

CSE4088 Introduction to Machine Learning

Homework 2 Report

- **Generalization Error**

At this section, we found the least number of examples N for the case $\epsilon = 0.05$ and the probability bound is at most 0.03.

$$P[|E_{in(g)} - E_{out(g)}| > \epsilon] \leq 2Me^{-2\epsilon^2 N}$$

1. $M = 1$

$$0.03 \leq 2 * 1 * e^{-2(0.05)^2 N}$$

$$0.015 \leq e^{-0.005N}$$

$$\ln 0.015 \leq -0.005N$$

$$N \geq 839.940$$

N must be at least 1000.

2. $M = 10$

$$0.03 \leq 2 * 10 * e^{-2(0.05)^2 N}$$

$$\ln 0.0015 \leq -0.005N$$

$$N \geq 1300.458$$

N must be at least 1500.

3. $M = 100$

$$0.03 \leq 2 * 100 * e^{-2(0.05)^2 N}$$

$$\ln 0.00015 \leq -0.005N$$

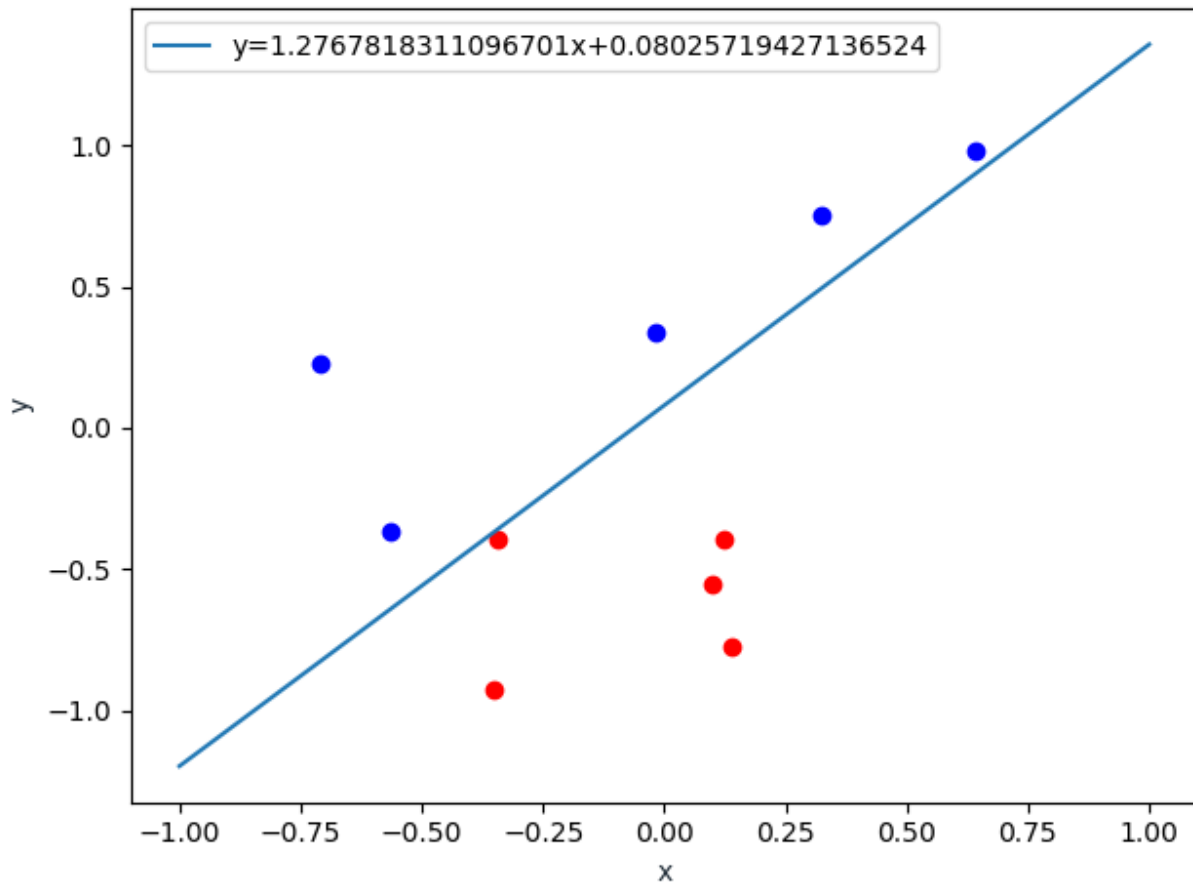
$$N \geq 1760.975$$

N must be at least 2000.

- **The Perceptron Learning Algorithm**

In this problem, we will implement the Perceptron Learning Algorithm.

For the $N = 10$, the random plot with the random function and random points.



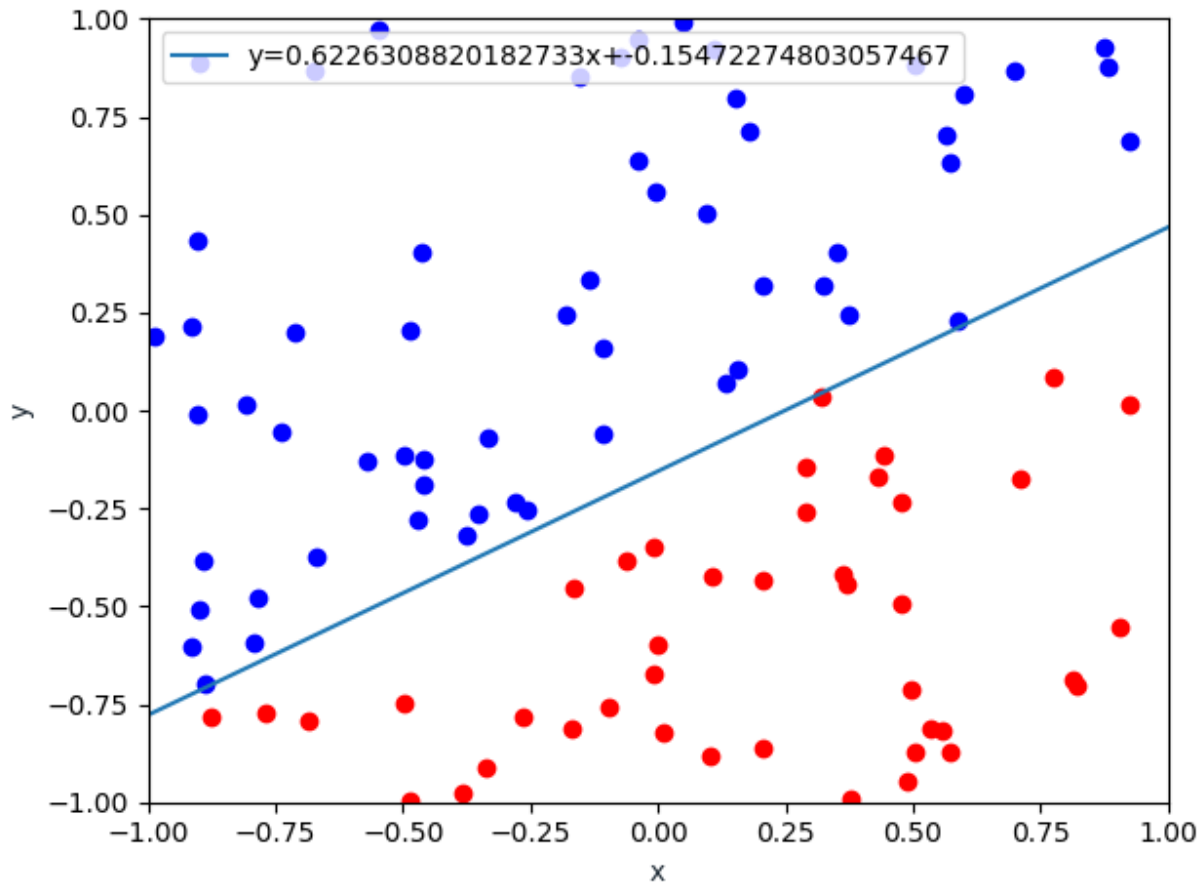
The last iteration of weight array is: $[0, 1.732768170372679, -2.1902796721228155]$.

Output:

```
number of misclassified samples: 0
number of classified samples: 1000
number of iteration average: 10.304
average of difference in function g: 0.10950000000000001
```

4. The average value is closest to 15.
5. The difference is closest to 0.1.

For the $N = 100$, the random plot with the random function and random points.



The last iteration of weight array is: $[-1, 3.8148902333611545, -5.70812883782177]$

Output:

```
number of misclassified samples: 0
number of classified samples: 1000
number of iteration average: 91.717
average of difference in function g: 0.013019999999999874
```

6. The average value is closest to 100.
7. The difference is closest to 0.01.

- **Linear Regression**

At this section, we explored how Linear Regression for classification works.

8. For the $N = 100$, we evaluated the average E_{in} of 1000 sample run.

Output:

The average E_{in} : [0.02455]

The average E_{in} is closest to 0.01

9. We evaluated the average E_{out} of 1000 sample run with 1000 fresh point.

Output:

The average E_{out} : [0.029091]

The average E_{out} is closest to 0.01

10. For the $N = 10$, the output is following for Linear Regression:

Output:

The average E_{in} : [0.0181]

The average E_{out} : [0.059946]

Found weights using Linear Regression, used as a vector of initial weights for the Perceptron Learning Algorithm. The average iteration is closest to 1.