
features.5.5.block.5.weight: requires_grad=False
features.5.5.block.5.bias: requires_grad=False
features.5.6.layer_scale: requires_grad=False
features.5.6.block.0.weight: requires_grad=False
features.5.6.block.0.bias: requires_grad=False
features.5.6.block.2.weight: requires_grad=False
features.5.6.block.2.bias: requires_grad=False
features.5.6.block.3.weight: requires_grad=False
features.5.6.block.3.bias: requires_grad=False
features.5.6.block.5.weight: requires_grad=False
features.5.6.block.5.bias: requires_grad=False
features.5.7.layer_scale: requires_grad=False
features.5.7.block.0.weight: requires_grad=False
features.5.7.block.0.bias: requires_grad=False
features.5.7.block.2.weight: requires_grad=False
features.5.7.block.2.bias: requires_grad=False
features.5.7.block.3.weight: requires_grad=False
features.5.7.block.3.bias: requires_grad=False
features.5.7.block.5.weight: requires_grad=False
features.5.7.block.5.bias: requires_grad=False
features.5.8.layer_scale: requires_grad=False
features.5.8.block.0.weight: requires_grad=False
features.5.8.block.0.bias: requires_grad=False
features.5.8.block.2.weight: requires_grad=False
features.5.8.block.2.bias: requires_grad=False
features.5.8.block.3.weight: requires_grad=False
features.5.8.block.3.bias: requires_grad=False
features.5.8.block.5.weight: requires_grad=False
features.5.8.block.5.bias: requires_grad=False
features.6.0.weight: requires_grad=False
features.6.0.bias: requires_grad=False
features.6.1.weight: requires_grad=False
features.6.1.bias: requires_grad=False
features.7.0.layer_scale: requires_grad=True
features.7.0.block.0.weight: requires_grad=True
features.7.0.block.0.bias: requires_grad=True
features.7.0.block.2.weight: requires_grad=True
features.7.0.block.2.bias: requires_grad=True
features.7.0.block.3.weight: requires_grad=True
features.7.0.block.3.bias: requires_grad=True
features.7.0.block.5.weight: requires_grad=True
features.7.0.block.5.bias: requires_grad=True
features.7.1.layer_scale: requires_grad=True
features.7.1.block.0.weight: requires_grad=True
features.7.1.block.0.bias: requires_grad=True
features.7.1.block.2.weight: requires_grad=True
features.7.1.block.2.bias: requires_grad=True
features.7.1.block.3.weight: requires_grad=True
features.7.1.block.3.bias: requires_grad=True
features.7.1.block.5.weight: requires_grad=True
features.7.1.block.5.bias: requires_grad=True
features.7.2.layer_scale: requires_grad=True
features.7.2.block.0.weight: requires_grad=True
features.7.2.block.0.bias: requires_grad=True
features.7.2.block.2.weight: requires_grad=True
features.7.2.block.2.bias: requires_grad=True
features.7.2.block.3.weight: requires_grad=True
features.7.2.block.3.bias: requires_grad=True
features.7.2.block.5.weight: requires_grad=True
features.7.2.block.5.bias: requires_grad=True
classifier.0.weight: requires_grad=True
classifier.0.bias: requires_grad=True
classifier.2.weight: requires_grad=True
classifier.2.bias: requires_grad=True
Files already downloaded and verified
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Files already downloaded and verified
Files already downloaded and verified
```

```
INFO:pytorch_lightning.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_
DEVICES: [0]
/usr/local/lib/python3.10/dist-packages/pytorch_lightning/core/optimiz
er.py:289: RuntimeWarning: A `OneCycleLR` scheduler is using 'interva
l': 'epoch'. Are you sure you didn't mean 'interval': 'step'?
  rank_zero_warn(
INFO:pytorch_lightning.callbacks.model_summary:
  | Name         | Type               | Params
----------------------------------------------------
0 | model        | ConvNeXt           | 27.8 M
1 | loss_fn      | CrossEntropyLoss   | 0
2 | train_metric | MulticlassAccuracy | 0
3 | val_metric   | MulticlassAccuracy | 0
4 | test_metric  | MulticlassAccuracy | 0
----------------------------------------------------
14.3 M    Trainable params
13.5 M    Non-trainable params
27.8 M    Total params
111.311   Total estimated model params size (MB)
```

```
Epoch 1: Val_Loss: 2.28, Val_Metric: 0.21 |
```

```
/usr/local/lib/python3.10/dist-packages/torchvision/transforms/functio
nal.py:1603: UserWarning: The default value of the antialias parameter
of all the resizing transforms (Resize(), RandomResizedCrop(), etc.) w
ill change from None to True in v0.17, in order to be consistent acros
s the PIL and Tensor backends. To suppress this warning, directly pass
antialias=True (recommended, future default), antialias=None (current
default, which means False for Tensors and True for PIL), or antialias
=False (only works on Tensors - PIL will still use antialiasing). This
also applies if you are using the inference transforms from the models
weights: update the call to weights.transforms(antialias=True).
  warnings.warn(
```

```
Epoch 1: Val_Loss: 0.17, Val_Metric: 0.94 | Train_Loss: 0.63, Train_Me
tric: 0.84
```

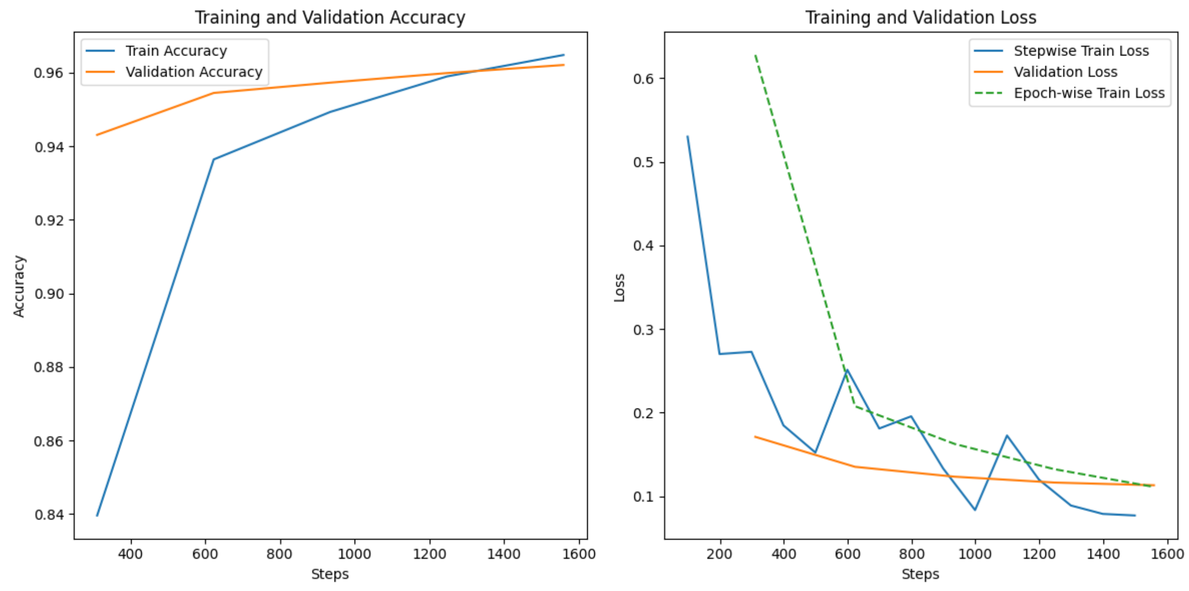
```
Epoch 2: Val_Loss: 0.14, Val_Metric: 0.95 | Train_Loss: 0.21, Train_Me
tric: 0.94


Epoch 3: Val_Loss: 0.12, Val_Metric: 0.96 | Train_Loss: 0.16, Train_Me
tric: 0.95


Epoch 4: Val_Loss: 0.12, Val_Metric: 0.96 | Train_Loss: 0.13, Train_Me
tric: 0.96


Epoch 5: Val_Loss: 0.11, Val_Metric: 0.96 | Train_Loss: 0.11, Train_Me
tric: 0.96

INFO:pytorch_lightning.utilities.rank_zero:`Trainer.fit` stopped: `max
_epochs=5` reached.
```



```
Files already downloaded and verified
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Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified

INFO:pytorch_lightning.utilities.rank_zero:Restoring states from the c
heckpoint path at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_App
lied_DeepLearning/Data/logs/csvlogger/version_106/checkpoints/epoch=4-
step=1560.ckpt
INFO:pytorch_lightning.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_
DEVICES: [0]
INFO:pytorch_lightning.utilities.rank_zero:Loaded model weights from t
he checkpoint at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_Appl
ied_DeepLearning/Data/logs/csvlogger/version_106/checkpoints/epoch=4-s
tep=1560.ckpt
```

```
Epoch 6: Val_Loss: 0.11, Val_Metric: 0.96 | Files already downloaded a
nd verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified
Files already downloaded and verified

INFO:pytorch_lightning.utilities.rank_zero:Restoring states from the c
heckpoint path at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_App
lied_DeepLearning/Data/logs/csvlogger/version_106/checkpoints/epoch=4-
step=1560.ckpt
INFO:pytorch_lightning.accelerators.cuda:LOCAL_RANK: 0 - CUDA_VISIBLE_
DEVICES: [0]
INFO:pytorch_lightning.utilities.rank_zero:Loaded model weights from t
he checkpoint at /content/drive/MyDrive/Colab_Notebooks/BUAN_6382_Appl
ied_DeepLearning/Data/logs/csvlogger/version_106/checkpoints/epoch=4-s
tep=1560.ckpt


Epoch 6: Val_Loss: 0.13, Val_Metric: 0.96 | Validation Accuracy: 96.21
Test Accuracy: 95.69
```

Run history:

epoch	
lr-AdamW	
train_loss_epoch	
train_loss_step	
train_metric	
trainer/global_step	
val_loss	
val_metric	

Run summary:

epoch	5
lr-AdamW	4e-05
train_loss_epoch	0.111
train_loss_step	0.07684
train_metric	0.96482
trainer/global_step	1560
val_loss	0.13227
val_metric	0.9569

View run cifar10_exp6 at:
https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/t3m0jx6z
(https://wandb.ai/harikrishnad/cifar10_multiclass_CNN/runs/t3m0jx6z)
Synced 5 W&B file(s), 1 media file(s), 0 artifact file(s) and 0 other file(s)

Find logs at:
```
./drive/MyDrive/Colab_Notebooks/BUAN_6382_Applied_DeepLearning/Data/log
20231117_071635-t3m0jx6z/logs
```