# Department of Data and Computational Science

# Indian Institute of Technology, Jodhpur

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# Fractal 3 Programming Assignment

**ReadME File:**

Variational Autoencoder (VAE) and Generative Adversarial Network (GAN) analysis of the Frey Face Dataset.
This Attached code uses The Frey Face dataset to create a Generative Adversarial Network (GAN) and a Variational Autoencoder (VAE). While the GAN provided fresh face samples, the VAE is used for image reconstruction and latent space interpolation.

**Requirements**
To run the code, we need the following latest versions software:

Python , PyTorch , NumPy , SciPy , Matplotlib

**Dataset**
Images of faces in grayscale are found in the Frey Face dataset. Putting the raw dataset file (frey_rawface.mat) in the same directory as the code files.

The vae.py file contains the **VAE** implementation. The following procedures are followed to train the VAE and sample from the learned distribution:

- Launch a terminal, go to the repository directory, and then Run.
- The trained VAE will then generate samples, which are displayed.

The gan.py file contains the **GAN** implementation. Follow these procedures to create new face samples and train the GAN:

- Run the repository directory command in a terminal after opening it, then create new face samples using the trained GAN.
- The trained GAN is then used to produce samples, which are displayed.

2> Implement variational Auto-encoders. Use the Frey Face dataset to train your network. Sample points from the learned distribution by varying different latent variables to show that your network has learned meaningful latent variables. Set the embedding vector size to 20.
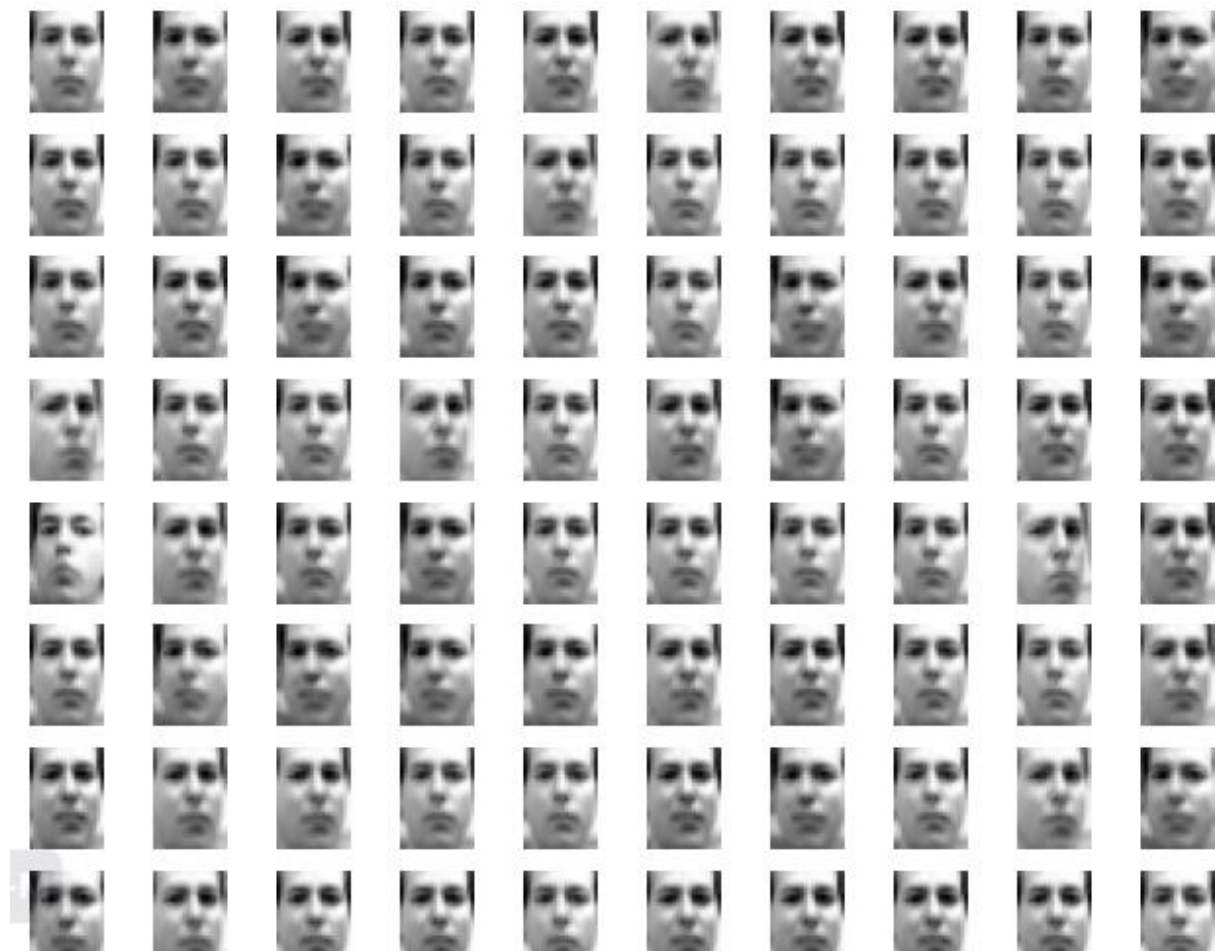Dataset: https://www.kaggle.com/datasets/hojjatk/mnist-dataset

Output:
```
Epoch 1/100, Loss: 360.8775808086832
Epoch 2/100, Loss: 352.6701783158397
Epoch 3/100, Loss: 352.39629701415396
Epoch 4/100, Loss: 352.2144566038486
Epoch 5/100, Loss: 352.070563971056
Epoch 6/100, Loss: 351.98772214933206
Epoch 7/100, Loss: 351.895737913486
Epoch 8/100, Loss: 351.89230776876593
Epoch 9/100, Loss: 351.847517096056
Epoch 10/100, Loss: 351.7672938533715
Epoch 11/100, Loss: 351.7135530971692
Epoch 12/100, Loss: 351.58921706027354
Epoch 13/100, Loss: 351.5106477616094
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Epoch 14/100, Loss: 351.4276419370229
Epoch 15/100, Loss: 351.2747380923982
Epoch 16/100, Loss: 351.0380824586514
Epoch 17/100, Loss: 350.79546556933843
Epoch 18/100, Loss: 350.5868738072519
Epoch 19/100, Loss: 350.4595424817112
Epoch 20/100, Loss: 350.2669559080789
Epoch 21/100, Loss: 350.20609444576974
Epoch 22/100, Loss: 350.0840211513995
Epoch 23/100, Loss: 349.9023556774809
Epoch 24/100, Loss: 349.92572608540075
Epoch 25/100, Loss: 349.81426924300257
Epoch 26/100, Loss: 349.77625785225825
Epoch 27/100, Loss: 349.74729047391855
Epoch 28/100, Loss: 349.72732884064885
Epoch 29/100, Loss: 349.63282094863234
Epoch 30/100, Loss: 349.5052192668575
Epoch 31/100, Loss: 349.546149908556
Epoch 32/100, Loss: 349.5315740298982
Epoch 33/100, Loss: 349.4396628498728
Epoch 34/100, Loss: 349.40726234494275
Epoch 35/100, Loss: 349.40737515903305
Epoch 36/100, Loss: 349.3563479047392
Epoch 37/100, Loss: 349.29951644004456
Epoch 38/100, Loss: 349.3131256957697
Epoch 39/100, Loss: 349.2150147105598
Epoch 40/100, Loss: 349.2647856035305
Epoch 41/100, Loss: 349.3173445451654
Epoch 42/100, Loss: 349.20759382951655
Epoch 43/100, Loss: 349.23749950302164
Epoch 44/100, Loss: 349.24501729484734
Epoch 45/100, Loss: 349.15628578244275
Epoch 46/100, Loss: 349.1884944537214
Epoch 47/100, Loss: 349.2720931735051
Epoch 48/100, Loss: 349.25590310909666
Epoch 49/100, Loss: 349.14459635416665
Epoch 50/100, Loss: 349.10549061704836
Epoch 51/100, Loss: 349.05125884621503
Epoch 52/100, Loss: 349.156085500159
Epoch 53/100, Loss: 349.0738952170802
Epoch 54/100, Loss: 349.03997246739823
Epoch 55/100, Loss: 349.082860706902
Epoch 56/100, Loss: 349.11991740219463
Epoch 57/100, Loss: 349.11145286657126
Epoch 58/100, Loss: 349.03056317589056
Epoch 59/100, Loss: 349.07934856075065
Epoch 60/100, Loss: 349.1022950461196
Epoch 61/100, Loss: 348.962946783556
Epoch 62/100, Loss: 349.00959565839696
Epoch 63/100, Loss: 349.00476353769085
Epoch 64/100, Loss: 348.9560666149809
Epoch 65/100, Loss: 348.9528794926845
Epoch 66/100, Loss: 349.00747057888043
Epoch 67/100, Loss: 349.01458730916033
Epoch 68/100, Loss: 348.990168773855
Epoch 69/100, Loss: 348.97866571246817
Epoch 70/100, Loss: 348.9524605399173
Epoch 71/100, Loss: 349.00447926606233
Epoch 72/100, Loss: 349.02057689249364
Epoch 73/100, Loss: 348.92277502783077
Epoch 74/100, Loss: 349.01728987754456
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Epoch 75/100, Loss: 348.9635128419211
Epoch 76/100, Loss: 348.90167282919845
Epoch 77/100, Loss: 348.919196783556
Epoch 78/100, Loss: 348.85397532999366
Epoch 79/100, Loss: 348.91355558206106
Epoch 80/100, Loss: 348.8646548982188
Epoch 81/100, Loss: 348.90174836991093
Epoch 82/100, Loss: 348.8960132395038
Epoch 83/100, Loss: 348.9113400524809
Epoch 84/100, Loss: 348.89920980438933
Epoch 85/100, Loss: 348.89337577528624
Epoch 86/100, Loss: 348.8856447797392
Epoch 87/100, Loss: 348.9131957697201
Epoch 88/100, Loss: 348.8546999244593
Epoch 89/100, Loss: 348.88090112118323
Epoch 90/100, Loss: 348.9165791984733
Epoch 91/100, Loss: 348.7992063255407
Epoch 92/100, Loss: 348.89842308762724
Epoch 93/100, Loss: 348.840794966603
Epoch 94/100, Loss: 348.83700948234736
Epoch 95/100, Loss: 348.848667600986
Epoch 96/100, Loss: 348.83632762802165
Epoch 97/100, Loss: 348.87143815601144
Epoch 98/100, Loss: 348.83361710798346
Epoch 99/100, Loss: 348.7817360448473
Epoch 100/100, Loss: 348.80564716523537
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Q3> Implement GAN and use the Frey Face dataset to train your network. Generate new samples and comment on the quality of the faces.
Dataset: https://cs.nyu.edu/~roweis/data/frey_rawface.mat

Output:
Epoch 1/100, Discriminator Loss: 1.0600167512893677, Generator Loss: 0.8463813066482544
Epoch 2/100, Discriminator Loss: 1.0978434085845947, Generator Loss: 0.9647741317749023
Epoch 3/100, Discriminator Loss: 1.0028835535049438, Generator Loss: 1.3155888319015503
Epoch 4/100, Discriminator Loss: 0.7064406275749207, Generator Loss: 1.3159910440444946
Epoch 5/100, Discriminator Loss: 0.0858013778924942, Generator Loss: 3.059990167617798
Epoch 6/100, Discriminator Loss: 0.026377558708190918, Generator Loss: 4.139719486236572
Epoch 7/100, Discriminator Loss: 0.3649160861968994, Generator Loss: 2.13153076171875
Epoch 8/100, Discriminator Loss: 2.489426851272583, Generator Loss: 0.5720013380050659
Epoch 9/100, Discriminator Loss: 0.33814215660095215, Generator Loss: 2.2340121269226074
Epoch 10/100, Discriminator Loss: 0.8794125318527222, Generator Loss: 1.81410551071167
Epoch 11/100, Discriminator Loss: 0.2697582244873047, Generator Loss: 3.208528995513916
Epoch 12/100, Discriminator Loss: 0.18476256728172302, Generator Loss: 3.315455436706543
Epoch 13/100, Discriminator Loss: 0.24875131249427795, Generator Loss: 3.450200319290161
Epoch 14/100, Discriminator Loss: 0.1733921468257904, Generator Loss: 3.1052327156066895
Epoch 15/100, Discriminator Loss: 0.11496420949697495, Generator Loss: 3.160433292388916
Epoch 16/100, Discriminator Loss: 0.135155588388443, Generator Loss: 3.151827335357666
Epoch 17/100, Discriminator Loss: 0.5974560976028442, Generator Loss: 2.247884750366211
Epoch 18/100, Discriminator Loss: 0.34397733211517334, Generator Loss: 2.2745816707611084
Epoch 19/100, Discriminator Loss: 1.4704327583312988, Generator Loss: 1.1488604545593262
Epoch 20/100, Discriminator Loss: 0.31236276030540466, Generator Loss: 2.708397626876831
Epoch 21/100, Discriminator Loss: 1.2501521110534668, Generator Loss: 1.0718107223510742
Epoch 22/100, Discriminator Loss: 2.2295827865600586, Generator Loss: 0.5884494185447693
Epoch 23/100, Discriminator Loss: 0.7733949422836304, Generator Loss: 2.239343086242676
Epoch 24/100, Discriminator Loss: 1.873605489730835, Generator Loss: 2.0669987201690674
Epoch 25/100, Discriminator Loss: 1.5850343704223633, Generator Loss: 1.5494706630706787
Epoch 26/100, Discriminator Loss: 0.3235824406147003, Generator Loss: 2.7719814777374268

Epoch 27/100, Discriminator Loss: 0.5489299893379211, Generator Loss: 2.1316475868225098

Epoch 28/100, Discriminator Loss: 0.7688087224960327, Generator Loss: 1.5149378776550293

Epoch 29/100, Discriminator Loss: 0.5169378519058228, Generator Loss: 1.9216207265853882

Epoch 30/100, Discriminator Loss: 0.1616036593914032, Generator Loss: 3.052665948867798

Epoch 31/100, Discriminator Loss: 3.118401288986206, Generator Loss: 0.26342204213142395

Epoch 32/100, Discriminator Loss: 0.9436159133911133, Generator Loss: 0.9929437637329102

Epoch 33/100, Discriminator Loss: 0.5438504219055176, Generator Loss: 1.8077284097671509

Epoch 34/100, Discriminator Loss: 0.6032924652099609, Generator Loss: 1.4275071620941162

Epoch 35/100, Discriminator Loss: 3.391818046569824, Generator Loss: 0.22366459667682648

Epoch 36/100, Discriminator Loss: 1.1628684997558594, Generator Loss: 0.8279201984405518

Epoch 37/100, Discriminator Loss: 1.0725678205490112, Generator Loss: 0.9092007875442505

Epoch 38/100, Discriminator Loss: 2.086400032043457, Generator Loss: 0.4224417507648468

Epoch 39/100, Discriminator Loss: 0.6793729066848755, Generator Loss: 1.4580796957015991

Epoch 40/100, Discriminator Loss: 1.3648217916488647, Generator Loss: 0.8412326574325562

Epoch 41/100, Discriminator Loss: 1.3909826278686523, Generator Loss: 1.165441870689392

Epoch 42/100, Discriminator Loss: 1.3256261348724365, Generator Loss: 1.1399154663085938

Epoch 43/100, Discriminator Loss: 1.46088504790125977, Generator Loss: 0.8240583539009094

Epoch 44/100, Discriminator Loss: 1.1948578357696533, Generator Loss: 1.1057024002075195

Epoch 45/100, Discriminator Loss: 2.367017984390259, Generator Loss: 1.174736738204956

Epoch 46/100, Discriminator Loss: 1.9881882667541504, Generator Loss: 1.3544713258743286

Epoch 47/100, Discriminator Loss: 0.3555659055709839, Generator Loss: 3.794365167617798

Epoch 48/100, Discriminator Loss: 0.15089008212089539, Generator Loss: 3.5071091651916504

Epoch 49/100, Discriminator Loss: 0.7000820636749268, Generator Loss: 1.594441533088684

Epoch 50/100, Discriminator Loss: 1.2104780673980713, Generator Loss: 1.0773038864135742

Epoch 51/100, Discriminator Loss: 0.2446122169494629, Generator Loss: 2.731316566467285

Epoch 52/100, Discriminator Loss: 1.6520347595214844, Generator Loss: 0.842619776725769

Epoch 53/100, Discriminator Loss: 0.5054768323898315, Generator Loss: 2.002411127090454

Epoch 54/100, Discriminator Loss: 0.6226611137390137, Generator Loss: 1.802565336227417

Epoch 55/100, Discriminator Loss: 1.5027973651885986, Generator Loss: 0.8508408665657043

Epoch 56/100, Discriminator Loss: 0.48862218856811523, Generator Loss: 1.7038404941558838

Epoch 57/100, Discriminator Loss: 1.0235505104064941, Generator Loss: 1.1487456560134888

Epoch 58/100, Discriminator Loss: 0.7350854277610779, Generator Loss: 1.6994882822036743

Epoch 59/100, Discriminator Loss: 2.199230670928955, Generator Loss: 0.7090604305267334

Epoch 60/100, Discriminator Loss: 1.4570797681808472, Generator Loss: 1.2968651056289673

Epoch 61/100, Discriminator Loss: 0.25646793842315674, Generator Loss: 2.6572113037109375

Epoch 62/100, Discriminator Loss: 1.342585563659668, Generator Loss: 0.929712176322937

Epoch 63/100, Discriminator Loss: 1.8808395862579346, Generator Loss: 0.7278570532798767

Epoch 64/100, Discriminator Loss: 1.9667741060256958, Generator Loss: 0.7384416460990906

Epoch 65/100, Discriminator Loss: 0.585999071598053, Generator Loss: 1.6580654382705688

Epoch 66/100, Discriminator Loss: 0.4497867226600647, Generator Loss: 2.0403988361358643

Epoch 67/100, Discriminator Loss: 1.0295809507369995, Generator Loss: 1.623766541481018

Epoch 68/100, Discriminator Loss: 1.7707650661468506, Generator Loss: 0.9878054261207581

Epoch 69/100, Discriminator Loss: 0.4824564456939697, Generator Loss: 2.374540090560913

Epoch 70/100, Discriminator Loss: 0.434036523103714, Generator Loss: 2.678255558013916

Epoch 71/100, Discriminator Loss: 2.5256032943725586, Generator Loss: 0.6608878970146179

Epoch 72/100, Discriminator Loss: 0.8057387471199036, Generator Loss: 1.2354981899261475

Epoch 73/100, Discriminator Loss: 0.1873268485069275, Generator Loss: 2.484109401702881

Epoch 74/100, Discriminator Loss: 0.24223165214061737, Generator Loss: 2.4762539863586426

Epoch 75/100, Discriminator Loss: 1.0492823123931885, Generator Loss: 1.2206556797027588

Epoch 76/100, Discriminator Loss: 2.3404502868652344, Generator Loss: 0.5206344127655029

Epoch 77/100, Discriminator Loss: 0.8698529005050659, Generator Loss: 1.202836036682129

Epoch 78/100, Discriminator Loss: 0.6603142023086548, Generator Loss: 1.3865926265716553

Epoch 79/100, Discriminator Loss: 1.4800158739089966, Generator Loss: 0.7311446070671082

Epoch 80/100, Discriminator Loss: 1.2866687774658203, Generator Loss: 0.9797961115837097

Epoch 81/100, Discriminator Loss: 1.2781238555908203, Generator Loss: 0.8533000349998474

Epoch 82/100, Discriminator Loss: 1.9245017766952515, Generator Loss: 1.0128273963928223

Epoch 83/100, Discriminator Loss: 0.5905075073242188, Generator Loss: 2.125206232070923

Epoch 84/100, Discriminator Loss: 0.7566375732421875, Generator Loss: 1.4844622611999512

Epoch 85/100, Discriminator Loss: 1.9779706001281738, Generator Loss: 0.799175500869751
Epoch 86/100, Discriminator Loss: 0.7836189866065979, Generator Loss: 2.2908222675323486
Epoch 87/100, Discriminator Loss: 0.26291337609291077, Generator Loss: 2.553786039352417
Epoch 88/100, Discriminator Loss: 1.031902551651001, Generator Loss: 1.2793712615966797
Epoch 89/100, Discriminator Loss: 1.0184746980667114, Generator Loss: 1.7846394777297974
Epoch 90/100, Discriminator Loss: 0.7123234272003174, Generator Loss: 1.6488816738128662
Epoch 91/100, Discriminator Loss: 0.6056606769561768, Generator Loss: 1.527683973312378
Epoch 92/100, Discriminator Loss: 0.5668858289718628, Generator Loss: 1.7959558963775635
Epoch 93/100, Discriminator Loss: 1.2969691753387451, Generator Loss: 0.9930509924888611
Epoch 94/100, Discriminator Loss: 0.5826837420463562, Generator Loss: 1.6637709140777588
Epoch 95/100, Discriminator Loss: 0.619807243347168, Generator Loss: 1.5243887901306152
Epoch 96/100, Discriminator Loss: 2.1377663612365723, Generator Loss: 0.6456637978553772
Epoch 97/100, Discriminator Loss: 1.5440034866333008, Generator Loss: 0.8821981549263
Epoch 98/100, Discriminator Loss: 0.4826492965221405, Generator Loss: 1.7630730867385864
Epoch 99/100, Discriminator Loss: 1.164106845855713, Generator Loss: 1.3583271503448486
Epoch 100/100, Discriminator Loss: 1.447829008102417, Generator Loss: 0.9258264899253845