In [ ]:
```
!pip install torch-fidelity
```

```
Collecting torch-fidelity
  Downloading torch_fidelity-0.3.0-py3-none-any.whl.metadata (2.0 kB)
Requirement already satisfied: numpy in /usr/local/lib/python3.11/dist-packa
ges (from torch-fidelity) (1.26.4)
Requirement already satisfied: Pillow in /usr/local/lib/python3.11/dist-pack
ages (from torch-fidelity) (11.1.0)
Requirement already satisfied: scipy in /usr/local/lib/python3.11/dist-packa
ges (from torch-fidelity) (1.13.1)
Requirement already satisfied: torch in /usr/local/lib/python3.11/dist-packa
ges (from torch-fidelity) (2.5.1+cu124)
Requirement already satisfied: torchvision in /usr/local/lib/python3.11/dist
-packages (from torch-fidelity) (0.20.1+cu124)
Requirement already satisfied: tqdm in /usr/local/lib/python3.11/dist-packag
es (from torch-fidelity) (4.67.1)
Requirement already satisfied: filelock in /usr/local/lib/python3.11/dist-pa
ckages (from torch->torch-fidelity) (3.17.0)
Requirement already satisfied: typing-extensions>=4.8.0 in /usr/local/lib/py
thon3.11/dist-packages (from torch->torch-fidelity) (4.12.2)
Requirement already satisfied: networkx in /usr/local/lib/python3.11/dist-pa
ckages (from torch->torch-fidelity) (3.4.2)
Requirement already satisfied: jinja2 in /usr/local/lib/python3.11/dist-pack
ages (from torch->torch-fidelity) (3.1.5)
Requirement already satisfied: fsspec in /usr/local/lib/python3.11/dist-pack
ages (from torch->torch-fidelity) (2024.10.0)
Collecting nvidia-cuda-nvrtc-cu12==12.4.127 (from torch->torch-fidelity)
  Downloading nvidia_cuda_nvrtc_cu12-12.4.127-py3-none-manylinux2014_x86_64.
whl.metadata (1.5 kB)
Collecting nvidia-cuda-runtime-cu12==12.4.127 (from torch->torch-fidelity)
  Downloading nvidia_cuda_runtime_cu12-12.4.127-py3-none-manylinux2014_x86_6
4.whl.metadata (1.5 kB)
Collecting nvidia-cuda-cupti-cu12==12.4.127 (from torch->torch-fidelity)
  Downloading nvidia_cuda_cupti_cu12-12.4.127-py3-none-manylinux2014_x86_64.
whl.metadata (1.6 kB)
Collecting nvidia-cudnn-cu12==9.1.0.70 (from torch->torch-fidelity)
  Downloading nvidia_cudnn_cu12-9.1.0.70-py3-none-manylinux2014_x86_64.whl.m
etadata (1.6 kB)
Collecting nvidia-cublas-cu12==12.4.5.8 (from torch->torch-fidelity)
  Downloading nvidia_cublas_cu12-12.4.5.8-py3-none-manylinux2014_x86_64.whl.
metadata (1.5 kB)
Collecting nvidia-cufft-cu12==11.2.1.3 (from torch->torch-fidelity)
  Downloading nvidia_cufft_cu12-11.2.1.3-py3-none-manylinux2014_x86_64.whl.m
etadata (1.5 kB)
Collecting nvidia-curand-cu12==10.3.5.147 (from torch->torch-fidelity)
  Downloading nvidia_curand_cu12-10.3.5.147-py3-none-manylinux2014_x86_64.wh
l.metadata (1.5 kB)
Collecting nvidia-cusolver-cu12==11.6.1.9 (from torch->torch-fidelity)
  Downloading nvidia_cusolver_cu12-11.6.1.9-py3-none-manylinux2014_x86_64.wh
l.metadata (1.6 kB)
Collecting nvidia-cusparse-cu12==12.3.1.170 (from torch->torch-fidelity)
  Downloading nvidia_cusparse_cu12-12.3.1.170-py3-none-manylinux2014_x86_64.
whl.metadata (1.6 kB)
Requirement already satisfied: nvidia-nccl-cu12==2.21.5 in /usr/local/lib/py
thon3.11/dist-packages (from torch->torch-fidelity) (2.21.5)
Requirement already satisfied: nvidia-nvtx-cu12==12.4.127 in /usr/local/lib/
python3.11/dist-packages (from torch->torch-fidelity) (12.4.127)
Collecting nvidia-nvjitlink-cu12==12.4.127 (from torch->torch-fidelity)
```

```
  Downloading nvidia_nvjitlink_cu12-12.4.127-py3-none-manylinux2014_x86_64.w
hl.metadata (1.5 kB)
Requirement already satisfied: triton==3.1.0 in /usr/local/lib/python3.11/di
st-packages (from torch->torch-fidelity) (3.1.0)
Requirement already satisfied: sympy==1.13.1 in /usr/local/lib/python3.11/di
st-packages (from torch->torch-fidelity) (1.13.1)
Requirement already satisfied: mpmath<1.4,>=1.1.0 in /usr/local/lib/python3.
11/dist-packages (from sympy==1.13.1->torch->torch-fidelity) (1.3.0)
Requirement already satisfied: MarkupSafe>=2.0 in /usr/local/lib/python3.11/
dist-packages (from jinja2->torch->torch-fidelity) (3.0.2)
Downloading torch_fidelity-0.3.0-py3-none-any.whl (37 kB)
Downloading nvidia_cublas_cu12-12.4.5.8-py3-none-manylinux2014_x86_64.whl (3
63.4 MB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 363.4/363.4 MB 1.4 MB/s eta 0:0
0:00
Downloading nvidia_cuda_cupti_cu12-12.4.127-py3-none-manylinux2014_x86_64.wh
l (13.8 MB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 13.8/13.8 MB 118.4 MB/s eta 0:0
0:00
Downloading nvidia_cuda_nvrtc_cu12-12.4.127-py3-none-manylinux2014_x86_64.wh
l (24.6 MB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 24.6/24.6 MB 86.0 MB/s eta 0:00:
00
Downloading nvidia_cuda_runtime_cu12-12.4.127-py3-none-manylinux2014_x86_64.
whl (883 kB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 883.7/883.7 kB 56.9 MB/s eta 0:0
0:00
Downloading nvidia_cudnn_cu12-9.1.0.70-py3-none-manylinux2014_x86_64.whl (66
4.8 MB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 664.8/664.8 MB 2.7 MB/s eta 0:0
0:00
Downloading nvidia_cufft_cu12-11.2.1.3-py3-none-manylinux2014_x86_64.whl (21
1.5 MB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 211.5/211.5 MB 5.4 MB/s eta 0:0
0:00
Downloading nvidia_curand_cu12-10.3.5.147-py3-none-manylinux2014_x86_64.whl
(56.3 MB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 56.3/56.3 MB 17.0 MB/s eta 0:00:
00
Downloading nvidia_cusolver_cu12-11.6.1.9-py3-none-manylinux2014_x86_64.whl
(127.9 MB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 127.9/127.9 MB 7.3 MB/s eta 0:0
0:00
Downloading nvidia_cusparse_cu12-12.3.1.170-py3-none-manylinux2014_x86_64.wh
l (207.5 MB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 207.5/207.5 MB 5.5 MB/s eta 0:0
0:00
Downloading nvidia_nvjitlink_cu12-12.4.127-py3-none-manylinux2014_x86_64.whl
(21.1 MB)
   ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 21.1/21.1 MB 42.4 MB/s eta 0:00:
00
Installing collected packages: nvidia-nvjitlink-cu12, nvidia-curand-cu12, nv
idia-cufft-cu12, nvidia-cuda-runtime-cu12, nvidia-cuda-nvrtc-cu12, nvidia-cu
da-cupti-cu12, nvidia-cublas-cu12, nvidia-cusparse-cu12, nvidia-cudnn-cu12,
nvidia-cusolver-cu12, torch-fidelity
  Attempting uninstall: nvidia-nvjitlink-cu12
```

```
    Found existing installation: nvidia-nvjitlink-cu12 12.5.82
    Uninstalling nvidia-nvjitlink-cu12-12.5.82:
      Successfully uninstalled nvidia-nvjitlink-cu12-12.5.82
  Attempting uninstall: nvidia-curand-cu12
    Found existing installation: nvidia-curand-cu12 10.3.6.82
    Uninstalling nvidia-curand-cu12-10.3.6.82:
      Successfully uninstalled nvidia-curand-cu12-10.3.6.82
  Attempting uninstall: nvidia-cufft-cu12
    Found existing installation: nvidia-cufft-cu12 11.2.3.61
    Uninstalling nvidia-cufft-cu12-11.2.3.61:
      Successfully uninstalled nvidia-cufft-cu12-11.2.3.61
  Attempting uninstall: nvidia-cuda-runtime-cu12
    Found existing installation: nvidia-cuda-runtime-cu12 12.5.82
    Uninstalling nvidia-cuda-runtime-cu12-12.5.82:
      Successfully uninstalled nvidia-cuda-runtime-cu12-12.5.82
  Attempting uninstall: nvidia-cuda-nvrtc-cu12
    Found existing installation: nvidia-cuda-nvrtc-cu12 12.5.82
    Uninstalling nvidia-cuda-nvrtc-cu12-12.5.82:
      Successfully uninstalled nvidia-cuda-nvrtc-cu12-12.5.82
  Attempting uninstall: nvidia-cuda-cupti-cu12
    Found existing installation: nvidia-cuda-cupti-cu12 12.5.82
    Uninstalling nvidia-cuda-cupti-cu12-12.5.82:
      Successfully uninstalled nvidia-cuda-cupti-cu12-12.5.82
  Attempting uninstall: nvidia-cublas-cu12
    Found existing installation: nvidia-cublas-cu12 12.5.3.2
    Uninstalling nvidia-cublas-cu12-12.5.3.2:
      Successfully uninstalled nvidia-cublas-cu12-12.5.3.2
  Attempting uninstall: nvidia-cusparse-cu12
    Found existing installation: nvidia-cusparse-cu12 12.5.1.3
    Uninstalling nvidia-cusparse-cu12-12.5.1.3:
      Successfully uninstalled nvidia-cusparse-cu12-12.5.1.3
  Attempting uninstall: nvidia-cudnn-cu12
    Found existing installation: nvidia-cudnn-cu12 9.3.0.75
    Uninstalling nvidia-cudnn-cu12-9.3.0.75:
      Successfully uninstalled nvidia-cudnn-cu12-9.3.0.75
  Attempting uninstall: nvidia-cusolver-cu12
    Found existing installation: nvidia-cusolver-cu12 11.6.3.83
    Uninstalling nvidia-cusolver-cu12-11.6.3.83:
      Successfully uninstalled nvidia-cusolver-cu12-11.6.3.83
Successfully installed nvidia-cublas-cu12-12.4.5.8 nvidia-cuda-cupti-cu12-1
2.4.127 nvidia-cuda-nvrtc-cu12-12.4.127 nvidia-cuda-runtime-cu12-12.4.127 nv
idia-cudnn-cu12-9.1.0.70 nvidia-cufft-cu12-11.2.1.3 nvidia-curand-cu12-10.3.
5.147 nvidia-cusolver-cu12-11.6.1.9 nvidia-cusparse-cu12-12.3.1.170 nvidia-n
vjitlink-cu12-12.4.127 torch-fidelity-0.3.0
```

In [ ]:
```
import os
import numpy as np
import torch
import torch.nn as nn
import torch.nn.functional as F
from torch.utils.data import DataLoader, TensorDataset
from torch.optim import Adam
from torch.cuda.amp import GradScaler, autocast
from tqdm import tqdm
import matplotlib.pyplot as plt
from torch_fidelity import calculate_metrics
```

In [ ]:
```
!pip install gdown
import gdown
import zipfile

file_id = "1cJyPQzVOzsCZQctNBuHCqxHnOY7v7UiA"
output = "dataset.zip"
gdown.download(f"https://drive.google.com/uc?id={file_id}", output, quiet =

with zipfile.ZipFile("dataset.zip", "r") as zip_ref:
  zip_ref.extractall("/content/dataset")
```

```
Requirement already satisfied: gdown in /usr/local/lib/python3.11/dist-packa
ges (5.2.0)
Requirement already satisfied: beautifulsoup4 in /usr/local/lib/python3.11/d
ist-packages (from gdown) (4.13.3)
Requirement already satisfied: filelock in /usr/local/lib/python3.11/dist-pa
ckages (from gdown) (3.17.0)
Requirement already satisfied: requests[socks] in /usr/local/lib/python3.11/
dist-packages (from gdown) (2.32.3)
Requirement already satisfied: tqdm in /usr/local/lib/python3.11/dist-packag
es (from gdown) (4.67.1)
Requirement already satisfied: soupsieve>1.2 in /usr/local/lib/python3.11/di
st-packages (from beautifulsoup4->gdown) (2.6)
Requirement already satisfied: typing-extensions>=4.0.0 in /usr/local/lib/py
thon3.11/dist-packages (from beautifulsoup4->gdown) (4.12.2)
Requirement already satisfied: charset-normalizer<4,>=2 in /usr/local/lib/py
thon3.11/dist-packages (from requests[socks]->gdown) (3.4.1)
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.11/dis
t-packages (from requests[socks]->gdown) (3.10)
Requirement already satisfied: urllib3<3,>=1.21.1 in /usr/local/lib/python3.
11/dist-packages (from requests[socks]->gdown) (2.3.0)
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.
11/dist-packages (from requests[socks]->gdown) (2025.1.31)
Requirement already satisfied: PySocks!=1.5.7,>=1.5.6 in /usr/local/lib/pyth
on3.11/dist-packages (from requests[socks]->gdown) (1.7.1)
Downloading...
From (original): https://drive.google.com/uc?id=1cJyPQzVOzsCZQctNBuHCqxHnOY7
v7UiA
From (redirected): https://drive.google.com/uc?id=1cJyPQzVOzsCZQctNBuHCqxHnO
Y7v7UiA&confirm=t&uuid=c3609420-c9d5-48b7-8078-ac84e41c92cb
To: /content/dataset.zip
100%|██████████| 304M/304M [00:08<00:00, 34.5MB/s]
```

In [ ]:
```
data_dir = "/content/dataset/Samples"
npy_files = [f for f in os.listdir(data_dir) if f.endswith('.npy')]
```

In [ ]:
```
images = []
for file in npy_files:
    img = np.load(os.path.join(data_dir, file))
    images.append(torch.from_numpy(img).float())
```

In [ ]:
```
images_tensor = torch.stack(images)
print(f"Dataset loaded. Shape: {images_tensor.shape}, Min: {images_tensor.mi
```

```
Dataset loaded. Shape: torch.Size([10000, 1, 150, 150]), Min: 0.0, Max: 1.0
```

In [ ]:
```
dataset = TensorDataset(images_tensor)
dataloader = DataLoader(dataset, batch_size=32, shuffle=True)
```

In [ ]:
```
device = torch.device('cuda' if torch.cuda.is_available() else 'cpu')
```

In [ ]:
```
class Diffusion(nn.Module):
  def __init__(self, T = 1000, beta_starts = 1e-4, beta_end = 0.02, device =
    super().__init__()
    self.T = T
    self.device = device
    betas = torch.linspace(beta_starts, beta_end, T).to(device)
    alphas = 1 - betas
    alpha_bars = torch.cumprod(alphas, dim = 0)

    self.register_buffer('sqrt_alpha_bars', torch.sqrt(alpha_bars))
    self.register_buffer('sqrt_one_minus_alpha_bars', torch.sqrt(1 - alpha_b

  def q_sample(self, x0, t, noise = None):
    if noise is None:
      noise = torch.randn_like(x0)
    batch_size = x0.shape[0]
    sqrt_alpha_bar = self.sqrt_alpha_bars[t].view(batch_size, 1, 1, 1)
    sqrt_one_minus_alpha_bar = self.sqrt_one_minus_alpha_bars[t].view(batch_
    return sqrt_alpha_bar * x0 + sqrt_one_minus_alpha_bar * noise

  def ddim_sample(self, model, n_samples, image_size, channels, steps=50):
    model.eval()
    with torch.no_grad():
      total_steps = self.T
      step_indices = torch.linspace(0, total_steps-1, steps, dtype=torch.lor
      timesteps = step_indices
      x = torch.randn(n_samples, channels, image_size, image_size, device=de

      for i in range(len(timesteps) - 1, -1, -1):
        t = timesteps[i].repeat(n_samples)
        t_next = timesteps[i-1] if i > 0 else -1
        predicted_noise = model(x, t)
        alpha_bar_t = self.sqrt_alpha_bars[t]**2
        alpha_bar_t_next = self.sqrt_alpha_bars[t_next]**2 if t_next >= 0 el
        sigma = 0
        x0_pred = (x - torch.sqrt(1 - alpha_bar_t) * predicted_noise) / torc
        if t_next >= 0:
```

```
            noise_dir = torch.sqrt(1 - alpha_bar_t_next - sigma**2) * predicte
            x = torch.sqrt(alpha_bar_t_next) * x0_pred + noise_dir
        else:
            x = x0_pred
    return x
```

In [ ]:
```
class SinusoidalEmbedding(nn.Module):
    def __init__(self, dim):
        super().__init__()
        self.dim = dim

    def forward(self, t):
        device = t.device
        half_dim = self.dim // 2
        emb = torch.arange(half_dim, device=device).float()
        emb = torch.exp(-emb * (np.log(10000) / half_dim))
        emb = t[:, None] * emb[None, :]
        return torch.cat([torch.sin(emb), torch.cos(emb)], dim=1)
```

In [ ]:
```
class UNetBlock(nn.Module):
    def __init__(self, in_channels, out_channels, time_dim):
        super().__init__()
        self.time_mlp = nn.Linear(time_dim, out_channels)
        self.conv1 = nn.Conv2d(in_channels, out_channels, 3, padding=1)
        self.conv2 = nn.Conv2d(out_channels, out_channels, 3, padding=1)
        self.norm1 = nn.GroupNorm(8, out_channels)
        self.norm2 = nn.GroupNorm(8, out_channels)
        self.relu = nn.ReLU()

    def forward(self, x, t):
        h = self.conv1(x)
        time_emb = self.relu(self.time_mlp(t))
        h = h + time_emb[:, :, None, None]
        h = self.norm1(h)
        h = self.relu(h)
        h = self.conv2(h)
        h = self.norm2(h)
        return self.relu(h)
```

In [ ]:
```
class UNet(nn.Module):
    def __init__(self, time_dim=128):
        super().__init__()
        self.time_emb = SinusoidalEmbedding(time_dim)
        self.time_mlp = nn.Sequential(nn.Linear(time_dim, time_dim), nn.ReLU

        # Downsampling
        self.down1 = UNetBlock(1, 64, time_dim)
        self.pool1 = nn.MaxPool2d(2)  # 150 -> 75
        self.down2 = UNetBlock(64, 128, time_dim)
        self.pool2 = nn.MaxPool2d(2)  # 75 -> 37

        # Bottleneck
        self.bottleneck = UNetBlock(128, 256, time_dim)

        # Upsampling
```

```
        self.upconv1 = nn.ConvTranspose2d(256, 128, 2, stride=2)  # 37 -> 74
        self.up1 = UNetBlock(256, 128, time_dim)
        self.upconv2 = nn.ConvTranspose2d(128, 64, 2, stride=2)  # 74 -> 148
        self.up2 = UNetBlock(128, 64, time_dim)

        # Output
        self.out = nn.Conv2d(64, 1, 1)

    def forward(self, x, t):
        t_emb = self.time_emb(t)
        t_emb = self.time_mlp(t_emb)

        d1 = self.down1(x, t_emb)
        d2 = self.pool1(d1)
        d3 = self.down2(d2, t_emb)
        d4 = self.pool2(d3)

        b = self.bottleneck(d4, t_emb)

        u1 = self.upconv1(b)
        u1 = torch.cat([F.interpolate(u1, size=d3.shape[2:], mode='bilinear'
        u2 = self.up1(u1, t_emb)
        u3 = self.upconv2(u2)
        u3 = torch.cat([F.interpolate(u3, size=d1.shape[2:], mode='bilinear'
        u4 = self.up2(u3, t_emb)

        return self.out(u4)
```

In [ ]:
```
diffusion = Diffusion(device=device).to(device)
model = UNet().to(device)
optimizer = Adam(model.parameters(), lr=1e-4)
scaler = GradScaler()
num_epochs = 50
```

```
<ipython-input-13-105fb84a9e88>:4: FutureWarning: `torch.cuda.amp.GradScaler
(args...)` is deprecated. Please use `torch.amp.GradScaler('cuda', args...)`
instead.
  scaler = GradScaler()
```

In [ ]:
```
for epoch in range(num_epochs):
    model.train()
    total_loss = 0
    for batch in tqdm(dataloader, desc=f"Epoch {epoch+1}/{num_epochs}"):
        x0 = batch[0].to(device)
        t = torch.randint(0, diffusion.T, (x0.shape[0],), device=device)
        noise = torch.randn_like(x0)
        xt = diffusion.q_sample(x0, t, noise)
        with autocast():
            predicted_noise = model(xt, t)
            loss = F.mse_loss(predicted_noise, noise)
        optimizer.zero_grad()
        scaler.scale(loss).backward()
        scaler.step(optimizer)
        scaler.update()
        total_loss += loss.item()
    avg_loss = total_loss / len(dataloader)
```

```
    print(f"Epoch {epoch+1}/{num_epochs}, Avg Loss: {avg_loss:.6f}")
    # Save checkpoint every 10 epochs
    if (epoch + 1) % 10 == 0:
        torch.save(model.state_dict(), f'diffusion_model_epoch_{epoch+1}.pth
```

```
Epoch 1/50:   0%|          | 0/313 [00:00<?, ?it/s]<ipython-input-14-9e358da
0f5fd>:9: FutureWarning: `torch.cuda.amp.autocast(args...)` is deprecated. P
lease use `torch.amp.autocast('cuda', args...)` instead.
  with autocast():
Epoch 1/50: 100%|██████████| 313/313 [01:24<00:00,  3.70it/s]
Epoch 1/50, Avg Loss: 0.061173
Epoch 2/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 2/50, Avg Loss: 0.008365
Epoch 3/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 3/50, Avg Loss: 0.006109
Epoch 4/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 4/50, Avg Loss: 0.004949
Epoch 5/50: 100%|██████████| 313/313 [01:22<00:00,  3.78it/s]
Epoch 5/50, Avg Loss: 0.004373
Epoch 6/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 6/50, Avg Loss: 0.004251
Epoch 7/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 7/50, Avg Loss: 0.003748
Epoch 8/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 8/50, Avg Loss: 0.003838
Epoch 9/50: 100%|██████████| 313/313 [01:22<00:00,  3.80it/s]
Epoch 9/50, Avg Loss: 0.003494
Epoch 10/50: 100%|██████████| 313/313 [01:22<00:00,  3.80it/s]
Epoch 10/50, Avg Loss: 0.003297
Epoch 11/50: 100%|██████████| 313/313 [01:22<00:00,  3.80it/s]
Epoch 11/50, Avg Loss: 0.003168
Epoch 12/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 12/50, Avg Loss: 0.003616
Epoch 13/50: 100%|██████████| 313/313 [01:22<00:00,  3.80it/s]
Epoch 13/50, Avg Loss: 0.003116
Epoch 14/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 14/50, Avg Loss: 0.002822
Epoch 15/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 15/50, Avg Loss: 0.002839
Epoch 16/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 16/50, Avg Loss: 0.002829
Epoch 17/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 17/50, Avg Loss: 0.002805
Epoch 18/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 18/50, Avg Loss: 0.002809
Epoch 19/50: 100%|██████████| 313/313 [01:22<00:00,  3.80it/s]
Epoch 19/50, Avg Loss: 0.002782
Epoch 20/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 20/50, Avg Loss: 0.002889
Epoch 21/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
```

```
Epoch 21/50, Avg Loss: 0.002983
Epoch 22/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 22/50, Avg Loss: 0.002647
Epoch 23/50: 100%|██████████| 313/313 [01:22<00:00,  3.80it/s]
Epoch 23/50, Avg Loss: 0.002530
Epoch 24/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 24/50, Avg Loss: 0.002551
Epoch 25/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 25/50, Avg Loss: 0.002328
Epoch 26/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 26/50, Avg Loss: 0.002647
Epoch 27/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 27/50, Avg Loss: 0.002692
Epoch 28/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 28/50, Avg Loss: 0.002683
Epoch 29/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 29/50, Avg Loss: 0.002508
Epoch 30/50: 100%|██████████| 313/313 [01:22<00:00,  3.78it/s]
Epoch 30/50, Avg Loss: 0.002139
Epoch 31/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 31/50, Avg Loss: 0.002213
Epoch 32/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 32/50, Avg Loss: 0.002151
Epoch 33/50: 100%|██████████| 313/313 [01:22<00:00,  3.80it/s]
Epoch 33/50, Avg Loss: 0.002427
Epoch 34/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 34/50, Avg Loss: 0.002314
Epoch 35/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 35/50, Avg Loss: 0.002134
Epoch 36/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 36/50, Avg Loss: 0.002307
Epoch 37/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 37/50, Avg Loss: 0.001954
Epoch 38/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 38/50, Avg Loss: 0.002340
Epoch 39/50: 100%|██████████| 313/313 [01:22<00:00,  3.78it/s]
Epoch 39/50, Avg Loss: 0.002319
Epoch 40/50: 100%|██████████| 313/313 [01:22<00:00,  3.78it/s]
Epoch 40/50, Avg Loss: 0.001903
Epoch 41/50: 100%|██████████| 313/313 [01:22<00:00,  3.78it/s]
Epoch 41/50, Avg Loss: 0.002443
Epoch 42/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 42/50, Avg Loss: 0.001773
Epoch 43/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 43/50, Avg Loss: 0.002127
Epoch 44/50: 100%|██████████| 313/313 [01:22<00:00,  3.78it/s]
Epoch 44/50, Avg Loss: 0.002165
Epoch 45/50: 100%|██████████| 313/313 [01:22<00:00,  3.78it/s]
Epoch 45/50, Avg Loss: 0.002119
```

```
Epoch 46/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 46/50, Avg Loss: 0.001924
Epoch 47/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 47/50, Avg Loss: 0.002269
Epoch 48/50: 100%|██████████| 313/313 [01:22<00:00,  3.79it/s]
Epoch 48/50, Avg Loss: 0.002248
Epoch 49/50: 100%|██████████| 313/313 [01:22<00:00,  3.80it/s]
Epoch 49/50, Avg Loss: 0.002209
Epoch 50/50: 100%|██████████| 313/313 [01:22<00:00,  3.78it/s]
Epoch 50/50, Avg Loss: 0.002010
```

In [ ]:

```
generated_images = diffusion.ddim_sample(model, n_samples=1000, image_size=1
generated_images = torch.clamp(generated_images, 0, 1)
```

```
---------------------------------------------------------------------------
OutOfMemoryError                          Traceback (most recent call last)
<ipython-input-17-c4d3fef7a10e> in <cell line: 0>()
----> 1 generated_images = diffusion.ddim_sample(model, n_samples=1000, imag
e_size=150, channels=1, steps=50)
      2 generated_images = torch.clamp(generated_images, 0, 1)

<ipython-input-9-77580367b9d0> in ddim_sample(self, model, n_samples, image_
size, channels, steps)
     30         t = timesteps[i].repeat(n_samples)
     31         t_next = timesteps[i-1] if i > 0 else -1
---> 32         predicted_noise = model(x, t)
     33         alpha_bar_t = self.sqrt_alpha_bars[t]**2
     34         alpha_bar_t_next = self.sqrt_alpha_bars[t_next]**2 if t_next
>= 0 else 1.0

/usr/local/lib/python3.11/dist-packages/torch/nn/modules/module.py in _wrapp
ed_call_impl(self, *args, **kwargs)
   1734             return self._compiled_call_impl(*args, **kwargs)  # typ
e: ignore[misc]
   1735         else:
-> 1736             return self._call_impl(*args, **kwargs)
   1737
   1738     # torchrec tests the code consistency with the following code

/usr/local/lib/python3.11/dist-packages/torch/nn/modules/module.py in _call_
impl(self, *args, **kwargs)
   1745                 or _global_backward_pre_hooks or _global_backward_ho
oks
   1746                 or _global_forward_hooks or _global_forward_pre_hook
s):
-> 1747             return forward_call(*args, **kwargs)
   1748
   1749         result = None

<ipython-input-12-b7592765fa37> in forward(self, x, t)
     27         t_emb = self.time_mlp(t_emb)
     28
---> 29         d1 = self.down1(x, t_emb)
     30         d2 = self.pool1(d1)
     31         d3 = self.down2(d2, t_emb)

/usr/local/lib/python3.11/dist-packages/torch/nn/modules/module.py in _wrapp
ed_call_impl(self, *args, **kwargs)
   1734             return self._compiled_call_impl(*args, **kwargs)  # typ
e: ignore[misc]
   1735         else:
-> 1736             return self._call_impl(*args, **kwargs)
   1737
   1738     # torchrec tests the code consistency with the following code

/usr/local/lib/python3.11/dist-packages/torch/nn/modules/module.py in _call_
impl(self, *args, **kwargs)
   1745                 or _global_backward_pre_hooks or _global_backward_ho
oks
   1746                 or _global_forward_hooks or _global_forward_pre_hook
```

```
s):
-> 1747             return forward_call(*args, **kwargs)
   1748
   1749         result = None

<ipython-input-11-05f8304e98a8> in forward(self, x, t)
     10
     11     def forward(self, x, t):
---> 12         h = self.conv1(x)
     13         time_emb = self.relu(self.time_mlp(t))
     14         h = h + time_emb[:, :, None, None]

/usr/local/lib/python3.11/dist-packages/torch/nn/modules/module.py in _wrapp
ed_call_impl(self, *args, **kwargs)
   1734             return self._compiled_call_impl(*args, **kwargs)  # typ
e: ignore[misc]
   1735         else:
-> 1736             return self._call_impl(*args, **kwargs)
   1737
   1738     # torchrec tests the code consistency with the following code

/usr/local/lib/python3.11/dist-packages/torch/nn/modules/module.py in _call_
impl(self, *args, **kwargs)
   1745                 or _global_backward_pre_hooks or _global_backward_ho
oks
   1746                 or _global_forward_hooks or _global_forward_pre_hook
s):
-> 1747             return forward_call(*args, **kwargs)
   1748
   1749         result = None

/usr/local/lib/python3.11/dist-packages/torch/nn/modules/conv.py in forward
(self, input)
    552
    553     def forward(self, input: Tensor) -> Tensor:
--> 554         return self._conv_forward(input, self.weight, self.bias)
    555
    556

/usr/local/lib/python3.11/dist-packages/torch/nn/modules/conv.py in _conv_fo
rward(self, input, weight, bias)
    547                 self.groups,
    548             )
--> 549         return F.conv2d(
    550             input, weight, bias, self.stride, self.padding, self.dil
ation, self.groups
    551         )

OutOfMemoryError: CUDA out of memory. Tried to allocate 5.37 GiB. GPU 0 has
a total capacity of 14.74 GiB of which 916.12 MiB is free. Process 5293 has
13.84 GiB memory in use. Of the allocated memory 11.57 GiB is allocated by P
yTorch, and 2.14 GiB is reserved by PyTorch but unallocated. If reserved but
unallocated memory is large try setting PYTORCH_CUDA_ALLOC_CONF=expandable_s
egments:True to avoid fragmentation.  See documentation for Memory Managemen
t  (https://pytorch.org/docs/stable/notes/cuda.html#environment-variables)
```

In [ ]:
```
generated_images_rgb = generated_images.repeat(1, 3, 1, 1).cpu()
real_images_rgb = images_tensor[:1000].repeat(1, 3, 1, 1)
metrics = calculate_metrics(
    input1=generated_images_rgb,
    input2=real_images_rgb,
    fid=True,
    cuda=True,
    isc=False,
    kid=False
)
fid = metrics['frechet_inception_distance']
print(f"FID Score: {fid}")
```

In [ ]:
```
fig, axes = plt.subplots(1, 5, figsize=(15, 3))
for i in range(5):
    axes[i].imshow(generated_images[i].squeeze().cpu().numpy(), cmap='gray')
    axes[i].axis('off')
plt.suptitle("Generated Strong Lensing Images")
plt.show()
```