Variational Autoencoder

October 16, 2018

1 Importing the packages

```
In [4]: import numpy as np
        import matplotlib.pyplot as plt
        from scipy.misc import imread , imresize
        import os
        import time
```

2 Parameters

```
In [30]: no_latent = 10
         lr = 1e-3
         epochs = 100
         batch_size = 5000
```

3 Declaring functions

```
In [6]: # Sigmoid

        def sigmoid(x):
            return 1/(1 + np.exp(-x))

        #derivative of sigmoid
        def deriv_sigmoid(x):
            return np.exp(-x)/((1+ np.multiply(np.exp(-x),np.exp(-x))))

        # softmax

        def softmax(x):
            out = np.zeros(x.shape)
            for i in range(0,x.shape[0]):
                for j in range(0,x.shape[1]):
                    out[i,j] = np.exp(x[i,j])/np.sum(np.exp(x[i]))
            return out

        # sum of Squared error
```

```python
        def squared_error(y_train, y_predicted):
            return np.sum(np.multiply(y_train - y_predicted , y_train - y_predicted))
```

In [7]:
```python
def load_flattened_images(Loc):
    Images = []
    for root, dirs, files in os.walk(Loc):
        for file in files:
            Image = imread(os.path.join(root, file))
            Image = Image / 255.0
            Images.append(Image.flatten())

    Images = np.asmatrix(Images)
    print(Images.shape)

    return Images
```

In [34]:
```python
## fitting the model

def net_fit_vae(x_t , y_t , epochs = 100 , no_latent = 10 , lr = 1e-3 , batch_size = 50
    input_dim = x_t.shape[1]
    training_samples = x_t.shape[0]
    output_dim = y_t.shape[1]
    costs = []
    x_t = np.hstack((np.ones((training_samples , 1)), x_t))
    #initializig the parameters
    alpha = np.asmatrix(np.random.normal(0,1e-5,(input_dim + 1 , no_latent)))
    gaama = np.asmatrix(np.random.normal(0,1e-5,(input_dim + 1 , no_latent)))
    beta = np.asmatrix(np.random.normal(0,1e-5,(no_latent+1 , output_dim)))

    #looping for number of itretions
    for epoch in range(0,epochs):
        for i in range(0,int(training_samples/batch_size)):
            x_train = x_t[i*batch_size:(i+1)*batch_size , :]
            y_train = y_t[i*batch_size:(i+1)*batch_size , :]
            mu_raw = x_train * alpha
            mu = sigmoid(mu_raw)
            sigma_raw = x_train * gaama
            sigma = sigmoid(sigma_raw)

            #finding z matrix
            epsilon = (np.repeat(np.asmatrix(np.random.multivariate_normal(np.zeros((no
            z = np.multiply( epsilon, np.exp(0.5*sigma))+mu
            z_biased = np.asmatrix(np.hstack((np.ones((batch_size,1)),z)))

            #finding y matrix
            y_raw = z_biased * beta
            y_predicted = sigmoid(y_raw)
```

```python
            ##finding the cost
            cost = squared_error(y_train , y_predicted) + 0.5*(np.sum(np.square(mu)) +
            costs.append(cost)
            #finding gradient w.r.t beta
            delta = np.multiply((y_predicted - y_train), deriv_sigmoid(y_raw))
            d_beta = z_biased.T * delta

            temp_beta = beta[1:,:]

            #finding gradient w.r.t alpha
            ss_alpha = np.multiply((delta * temp_beta.T),deriv_sigmoid(mu_raw))
            d_alpha = x_train.T * (ss_alpha + np.multiply(mu , deriv_sigmoid(mu_raw)))

            #finding gradient w.r.t gaama
            ss_beta = np.multiply((delta * temp_beta.T),deriv_sigmoid(sigma_raw))
            d_gaama = x_train.T * 0.5*( - 1* np.multiply(epsilon , np.multiply(ss_beta

            #updating the weights
            beta = beta - lr * d_beta
            alpha = alpha - lr*d_alpha
            gaama = gaama - lr*d_gaama
#           print(np.max(alpha) , np.max(beta) , np.min(alpha) , np.min(beta))
            print("\nEpoch: " + str(epoch+1) + "   batch : " + str(i+1) + "   cost : "
    return beta , costs
```

In [80]: *#prediction*

```python
def net_generate(number , weights , no_latent):
    generated = []
    for i in range(0,number):
        x = np.asmatrix(np.random.multivariate_normal(np.zeros((no_latent)) , np.eye(no
        x = np.asmatrix(np.hstack(([[1]],x)))
        gen = sigmoid(x * weights)
        gen_image = np.round(gen.reshape(28,28))
        generated.append(gen_image)
    return generated
```

4   Generating training data

In [89]: *# x_train = load_flattened_images("/home/snehith/Documents/machine learning/datasets/mr*
         # np.save("train_set_vae.npy" , x_train)
```python
x_train = np.asmatrix(np.load("train_set_vae.npy"))
print(x_train.shape)
```

(28000, 784)

5 Training the Model

```
In [35]: # alpha , beta , losses = net_fit(x_Train , y_train_and , hidden_nodes = hidden_nodes ,
         tic = time.time()
         weights , lossses = net_fit_vae(x_train , x_train , no_latent = no_latent , epochs = ep
         print("time taken: "+ str(time.time() - tic) + "sec")
         # print("\nalpha:\n",alpha ,"\nbeta:\n", beta,"\n" ,"\nloss:\n", losses[epochs-1])
         np.save("weights_vae.npy" , weights)
         # np.save("beta_weights_vae.npy" , beta)
```

```
Epoch: 1   batch : 1   cost : 894881.5249358417

Epoch: 1   batch : 2   cost : 1676604.399344305

Epoch: 1   batch : 3   cost : 836585.4236027156

Epoch: 1   batch : 4   cost : 2236734.8544620196

Epoch: 1   batch : 5   cost : 347814.4512032438

Epoch: 2   batch : 1   cost : 317521.29779653245

Epoch: 2   batch : 2   cost : 509330.21611798066

Epoch: 2   batch : 3   cost : 354953.83838184056

Epoch: 2   batch : 4   cost : 3169763.9514268045

Epoch: 2   batch : 5   cost : 2167246.5699105226

Epoch: 3   batch : 1   cost : 2432599.972278135

Epoch: 3   batch : 2   cost : 371774.3044271679

Epoch: 3   batch : 3   cost : 3148258.8589601796

Epoch: 3   batch : 4   cost : 299496.00505048194

Epoch: 3   batch : 5   cost : 351601.627779848

Epoch: 4   batch : 1   cost : 375597.57715359563

Epoch: 4   batch : 2   cost : 349980.09691169363

Epoch: 4   batch : 3   cost : 3055150.5294021782

Epoch: 4   batch : 4   cost : 1405978.3770361503
```

```
Epoch: 4    batch : 5    cost : 506721.0524602135

Epoch: 5    batch : 1    cost : 1705950.434894276

Epoch: 5    batch : 2    cost : 372211.36472275737

Epoch: 5    batch : 3    cost : 337531.02700029017

Epoch: 5    batch : 4    cost : 1386260.2617328533

Epoch: 5    batch : 5    cost : 667577.3418397839

Epoch: 6    batch : 1    cost : 423548.9424026123

Epoch: 6    batch : 2    cost : 331173.4661909817

Epoch: 6    batch : 3    cost : 891115.1277096414

Epoch: 6    batch : 4    cost : 1519799.3333451445

Epoch: 6    batch : 5    cost : 362955.64441618806

Epoch: 7    batch : 1    cost : 456252.90245337016

Epoch: 7    batch : 2    cost : 364562.7429126703

Epoch: 7    batch : 3    cost : 379249.9388141697

Epoch: 7    batch : 4    cost : 349128.09692617704

Epoch: 7    batch : 5    cost : 496822.38210271683

Epoch: 8    batch : 1    cost : 371634.7527114676

Epoch: 8    batch : 2    cost : 360707.39480689005

Epoch: 8    batch : 3    cost : 550437.4437581858

Epoch: 8    batch : 4    cost : 362735.736169687

Epoch: 8    batch : 5    cost : 425497.30208456743

Epoch: 9    batch : 1    cost : 361123.17208818265

Epoch: 9    batch : 2    cost : 354001.877230114

Epoch: 9    batch : 3    cost : 325349.594918995
```

```
Epoch: 9    batch : 4    cost : 343856.47501076834

Epoch: 9    batch : 5    cost : 354886.13308531116

Epoch: 10   batch : 1    cost : 829234.0365832951

Epoch: 10   batch : 2    cost : 406060.9820890123

Epoch: 10   batch : 3    cost : 389110.5974712974

Epoch: 10   batch : 4    cost : 344682.76189954224

Epoch: 10   batch : 5    cost : 358994.41502576333

Epoch: 11   batch : 1    cost : 361686.8657097705

Epoch: 11   batch : 2    cost : 381185.2943366271

Epoch: 11   batch : 3    cost : 1689011.277850785

Epoch: 11   batch : 4    cost : 369037.2368646116

Epoch: 11   batch : 5    cost : 340194.98925384105

Epoch: 12   batch : 1    cost : 349306.8203414394

Epoch: 12   batch : 2    cost : 357300.4393059197

Epoch: 12   batch : 3    cost : 370825.2881118607

Epoch: 12   batch : 4    cost : 350951.17144898564

Epoch: 12   batch : 5    cost : 526518.544314013

Epoch: 13   batch : 1    cost : 502167.9490078639

Epoch: 13   batch : 2    cost : 520405.6478246604

Epoch: 13   batch : 3    cost : 369670.5314211751

Epoch: 13   batch : 4    cost : 395225.51636791765

Epoch: 13   batch : 5    cost : 366280.411091237

Epoch: 14   batch : 1    cost : 350047.432950887

Epoch: 14   batch : 2    cost : 370753.0668403734
```

Epoch: 14   batch : 3   cost : 376860.4446962331

Epoch: 14   batch : 4   cost : 367612.9391222404

Epoch: 14   batch : 5   cost : 772124.1051101264

Epoch: 15   batch : 1   cost : 599765.2732413582

Epoch: 15   batch : 2   cost : 383663.70106951793

Epoch: 15   batch : 3   cost : 381160.54025396856

Epoch: 15   batch : 4   cost : 381222.7065542868

Epoch: 15   batch : 5   cost : 364059.3850401185

Epoch: 16   batch : 1   cost : 486296.6403732618

Epoch: 16   batch : 2   cost : 382105.94964590226

Epoch: 16   batch : 3   cost : 352374.90356640966

Epoch: 16   batch : 4   cost : 387475.81715471915

Epoch: 16   batch : 5   cost : 401955.15835433564

Epoch: 17   batch : 1   cost : 370661.58868778334

Epoch: 17   batch : 2   cost : 370348.6252363222

Epoch: 17   batch : 3   cost : 366910.7093360341

Epoch: 17   batch : 4   cost : 360391.05740447284

Epoch: 17   batch : 5   cost : 388863.45611935016

Epoch: 18   batch : 1   cost : 370804.8065694805

Epoch: 18   batch : 2   cost : 376470.4764457072

Epoch: 18   batch : 3   cost : 366114.244291099

Epoch: 18   batch : 4   cost : 377575.1450789321

Epoch: 18   batch : 5   cost : 379617.5372575375

Epoch: 19   batch : 1   cost : 387910.13844222826

```
Epoch: 19    batch : 2    cost : 377804.2659269273

Epoch: 19    batch : 3    cost : 380054.4527457212

Epoch: 19    batch : 4    cost : 363533.62096288416

Epoch: 19    batch : 5    cost : 395274.0440290438

Epoch: 20    batch : 1    cost : 394142.19176380726

Epoch: 20    batch : 2    cost : 392466.06503573054

Epoch: 20    batch : 3    cost : 356538.6976652741

Epoch: 20    batch : 4    cost : 459402.36236992327

Epoch: 20    batch : 5    cost : 415465.64663228526

Epoch: 21    batch : 1    cost : 360484.9092142089

Epoch: 21    batch : 2    cost : 398407.2488674678

Epoch: 21    batch : 3    cost : 362801.21648409846

Epoch: 21    batch : 4    cost : 388199.7894238662

Epoch: 21    batch : 5    cost : 374343.9677086741

Epoch: 22    batch : 1    cost : 367874.59517047333

Epoch: 22    batch : 2    cost : 420193.1137320784

Epoch: 22    batch : 3    cost : 378462.615442715

Epoch: 22    batch : 4    cost : 488958.29947646376

Epoch: 22    batch : 5    cost : 399052.1730023442

Epoch: 23    batch : 1    cost : 561037.1506268834

Epoch: 23    batch : 2    cost : 408734.89674006857

Epoch: 23    batch : 3    cost : 380605.04178547347

Epoch: 23    batch : 4    cost : 381121.77576585946

Epoch: 23    batch : 5    cost : 363229.6485763206
```

```
Epoch: 24    batch : 1    cost : 369029.83367379545

Epoch: 24    batch : 2    cost : 379701.1934751491

Epoch: 24    batch : 3    cost : 384973.58827627526

Epoch: 24    batch : 4    cost : 356118.05786255596

Epoch: 24    batch : 5    cost : 471186.557449086

Epoch: 25    batch : 1    cost : 377031.4273713295

Epoch: 25    batch : 2    cost : 370635.1587020446

Epoch: 25    batch : 3    cost : 375174.692799081

Epoch: 25    batch : 4    cost : 387709.6428872521

Epoch: 25    batch : 5    cost : 400784.78201553173

Epoch: 26    batch : 1    cost : 363752.720508917

Epoch: 26    batch : 2    cost : 382904.73530189146

Epoch: 26    batch : 3    cost : 379745.79578864895

Epoch: 26    batch : 4    cost : 376427.7945138029

Epoch: 26    batch : 5    cost : 369914.3121563745

Epoch: 27    batch : 1    cost : 364306.8449365747

Epoch: 27    batch : 2    cost : 411576.4527024198

Epoch: 27    batch : 3    cost : 392458.6324722377

Epoch: 27    batch : 4    cost : 381442.53720474447

Epoch: 27    batch : 5    cost : 395302.98015117535

Epoch: 28    batch : 1    cost : 378703.1219298445

Epoch: 28    batch : 2    cost : 370570.34953455155

Epoch: 28    batch : 3    cost : 361172.23910308076

Epoch: 28    batch : 4    cost : 377547.66765242215
```

```
Epoch: 28    batch : 5    cost : 374276.665222065

Epoch: 29    batch : 1    cost : 381677.4239267636

Epoch: 29    batch : 2    cost : 399801.0014918844

Epoch: 29    batch : 3    cost : 386935.3681460631

Epoch: 29    batch : 4    cost : 371440.77508594154

Epoch: 29    batch : 5    cost : 383384.599450979

Epoch: 30    batch : 1    cost : 366912.2492407307

Epoch: 30    batch : 2    cost : 370199.94889992423

Epoch: 30    batch : 3    cost : 391485.4634859952

Epoch: 30    batch : 4    cost : 358144.8313504965

Epoch: 30    batch : 5    cost : 373264.7053642994

Epoch: 31    batch : 1    cost : 399065.3349567207

Epoch: 31    batch : 2    cost : 398206.4357324095

Epoch: 31    batch : 3    cost : 401272.5221758087

Epoch: 31    batch : 4    cost : 379778.1500150035

Epoch: 31    batch : 5    cost : 361927.42292744276

Epoch: 32    batch : 1    cost : 370654.0511645674

Epoch: 32    batch : 2    cost : 401112.7106181223

Epoch: 32    batch : 3    cost : 360633.91367312166

Epoch: 32    batch : 4    cost : 373287.93542307266

Epoch: 32    batch : 5    cost : 375302.01051702077

Epoch: 33    batch : 1    cost : 384000.1601312193

Epoch: 33    batch : 2    cost : 392331.29463738296

Epoch: 33    batch : 3    cost : 364079.24153587356
```

```
Epoch: 33    batch : 4    cost : 385519.20058874105

Epoch: 33    batch : 5    cost : 361837.32077460916

Epoch: 34    batch : 1    cost : 375469.3474709418

Epoch: 34    batch : 2    cost : 385187.74681602366

Epoch: 34    batch : 3    cost : 384486.2245251813

Epoch: 34    batch : 4    cost : 369785.78630550584

Epoch: 34    batch : 5    cost : 384684.8208451181

Epoch: 35    batch : 1    cost : 364403.0136873008

Epoch: 35    batch : 2    cost : 369956.7231989068

Epoch: 35    batch : 3    cost : 372300.2909645963

Epoch: 35    batch : 4    cost : 370976.0197647894

Epoch: 35    batch : 5    cost : 363825.97150601

Epoch: 36    batch : 1    cost : 419132.2380083096

Epoch: 36    batch : 2    cost : 396456.8574731221

Epoch: 36    batch : 3    cost : 456435.9380035514

Epoch: 36    batch : 4    cost : 368838.9684825259

Epoch: 36    batch : 5    cost : 378171.69561898184

Epoch: 37    batch : 1    cost : 371741.6006649504

Epoch: 37    batch : 2    cost : 365715.6259041299

Epoch: 37    batch : 3    cost : 477908.9802839797

Epoch: 37    batch : 4    cost : 374487.9476938455

Epoch: 37    batch : 5    cost : 394575.12378192437

Epoch: 38    batch : 1    cost : 374484.8059010422

Epoch: 38    batch : 2    cost : 365684.7888374939
```

```
Epoch: 38    batch : 3    cost : 380927.60712002445

Epoch: 38    batch : 4    cost : 388371.50431824115

Epoch: 38    batch : 5    cost : 387978.9784335108

Epoch: 39    batch : 1    cost : 373342.5876907832

Epoch: 39    batch : 2    cost : 368575.07859288534

Epoch: 39    batch : 3    cost : 356134.6350215666

Epoch: 39    batch : 4    cost : 358681.72219981876

Epoch: 39    batch : 5    cost : 426503.16167869646

Epoch: 40    batch : 1    cost : 376243.39166103856

Epoch: 40    batch : 2    cost : 361513.1779210053

Epoch: 40    batch : 3    cost : 387488.9811822424

Epoch: 40    batch : 4    cost : 363615.79898985586

Epoch: 40    batch : 5    cost : 386187.59949834587

Epoch: 41    batch : 1    cost : 367279.98138372845

Epoch: 41    batch : 2    cost : 361187.5506240499

Epoch: 41    batch : 3    cost : 379770.8032754283

Epoch: 41    batch : 4    cost : 371518.40582513844

Epoch: 41    batch : 5    cost : 361652.15527150943

Epoch: 42    batch : 1    cost : 418310.4357202608

Epoch: 42    batch : 2    cost : 379833.345709098

Epoch: 42    batch : 3    cost : 361251.23912650824

Epoch: 42    batch : 4    cost : 383676.94922145456

Epoch: 42    batch : 5    cost : 359825.621153571

Epoch: 43    batch : 1    cost : 365229.2533963977
```

```
Epoch: 43    batch : 2    cost : 369998.27834852476

Epoch: 43    batch : 3    cost : 398551.5227114817

Epoch: 43    batch : 4    cost : 386539.4575926856

Epoch: 43    batch : 5    cost : 375139.7202816211

Epoch: 44    batch : 1    cost : 396820.8100404915

Epoch: 44    batch : 2    cost : 372228.42358973046

Epoch: 44    batch : 3    cost : 362614.11013121036

Epoch: 44    batch : 4    cost : 374777.9926854398

Epoch: 44    batch : 5    cost : 385222.74849790265

Epoch: 45    batch : 1    cost : 397825.4063210196

Epoch: 45    batch : 2    cost : 372862.28328318783

Epoch: 45    batch : 3    cost : 436598.161295448

Epoch: 45    batch : 4    cost : 380109.80743975146

Epoch: 45    batch : 5    cost : 380866.0876383866

Epoch: 46    batch : 1    cost : 384481.0346047879

Epoch: 46    batch : 2    cost : 376968.1239575672

Epoch: 46    batch : 3    cost : 374819.9317715304

Epoch: 46    batch : 4    cost : 389067.8895227598

Epoch: 46    batch : 5    cost : 395248.5069230972

Epoch: 47    batch : 1    cost : 412321.70993695676

Epoch: 47    batch : 2    cost : 371991.82868275273

Epoch: 47    batch : 3    cost : 380440.88972698926

Epoch: 47    batch : 4    cost : 375456.9781959909

Epoch: 47    batch : 5    cost : 383626.94812737784
```

```
Epoch: 48    batch : 1    cost : 386626.21174498094

Epoch: 48    batch : 2    cost : 377601.4903268782

Epoch: 48    batch : 3    cost : 382059.78699069086

Epoch: 48    batch : 4    cost : 353951.3160504736

Epoch: 48    batch : 5    cost : 366972.73054454394

Epoch: 49    batch : 1    cost : 380229.78112477635

Epoch: 49    batch : 2    cost : 378895.63819146977

Epoch: 49    batch : 3    cost : 380505.65326517756

Epoch: 49    batch : 4    cost : 367200.67073872464

Epoch: 49    batch : 5    cost : 375985.0971682116

Epoch: 50    batch : 1    cost : 380560.93879250373

Epoch: 50    batch : 2    cost : 377870.7648372308

Epoch: 50    batch : 3    cost : 393234.82259688707

Epoch: 50    batch : 4    cost : 396377.07691354555

Epoch: 50    batch : 5    cost : 380359.50303083233

Epoch: 51    batch : 1    cost : 401292.03954589774

Epoch: 51    batch : 2    cost : 406066.9672278115

Epoch: 51    batch : 3    cost : 394448.2651155442

Epoch: 51    batch : 4    cost : 393119.9738016764

Epoch: 51    batch : 5    cost : 384055.2460141788

Epoch: 52    batch : 1    cost : 387783.3387661972

Epoch: 52    batch : 2    cost : 376344.7564865915

Epoch: 52    batch : 3    cost : 374326.09721610806

Epoch: 52    batch : 4    cost : 380146.25488632655
```

```
Epoch: 52    batch : 5    cost : 373741.00552299136

Epoch: 53    batch : 1    cost : 418485.8847950184

Epoch: 53    batch : 2    cost : 390979.9222793502

Epoch: 53    batch : 3    cost : 402576.07767010527

Epoch: 53    batch : 4    cost : 393609.1164896341

Epoch: 53    batch : 5    cost : 392303.24644563353

Epoch: 54    batch : 1    cost : 369462.56242713705

Epoch: 54    batch : 2    cost : 373158.8224376496

Epoch: 54    batch : 3    cost : 394548.49416877073

Epoch: 54    batch : 4    cost : 395857.73941517714

Epoch: 54    batch : 5    cost : 378008.34415715473

Epoch: 55    batch : 1    cost : 453370.07259887084

Epoch: 55    batch : 2    cost : 386843.7857970175

Epoch: 55    batch : 3    cost : 373606.53894974233

Epoch: 55    batch : 4    cost : 407202.0678722843

Epoch: 55    batch : 5    cost : 395776.9179965028

Epoch: 56    batch : 1    cost : 419131.35005640716

Epoch: 56    batch : 2    cost : 450157.28879819845

Epoch: 56    batch : 3    cost : 383191.65925101703

Epoch: 56    batch : 4    cost : 399078.5158857723

Epoch: 56    batch : 5    cost : 382204.3937427347

Epoch: 57    batch : 1    cost : 370844.3095566645

Epoch: 57    batch : 2    cost : 397956.5135565944

Epoch: 57    batch : 3    cost : 390606.3637045006
```

```
Epoch: 57    batch : 4    cost : 395685.51355177455

Epoch: 57    batch : 5    cost : 391131.753334375

Epoch: 58    batch : 1    cost : 399825.35978018626

Epoch: 58    batch : 2    cost : 399648.07761137583

Epoch: 58    batch : 3    cost : 398502.29944678023

Epoch: 58    batch : 4    cost : 387905.3233020655

Epoch: 58    batch : 5    cost : 385836.5425549794

Epoch: 59    batch : 1    cost : 414540.27659299795

Epoch: 59    batch : 2    cost : 384892.6997853966

Epoch: 59    batch : 3    cost : 379048.7782744143

Epoch: 59    batch : 4    cost : 392296.8352067441

Epoch: 59    batch : 5    cost : 399189.5045435761

Epoch: 60    batch : 1    cost : 383242.2761277647

Epoch: 60    batch : 2    cost : 403240.7157319934

Epoch: 60    batch : 3    cost : 389172.5660761838

Epoch: 60    batch : 4    cost : 396348.44589442614

Epoch: 60    batch : 5    cost : 399264.6641083303

Epoch: 61    batch : 1    cost : 378205.81675504416

Epoch: 61    batch : 2    cost : 395890.5974267349

Epoch: 61    batch : 3    cost : 390037.4202583877

Epoch: 61    batch : 4    cost : 396889.9718692182

Epoch: 61    batch : 5    cost : 409520.09769495303

Epoch: 62    batch : 1    cost : 381877.31501933077

Epoch: 62    batch : 2    cost : 427908.9471461009
```

```
Epoch: 62    batch : 3    cost : 389131.64208782354

Epoch: 62    batch : 4    cost : 378704.1548004042

Epoch: 62    batch : 5    cost : 390456.1701968506

Epoch: 63    batch : 1    cost : 401091.27878969954

Epoch: 63    batch : 2    cost : 390127.2595455087

Epoch: 63    batch : 3    cost : 385517.62500787893

Epoch: 63    batch : 4    cost : 403185.84479457454

Epoch: 63    batch : 5    cost : 378562.7362883314

Epoch: 64    batch : 1    cost : 395897.6283465202

Epoch: 64    batch : 2    cost : 389134.5004429809

Epoch: 64    batch : 3    cost : 388929.17605538154

Epoch: 64    batch : 4    cost : 379809.4873517154

Epoch: 64    batch : 5    cost : 379333.8643021571

Epoch: 65    batch : 1    cost : 383016.05825817474

Epoch: 65    batch : 2    cost : 380750.9439555575

Epoch: 65    batch : 3    cost : 399908.1256084409

Epoch: 65    batch : 4    cost : 386430.6803692072

Epoch: 65    batch : 5    cost : 374918.60021033534

Epoch: 66    batch : 1    cost : 422985.8879163598

Epoch: 66    batch : 2    cost : 407260.5285692924

Epoch: 66    batch : 3    cost : 381837.24768361985

Epoch: 66    batch : 4    cost : 376291.81857381016

Epoch: 66    batch : 5    cost : 370714.4714561359

Epoch: 67    batch : 1    cost : 408073.229049813
```

```
Epoch: 67    batch : 2    cost : 385982.20596246753

Epoch: 67    batch : 3    cost : 374924.70562269783

Epoch: 67    batch : 4    cost : 393002.66844454466

Epoch: 67    batch : 5    cost : 380553.0014476797

Epoch: 68    batch : 1    cost : 390624.39093751065

Epoch: 68    batch : 2    cost : 385634.0037266076

Epoch: 68    batch : 3    cost : 382254.7364555289

Epoch: 68    batch : 4    cost : 407989.168785062

Epoch: 68    batch : 5    cost : 410079.501117883

Epoch: 69    batch : 1    cost : 386104.83163251326

Epoch: 69    batch : 2    cost : 383112.9515129432

Epoch: 69    batch : 3    cost : 388774.91895711084

Epoch: 69    batch : 4    cost : 392219.2531165233

Epoch: 69    batch : 5    cost : 386697.1155522425

Epoch: 70    batch : 1    cost : 376610.75910581654

Epoch: 70    batch : 2    cost : 384691.0319132913

Epoch: 70    batch : 3    cost : 388104.7077300143

Epoch: 70    batch : 4    cost : 394262.8851122813

Epoch: 70    batch : 5    cost : 385970.94268098037

Epoch: 71    batch : 1    cost : 385160.2091417122

Epoch: 71    batch : 2    cost : 397771.443192827

Epoch: 71    batch : 3    cost : 381753.119120129

Epoch: 71    batch : 4    cost : 388973.7594100753

Epoch: 71    batch : 5    cost : 385672.3315790706
```

```
Epoch: 72    batch : 1    cost : 393449.9566483828

Epoch: 72    batch : 2    cost : 384619.22193135327

Epoch: 72    batch : 3    cost : 385091.1489177354

Epoch: 72    batch : 4    cost : 390864.48005289224

Epoch: 72    batch : 5    cost : 385503.63647394313

Epoch: 73    batch : 1    cost : 430022.6254021217

Epoch: 73    batch : 2    cost : 372501.6042143973

Epoch: 73    batch : 3    cost : 395024.3861492805

Epoch: 73    batch : 4    cost : 387943.5327443105

Epoch: 73    batch : 5    cost : 454500.92811681615

Epoch: 74    batch : 1    cost : 384815.0378002448

Epoch: 74    batch : 2    cost : 414869.75049245317

Epoch: 74    batch : 3    cost : 393150.7948487134

Epoch: 74    batch : 4    cost : 379408.9507098907

Epoch: 74    batch : 5    cost : 379332.16047057597

Epoch: 75    batch : 1    cost : 387343.57675365655

Epoch: 75    batch : 2    cost : 418341.6778025913

Epoch: 75    batch : 3    cost : 393999.8664266253

Epoch: 75    batch : 4    cost : 397054.66831983125

Epoch: 75    batch : 5    cost : 399191.1770999615

Epoch: 76    batch : 1    cost : 388162.5849495444

Epoch: 76    batch : 2    cost : 381486.4049460715

Epoch: 76    batch : 3    cost : 403959.5117328571

Epoch: 76    batch : 4    cost : 377036.7082421789
```

```
Epoch: 76    batch : 5    cost : 373808.72793638776

Epoch: 77    batch : 1    cost : 390645.57025378797

Epoch: 77    batch : 2    cost : 418583.7488198804

Epoch: 77    batch : 3    cost : 398384.10862921434

Epoch: 77    batch : 4    cost : 404670.82037557435

Epoch: 77    batch : 5    cost : 410453.9759875422

Epoch: 78    batch : 1    cost : 384833.7046602175

Epoch: 78    batch : 2    cost : 384241.0398536972

Epoch: 78    batch : 3    cost : 393019.0599189544

Epoch: 78    batch : 4    cost : 392252.36090719316

Epoch: 78    batch : 5    cost : 370719.5410715468

Epoch: 79    batch : 1    cost : 383904.22996020573

Epoch: 79    batch : 2    cost : 400391.10196350573

Epoch: 79    batch : 3    cost : 385560.90294457704

Epoch: 79    batch : 4    cost : 394881.0913831472

Epoch: 79    batch : 5    cost : 379757.1041823386

Epoch: 80    batch : 1    cost : 394782.15221344435

Epoch: 80    batch : 2    cost : 379464.5850654384

Epoch: 80    batch : 3    cost : 377720.99954066385

Epoch: 80    batch : 4    cost : 385018.4230975112

Epoch: 80    batch : 5    cost : 387551.76084539

Epoch: 81    batch : 1    cost : 388884.20860898285

Epoch: 81    batch : 2    cost : 388862.1214361409

Epoch: 81    batch : 3    cost : 383719.50229956553
```

```
Epoch: 81   batch : 4   cost : 383732.528378197

Epoch: 81   batch : 5   cost : 388603.6625357904

Epoch: 82   batch : 1   cost : 380393.40970464837

Epoch: 82   batch : 2   cost : 376919.54173941066

Epoch: 82   batch : 3   cost : 385621.03881618497

Epoch: 82   batch : 4   cost : 384413.85300736676

Epoch: 82   batch : 5   cost : 372782.882666477

Epoch: 83   batch : 1   cost : 386070.9737139491

Epoch: 83   batch : 2   cost : 391432.69580766093

Epoch: 83   batch : 3   cost : 378031.3251720275

Epoch: 83   batch : 4   cost : 396215.8251516057

Epoch: 83   batch : 5   cost : 387588.19182915724

Epoch: 84   batch : 1   cost : 393146.74301027163

Epoch: 84   batch : 2   cost : 381928.4508728939

Epoch: 84   batch : 3   cost : 380737.4299821435

Epoch: 84   batch : 4   cost : 382033.7715530904

Epoch: 84   batch : 5   cost : 387234.6393710547

Epoch: 85   batch : 1   cost : 389111.1674321563

Epoch: 85   batch : 2   cost : 377728.0628297289

Epoch: 85   batch : 3   cost : 388517.346157924

Epoch: 85   batch : 4   cost : 384067.5785591372

Epoch: 85   batch : 5   cost : 369227.58025734586

Epoch: 86   batch : 1   cost : 392090.72784438834

Epoch: 86   batch : 2   cost : 384218.818813032
```

```
Epoch: 86    batch : 3    cost : 390862.84463922575

Epoch: 86    batch : 4    cost : 400331.7875580071

Epoch: 86    batch : 5    cost : 382944.74228868587

Epoch: 87    batch : 1    cost : 389840.79238785396

Epoch: 87    batch : 2    cost : 410740.42057458416

Epoch: 87    batch : 3    cost : 388771.93335850554

Epoch: 87    batch : 4    cost : 387429.4226539494

Epoch: 87    batch : 5    cost : 383838.0084044421

Epoch: 88    batch : 1    cost : 388330.1444710021

Epoch: 88    batch : 2    cost : 393316.4851430407

Epoch: 88    batch : 3    cost : 385945.40280870703

Epoch: 88    batch : 4    cost : 385541.1661583775

Epoch: 88    batch : 5    cost : 374258.4147161241

Epoch: 89    batch : 1    cost : 370014.21203457343

Epoch: 89    batch : 2    cost : 387325.4050663948

Epoch: 89    batch : 3    cost : 375937.7041617186

Epoch: 89    batch : 4    cost : 405462.15091088903

Epoch: 89    batch : 5    cost : 380486.986851737

Epoch: 90    batch : 1    cost : 377206.4876611927

Epoch: 90    batch : 2    cost : 392917.7973418301

Epoch: 90    batch : 3    cost : 381683.7781168005

Epoch: 90    batch : 4    cost : 381588.9124043903

Epoch: 90    batch : 5    cost : 372729.59917097766

Epoch: 91    batch : 1    cost : 366540.15856403945
```

Epoch: 91   batch : 2   cost : 376778.0361052168

Epoch: 91   batch : 3   cost : 385354.4019060463

Epoch: 91   batch : 4   cost : 388259.2163103925

Epoch: 91   batch : 5   cost : 380317.00421880116

Epoch: 92   batch : 1   cost : 388326.02082222246

Epoch: 92   batch : 2   cost : 392524.4614465859

Epoch: 92   batch : 3   cost : 392827.2706470245

Epoch: 92   batch : 4   cost : 381198.9082991764

Epoch: 92   batch : 5   cost : 372076.95319423504

Epoch: 93   batch : 1   cost : 391960.0638456567

Epoch: 93   batch : 2   cost : 385902.3395041327

Epoch: 93   batch : 3   cost : 375970.83002128376

Epoch: 93   batch : 4   cost : 371325.31262853584

Epoch: 93   batch : 5   cost : 365559.1455711167

Epoch: 94   batch : 1   cost : 390614.92249400576

Epoch: 94   batch : 2   cost : 417283.5401668897

Epoch: 94   batch : 3   cost : 394452.3196891679

Epoch: 94   batch : 4   cost : 435809.3996758036

Epoch: 94   batch : 5   cost : 381780.1532532945

Epoch: 95   batch : 1   cost : 393194.47962792264

Epoch: 95   batch : 2   cost : 380694.8767854122

Epoch: 95   batch : 3   cost : 381566.8807664006

Epoch: 95   batch : 4   cost : 401440.12047537393

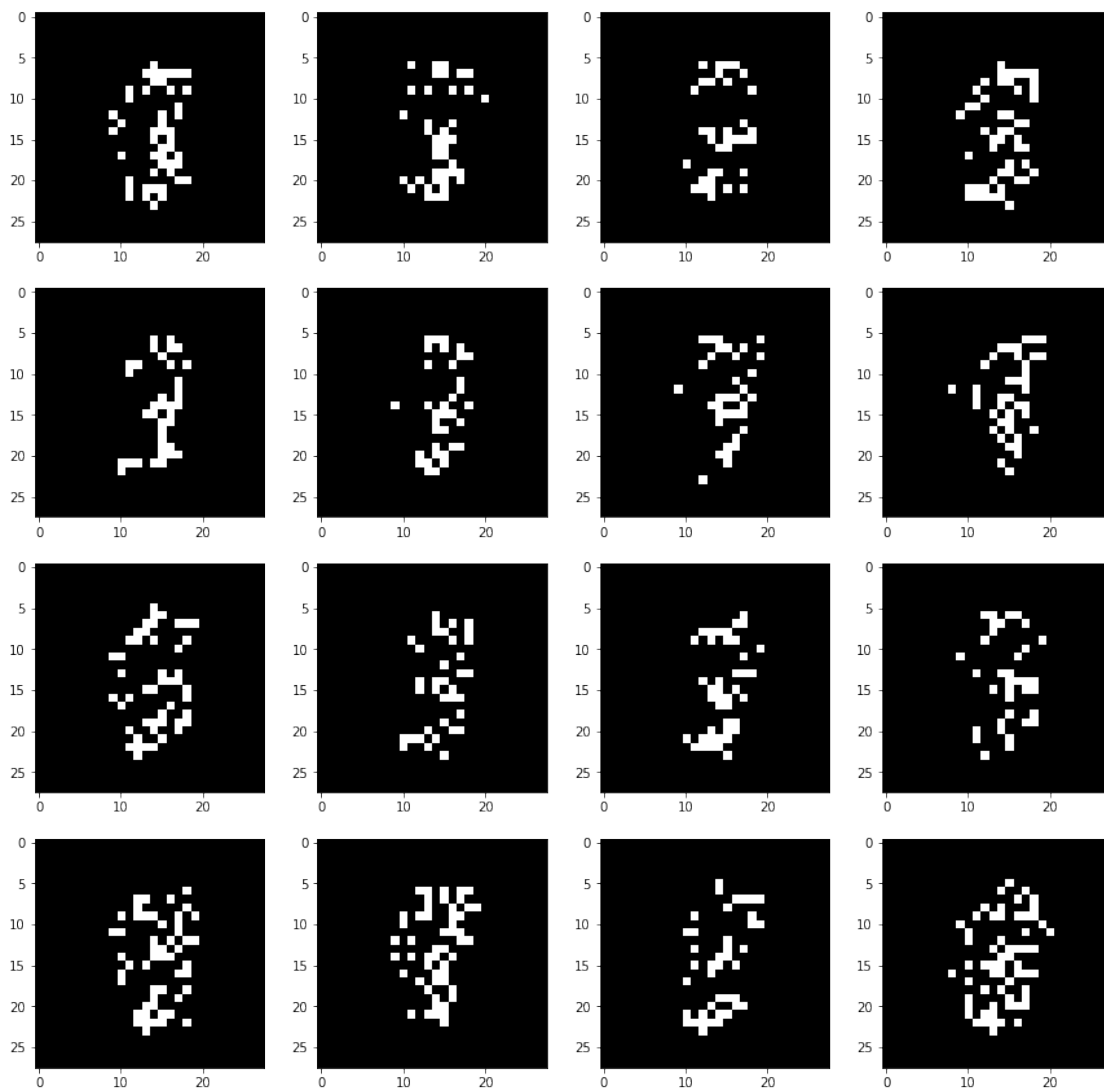Epoch: 95   batch : 5   cost : 376294.1760282921

```
Epoch: 96   batch : 1   cost : 388608.5159898003

Epoch: 96   batch : 2   cost : 393582.2935896662

Epoch: 96   batch : 3   cost : 394222.03123207693

Epoch: 96   batch : 4   cost : 400153.2385986445

Epoch: 96   batch : 5   cost : 367965.8404721447

Epoch: 97   batch : 1   cost : 373924.361722677

Epoch: 97   batch : 2   cost : 379269.2044880599

Epoch: 97   batch : 3   cost : 396631.78704500536

Epoch: 97   batch : 4   cost : 391578.99110759

Epoch: 97   batch : 5   cost : 373211.0092878053

Epoch: 98   batch : 1   cost : 383722.6022924775

Epoch: 98   batch : 2   cost : 393833.44619494426

Epoch: 98   batch : 3   cost : 386814.11418744636

Epoch: 98   batch : 4   cost : 380908.3368854595

Epoch: 98   batch : 5   cost : 382166.5589008395

Epoch: 99   batch : 1   cost : 381995.174765198

Epoch: 99   batch : 2   cost : 392830.6962310641

Epoch: 99   batch : 3   cost : 372973.6015363721

Epoch: 99   batch : 4   cost : 385830.7161260835

Epoch: 99   batch : 5   cost : 390707.27737520763

Epoch: 100   batch : 1   cost : 381133.7317133874

Epoch: 100   batch : 2   cost : 382274.33306743356

Epoch: 100   batch : 3   cost : 394116.710108392

Epoch: 100   batch : 4   cost : 379346.7504260815
```

```
Epoch: 100   batch : 5   cost : 399816.61837643705
time taken: 281.8900511264801sec
```

5.0.1   Generating new images

```
In [81]: #Generating new images
         result = net_generate(16 , weights , no_latent)
         plt.figure(figsize = (15,15))
         for i in range(0,16):
             plt.subplot(4,4,i+1)
             plt.imshow(result[i] , cmap = 'gray')
```

```
In [37]: #ploting the cost vs epochs
         plt.plot(np.arange(len(lossses)),lossses)
         plt.title("training samples: " + str(x_train.shape[0]))
         plt.xlabel("epochs")
         plt.ylabel("cost")
         plt.show()
```


training samples: 28000