```
from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force_remount=T
```

```
import os
import time
import torch
import torch.nn as nn
import torchvision
from torchvision import datasets
from PIL import Image
from torchvision import transforms
from torch.utils.data import Dataset, DataLoader

import numpy as np
from tqdm import tqdm
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split


def aspect_ratio_preserving_resize(image, target_size):
    width, height = image.size
    target_width, target_height = target_size

    # Calculate the aspect ratio
    aspect_ratio = width / height

    if width > height:
        new_width = target_width
        new_height = int(new_width / aspect_ratio)
    else:
        new_height = target_height
        new_width = int(new_height * aspect_ratio)

    # Perform the resize
    image = transforms.functional.resize(image, (new_height, new_width))

    # Create a new image with the target size and paste the resized image in the center
    new_image = Image.new("L", target_size)
    new_image.paste(image, ((target_width - new_width) // 2, (target_height - new_height) // 2))

    return new_image


class MyDataset(Dataset):
    def __init__(self, data_dir, transform=None):
        self.data_dir = data_dir
        self.transform = transform
        self.image_paths = [os.path.join(data_dir, file) for file in os.listdir(data_dir)]

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

    def __getitem__(self, idx):
        image_path = self.image_paths[idx]
        image = Image.open(image_path)

        # Apply aspect ratio-preserving resize
        resized_image = aspect_ratio_preserving_resize(image, (100, 100))

        if self.transform:
            transformed_image = self.transform(resized_image)
        else:
            transformed_image = resized_image

        return transformed_image


# Define your data transformation
train_transform = transforms.Compose([
    transforms.Resize((100, 100)),
    transforms.RandomHorizontalFlip(p=0.2),
    transforms.RandomVerticalFlip(p=0.2),
    transforms.RandomRotation(degrees=(5, 15)),
```

```
    transforms.ColorJitter(brightness=0.2, contrast=0.2, saturation=0.2, hue=0.2),
    transforms.RandomResizedCrop((100, 100), scale=(0.8, 1.0)),
    transforms.ToTensor(),
])


test_transform = transforms.Compose([
    transforms.Resize((100, 100)),
    transforms.ToTensor(),
])



batch_size = 16

# Load data
train_dataset = MyDataset(data_dir='/content/drive/MyDrive/AE_xray/train', transform=test_transform)
test_dataset = MyDataset(data_dir='/content/drive/MyDrive/AE_xray/test', transform=test_transform)
train_data, valid_data = train_test_split(train_dataset, test_size=0.1, random_state=42)

# Dataloader
train_dl = DataLoader(train_data, batch_size=batch_size, shuffle=True)
valid_dl = DataLoader(valid_data, batch_size=batch_size, shuffle=True)
test_dl = DataLoader(test_dataset, batch_size=batch_size, shuffle=True)


class Encoder(nn.Module):
  def __init__(self , input_size = 10000 , hidden_size1 = 2500, hidden_size2 = 1000 , hidden_size3 = 500, hidden_size4 = 200, z_d
    super().__init__()
    self.fc1 = nn.Linear(input_size , hidden_size1)
    self.fc2 = nn.Linear(hidden_size1 , hidden_size2)
    self.fc3 = nn.Linear(hidden_size2 , hidden_size3)
    self.fc4 = nn.Linear(hidden_size3 , hidden_size4)
    self.fc5 = nn.Linear(hidden_size4 , z_dim)
    self.relu = nn.ReLU()
  def forward(self, x):
    x = self.relu(self.fc1(x))
    x = self.relu(self.fc2(x))
    x = self.relu(self.fc3(x))
    x = self.relu(self.fc4(x))
    x = self.fc5(x)
    return x



class Decoder(nn.Module):
  def __init__(self , output_size = 10000 , hidden_size1 = 2500, hidden_size2 = 1000 , hidden_size3 = 500, hidden_size4 = 200, z_
    super().__init__()
    self.fc1 = nn.Linear(z_dim , hidden_size4)
    self.fc2 = nn.Linear(hidden_size4 , hidden_size3)
    self.fc3 = nn.Linear(hidden_size3 , hidden_size2)
    self.fc4 = nn.Linear(hidden_size2 , hidden_size1)
    self.fc5 = nn.Linear(hidden_size1 , output_size)
    self.relu = nn.ReLU()
  def forward(self, x):
    x = self.relu(self.fc1(x))
    x = self.relu(self.fc2(x))
    x = self.relu(self.fc3(x))
    x = self.relu(self.fc4(x))
    x = torch.sigmoid(self.fc5(x))
    return x


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

```
device(type='cuda')
```

```
enc = Encoder().to(device)
dec = Decoder().to(device)


loss_fn = nn.MSELoss()
optimizer_enc = torch.optim.Adam(enc.parameters())
optimizer_dec = torch.optim.Adam(dec.parameters())



train_loss = []
```

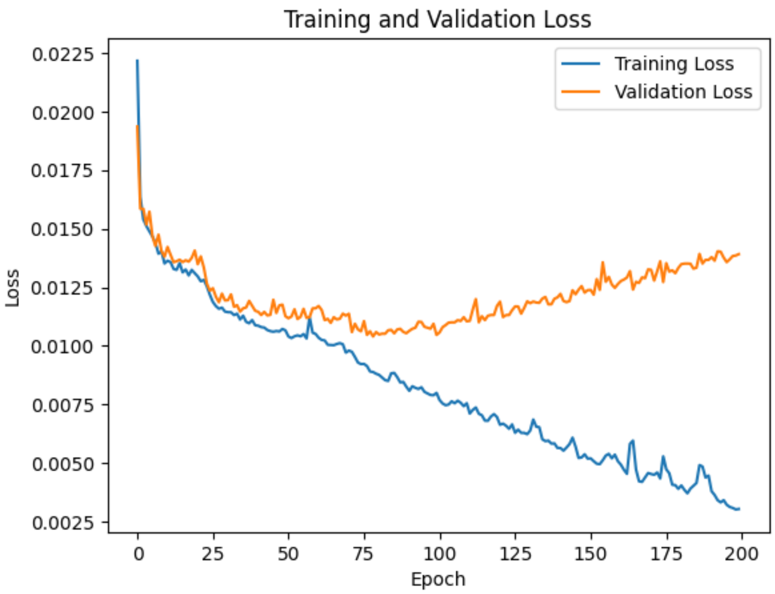
```
val_loss = []
num_epochs = 150
checkpoint_path = "/content/drive/MyDrive/model/Autoencoder/wa_val_xray_checkpoint_30z_5h_200e.pth"


# Check if a checkpoint exists to resume training
if os.path.exists(checkpoint_path):
  checkpoint = torch.load(checkpoint_path)
  enc.load_state_dict(checkpoint["enc_state_dict"])
  dec.load_state_dict(checkpoint["dec_state_dict"])
  optimizer_enc.load_state_dict(checkpoint["optimizer_enc_state_dict"])
  optimizer_dec.load_state_dict(checkpoint["optimizer_dec_state_dict"])
  train_loss = checkpoint["train_loss"]
  val_loss = checkpoint["val_loss"]
  start_epoch = checkpoint["epoch"] + 1  # Start from the next epoch after the loaded checkpoint
  print("Resume training from epoch", start_epoch)
else:
  start_epoch = 1
```

```
    Resume training from epoch 201
```

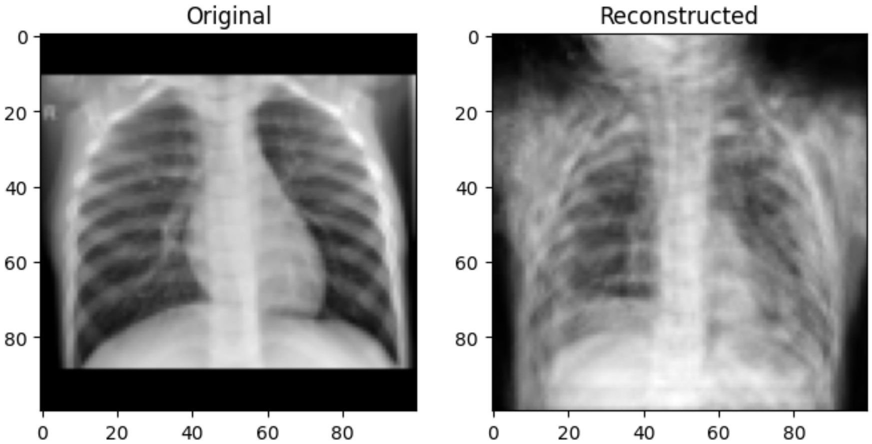
```
total_batches_train = len(train_dl)
total_batches_valid = len(valid_dl)
for epoch in range(start_epoch,num_epochs+1):
    train_epoch_loss = 0
    valid_epoch_loss = 0
    start_time = time.time()
    # Create a tqdm progress bar for the epoch
    epoch_progress = tqdm(enumerate(train_dl, 1), total=total_batches_train, desc=f'Epoch {epoch}/{num_epochs}', leave=False)
    for step, imgs in epoch_progress:
        imgs = imgs.to(device)
        imgs = imgs.flatten(1)
        latents = enc(imgs)
        output = dec(latents)
        loss = loss_fn(output, imgs)
        train_epoch_loss += loss.item()
        optimizer_enc.zero_grad()
        optimizer_dec.zero_grad()
        loss.backward()
        optimizer_enc.step()
        optimizer_dec.step()

    with torch.no_grad():
      for val_imgs in valid_dl:
        val_imgs = val_imgs.to(device)
        # val_imgs = add_noise(val_imgs)
        val_imgs = val_imgs.flatten(1)
        val_reconstructed = dec(enc(val_imgs))
        step_loss = loss_fn(val_reconstructed, val_imgs)
        valid_epoch_loss += step_loss.item()

    # epoch_progress.set_description(f'Epoch {epoch}/{num_epochs}, Step {step}/{total_batches}, Train_step_loss: {loss.item():.4f
    # Calculate average loss
    train_epoch_loss /= total_batches_train
    valid_epoch_loss /= total_batches_valid

    train_loss.append(train_epoch_loss)
    val_loss.append(valid_epoch_loss)
    # Close the tqdm progress bar for the epoch
    epoch_progress.close()

    # Print the epoch loss after each epoch
    print('\n')
    print(f'Epoch {epoch}/{num_epochs}, Train_loss: {train_epoch_loss:.4f}, Val_loss: {valid_epoch_loss:.4f}, Time taken: [{time.

    # Save the model checkpoint along with training-related information
    checkpoint = {
        'epoch': epoch,
        'enc_state_dict': enc.state_dict(),
        'dec_state_dict':dec.state_dict(),
        'optimizer_enc_state_dict': optimizer_enc.state_dict(),
        'optimizer_dec_state_dict': optimizer_dec.state_dict(),
        'train_loss': train_loss,
        'val_loss': val_loss
    }
```

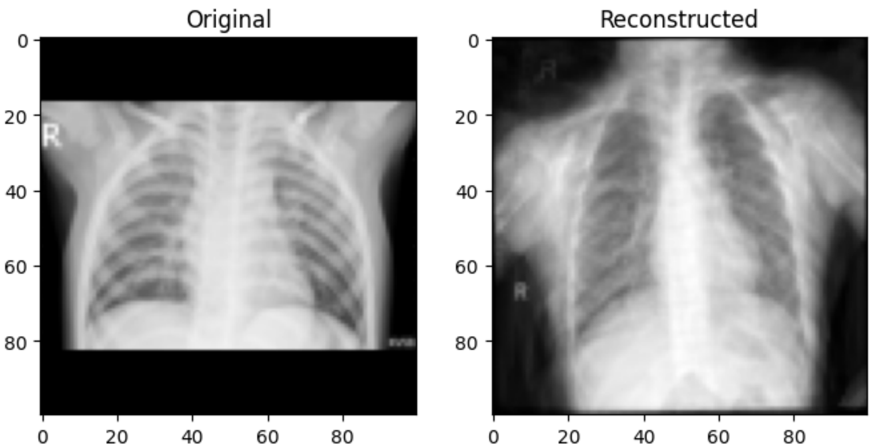
```
    torch.save(checkpoint, checkpoint_path)
```

```
# checkpoint = torch.load(checkpoint_path)
train_loss = checkpoint['train_loss']
valid_loss = checkpoint['val_loss']

plt.plot(train_loss, label='Training Loss')
plt.plot(valid_loss, label='Validation Loss')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.legend()
plt.title('Training and Validation Loss')
plt.show()
```




```
# Plot some original and reconstructed images
n_samples = 5  # Number of samples to visualize

with torch.no_grad():
    for i, batch in enumerate(test_dl):
        if i >= n_samples:
            break
        batch = batch.to(device)
        batch = batch.flatten(1)
        reconstructed = dec(enc(batch))

        original_image = batch[0].view(100,-1).cpu().numpy()
        reconstructed_image = reconstructed[0].view(100,-1).cpu().numpy()

        plt.figure(figsize=(8, 4))
        plt.subplot(1, 2, 1)
        plt.title('Original')
        plt.imshow(original_image, cmap='gray')  # Convert to grayscale for display

        plt.subplot(1, 2, 2)
        plt.title('Reconstructed')
        plt.imshow(reconstructed_image, cmap='gray')  # Convert to grayscale for display

        plt.show()
```


Original
Reconstructed
0
20
40
60
80


Original
Reconstructed
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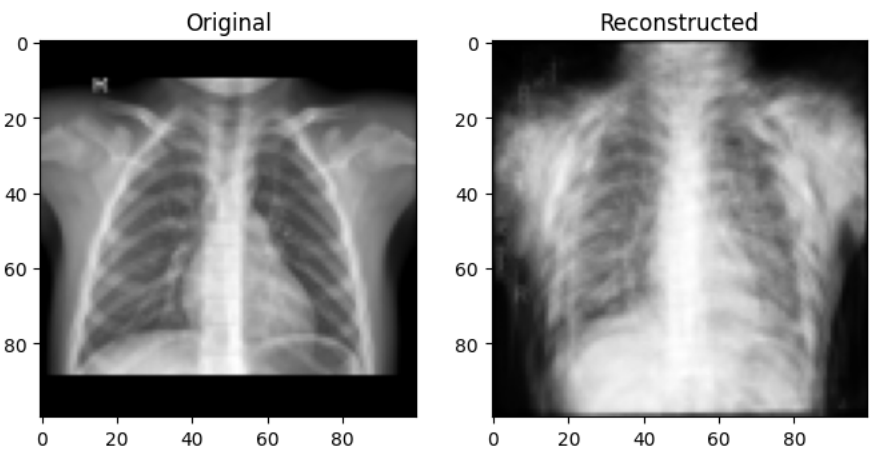
Original
Reconstructed
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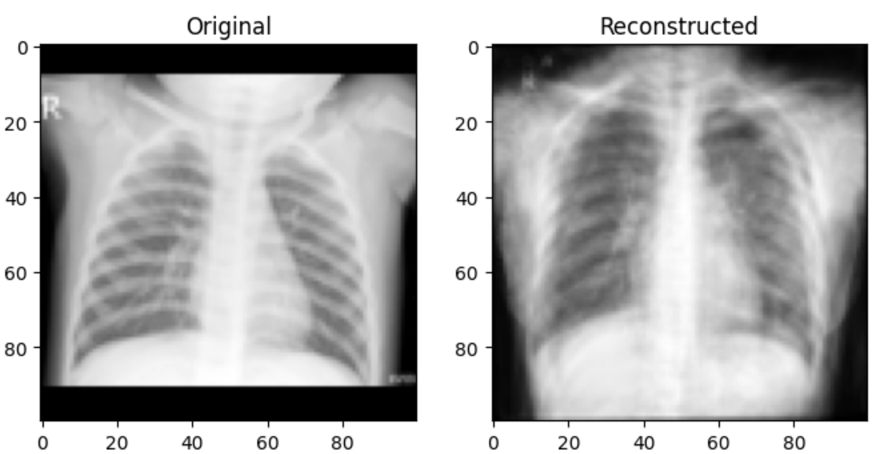
60
80


Original
Reconstructed
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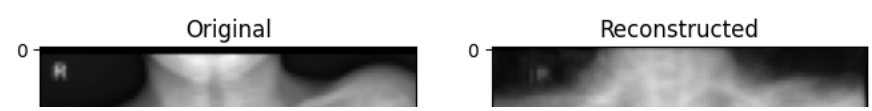
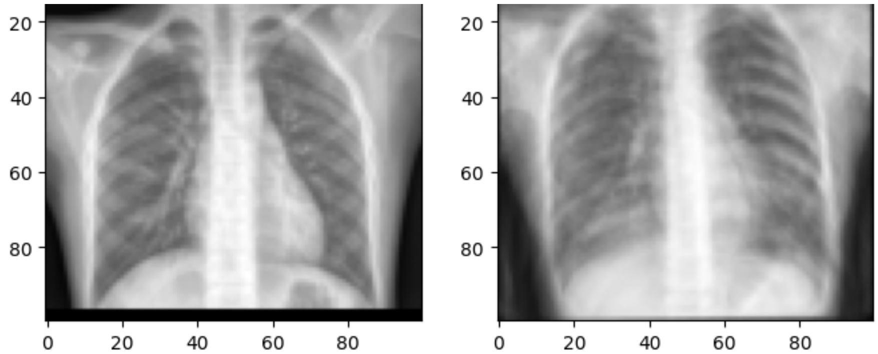

Original
Reconstructed
0


20
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