Dataset4-Capital_Punishment_output_2

October 7, 2021

[1]:
```
# Parameters
std = 0.1
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

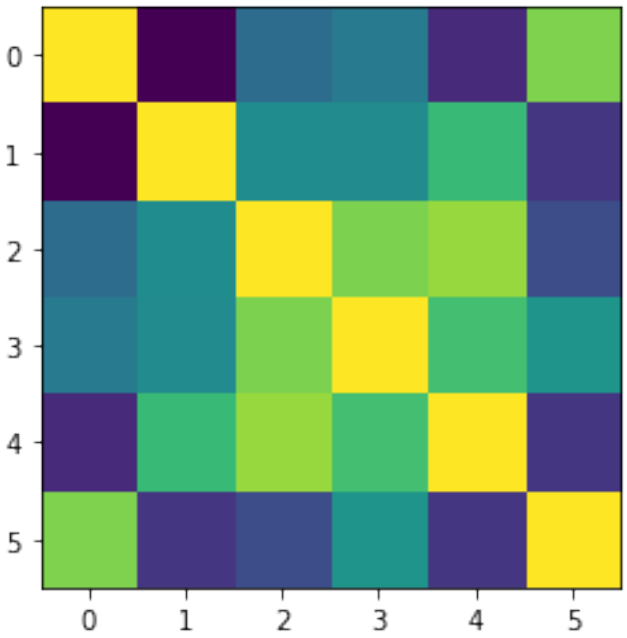
[3]:
```
import warnings
warnings.filterwarnings('ignore')
```

[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
```

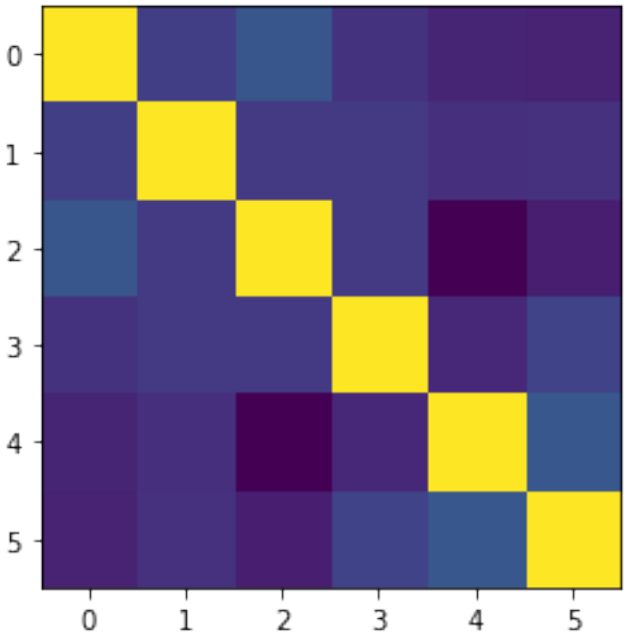
```
import pandas as pd
%matplotlib inline
```

[5]:
```
#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)
```

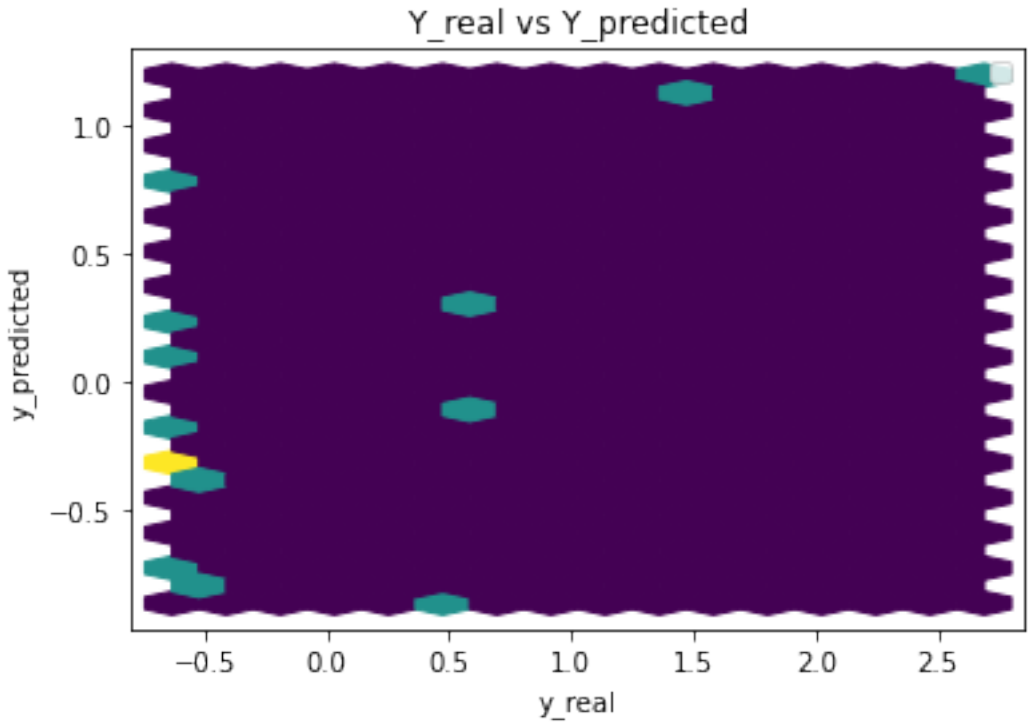
```
No handles with labels found to put in legend.
```

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:	14:59:23	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
```

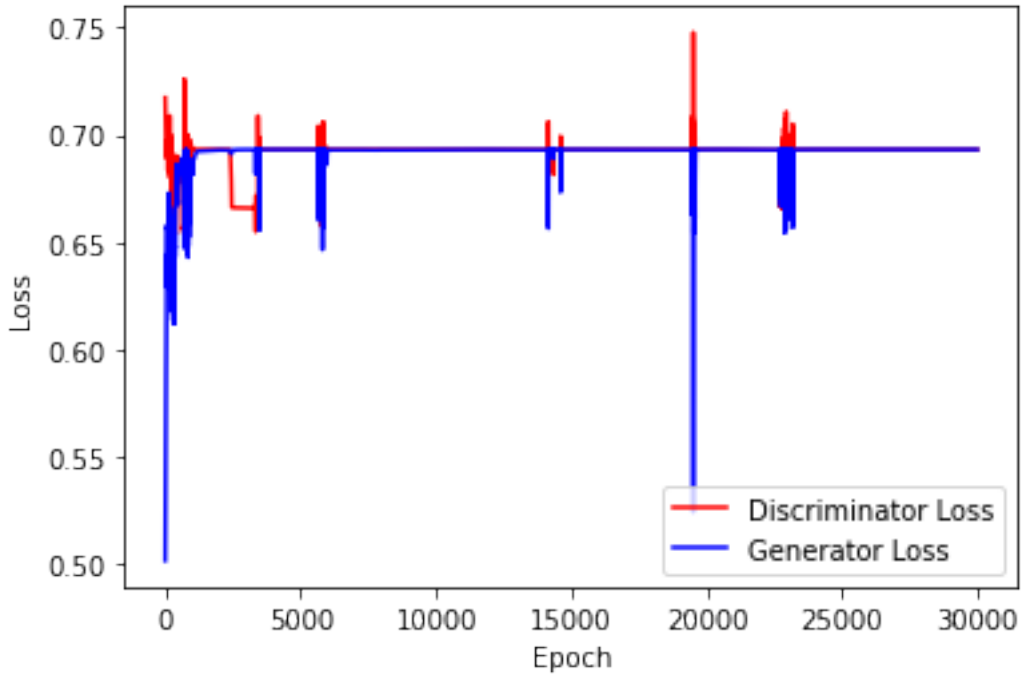
4 GAN Model

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

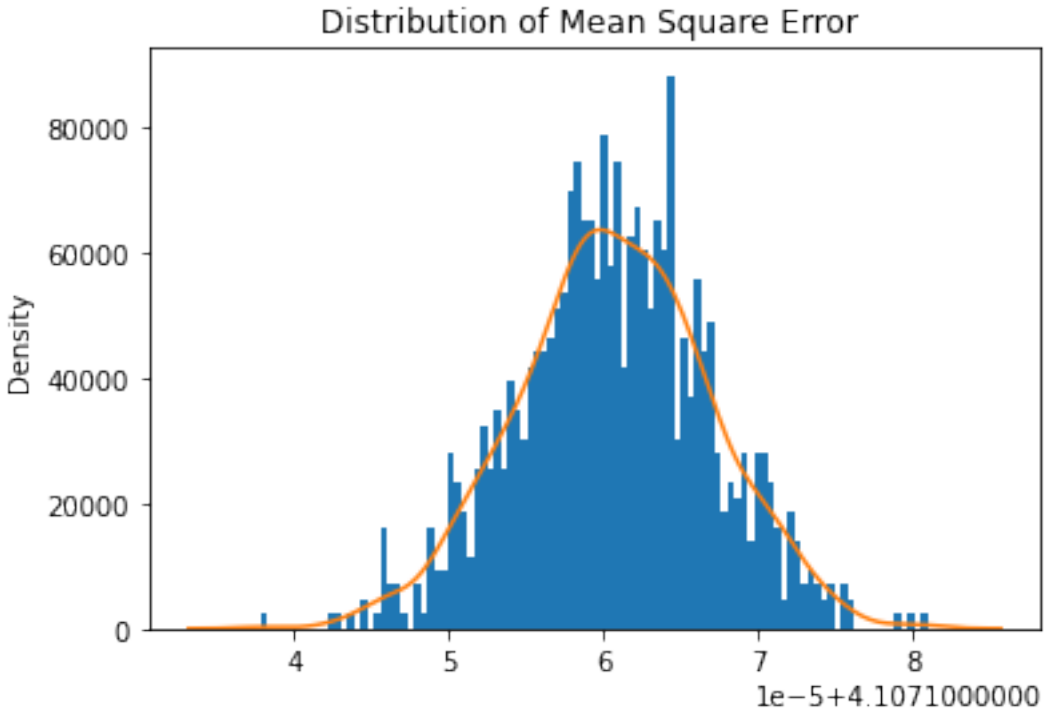
[11]:
```
generator = Generator(n_features+2)
discriminator = Discriminator(n_features+2,hidden_nodes)

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
```

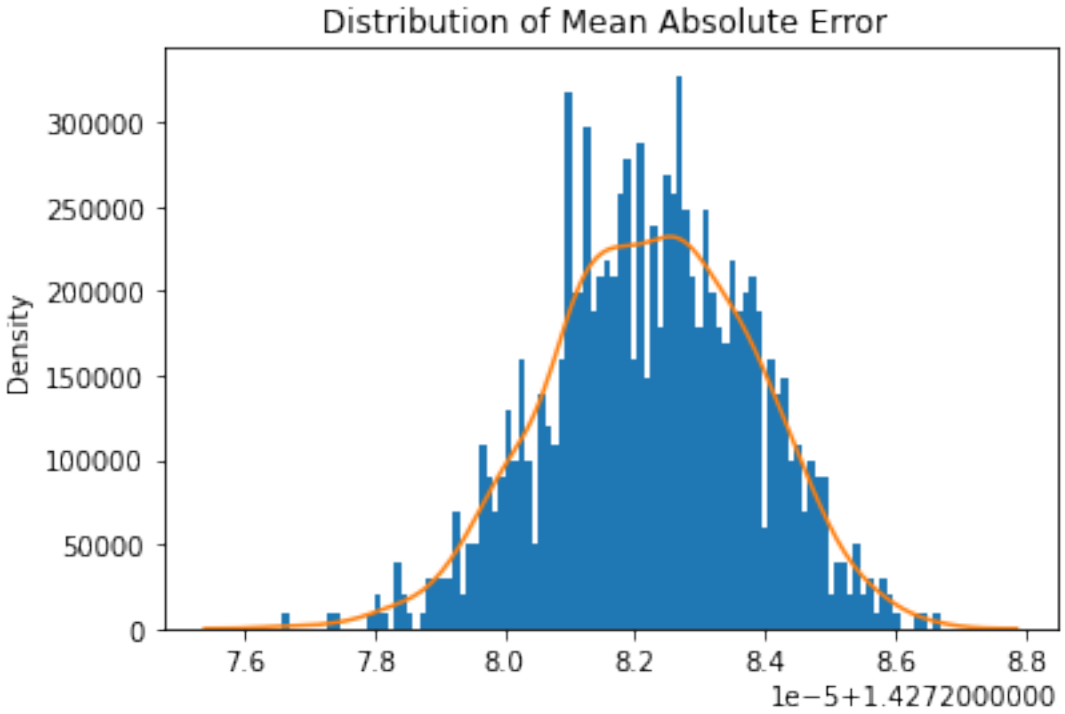
[13]:
```
train_test.
↪training_GAN(discriminator,generator,disc_opt,gen_opt,real_dataset,batch_size,␣
↪n_epochs,criterion,device)
```



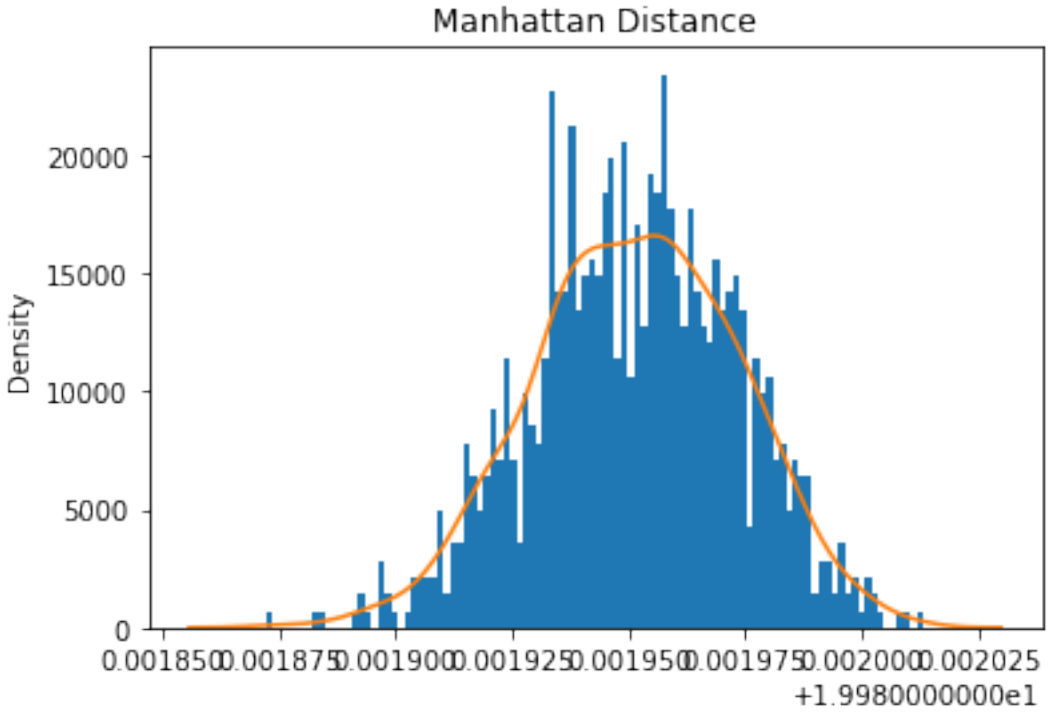
[14]:
```
train_test.test_generator(generator,real_dataset,device)
```



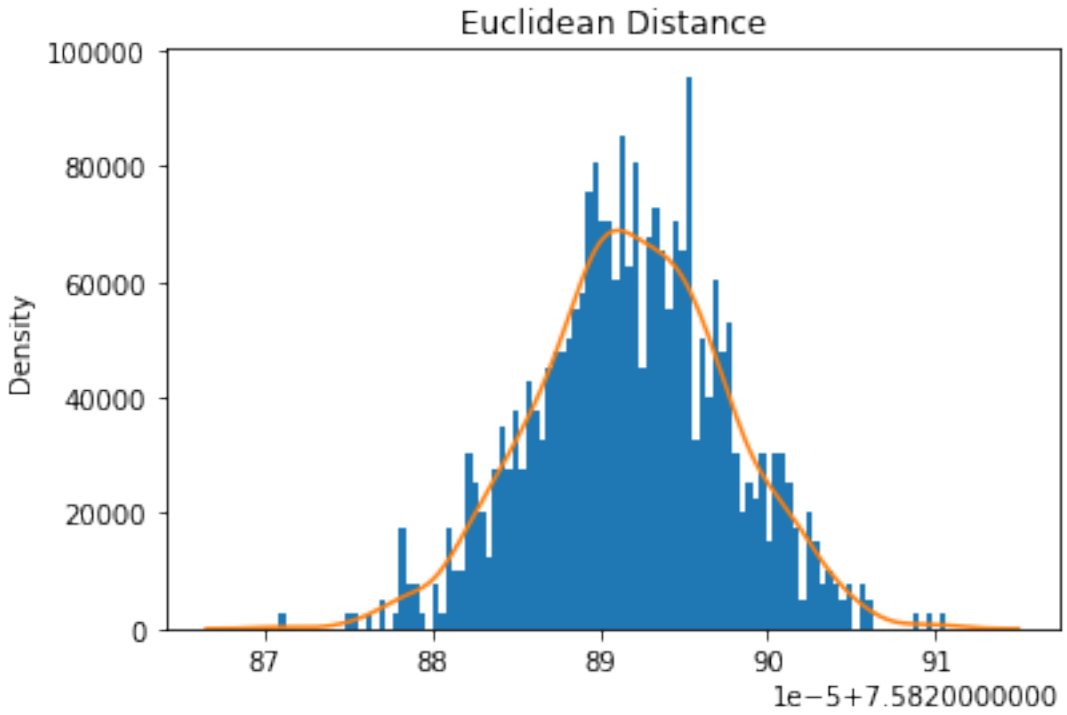
Mean Square Error: 4.10716065247043



Mean Absolute Error: 1.4272822431921959



```
Mean Manhattan Distance: 19.981951404690744
```



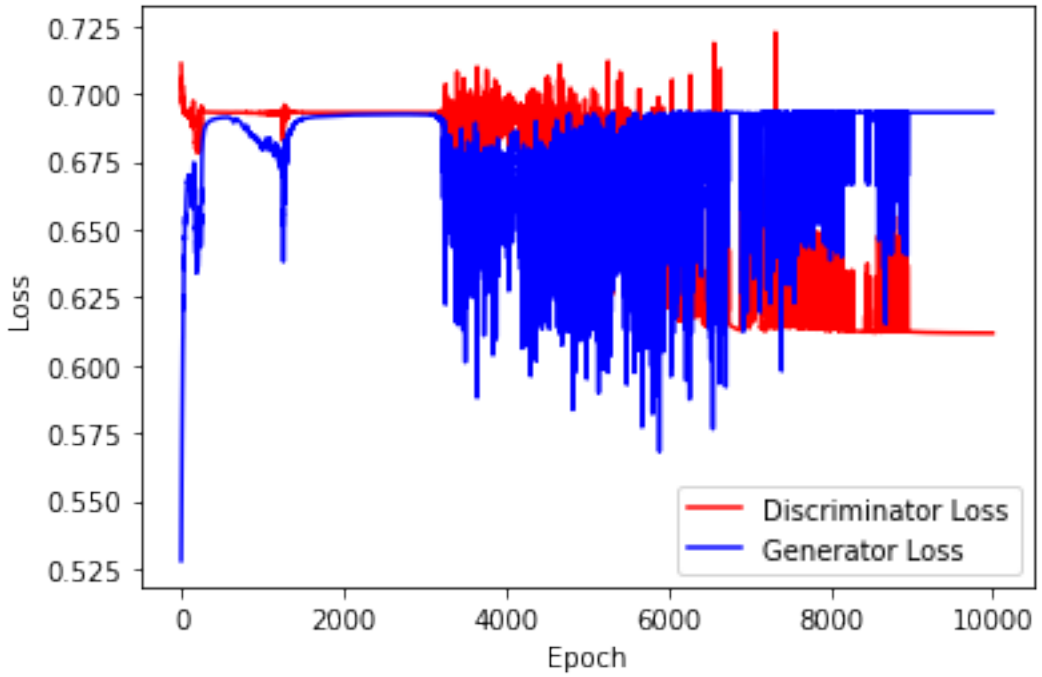

```
Mean Euclidean Distance: 19.981951404690744
```

5 ABC GAN Model

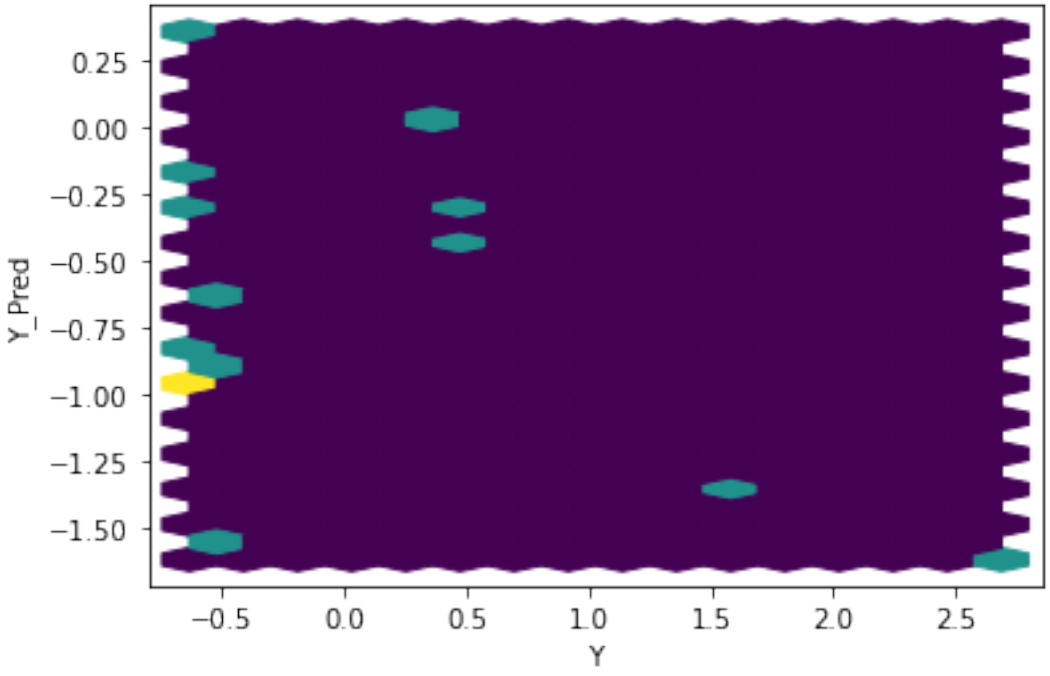
[15]:
```
gen = Generator(n_features+2)
disc = Discriminator(n_features+2,hidden_nodes)

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))
```

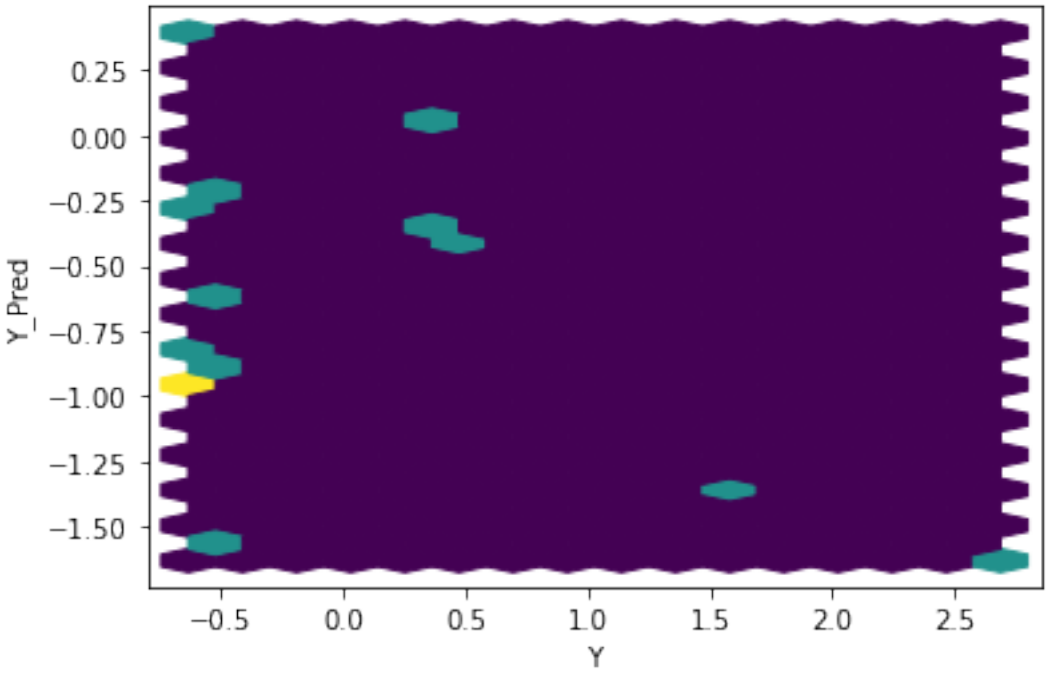
[16]:
```
n_epoch_abc = 10000
batch_size = sample_size
```

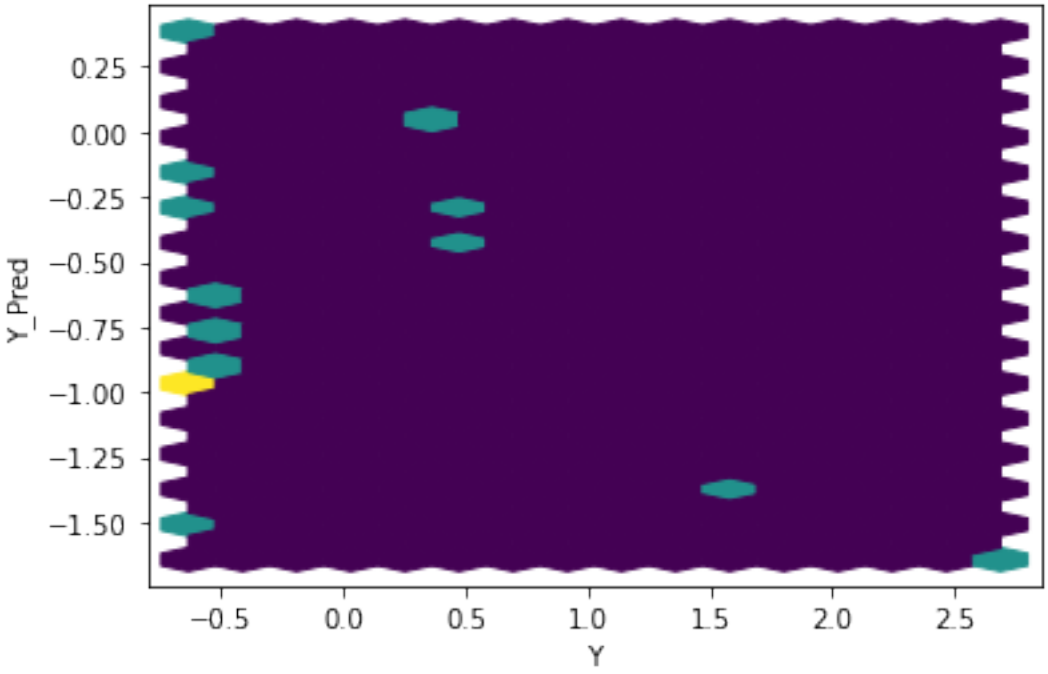
[17]:
```
ABC_train_test.training_GAN(disc, gen,disc_opt,gen_opt,real_dataset,␣
↪batch_size, n_epoch_abc,criterion,coeff,mean,std,device)
```

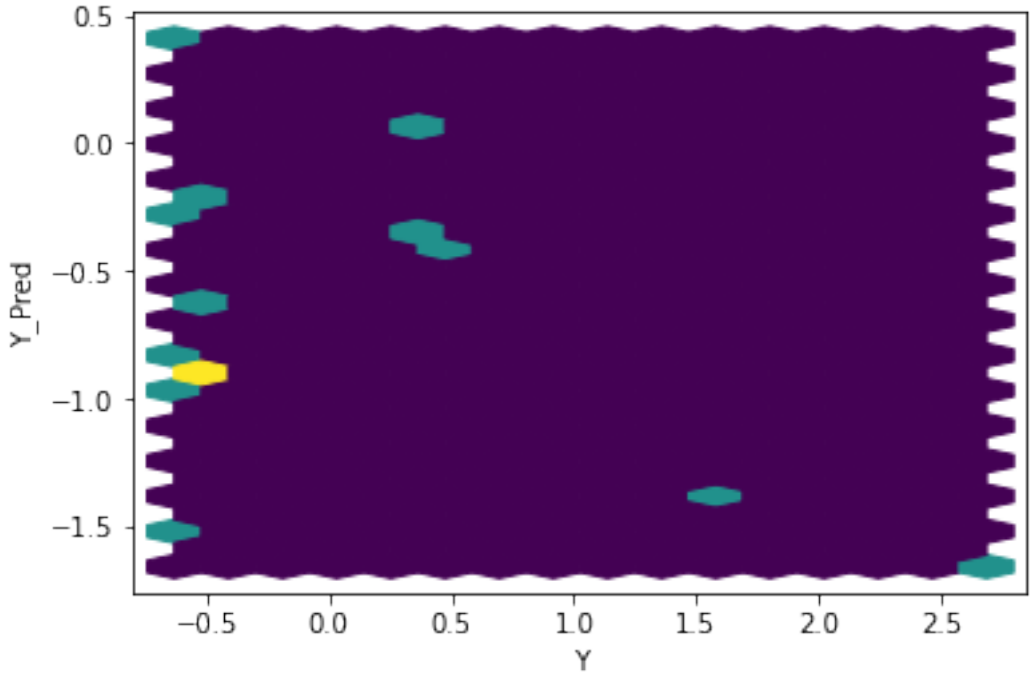


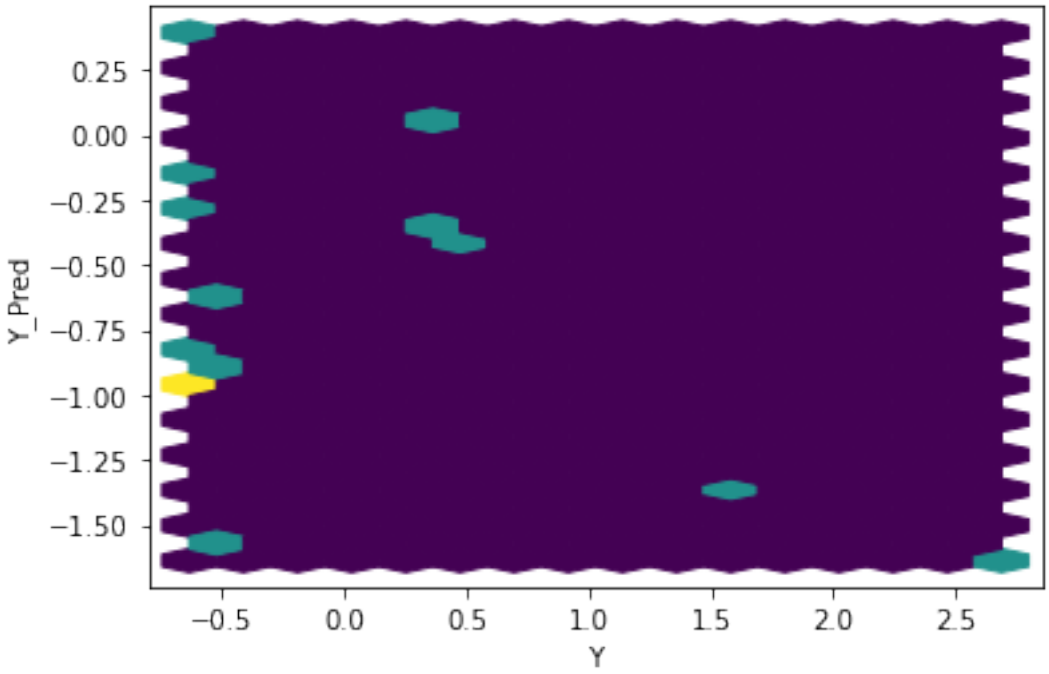
[18]:
```
ABC_train_test.test_generator(gen,real_dataset,coeff,mean,std,device)
```

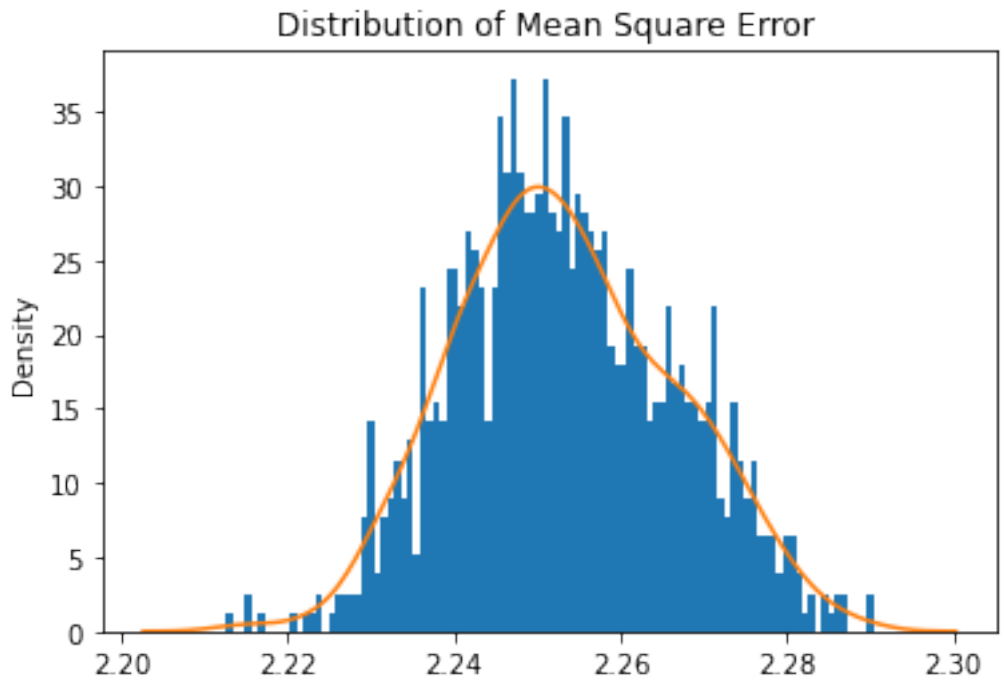



0.25
0.00
−0.25
−0.50
−0.75
−1.00
−1.25
−1.50
Y_Pred
−0.5
0.0
0.5
1.0
1.5
2.0
2.5
Y

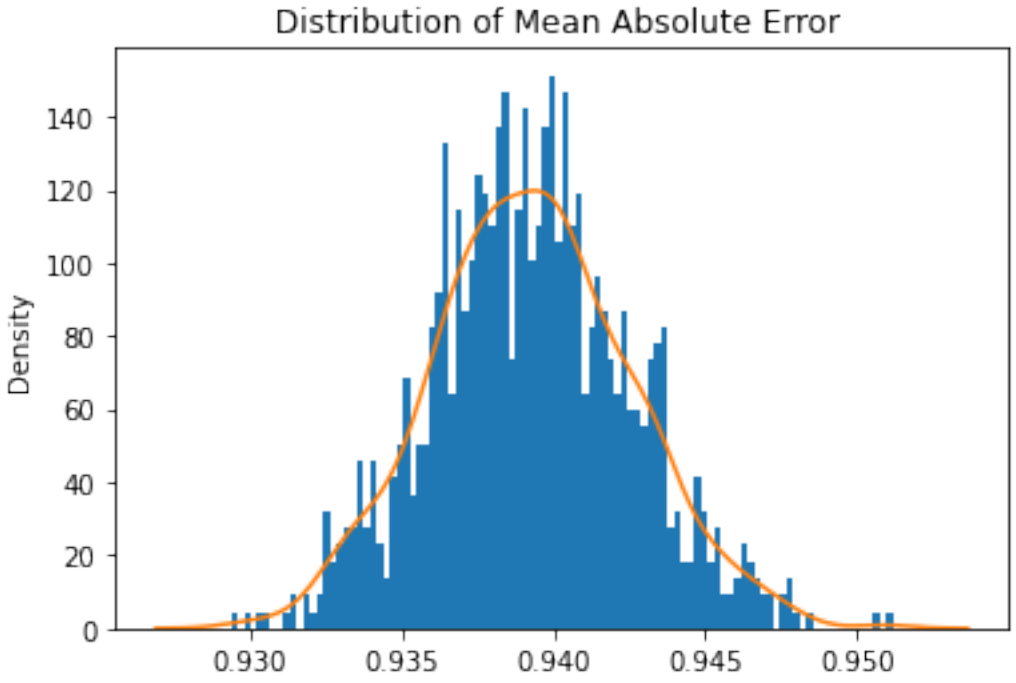

0.25
0.00
−0.25
−0.50
−0.75
−1.00
−1.25
−1.50
Y_Pred
−0.5
0.0
0.5
1.0
1.5
2.0
2.5
Y


0.5
0.0
−0.5
−1.0
−1.5
Y_Pred
−0.5
0.0
0.5
1.0
1.5
2.0
2.5
Y

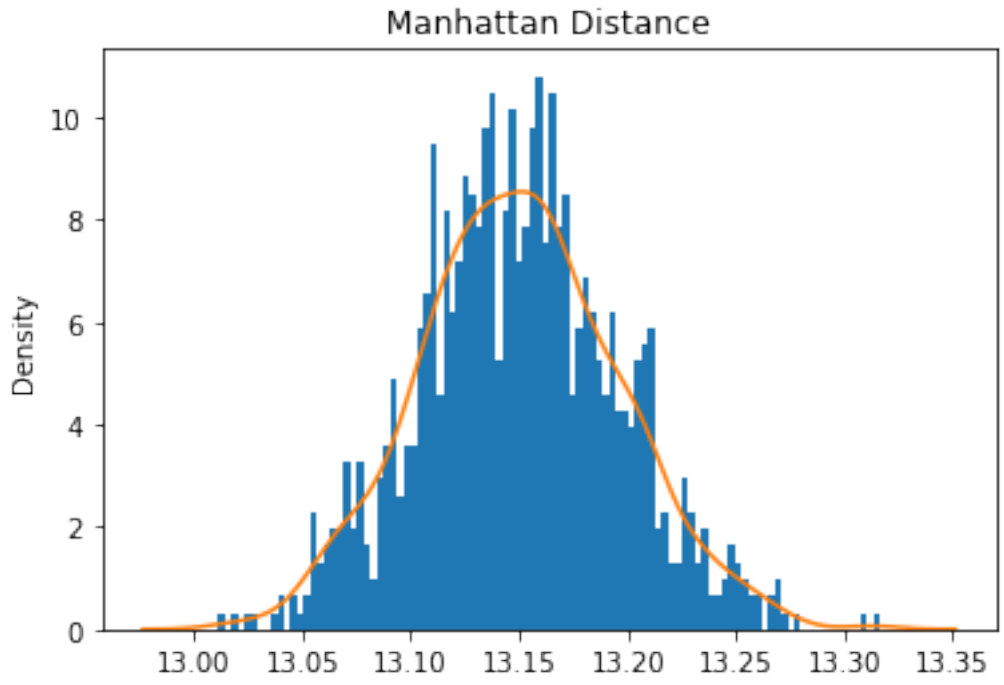

0.25
0.00
−0.25
−0.50
−0.75
−1.00
−1.25
−1.50
Y_Pred
−0.5
0.0
0.5
1.0
1.5
2.0
2.5
Y



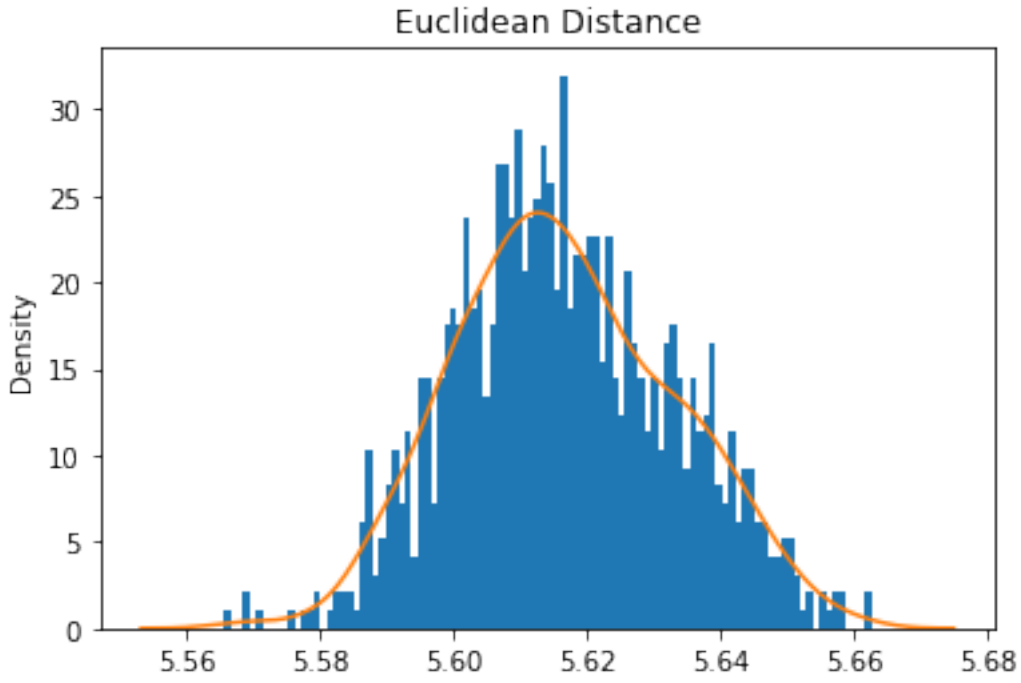

```
Mean Square Error: 2.253269160290068
```



```
Mean Absolute Error: 0.9392841258559909
Mean Manhattan Distance: 13.149977761983871
```

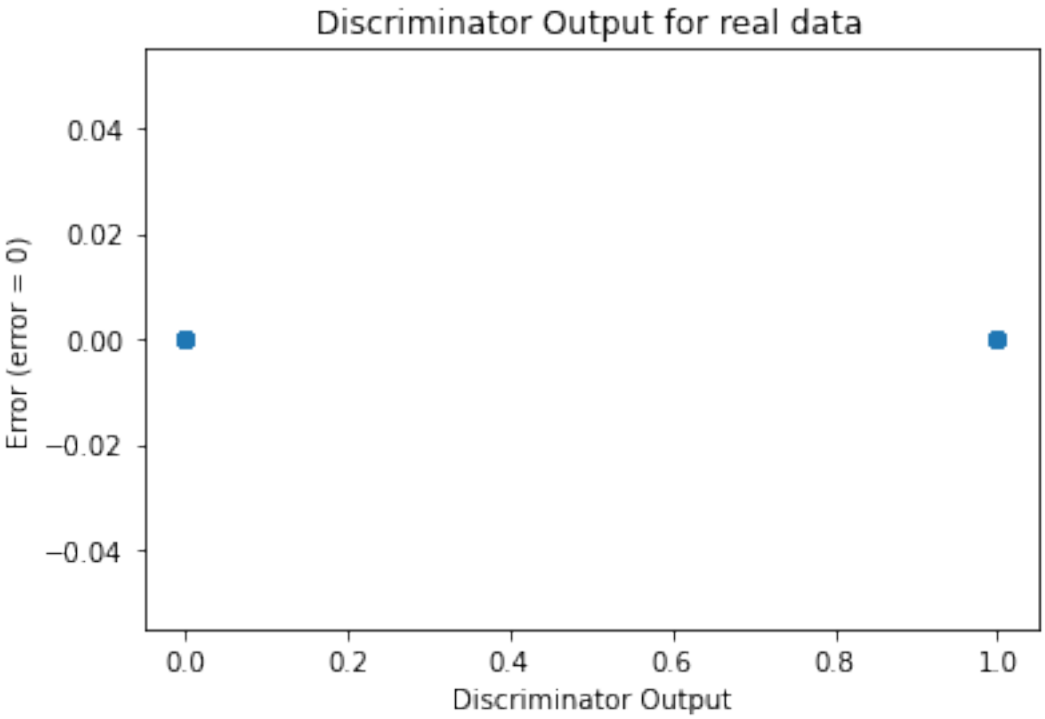


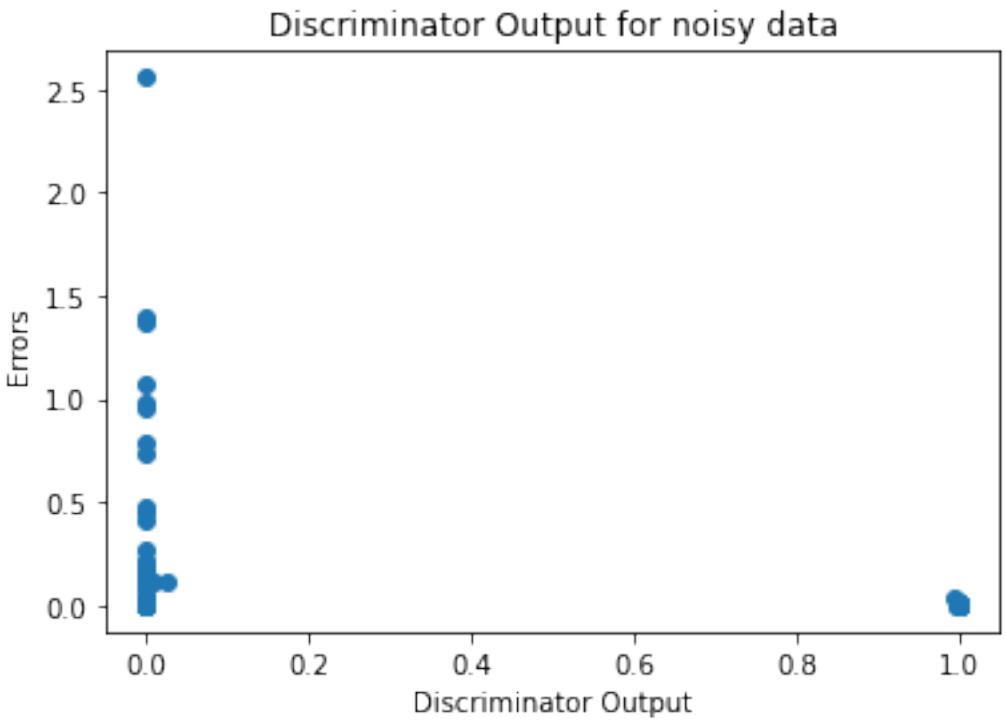

```
Mean Euclidean Distance: 5.616537999750212
```



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([[-0.2282,  0.0994,  0.2850,  0.3780, -0.2547, -0.4240,  0.6278,
0.0042]],
       requires_grad=True)
output.bias Parameter containing:
tensor([-0.4527], requires_grad=True)
```