Dataset4-Capital_Punishment_output_1

October 7, 2021

[1]:
```
# Parameters
std = 1
mean = 1
```

1 Dataset 4 - Capital Punishment

1.1 Parameters

[2]:
```
#ABC_Generator
std = 1
mean = 1
prior = 0

#Discriminator
hidden_nodes = 7
```

1.2 Import Libraries and Dataset

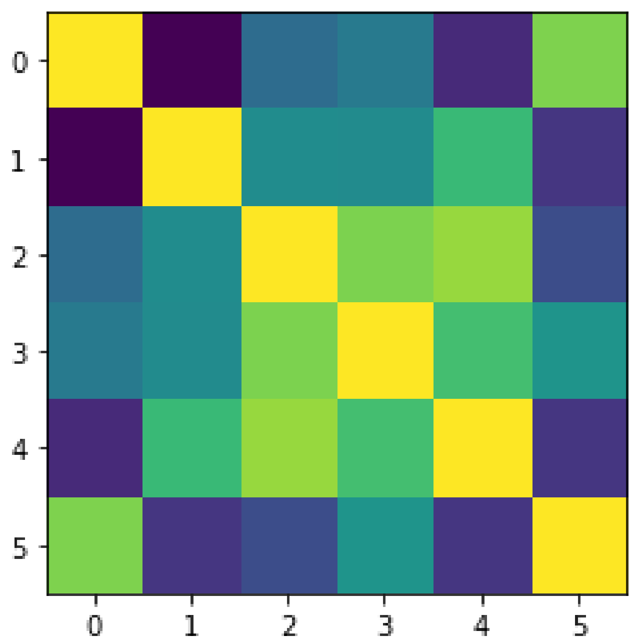
[3]:
```
import warnings
warnings.filterwarnings('ignore')
```

[4]:
```
import cpunishDataset
import train_test
import ABC_train_test
import network
import statsModel
import performanceMetrics
import dataset
import sanityChecks

import torch
from torch import nn
from torch.utils.data import Dataset , DataLoader
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from statistics import mean
```

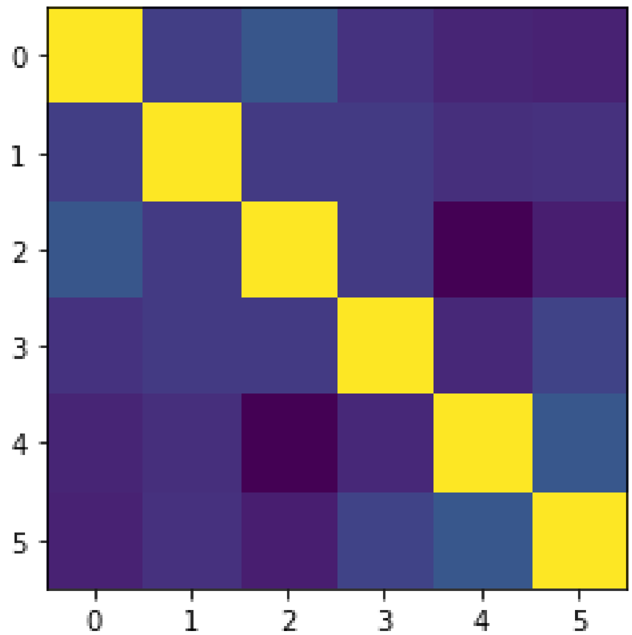
```python
import pandas as pd
%matplotlib inline
```

[5]:
```python
#Load the dataset
X,Y = cpunishDataset.cpunish_data()
n_features = 6
```

```
[[ 1.         -0.78987947 -0.15604396 -0.05494505 -0.5731902   0.65634511]
 [-0.78987947  1.          0.08140819  0.07700775  0.42573825 -0.50722951]
 [-0.15604396  0.08140819  1.          0.64395604  0.72111026 -0.37030281]
 [-0.05494505  0.07700775  0.64395604  1.          0.46225016  0.13747769]
 [-0.5731902   0.42573825  0.72111026  0.46225016  1.         -0.50367775]
 [ 0.65634511 -0.50722951 -0.37030281  0.13747769 -0.50367775  1.        ]]
```




```
[[ 1.          0.06373626  0.16043956  0.01978022 -0.02857143 -0.03736264]
 [ 0.06373626  1.          0.04615385  0.04615385  0.00659341  0.01538462]
 [ 0.16043956  0.04615385  1.          0.04615385 -0.14725275 -0.05054945]
 [ 0.01978022  0.04615385  0.04615385  1.         -0.01538462  0.08131868]
 [-0.02857143  0.00659341 -0.14725275 -0.01538462  1.          0.16483516]
 [-0.03736264  0.01538462 -0.05054945  0.08131868  0.16483516  1.        ]]
```

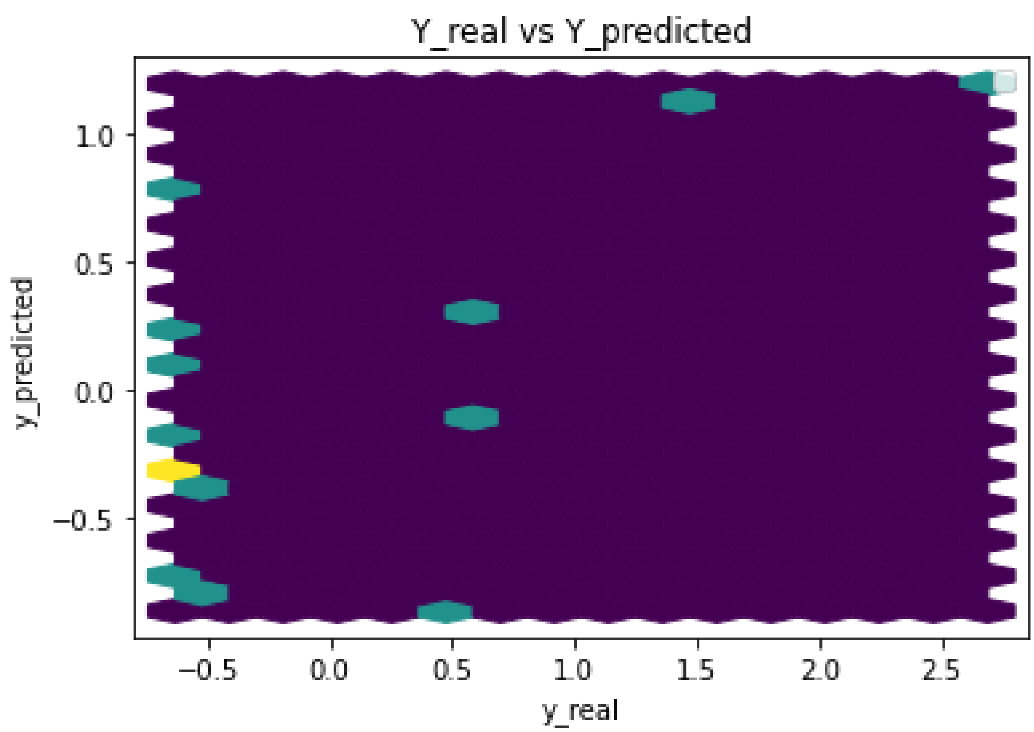


2 Stats Model

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

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

                            OLS Regression Results
==============================================================================
Dep. Variable:             EXECUTIONS   R-squared:                       0.409
Model:                            OLS   Adj. R-squared:                 -0.098
Method:                 Least Squares   F-statistic:                    0.8073
Date:                Thu, 07 Oct 2021   Prob (F-statistic):              0.595
Time:                        14:57:38   Log-Likelihood:                -16.184
No. Observations:                  14   AIC:                             46.37
Df Residuals:                       7   BIC:                             50.84
Df Model:                           6
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const               0      0.291          0      1.000      -0.687       0.687
x1            -0.3071      0.167     -1.835      0.109      -0.703       0.089
x2            -0.0727      0.210     -0.347      0.739      -0.569       0.423
x3            -0.0780      0.406     -0.192      0.853      -1.039       0.883
x4             0.2846      0.539      0.528      0.614      -0.989       1.558
x5             0.6329      0.622      1.017      0.343      -0.839       2.104
```

```
x6            -0.1115      1.356     -0.082      0.937      -3.318       3.095
==============================================================================
Omnibus:                        0.509   Durbin-Watson:                   0.960
Prob(Omnibus):                  0.775   Jarque-Bera (JB):                0.285
Skew:                           0.314   Prob(JB):                        0.867
Kurtosis:                       2.696   Cond. No.                         8.10
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly
specified.
Parameters:  const    0.000000
x1      -0.307149
x2      -0.072734
x3      -0.077971
x4       0.284622
x5       0.632853
x6      -0.111469
dtype: float64
```




```
Performance Metrics
Mean Squared Error: 0.5910184401346179
Mean Absolute Error: 0.6107560111864074
Manhattan distance: 8.550584156609704
```

```
Euclidean distance: 2.876501027617521
```

3 Generator and Discriminator Networks

GAN Generator

[7]:
```
class Generator(nn.Module):
  def __init__(self,n_input):
    super().__init__()
    #Input to Output Layer Linear Transformation
    self.output = nn.Linear(n_input,1)

  def forward(self, x):
    #Pass the input tensor through the operations
    x = self.output(x)
    return x
```

GAN Discriminator

[8]:
```
class Discriminator(nn.Module):
  def __init__(self,n_input,hiddenNodes):
    super().__init__()
    self.hidden = nn.Linear(n_input,hiddenNodes)
    self.output = nn.Linear(hiddenNodes,1)
    #Define LeakyRelu Activation and sigmoid output
    self.sigmoid = nn.Sigmoid()
    self.leakyRelu = nn.LeakyReLU()

  def forward(self, x):
    #Pass the input tensor through the operations
    x = self.hidden(x)
    x = self.leakyRelu(x)
    x = self.output(x)
    x = self.sigmoid(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^*

[9]:
```
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
```

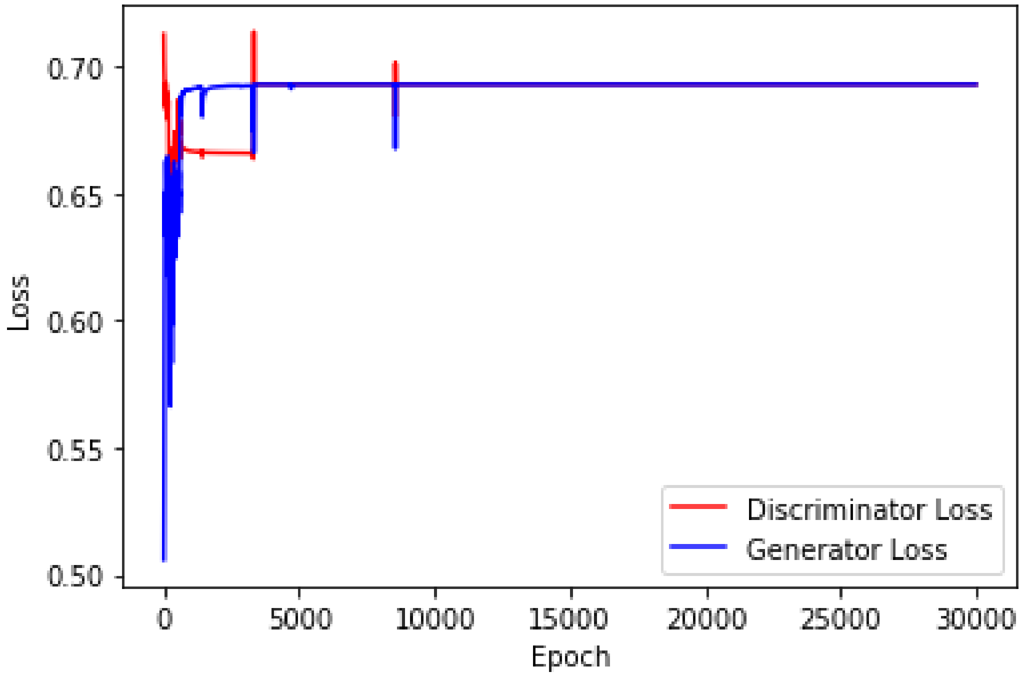
4 GAN Model

[10]:
```
real_dataset = dataset.CustomDataset(X,Y)
device = torch.device('cuda' if torch.cuda.is_available() else 'cpu')
```

[11]:
```
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))
```

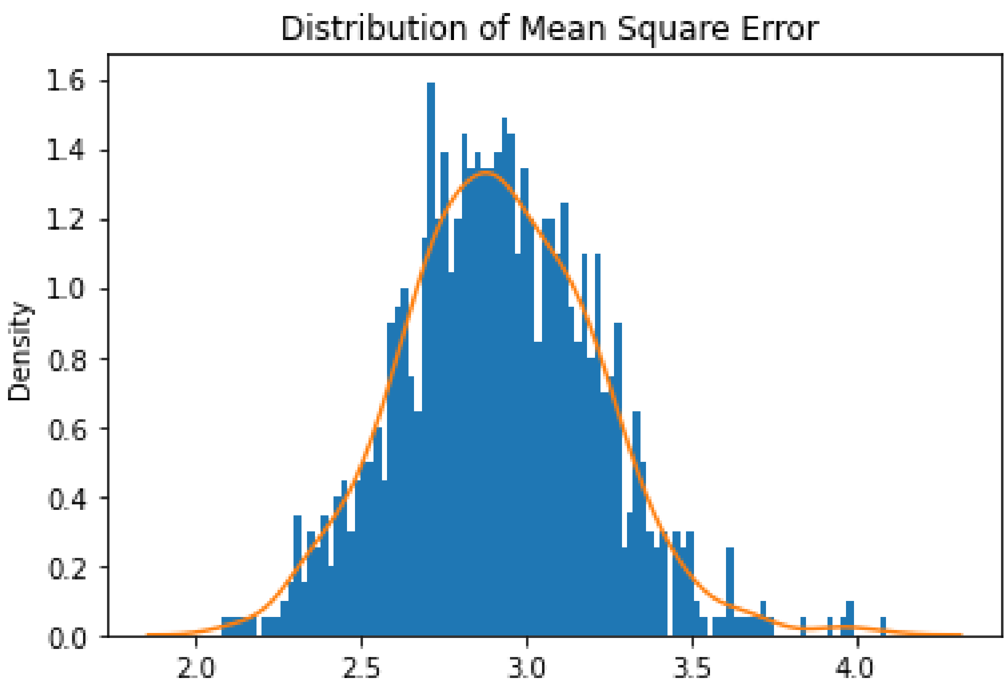
[12]:
```
sample_size = len(real_dataset)
n_epochs = 30000
batch_size = sample_size
```

[13]:
```
train_test.
 ↪training_GAN(discriminator,generator,disc_opt,gen_opt,real_dataset,batch_size,␣
 ↪n_epochs,criterion,device)
```

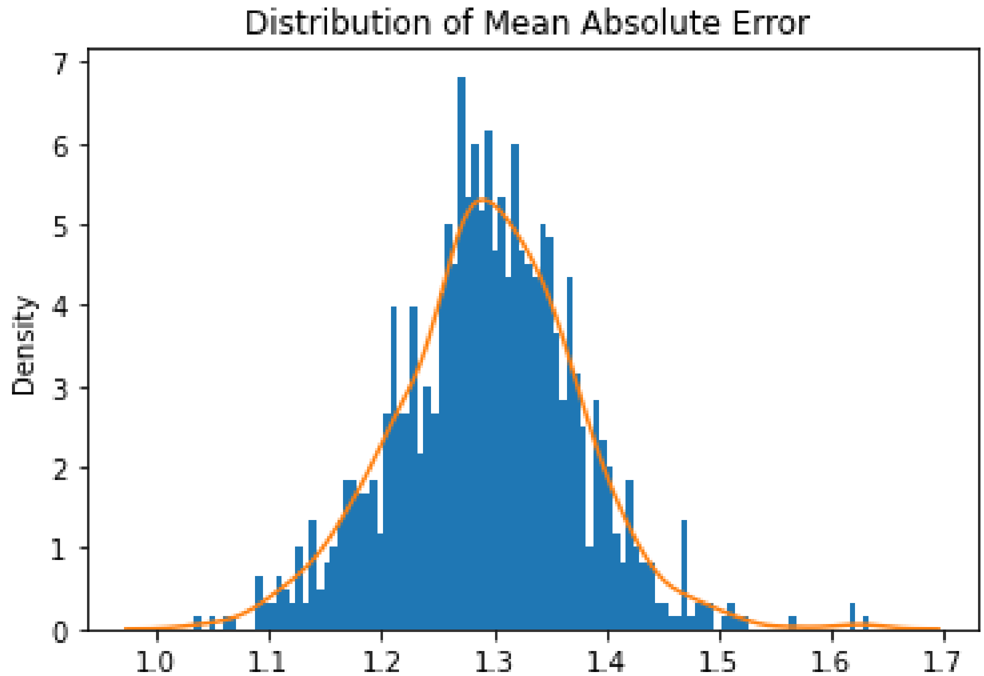


[14]:

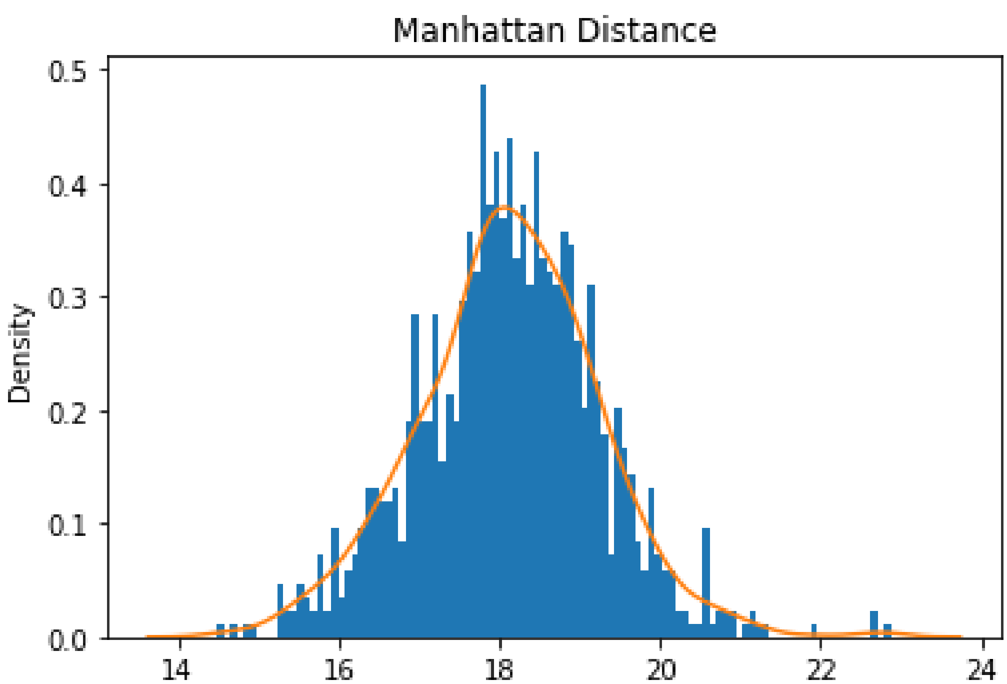
```
train_test.test_generator(generator,real_dataset,device)
```



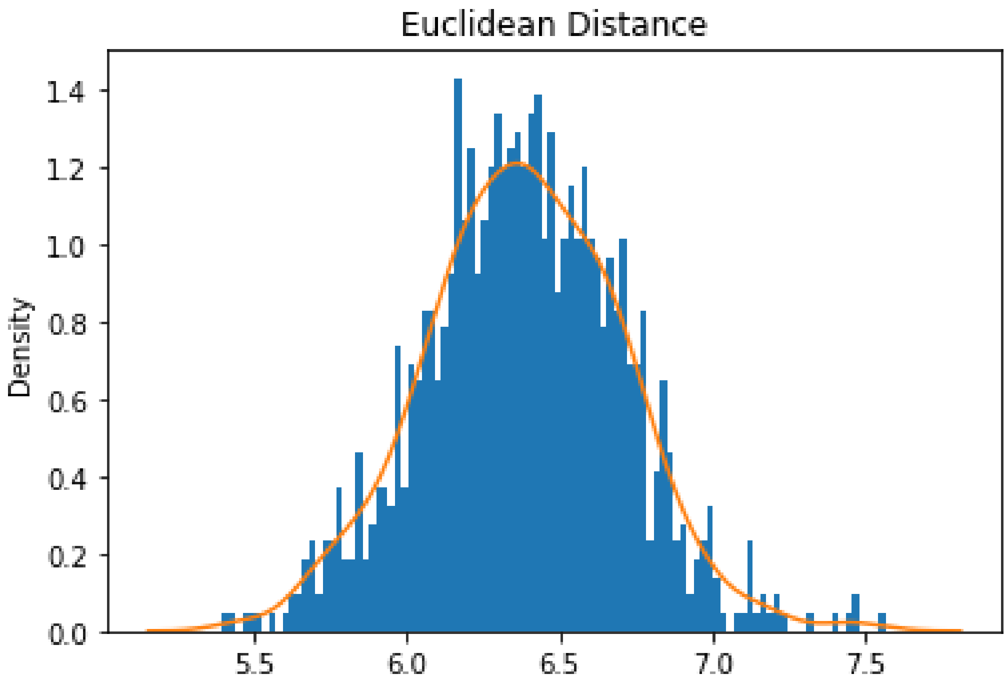
Mean Square Error: 2.9176517908874513



Mean Absolute Error: 1.2943357680439949



```
Mean Manhattan Distance: 18.120700752615928
```



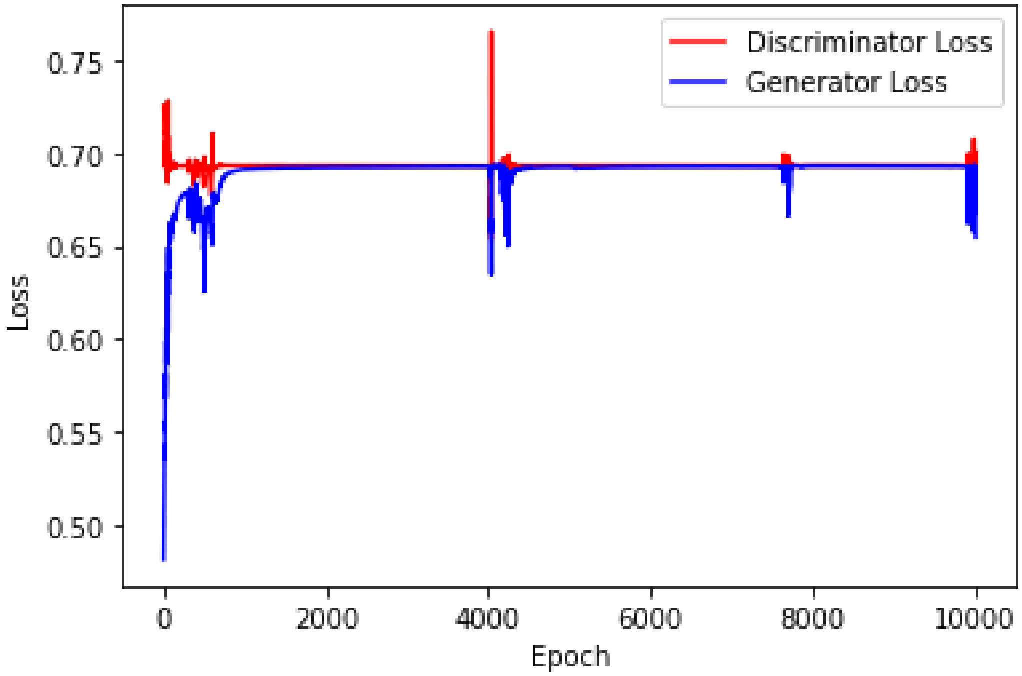

```
Mean Euclidean Distance: 18.120700752615928
```

5 ABC GAN Model

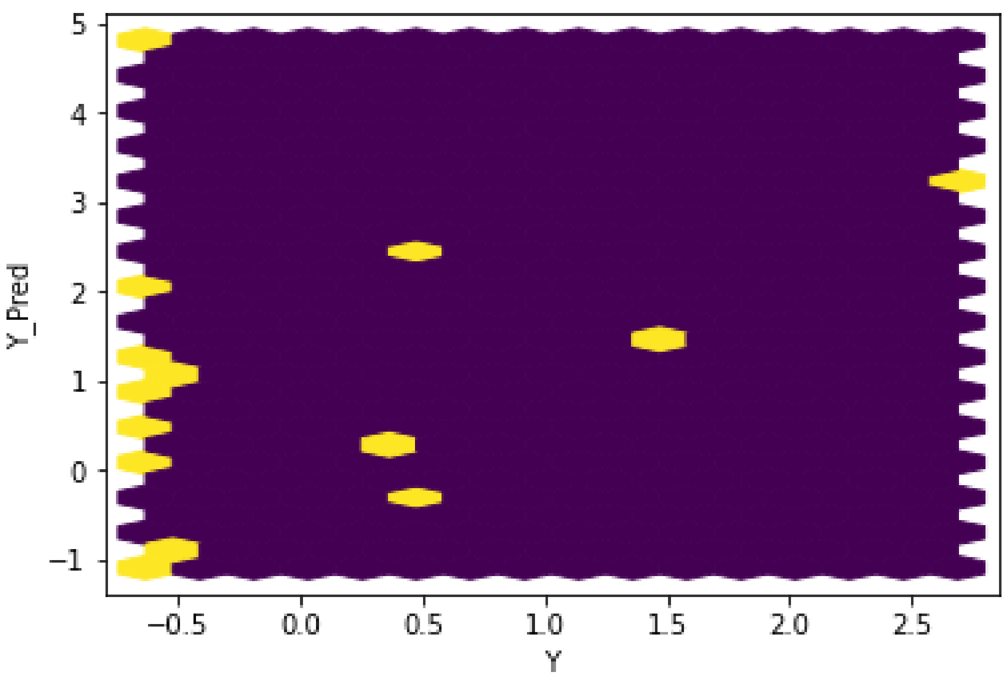
[15]:
```
gen = Generator(n_features+2)
disc = Discriminator(n_features+2,hidden_nodes)

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))
```

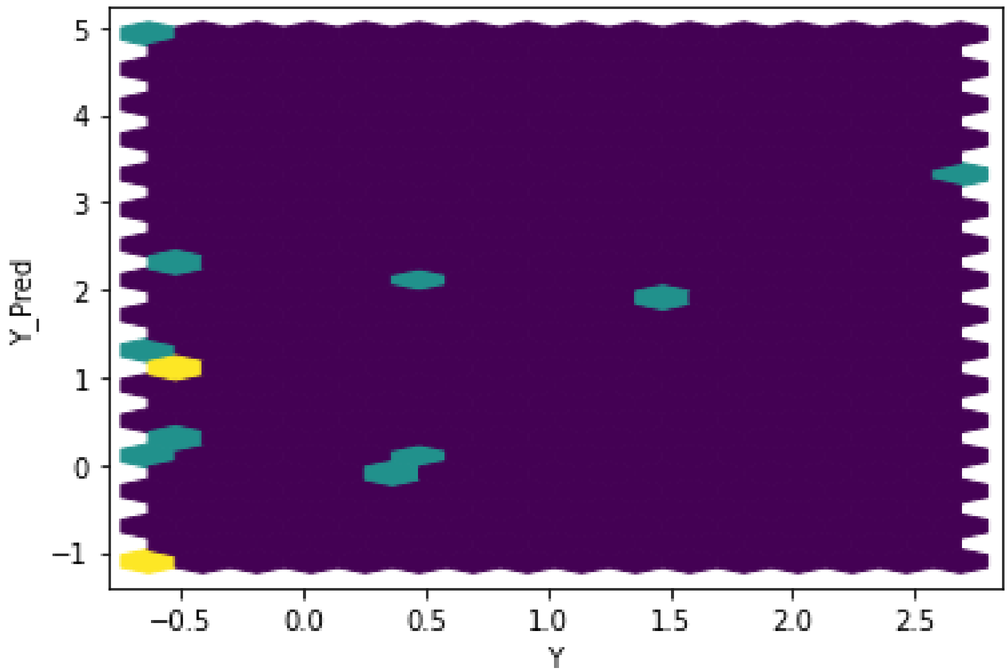
[16]:
```
n_epoch_abc = 10000
batch_size = sample_size
```

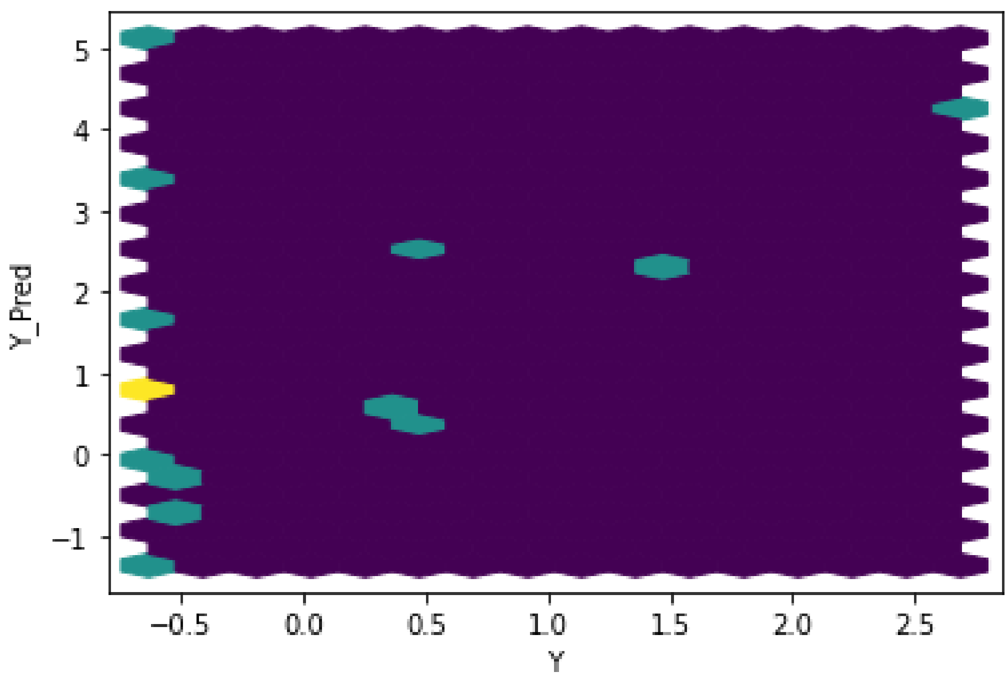
[17]:
```
ABC_train_test.training_GAN(disc, gen,disc_opt,gen_opt,real_dataset,␣
↪batch_size, n_epoch_abc,criterion,coeff,mean,std,device)
```

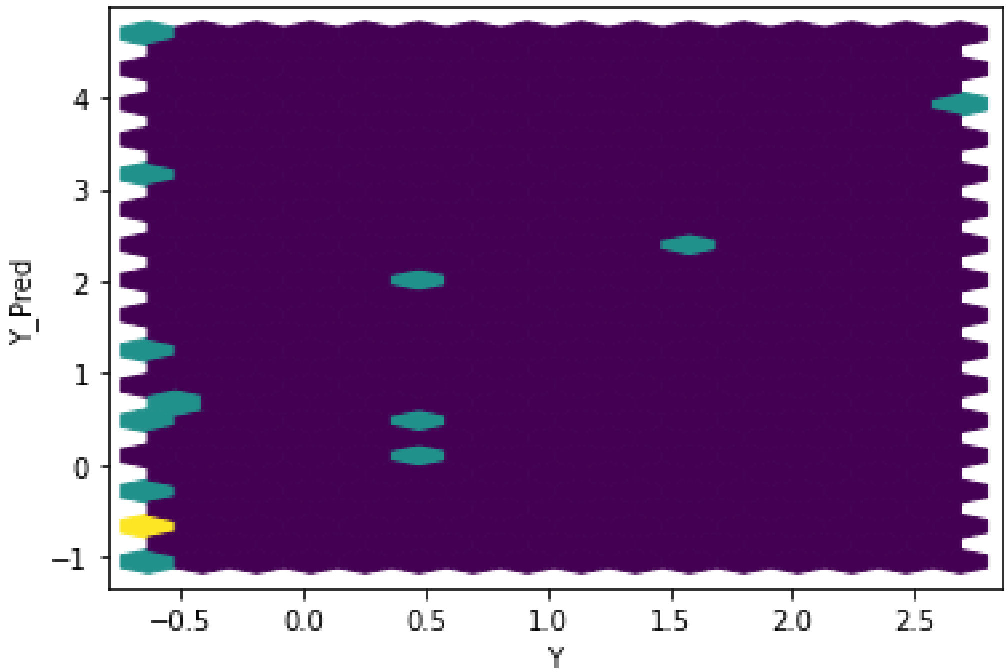


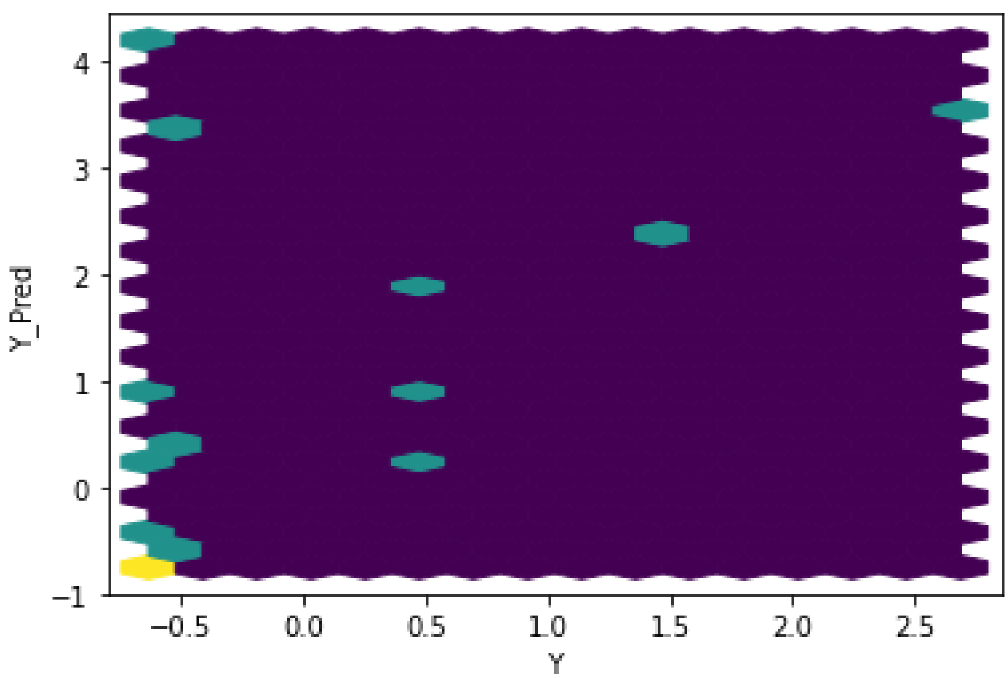
[18]:
```
ABC_train_test.test_generator(gen,real_dataset,coeff,mean,std,device)
```

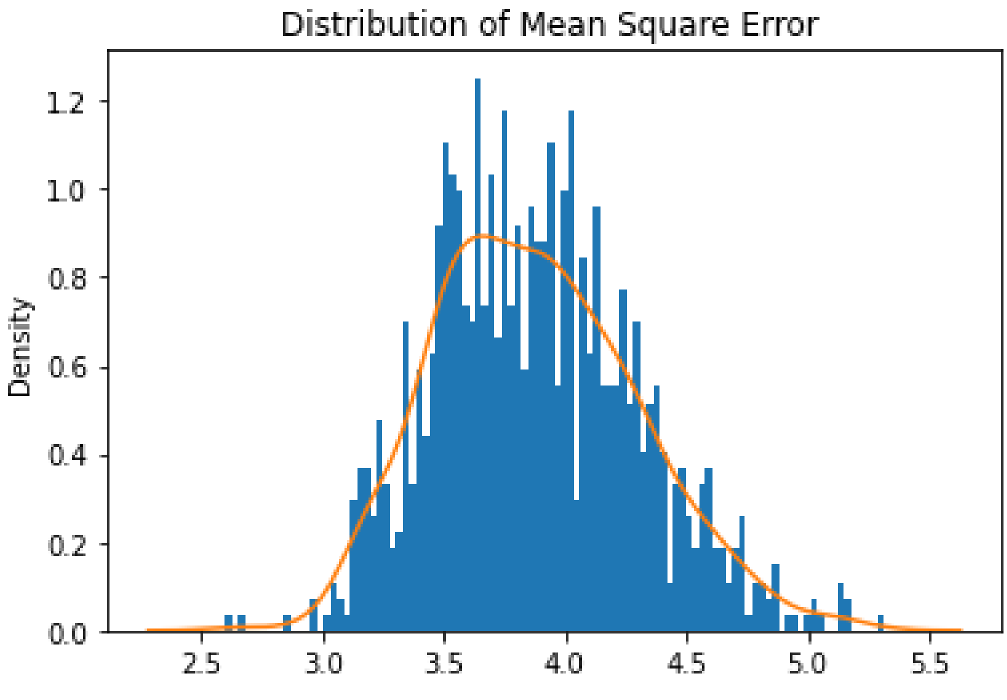



Y_Pred
Y
5
4
3
2
1
0
−1
−0.5
0.0
0.5
1.0
1.5
2.0
2.5

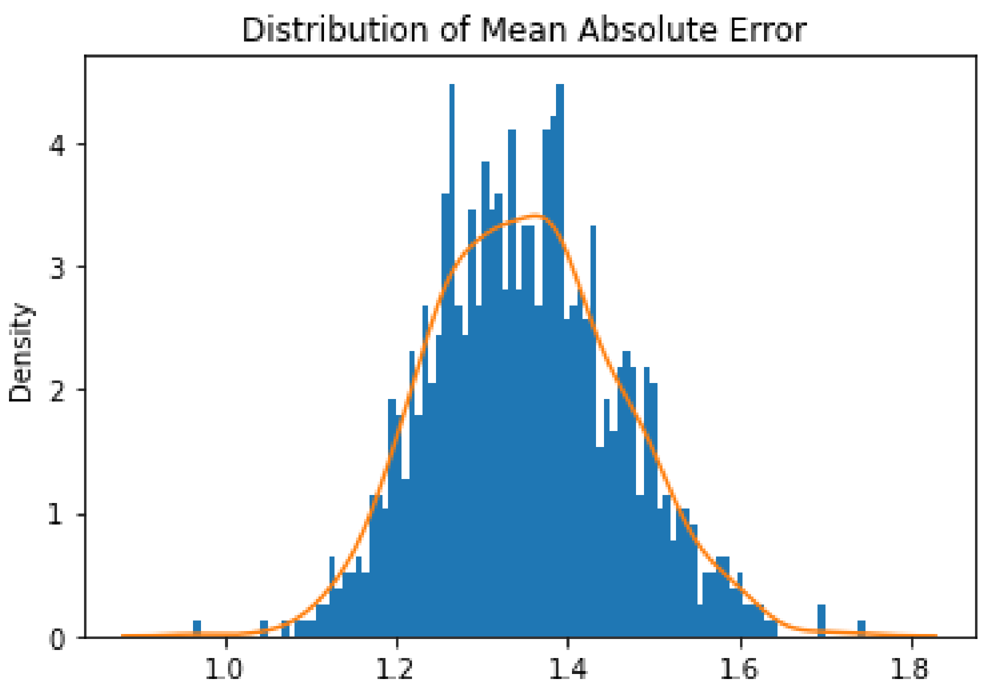

Y_Pred
Y
5
4
3
2
1
0
−1
−0.5
0.0
0.5
1.0
1.5
2.0
2.5


Y_Pred
Y
−1
0
1
2
3
4
−0.5
0.0
0.5
1.0
1.5
2.0
2.5

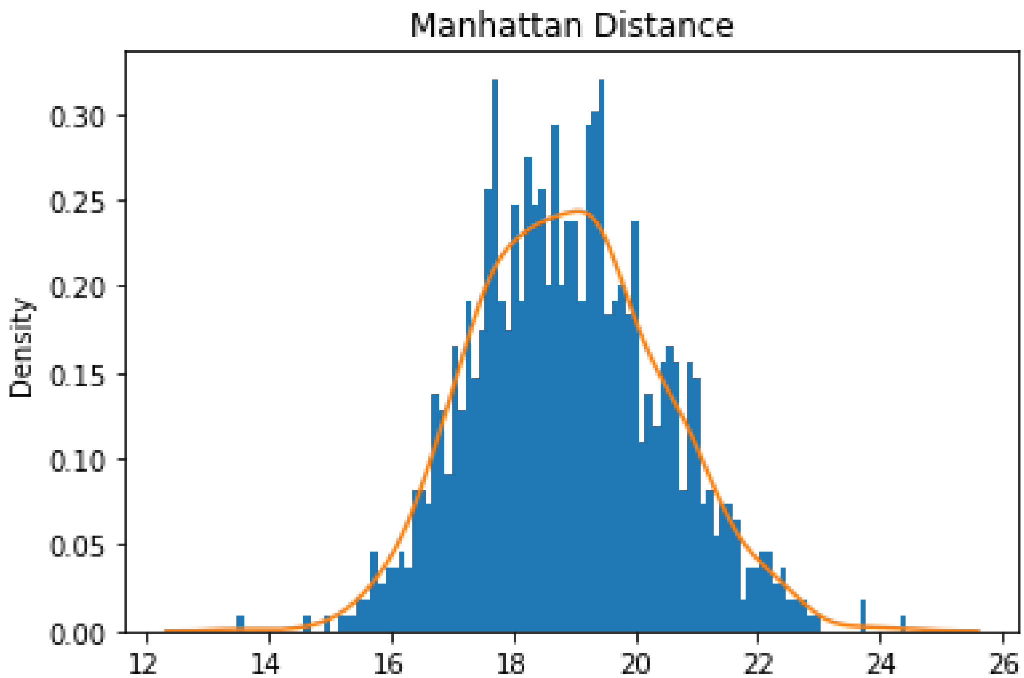

Y_Pred
Y
−1
0
1
2
3
4
−0.5
0.0
0.5
1.0
1.5
2.0
2.5



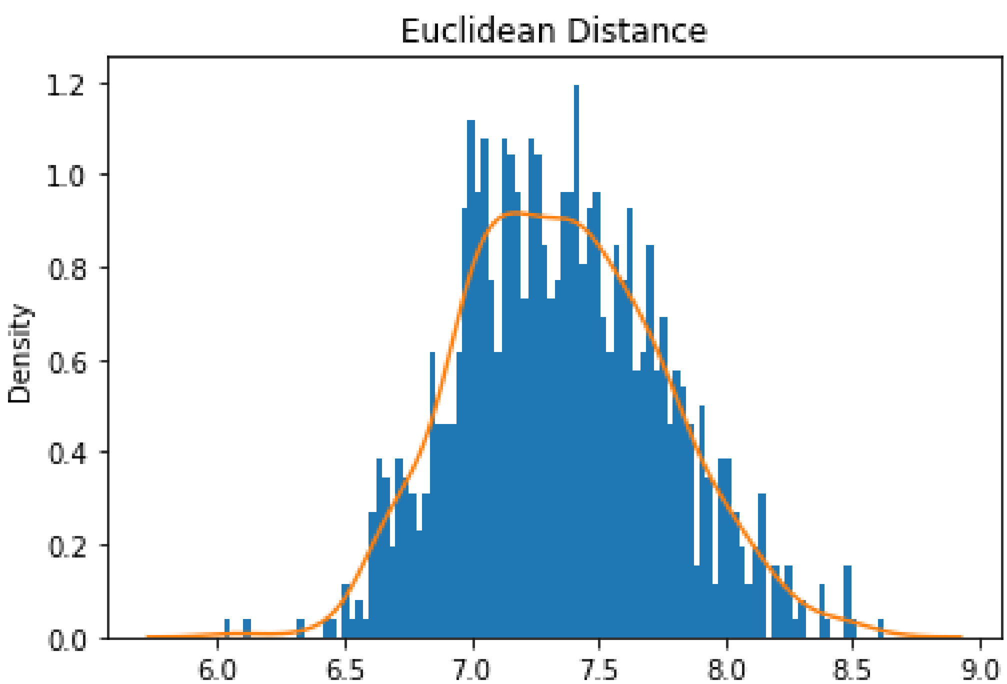
Mean Square Error: 3.8759474730787704



```
Mean Absolute Error: 1.3503956647387572
Mean Manhattan Distance: 18.9055393063426
```

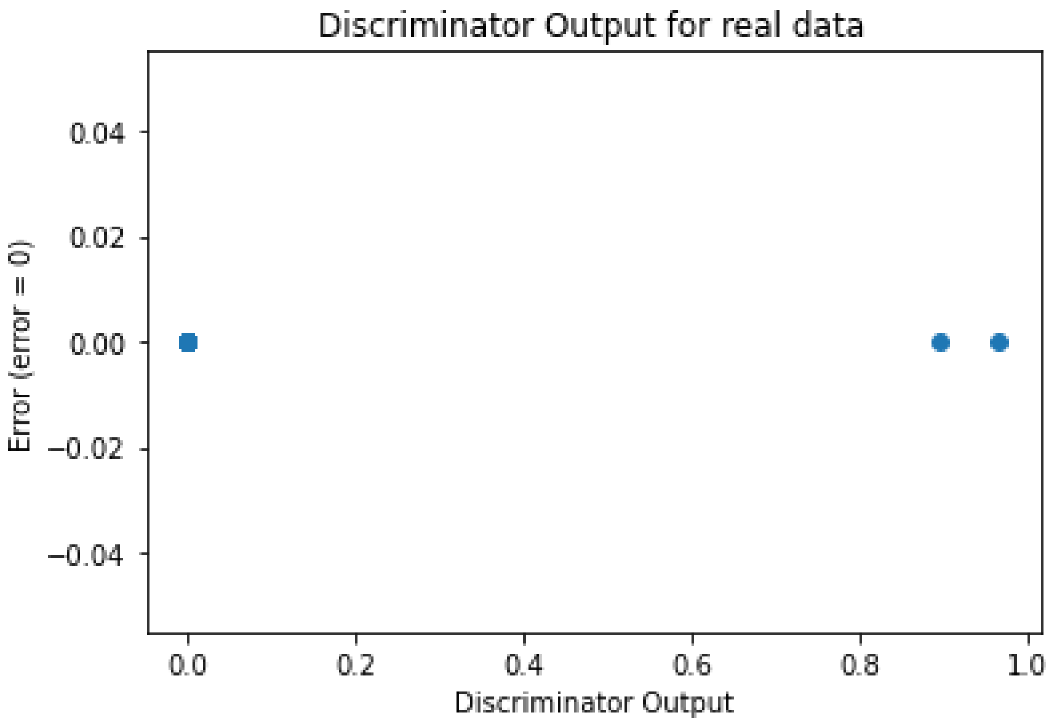


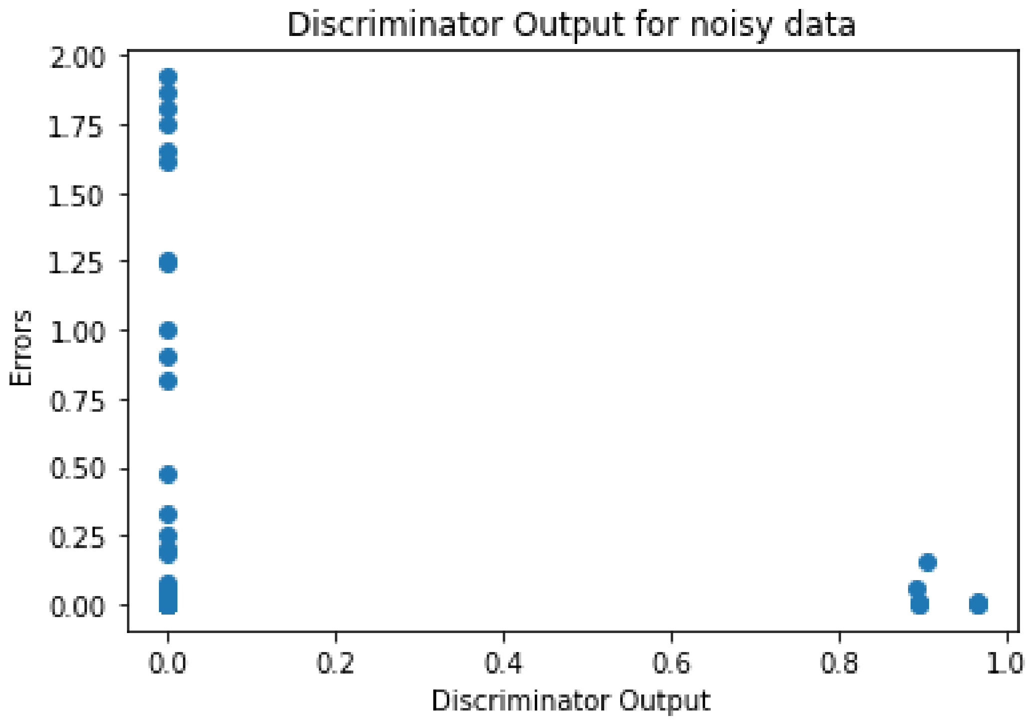

```
Mean Euclidean Distance: 7.355628426275923
```



Sanity Check

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





Visualisation of Trained GAN Generator

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

```
output.weight Parameter containing:
tensor([[ 0.7806, -0.4491, -0.7048, -0.2351, -1.2459,  0.8729, -1.5575,
0.1123]],
       requires_grad=True)
output.bias Parameter containing:
tensor([0.4536], requires_grad=True)
```