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மரம் வளர்ப்போம்
மழை வளம் காப்போம்

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Name : Vishwa S

Subject : DL

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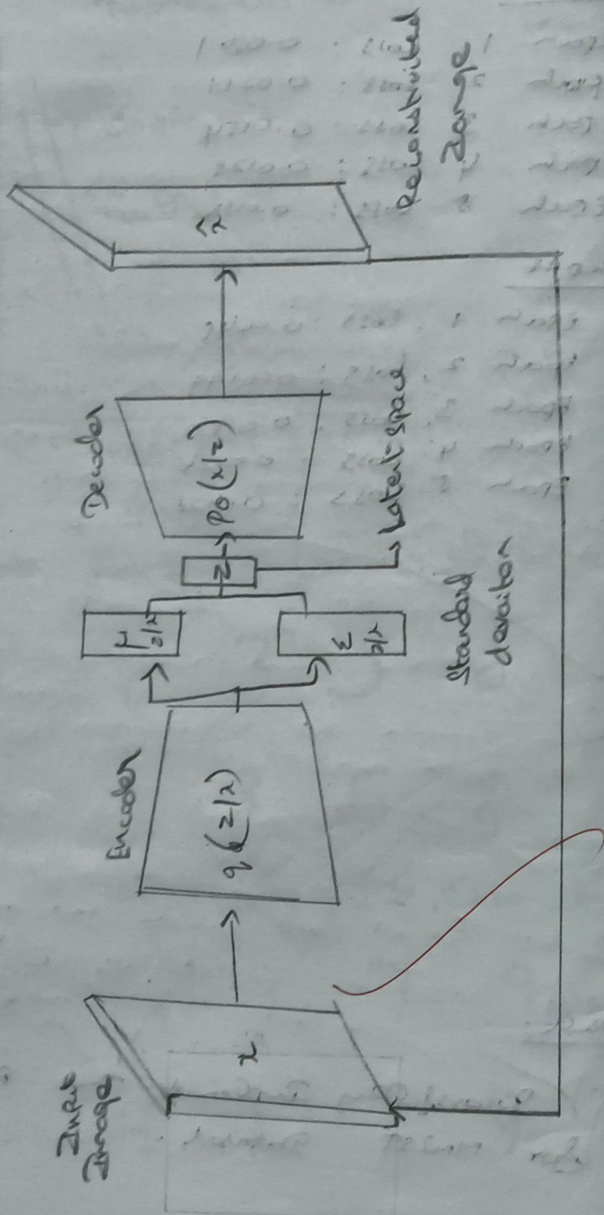


Architecture of VAE

9/10/25

Lab 11: Experiments using Variational Autoencoder (VAE)

Aim:

To implement a variational Autoencoder to learn probabilistic latent representations of MNIST image and generate new images from the learned latent space.

Objectives

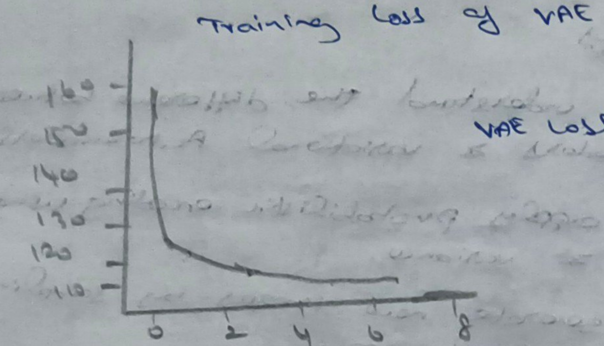
1) To understand the difference between Autoencoders & variational Autoencoders.
2) To apply probabilistic encoding using mean & variance.
3) To generate new images by sampling from the latent space.
4) To visualize the learned latent distribution & reconstructed images

Observation

- The VAE extends the Autoencoder by introducing probabilistic latent variables
- It learns a distribution rather than a fixed encoding, allowing sampling & generation of new data.
- The model is trained using a reconstruction loss and a KL divergence loss to balance accuracy & latent regularization
- The generated samples resemble hand written digits, showing that the model learned the data distribution.

Output.

Epoch 1: Loss : 164.378
Epoch 2 : Loss : 121.2820
Epoch 3 : Loss : 114.5211
Epoch 4 : Loss : 111.6013
Epoch 5 : Loss : 109.8342
Epoch 6 : Loss : 108.6767
Epoch 7 : Loss : 107.8209
Epoch 8 : Loss : 107.1637
Epoch 9 : Loss : 106.6916
Epoch 10 : Loss : 106.2222



Top : original Images | Bottom : VAE Reconstruction

0 2 6 4 0 9 8 5

0 2 6 4 0 9 8 5

Generated Digits from Random Latent Space

2 2 8 3 4 8 3 8

Pseudocode.

BEGIN

St-1 : Import libraries

St-2 : Load & normalize MNIST dataset

St-3 : Define encoder

- Input : 784-dimensional image
- Dense hidden layers
- Output : mean (μ) and log-variance (σ^2)

St-4 : Sample latent vector $z = \mu + \sigma * \varepsilon$

St-5 : Define decoder

- Input : z
- Dense layers to reconstruct 784-dimensional output

St-6 : Define loss function

- Reconstruction loss + KL divergence

St-7 : Train VAE using training data

St-8 : Generate new images by sampling from latent space

St-9 : Visualize reconstructed and generated images

END.

Result:

Successfully Implemented the VAE for MNIST dataset.

dltlab11.ipynb

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!pip install torch torchvision matplotlib
```

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```

[ ]
```python
# vae_mnist.py
import torch
import torch.nn as nn
import torch.optim as optim
from torchvision import datasets, transforms
from torch.utils.data import DataLoader
```

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```
import torch
import torch.nn as nn
import torch.optim as optim
from torchvision import datasets, transforms
from torch.utils.data import DataLoader
import matplotlib.pyplot as plt

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

# ---- Load MNIST dataset
tf = transforms.Compose([transforms.ToTensor()])
train_data = datasets.MNIST(root='data', train=True, transform=tf, download=True)
train_loader = DataLoader(train_data, batch_size=128, shuffle=True)

# ---- Variational Autoencoder
class VAE(nn.Module):
    def __init__(self):
        super(VAE, self).__init__()
        self.fc1 = nn.Linear(784, 400)
        self.fc_mu = nn.Linear(400, 20)      # Mean of latent vector
        self.fc_logvar = nn.Linear(400, 20) # Log variance of latent vector
        self.fc2 = nn.Linear(20, 400)
        self.fc3 = nn.Linear(400, 784)
        self.relu = nn.ReLU()
        self.sigmoid = nn.Sigmoid()

    def encode(self, x):
        h1 = self.relu(self.fc1(x))
        mu = self.fc_mu(h1)
        logvar = self.fc_logvar(h1)
        return mu, logvar

    def reparameterize(self, mu, logvar):
        std = torch.exp(0.5 * logvar)
        eps = torch.randn_like(std)
        return mu + eps * std  # z = μ + σ * ε

    def decode(self, z):
        h2 = self.relu(self.fc2(z))
        return self.sigmoid(self.fc3(h2))

    def forward(self, x):
        x = x.view(-1, 784)
        mu, logvar = self.encode(x)
```

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```
# ---- Loss Function (Reconstruction + KL Divergence)
def vae_loss(recon_x, x, mu, logvar):
    BCE = nn.functional.binary_cross_entropy(recon_x, x.view(-1, 784), reduction='sum')
    # KL Divergence: how latent distribution differs from standard normal
    KLD = -0.5 * torch.sum(1 + logvar - mu.pow(2) - logvar.exp())
    return BCE + KLD

# ---- Model, Optimizer
model = VAE().to(device)
optimizer = optim.Adam(model.parameters(), lr=1e-3)

# ---- Training
epochs = 10
train_losses = []

for epoch in range(1, epochs + 1):
    model.train()
    total_loss = 0
    for imgs, _ in train_loader:
        imgs = imgs.to(device)
        optimizer.zero_grad()
        recon, mu, logvar = model(imgs)
        loss = vae_loss(recon, imgs, mu, logvar)
        loss.backward()
        total_loss += loss.item()
        optimizer.step()

    avg_loss = total_loss / len(train_loader.dataset)
    train_losses.append(avg_loss)
    print(f"Epoch [{epoch}/{epochs}] Loss: {avg_loss:.4f}")

# ---- Plot Training Loss
plt.plot(train_losses, label="VAE Loss")
plt.xlabel("Epochs")
plt.ylabel("Loss")
plt.title("Training Loss of Variational Autoencoder")
plt.legend()
plt.show()

# ---- Reconstruction Visualization
model.eval()
imgs, _ = next(iter(train_loader))
imgs = imgs[:8].to(device)
with torch.no_grad():
    recons, _, _ = model(imgs)
```

Variables Terminal

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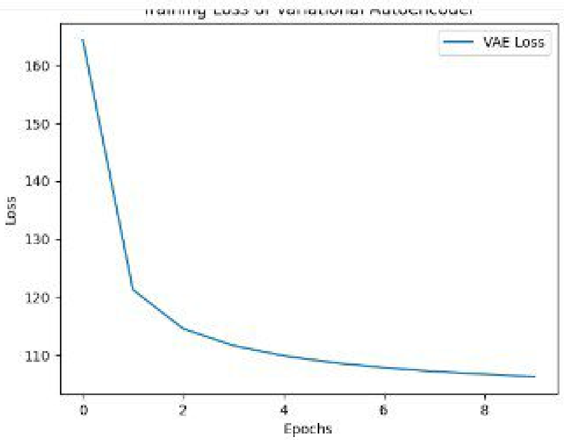
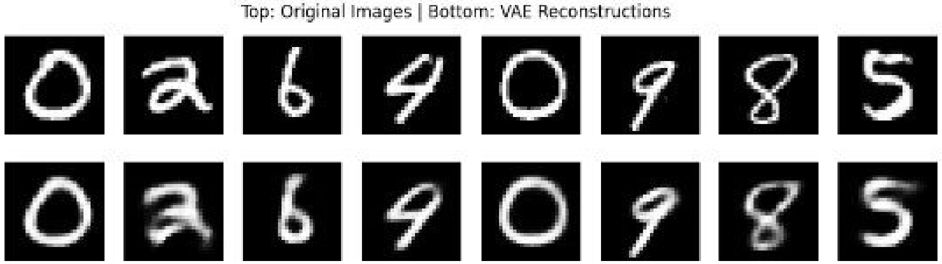
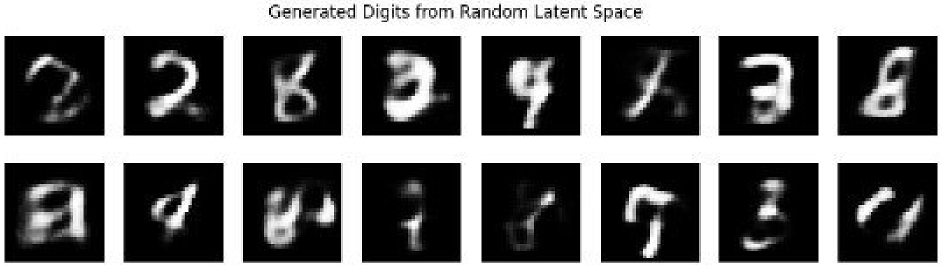
```
plt.show()
```







Variables Terminal