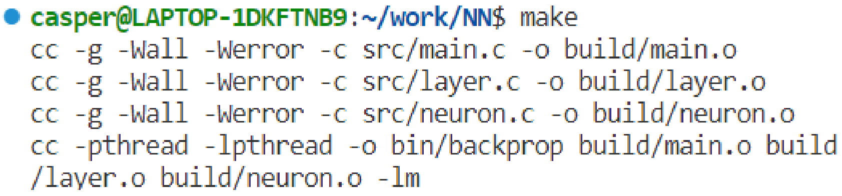
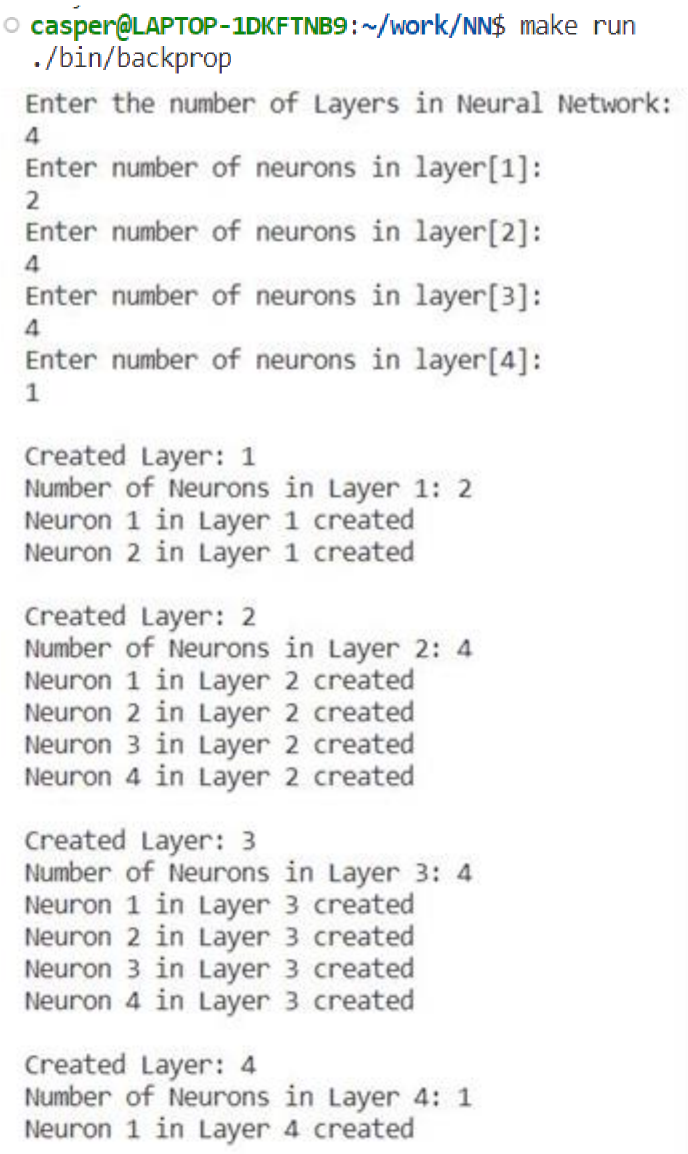
Assighment_1

1. 編譯結果

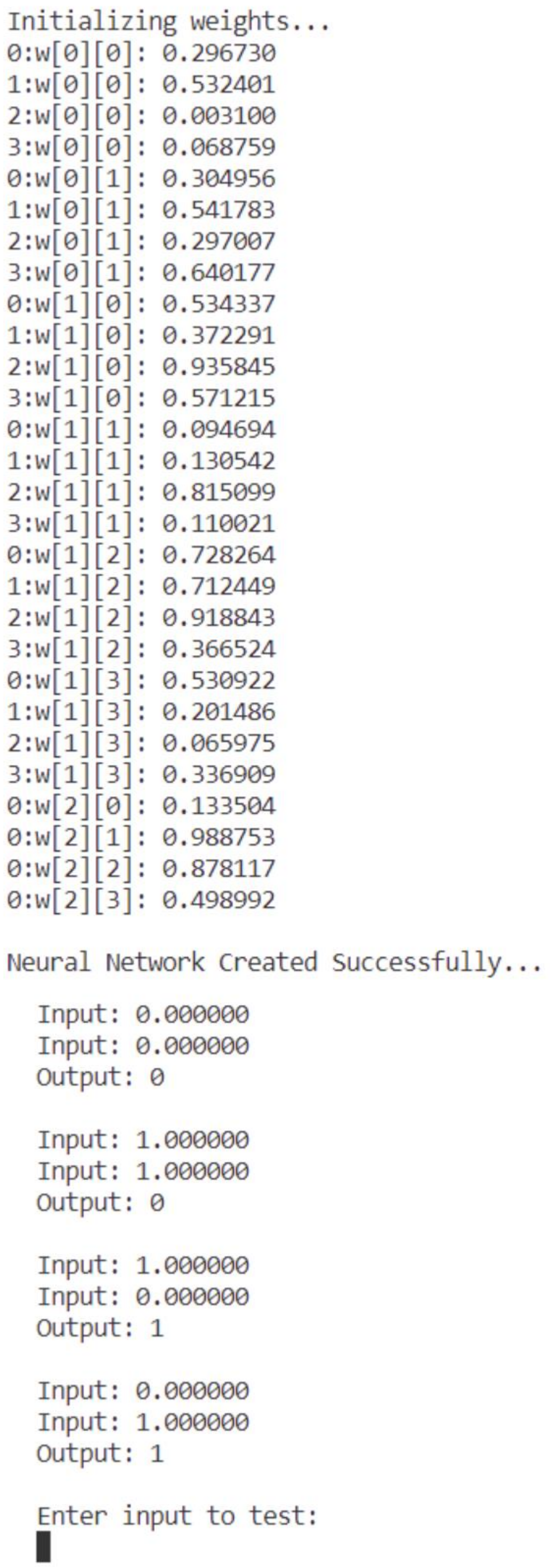


```
casper@LAPTOP-1DKFTNB9:~/work/NN$ make
cc -g -Wall -Werror -c src/main.c -o build/main.o
cc -g -Wall -Werror -c src/layer.c -o build/layer.o
cc -g -Wall -Werror -c src/neuron.c -o build/neuron.o
cc -pthread -lpthread -o bin/backprop build/main.o build
/layer.o build/neuron.o -lm
```

2. 執行結果

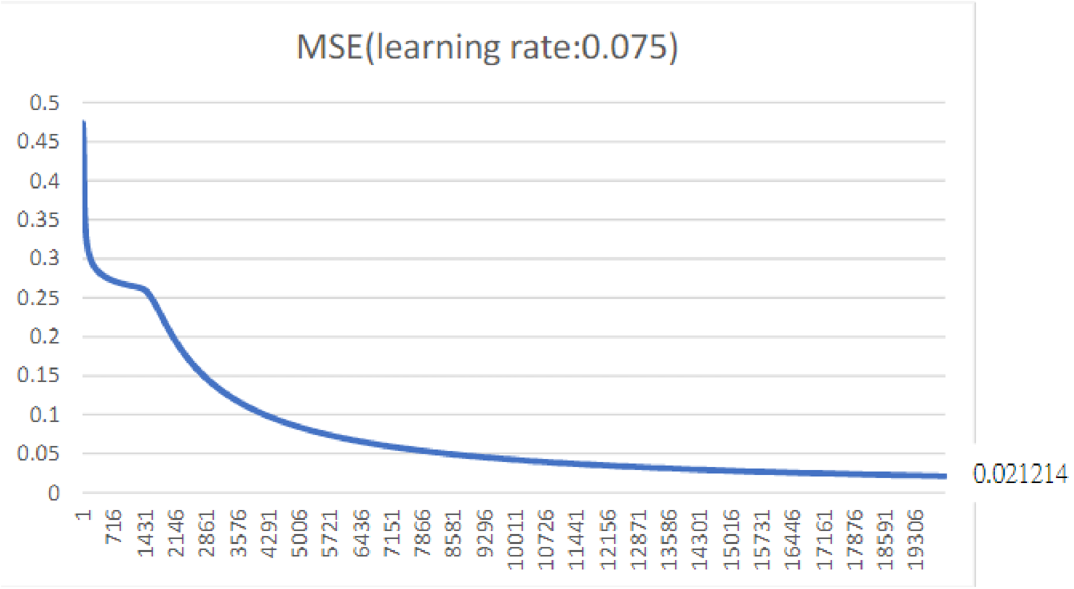


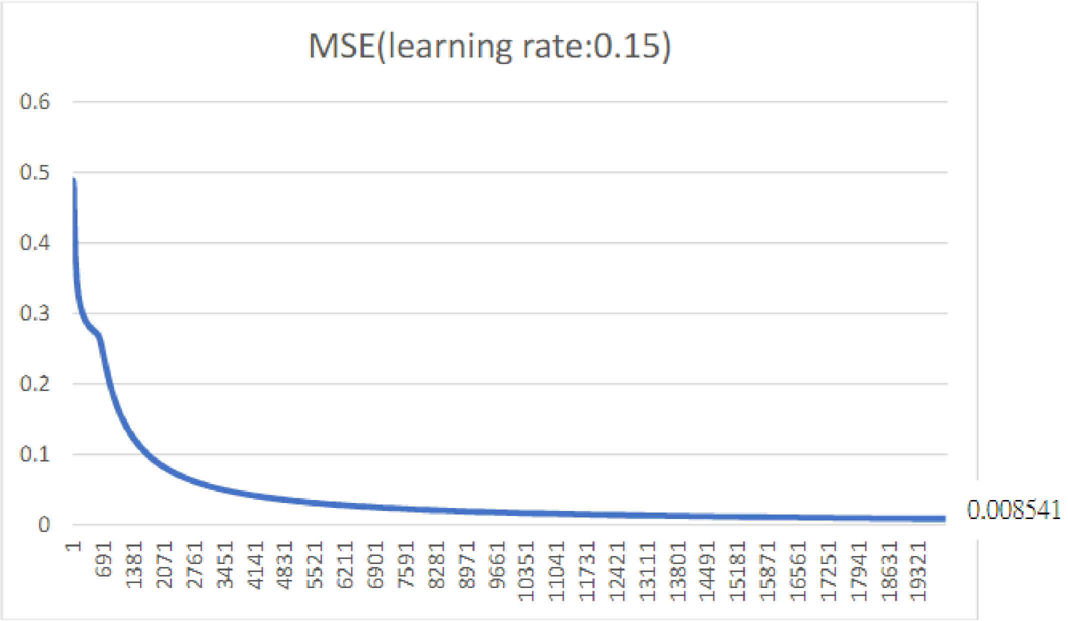
```
casper@LAPTOP-1DKFTNB9:~/work/NN$ make run
./bin/backprop
Enter the number of Layers in Neural Network:
4
Enter number of neurons in layer[1]:
2
Enter number of neurons in layer[2]:
4
Enter number of neurons in layer[3]:
4
Enter number of neurons in layer[4]:
1

Created Layer: 1
Number of Neurons in Layer 1: 2
Neuron 1 in Layer 1 created
Neuron 2 in Layer 1 created

Created Layer: 2
Number of Neurons in Layer 2: 4
Neuron 1 in Layer 2 created
Neuron 2 in Layer 2 created
Neuron 3 in Layer 2 created
Neuron 4 in Layer 2 created

Created Layer: 3
Number of Neurons in Layer 3: 4
Neuron 1 in Layer 3 created
Neuron 2 in Layer 3 created
Neuron 3 in Layer 3 created
Neuron 4 in Layer 3 created

Created Layer: 4
Number of Neurons in Layer 4: 1
Neuron 1 in Layer 4 created
```

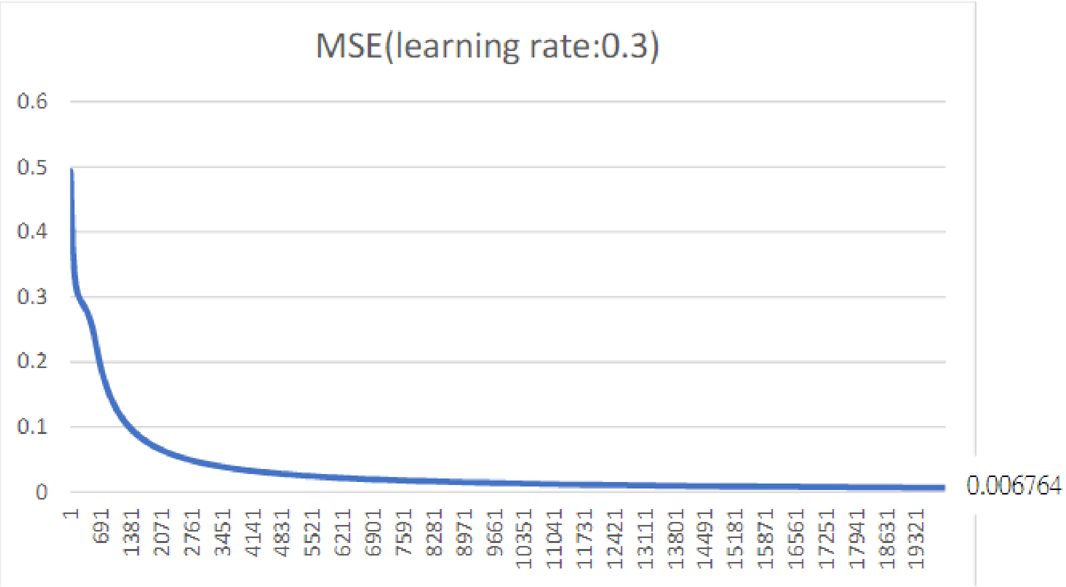


```
Initializing weights...
0:w[0][0]: 0.296730
1:w[0][0]: 0.532401
2:w[0][0]: 0.003100
3:w[0][0]: 0.068759
0:w[0][1]: 0.304956
1:w[0][1]: 0.541783
2:w[0][1]: 0.297007
3:w[0][1]: 0.640177
0:w[1][0]: 0.534337
1:w[1][0]: 0.372291
2:w[1][0]: 0.935845
3:w[1][0]: 0.571215
0:w[1][1]: 0.094694
1:w[1][1]: 0.130542
2:w[1][1]: 0.815099
3:w[1][1]: 0.110021
0:w[1][2]: 0.728264
1:w[1][2]: 0.712449
2:w[1][2]: 0.918843
3:w[1][2]: 0.366524
0:w[1][3]: 0.530922
1:w[1][3]: 0.201486
2:w[1][3]: 0.065975
3:w[1][3]: 0.336909
0:w[2][0]: 0.133504
0:w[2][1]: 0.988753
0:w[2][2]: 0.878117
0:w[2][3]: 0.498992

Neural Network Created Successfully...
  Input: 0.000000
  Input: 0.000000
  Output: 0

  Input: 1.000000
  Input: 1.000000
  Output: 0

  Input: 1.000000
  Input: 0.000000
  Output: 1

  Input: 0.000000
  Input: 1.000000
  Output: 1

  Enter input to test:
```

3. 分析


MSE(learning rate:0.075)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
1
716
1431
2146
2861
3576
4291
5006
5721
6436
7151
7866
8581
9296
10011
10726
11441
12156
12871
13586
14301
15016
15731
16446
17161
17876
18591
19306
0.021214


MSE(learning rate:0.15)
0.6
0.5
0.4
0.3
0.2
0.1
0
1
691
1381
2071
2761
3451
4141
4831
5521
6211
6901
7591
8281
8971
9661
10351
11041
11731
12421
13111
13801
14491
15181
15871
16561
17251
17941
18631
19321
0.008541



此類神經網路程式呈現 2 位元 XOR 的結果，根據 Mean Square Error(MSE)修正權重，最終使 MSE 趨近於 0，讓輸出接近想要的結果。

$$MSE = \frac{\sum_{i=1}^{n} (y_i - y_i^p)^2}{n}$$

圖表中每 4 個數據一組算出平均 MSE，重複計算了 20000 組資料，可以看出 MSE 收斂於 0，且當 learning rate 升高時，MSE 最終會越接近於 0，輸出越準確。

4. 參考資料

https://medium.com/analytics-vidhya/building-neural-network-framework-in-c-using-backpropagation-8ad589a0752d