PR, Fall 2018 Project #2(a): Multilayer Perceptron **Prof. K. Y. Huang**

何時給 project: 11/21, 2018. **何時交 project: 12/11, 2018** **遲交不收，抄襲 0 分。**

In multilayer perceptron model, use gradient descent method to solve the following problems:

1. Two spiral problem:

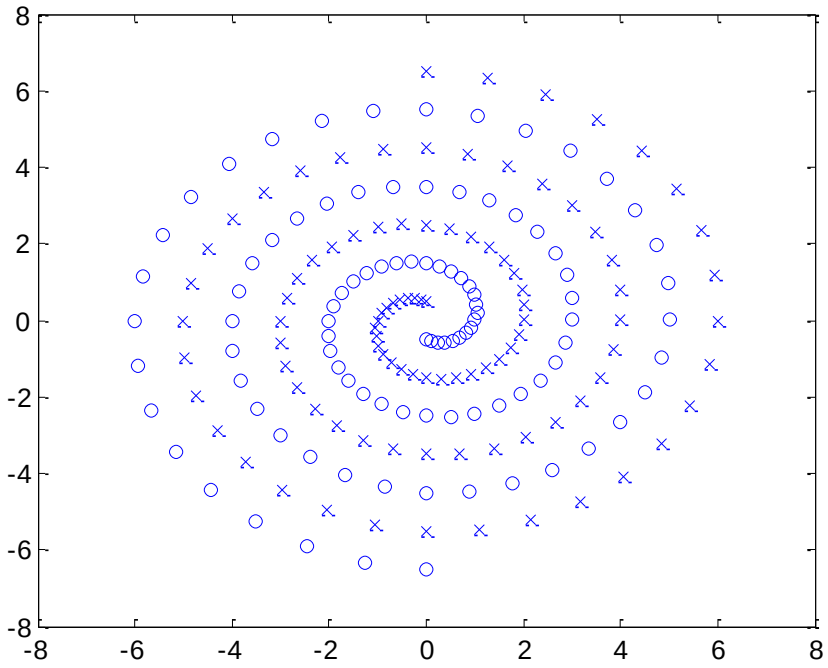
$(x_i, y_i) = (r_i \sin\theta_i, r_i \cos\theta_i) \in C_1$,

where $r_i = 6.5 \times \frac{(104 - i)}{104}, \theta_i = \frac{\pi}{16} i, i = 0,1,2,...,96$

$(x_j, y_j) = (-r_j \sin\theta_j, -r_j \cos\theta_j) \in C_2$,

where $r_j = 6.5 \times \frac{(104 - j)}{104}, \theta_j = \frac{\pi}{16} j, j = 0,1,2,...,96$

Desired output (d_1, d_2) of C_1 is (1, 0) and desired output of C_2 is (0, 1).



Design a network to classify above 194 patterns into their corresponding two classes. That is, the number of hidden layers and hidden nodes is designed by you.

2. Double-moon problem:

Use the following scripts to generate data.

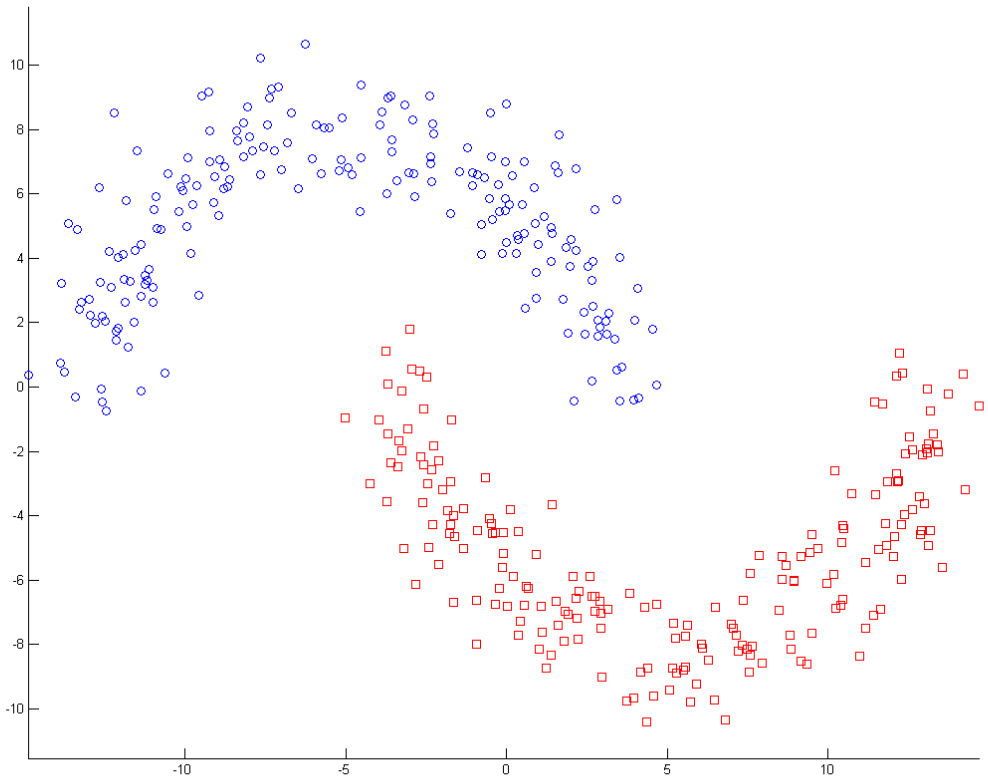
```
N=250;
theta1 = linspace(-180,180, N)*pi/360;

r = 8
x1 = -5 + r*sin(theta1)+randn(1,N);
y1 = r*cos(theta1)+randn(1,N);

x2 = 5 + r*sin(theta1)+randn(1,N);
y2 = -r*cos(theta1)+randn(1,N);
```

```
figure;
hold on;
axis equal;
plot(x1,y1,'bo');
plot(x2,y2,'rs');
```

Blue points are for class 1, and red points belong to class 2.
Design a network to classify above 500 patterns into their corresponding two classes.



3. Given 4 classes with Gaussian distribution:

$M_1 = \begin{bmatrix}0\\0\end{bmatrix}$ $\Sigma_1 = \begin{bmatrix}1 & 0\\0 & 1\end{bmatrix}$, $M_2 = \begin{bmatrix}14\\0\end{bmatrix}$ $\Sigma_2 = \begin{bmatrix}1 & 0\\0 & 4\end{bmatrix}$, $M_3 = \begin{bmatrix}7\\14\end{bmatrix}$ $\Sigma_3 = \begin{bmatrix}4 & 0\\0 & 1\end{bmatrix}$,

$M_4 = \begin{bmatrix}7\\7\end{bmatrix}$ $\Sigma_4 = \begin{bmatrix}1 & 0\\0 & 1\end{bmatrix}$，各產生 150 點， use multilayer perceptron to find the decision regions。

(a) activation function 用 sigmoidal function，自己用 MATLAB 寫程式，

(b) 將 activation function 改為 ReLu function, 先寫出 w_{kj}, w_{ji} 完整的 learning rule。再跑程式，收斂有何不一樣?

(c) 利用 MATLAB 的 neural networks 的 toolbox，並做比較。

For each problem:
Describe parameters of your network: number of hidden layers, number of hidden nodes, learning rate parameter (η), stop criterion, …, etc.

Plot the figure of average error vs. iteration,
Plot the decision region.
寫 MATLAB program 不要用內建的 neural network function，也就是不要用 toolbox。

Discussion (10%)

How to determine the hidden node number in each problem? Describe in detail. Describe any phenomenon you watched, any try to explain it if possible.

Any experiment like changing learning rate parameter, designing more layers, determining the hidden node number, or adding momentum term is greatly encouraged. 需要用到 high order inputs?

References

要交的東西:

(1) 在指定日的上課前，交紙本報告 (包含敘述如何做，flowchart，結果，討論，參考文獻，及 Matlab programs).

(2) 將要交紙本報告的 doc file 及分開的 MATLAB program file 建成一個 directory (資料夾)，壓縮成 7z 的壓縮檔後，上傳到 e3 system.

Directory name 的名稱: Proj#2(a)_姓名_PR_2018_Fall。