Dataset1-Regression_output_3

October 7, 2021

1 Dataset 1 - Regression

1.1 Import Libraries

[1]:

```python
import train_test
import ABC_train_test
import regressionDataset
import network
import statsModel
import performanceMetrics
import dataset
import sanityChecks
import torch
import matplotlib.pyplot as plt
import seaborn as sns
from scipy.stats import norm
from torch.utils.data import Dataset,DataLoader
from torch import nn
import warnings
warnings.filterwarnings('ignore')
```

1.2 Parameters

General Parameters

1. Number of Samples

Discriminator Parameters

1. Size : number of hidden nodes

ABC-Generator parameters are as mentioned below: 1. mean : 1 ($\beta \sim N(\beta^*, \sigma)$ where β^* are coefficients of statistical model) or 1 ($\beta \sim N(0, \sigma)$ 2. std : $\sigma = 1, 0.1, 0.01$ (standard deviation)

[2]:

```python
n_features = 10
sample_size = 100
#Discriminator Parameters
hidden_nodes = 25
#ABC Generator Parameters
mean = 1
```

```
variance = 0.001
```

1.3 Dataset

Generate a random regression problem

$Y = 1 + \beta_1 x_1 + \beta_2 x_2 + \beta_2 x_3 + ... + \beta_n x_n + N(0, \sigma)$ where $\sigma = 0.1$

[3]:

```
X,Y = regressionDataset.regression_data(sample_size,n_features)
```

```
         X1        X2        X3        X4        X5        X6        X7  \
0 -1.003770  0.467473 -0.218651 -0.676265 -0.016443  0.780346 -1.078272
1  0.547605  0.029382 -2.033179  0.028702 -0.491520  0.529759 -0.553983
2  0.220598  1.192805  2.797058  0.571669  0.460904  0.486202 -2.335393
3  0.184011 -0.167748 -1.242045 -0.081350  1.335627 -1.449922  0.481887
4  1.464577 -1.529598  1.465365 -0.185177  2.035783 -0.050075 -1.274503

         X8        X9       X10           Y
0  0.538080 -0.295357  0.224507 -125.184155
1  1.613541 -0.666623  1.439294  -54.744569
2 -0.033403 -0.397156 -0.596488  287.954812
3 -0.189243 -0.204796 -1.159570 -153.068164
4  1.246308  1.063228 -0.063595  124.484165
```

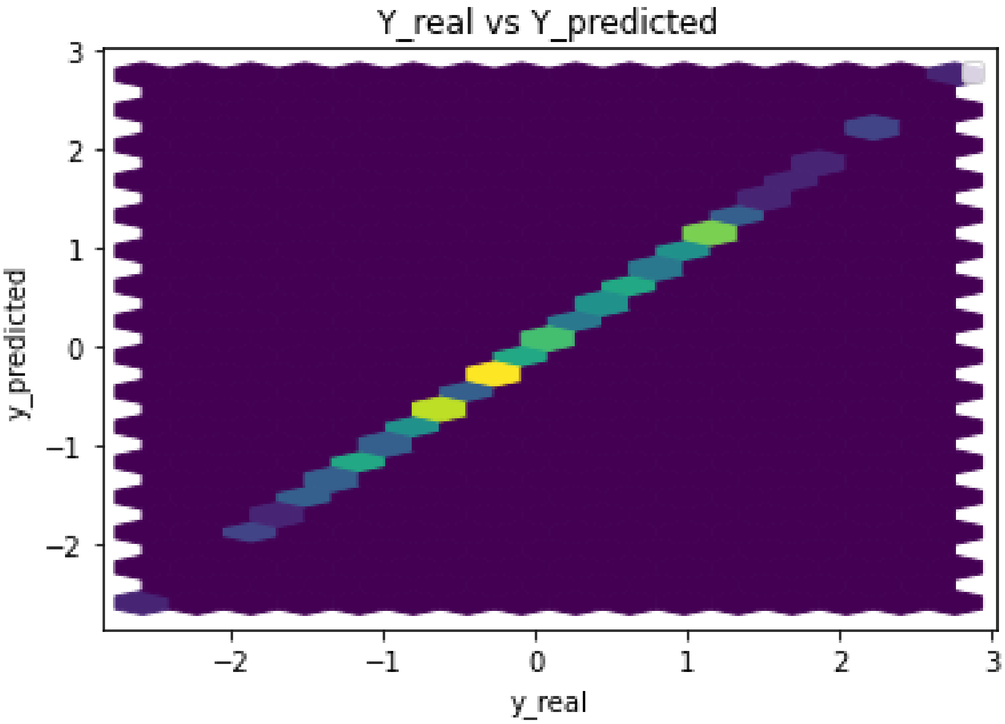
1.4 Stats Model

[4]:

```
[coeff,y_pred] = statsModel.statsModel(X,Y)
```

```
No handles with labels found to put in legend.

                            OLS Regression Results
==============================================================================
Dep. Variable:                      Y   R-squared:                       1.000
Model:                            OLS   Adj. R-squared:                  1.000
Method:                 Least Squares   F-statistic:                 5.308e+07
Date:                Thu, 07 Oct 2021   Prob (F-statistic):          6.27e-297
Time:                        18:58:22   Log-Likelihood:                 638.17
No. Observations:                 100   AIC:                            -1254.
Df Residuals:                      89   BIC:                            -1226.
Df Model:                          10
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const               0   4.34e-05          0      1.000   -8.62e-05    8.62e-05
x1             0.4174   4.53e-05   9222.353      0.000       0.417       0.417
x2             0.4774   4.81e-05   9930.722      0.000       0.477       0.477
x3             0.3890   4.81e-05   8080.858      0.000       0.389       0.389
x4             0.3486   4.49e-05   7764.178      0.000       0.348       0.349
x5             0.1743    4.6e-05   3788.596      0.000       0.174       0.174
```

```
x6             0.0305   4.61e-05    660.916      0.000       0.030       0.031
x7             0.1851   4.66e-05   3968.913      0.000       0.185       0.185
x8             0.0161   4.42e-05    364.179      0.000       0.016       0.016
x9             0.1107   4.45e-05   2488.266      0.000       0.111       0.111
x10            0.3479   4.55e-05   7640.317      0.000       0.348       0.348
==============================================================================
Omnibus:                        0.965   Durbin-Watson:                   2.019
Prob(Omnibus):                  0.617   Jarque-Bera (JB):                0.879
Skew:                           0.226   Prob(JB):                        0.644
Kurtosis:                       2.919   Cond. No.                         1.82
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
Parameters:  const    0.000000
x1       0.417408
x2       0.477400
x3       0.389030
x4       0.348554
x5       0.174331
x6       0.030486
x7       0.185063
x8       0.016099
x9       0.110691
x10      0.347908
dtype: float64
```



```
Performance Metrics
Mean Squared Error: 1.6768415750084017e-07
Mean Absolute Error: 0.00031606358169905O4
Manhattan distance: 0.03160635816990504
Euclidean distance: 0.004094925609835179
```

2 Generator and Discriminator Networks

GAN Generator

[5]:
```
class Generator(nn.Module):

  def __init__(self,n_input):
    super().__init__()
    self.output = nn.Linear(n_input,1)

  def forward(self, x):
    x = self.output(x)
    return x
```

GAN Discriminator

[6]:
```
class Discriminator(nn.Module):
  def __init__(self,n_input,n_hidden):

    super().__init__()
    self.hidden = nn.Linear(n_input,n_hidden)
    self.output = nn.Linear(n_hidden,1)
    self.relu = nn.ReLU()

  def forward(self, x):
    x = self.hidden(x)
    x = self.relu(x)
    x = self.output(x)
    return x
```

ABC Generator

The ABC generator is defined as follows:

$Y = 1 + \beta_1 x_1 + \beta_2 x_2 + \beta_2 x_3 + ... + \beta_n x_n + N(0, \sigma)$ where $\sigma = 0.1$

$\beta_i \sim N(0, \sigma^*)$ when $\mu = 0$ else

$\beta_i \sim N(\beta_i^*, \sigma^*)$ where $\beta_i^* s$ are coefficients obtained from stats model

Parameters : μ and σ^*

σ^* takes the values 0.01,0.1 and 1

[7]:

```
def ABC_pre_generator(x_batch,coeff,variance,mean,device):

  coeff_len = len(coeff)

  if mean == 0:
    weights = np.random.normal(0,variance,size=(coeff_len,1))
    weights = torch.from_numpy(weights).reshape(coeff_len,1)
  else:
    weights = []
    for i in range(coeff_len):
      weights.append(np.random.normal(coeff[i],variance))
    weights = torch.tensor(weights).reshape(coeff_len,1)

  y_abc =  torch.matmul(x_batch,weights.float())
  gen_input = torch.cat((x_batch,y_abc),dim = 1).to(device)
  return gen_input
```

3 GAN Model

[8]:

```
real_dataset = dataset.CustomDataset(X,Y)
device = torch.device('cuda' if torch.cuda.is_available() else 'cpu')
```

[9]:

```
generator = Generator(n_features+2)
discriminator = Discriminator(n_features+2,hidden_nodes)

criterion = torch.nn.BCEWithLogitsLoss()
gen_opt = torch.optim.Adam(generator.parameters(), lr=0.01, betas=(0.5, 0.999))
disc_opt = torch.optim.Adam(discriminator.parameters(), lr=0.01, betas=(0.5, 0.
 ↪999))
```

[10]:

```
print(generator)
print(discriminator)
```

```
Generator(
  (output): Linear(in_features=12, out_features=1, bias=True)
)
Discriminator(
  (hidden): Linear(in_features=12, out_features=25, bias=True)
  (output): Linear(in_features=25, out_features=1, bias=True)
  (relu): ReLU()
)
```

[11]:

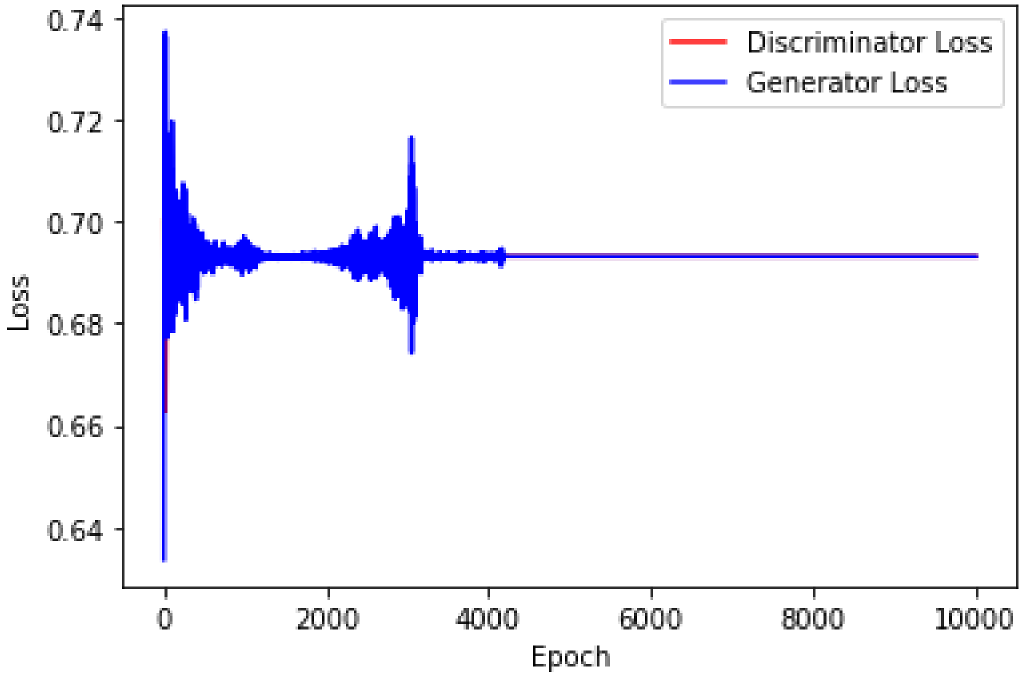
```
n_epochs = 5000
batch_size = sample_size//2
```

[12]:

```
# Parameters
sample_size = 1000000
mean = 1
std = 1
```

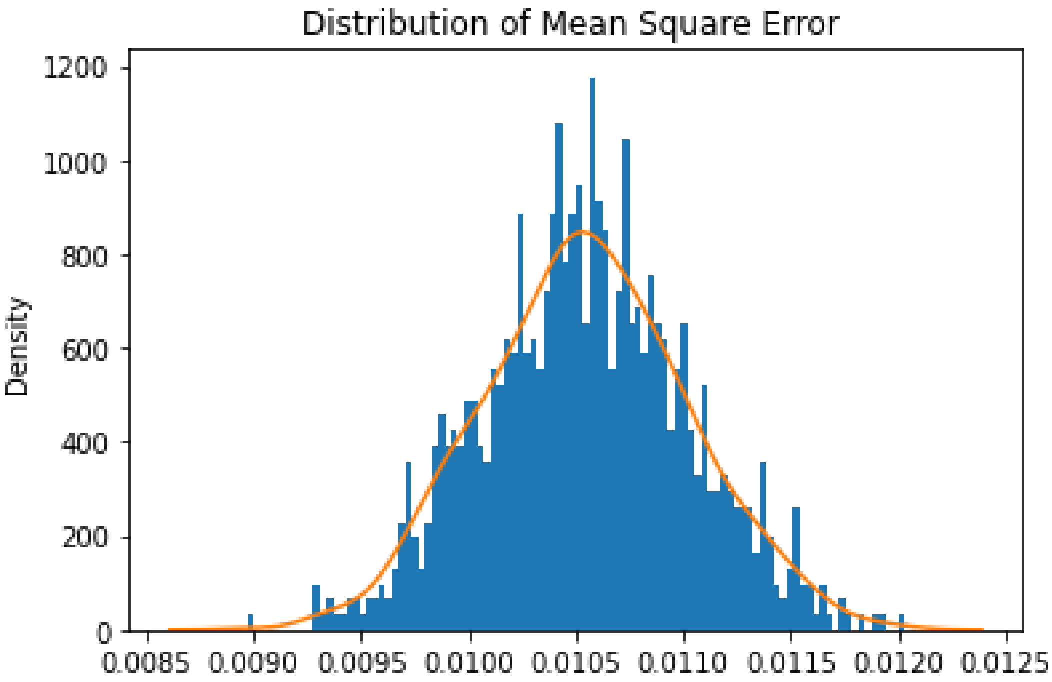
[13]:

```
train_test.
 ↪training_GAN(discriminator,generator,disc_opt,gen_opt,real_dataset,batch_size,␣
 ↪n_epochs,criterion,device)
```

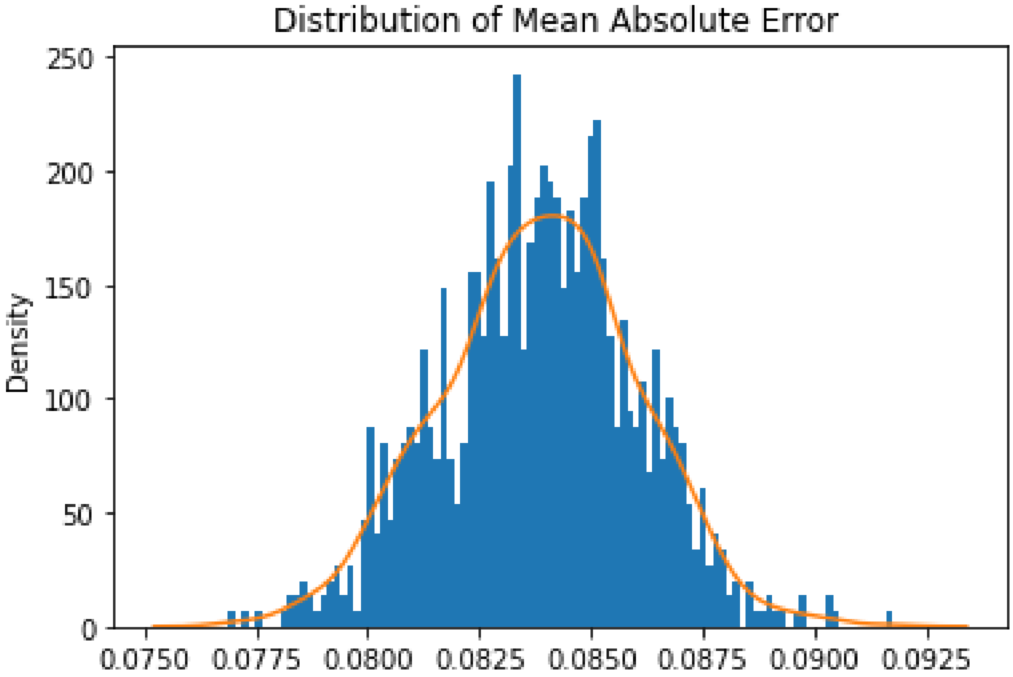


[14]:

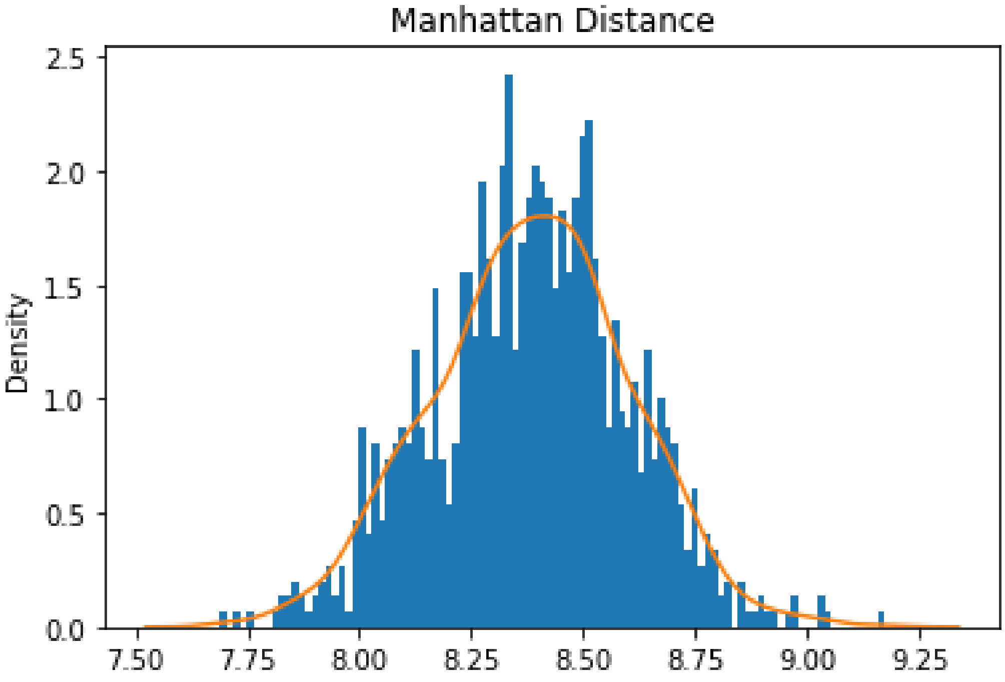
```
train_test.test_generator(generator,real_dataset,device)
```



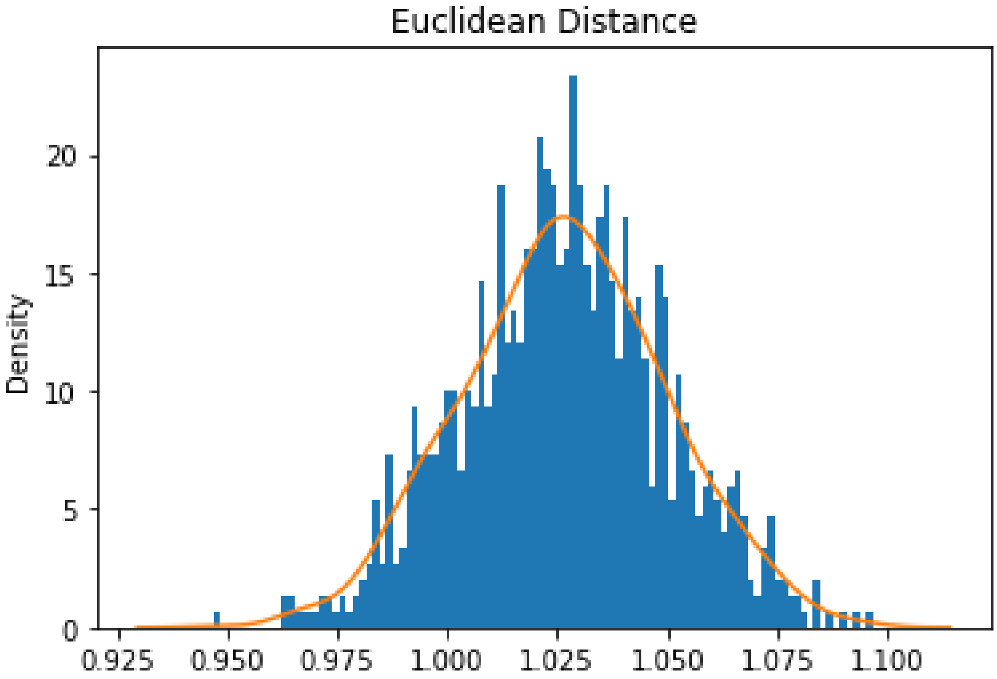
```
Mean Square Error: 0.010544361224138986
```



```
Mean Absolute Error: 0.08383256637070328
```



```
Mean Manhattan Distance: 8.383256637070328
```



```
Mean Euclidean Distance: 8.383256637070328
```

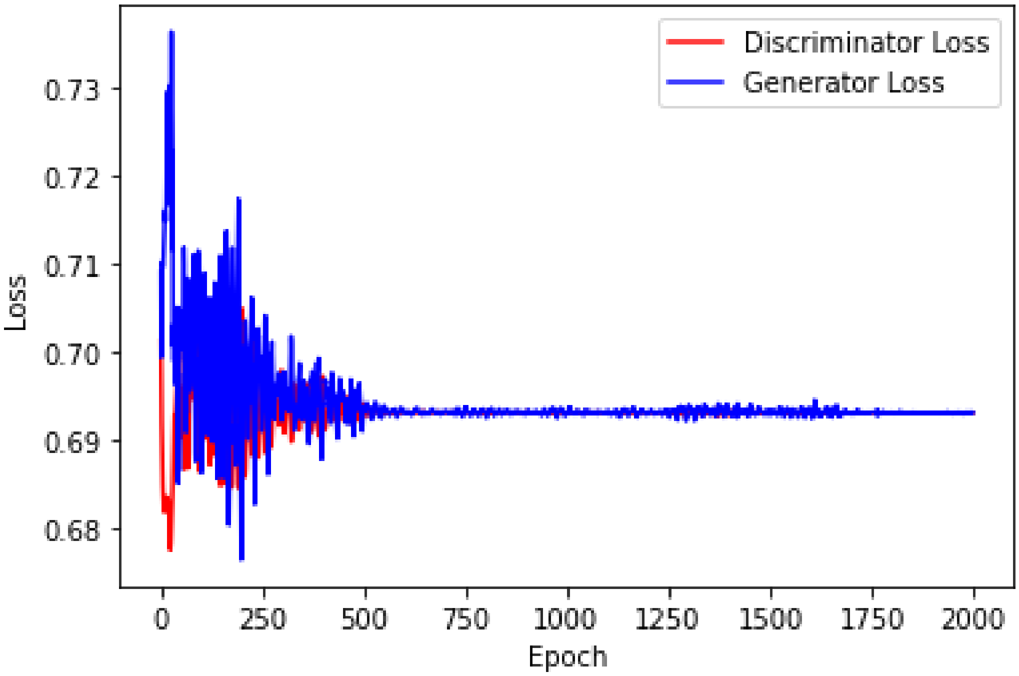
4 ABC GAN Model

Training the network

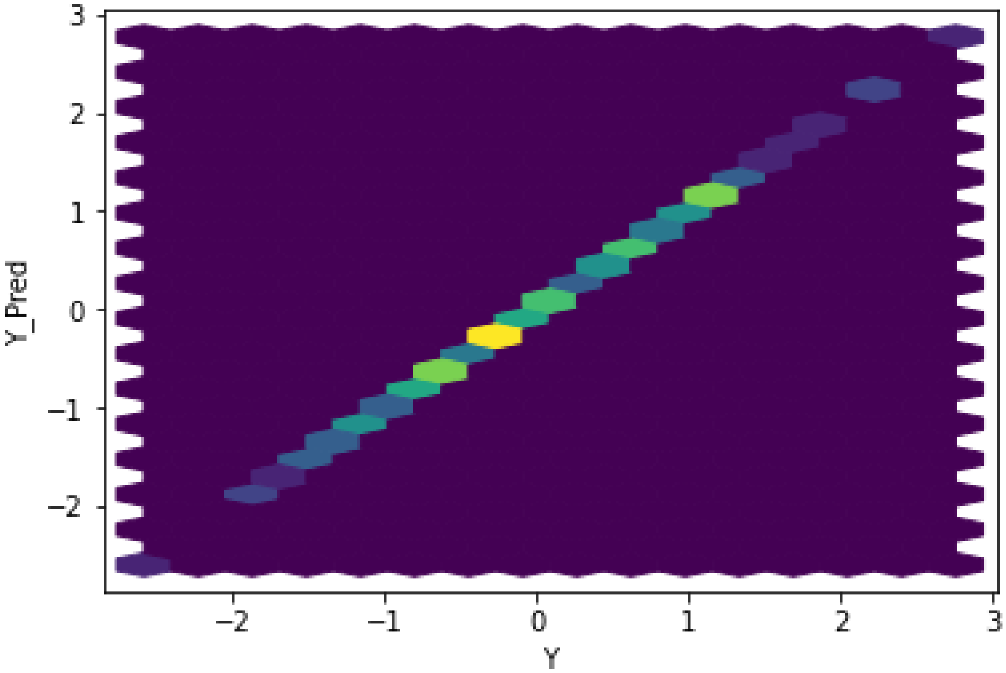
[15]:
```
gen = Generator(n_features+2)
disc = Discriminator(n_features+2,hidden_nodes)

criterion = torch.nn.BCEWithLogitsLoss()
gen_opt = torch.optim.Adam(gen.parameters(), lr=0.01, betas=(0.5, 0.999))
disc_opt = torch.optim.Adam(disc.parameters(), lr=0.01, betas=(0.5, 0.999))
```

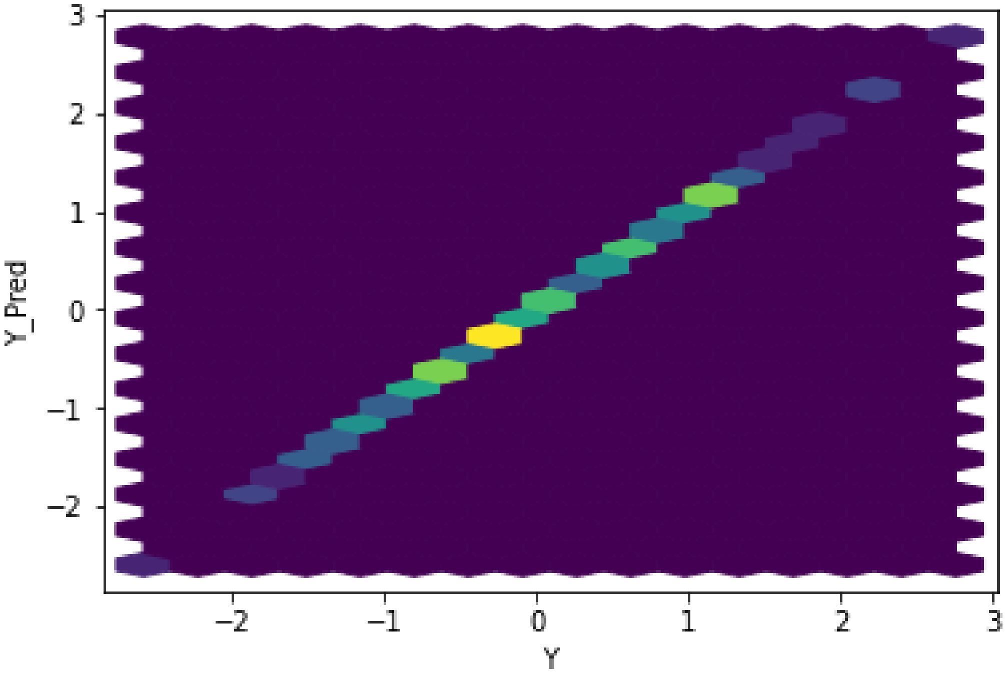
[16]:
```
n_epoch_abc = 2000
batch_size = sample_size//2
```

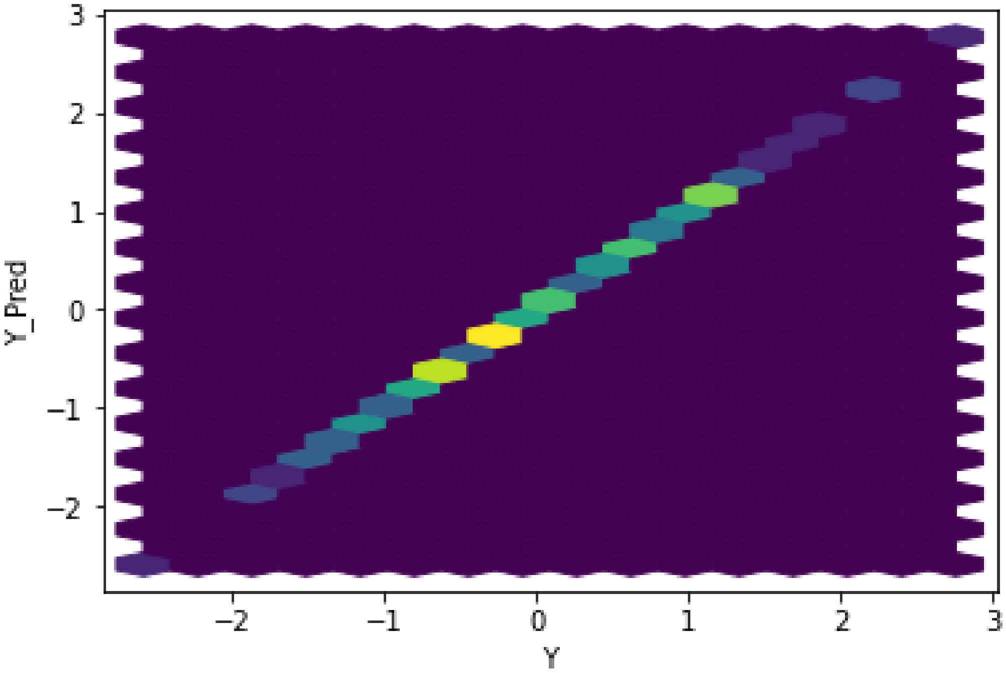
[17]:
```
ABC_train_test.training_GAN(disc, gen,disc_opt,gen_opt,real_dataset,␣
 ↪batch_size, n_epoch_abc,criterion,coeff,mean,variance,device)
```

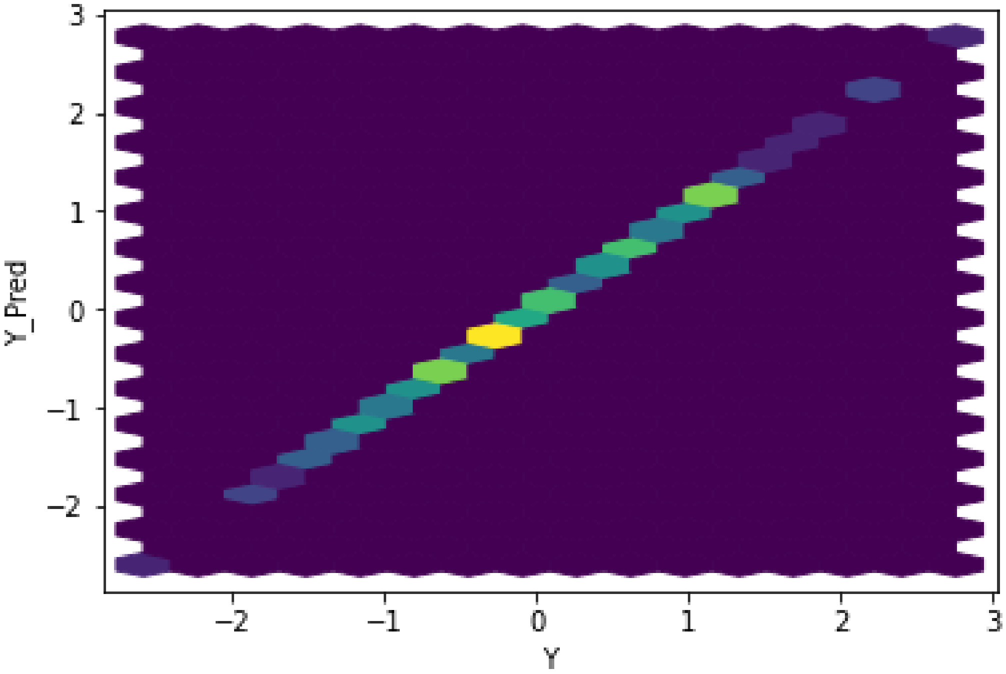


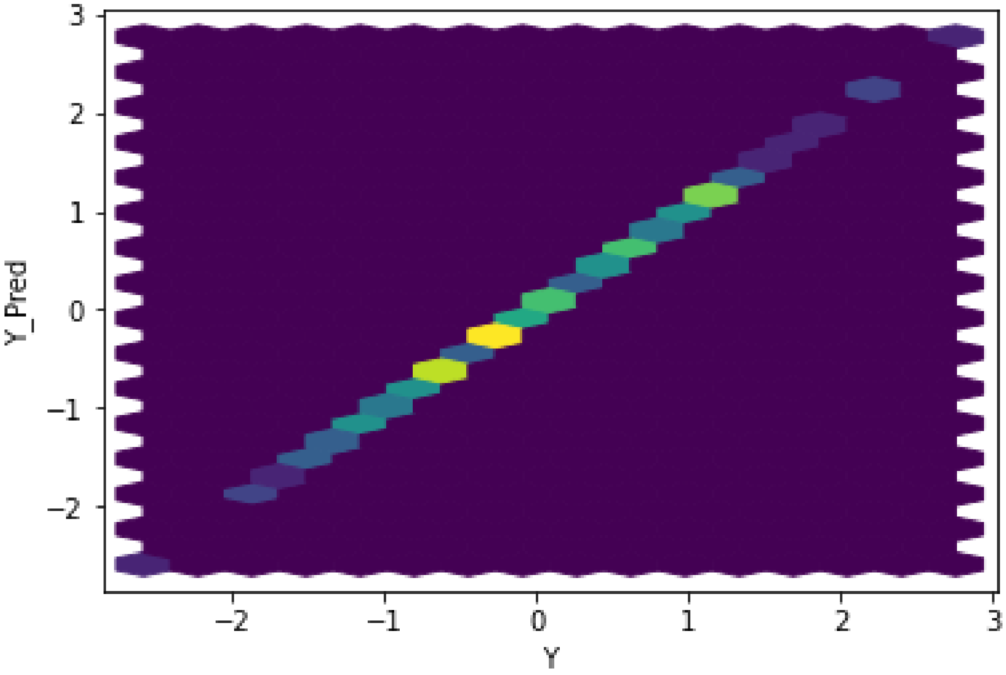
[18]:
```
ABC_train_test.test_generator(gen,real_dataset,coeff,mean,variance,device)
```

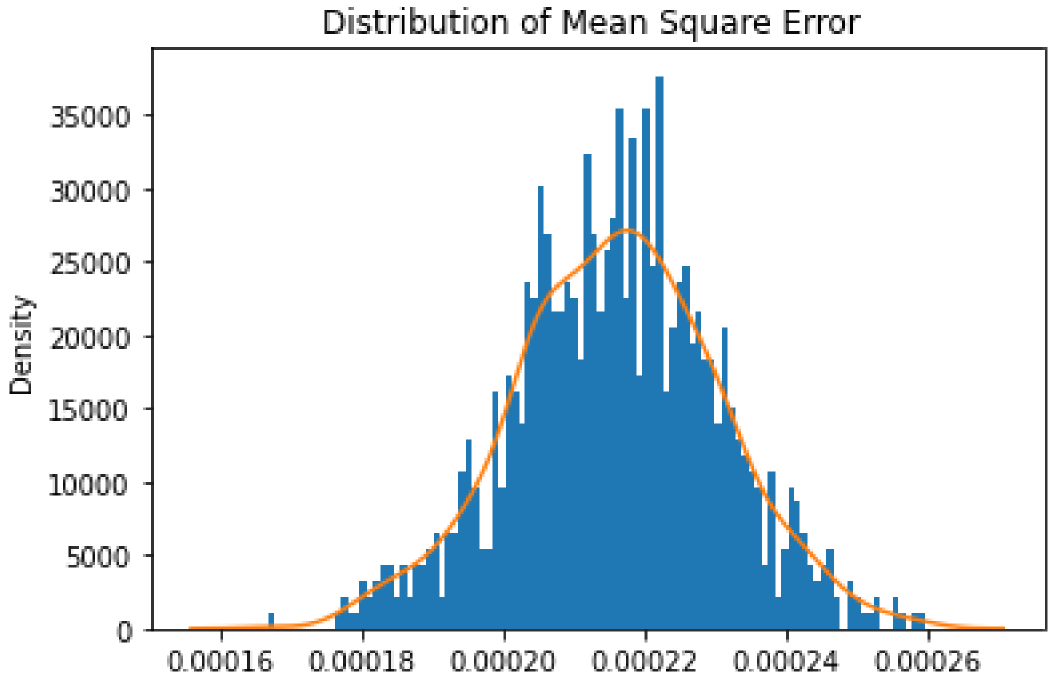



3
2
1
0
−1
−2
Y_Pred
−2
−1
0
1
2
3
Y

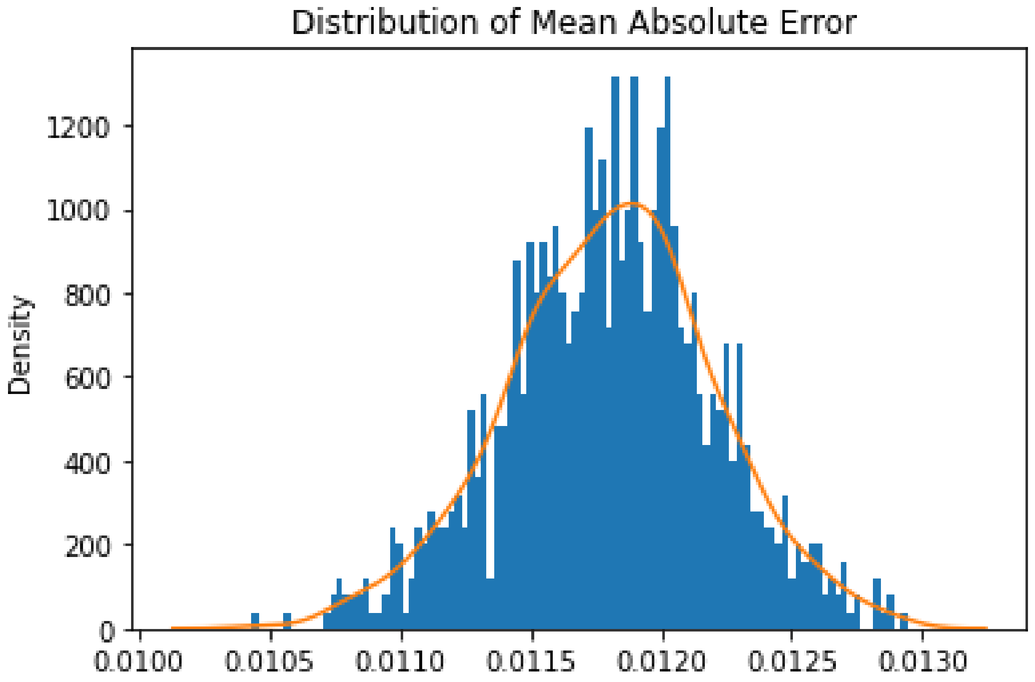

3
2
1
0
−1
−2
Y_Pred
−2
−1
0
1
2
3
Y


3
2
1
0
−1
−2
Y_Pred
−2
−1
0
1
2
3
Y

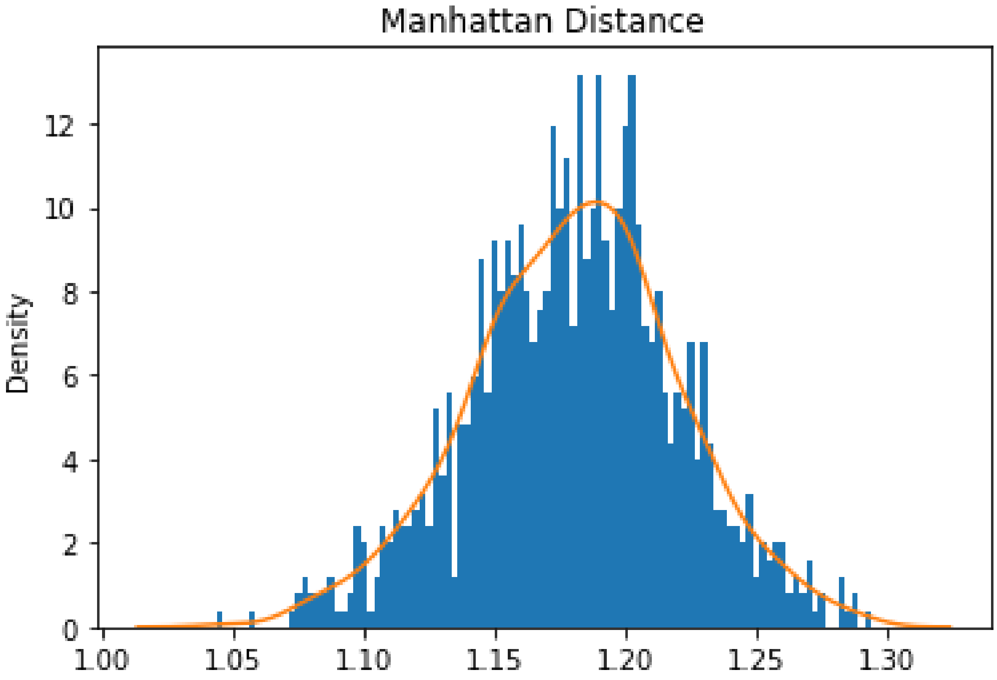

3
2
1
0
−1
−2
Y_Pred
−2
−1
0
1
2
3
Y



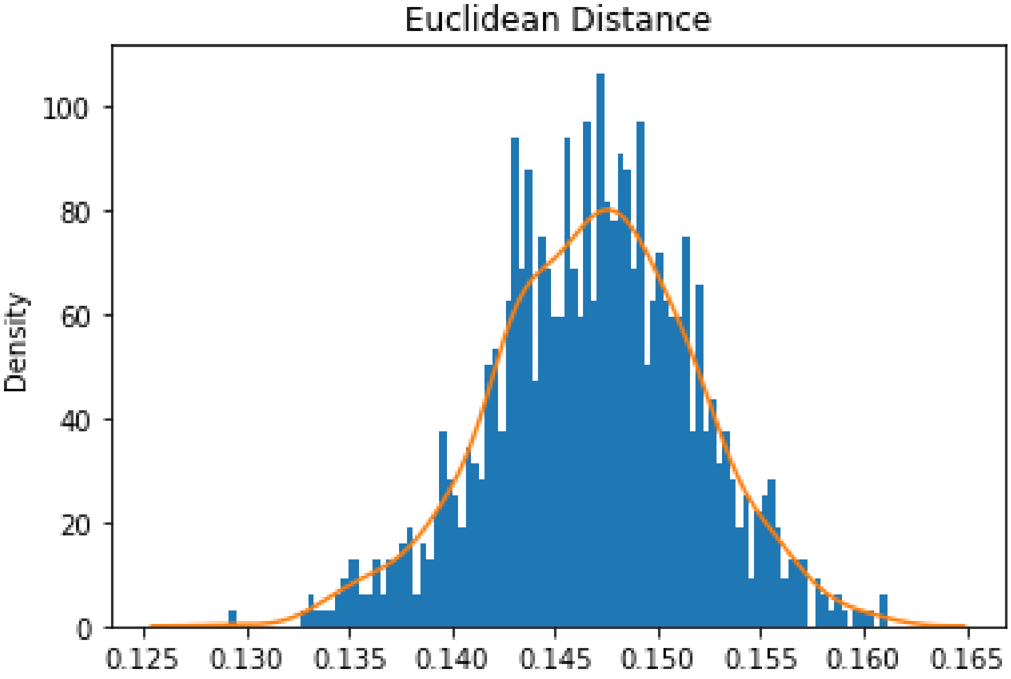
```
Mean Square Error: 0.00021596995307518l7
```



```
Mean Absolute Error: 0.01180549354068935
Mean Manhattan Distance: 1.180549354068935
```

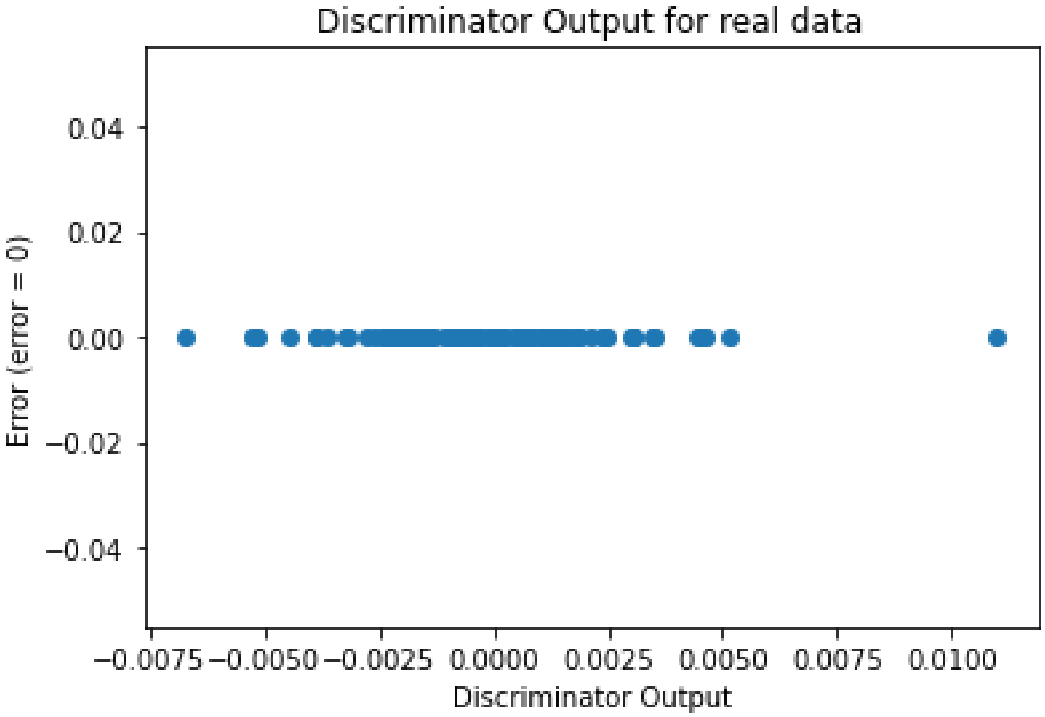


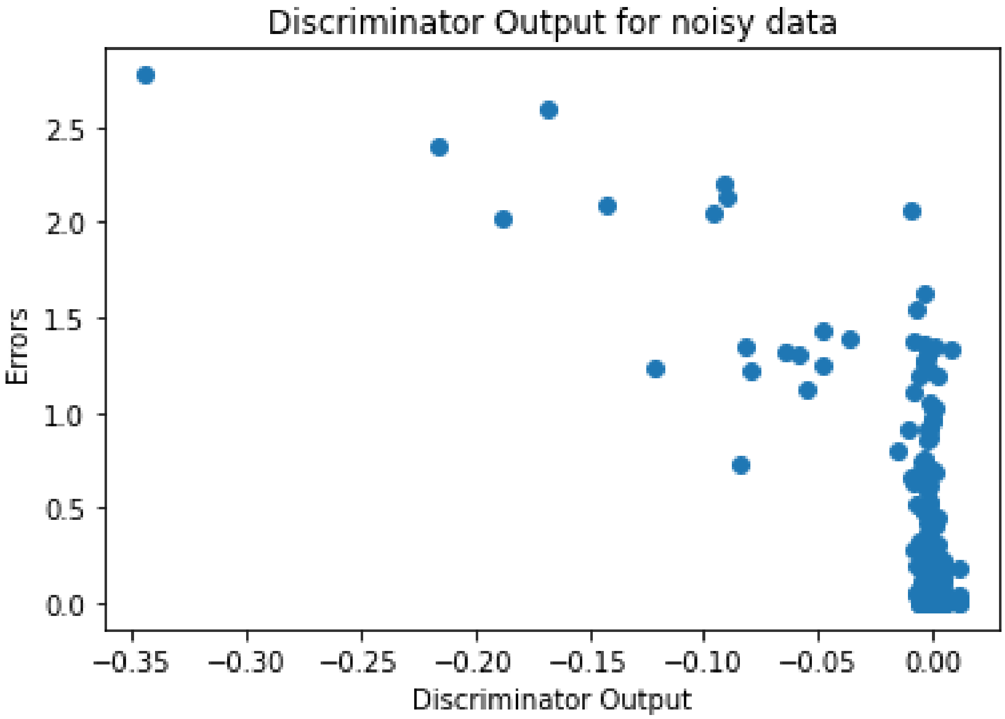
```
Mean Euclidean Distance: 0.1468753210802312
```



Sanity Checks

```
[19]: sanityChecks.discProbVsError(real_dataset,disc,device)
```





4.1 Visualization of trained GAN generator

[20]:
```
for name, param in gen.named_parameters():
    print(name,param)
```

```
output.weight Parameter containing:
tensor([[0.0306, 0.2091, 0.2453, 0.1987, 0.1767, 0.0922, 0.0188, 0.0998, 0.0140,
         0.0513, 0.1694, 0.4933]], requires_grad=True)
output.bias Parameter containing:
tensor([-0.0276], requires_grad=True)
```