Assignment #1

110503517 通訊二 游晉陽

1. 編譯結果

```
(base) youjinyang@youjinyangdeMacBook-Pro 110503517_assignment_1_update % make all
gcc -Wall ./src/110503517_assignment_1_update.c -I ./inc -c
gcc ./obj/110503517_assignment_1_update.o -o ./bin/main
```

2. 執行結果

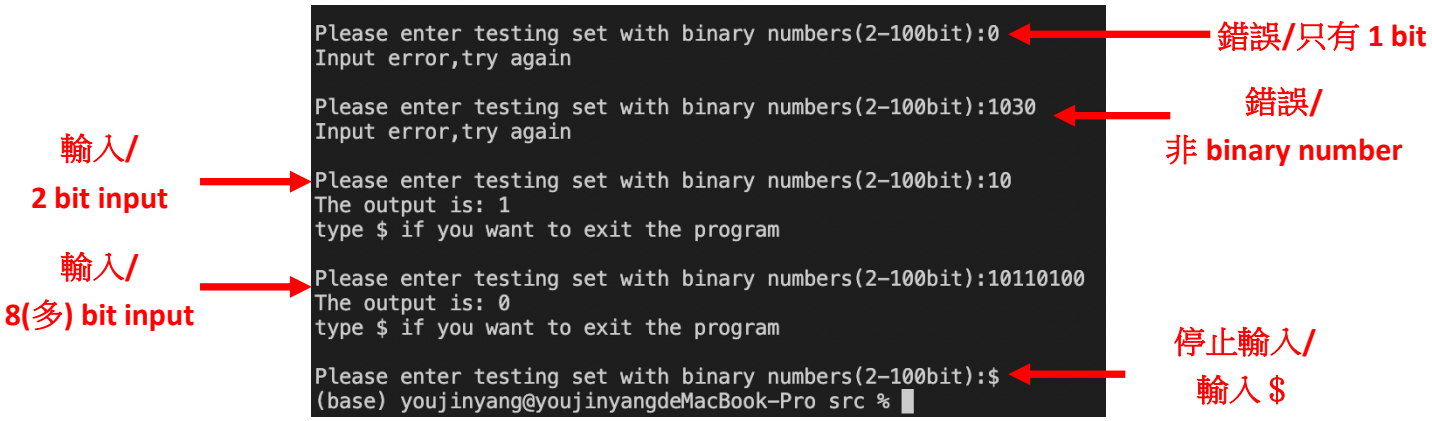
```
(base) youjinyang@youjinyangdeMacBook-Pro 110503517_assignment_1_update % cd bin
(base) youjinyang@youjinyangdeMacBook-Pro bin % ./main
```

```
at    200 epochs the total loss is 2.000105
at    400 epochs the total loss is 1.999956
at    600 epochs the total loss is 1.999764
at    800 epochs the total loss is 1.999030
at   1000 epochs the total loss is 1.990587
at   1200 epochs the total loss is 1.843368
at   1400 epochs the total loss is 1.577529
at   1600 epochs the total loss is 1.367282
at   1800 epochs the total loss is 1.208874
at   2000 epochs the total loss is 1.086904
at   2200 epochs the total loss is 0.990529
at   2400 epochs the total loss is 0.912570
at   2600 epochs the total loss is 0.848215
at   2800 epochs the total loss is 0.794163
at   3000 epochs the total loss is 0.748086
at   3200 epochs the total loss is 0.708303
at   3400 epochs the total loss is 0.673575
at   3600 epochs the total loss is 0.642966
at   3800 epochs the total loss is 0.615759
at   4000 epochs the total loss is 0.591397
at   4200 epochs the total loss is 0.569437
at   4400 epochs the total loss is 0.549525
at   4600 epochs the total loss is 0.531374
at   4800 epochs the total loss is 0.514750
at   5000 epochs the total loss is 0.499458
at   5200 epochs the total loss is 0.485335
at   5400 epochs the total loss is 0.472246
at   5600 epochs the total loss is 0.460074
at   5800 epochs the total loss is 0.448722
at   6000 epochs the total loss is 0.438103
at   6200 epochs the total loss is 0.428145
at   6400 epochs the total loss is 0.418785
at   6600 epochs the total loss is 0.409966
at   6800 epochs the total loss is 0.401640
at   7000 epochs the total loss is 0.393765
at   7200 epochs the total loss is 0.386302
at   7400 epochs the total loss is 0.379217
at   7600 epochs the total loss is 0.372481
at   7800 epochs the total loss is 0.366067
at   8000 epochs the total loss is 0.359950
at   8200 epochs the total loss is 0.354109
at   8400 epochs the total loss is 0.348525
at   8600 epochs the total loss is 0.343179
at   8800 epochs the total loss is 0.338056
at   9000 epochs the total loss is 0.333141
at   9200 epochs the total loss is 0.328420
at   9400 epochs the total loss is 0.323882
at   9600 epochs the total loss is 0.319515
at   9800 epochs the total loss is 0.315309
at  10000 epochs the total loss is 0.311255
```

```
at  10200 epochs the total loss is 0.307344
at  10400 epochs the total loss is 0.303567
at  10600 epochs the total loss is 0.299919
at  10800 epochs the total loss is 0.296391
at  11000 epochs the total loss is 0.292977
at  11200 epochs the total loss is 0.289672
at  11400 epochs the total loss is 0.286469
at  11600 epochs the total loss is 0.283365
at  11800 epochs the total loss is 0.280354
at  12000 epochs the total loss is 0.277431
at  12200 epochs the total loss is 0.274592
at  12400 epochs the total loss is 0.271835
at  12600 epochs the total loss is 0.269154
at  12800 epochs the total loss is 0.266546
at  13000 epochs the total loss is 0.264009
at  13200 epochs the total loss is 0.261539
at  13400 epochs the total loss is 0.259133
at  13600 epochs the total loss is 0.256790
at  13800 epochs the total loss is 0.254505
at  14000 epochs the total loss is 0.252277
at  14200 epochs the total loss is 0.250103
at  14400 epochs the total loss is 0.247982
at  14600 epochs the total loss is 0.245911
at  14800 epochs the total loss is 0.243888
at  15000 epochs the total loss is 0.241912
at  15200 epochs the total loss is 0.239981
at  15400 epochs the total loss is 0.238093
at  15600 epochs the total loss is 0.236247
at  15800 epochs the total loss is 0.234440
at  16000 epochs the total loss is 0.232673
at  16200 epochs the total loss is 0.230943
at  16400 epochs the total loss is 0.229249
at  16600 epochs the total loss is 0.227590
at  16800 epochs the total loss is 0.225965
at  17000 epochs the total loss is 0.224373
at  17200 epochs the total loss is 0.222812
at  17400 epochs the total loss is 0.221282
at  17600 epochs the total loss is 0.219781
at  17800 epochs the total loss is 0.218309
at  18000 epochs the total loss is 0.216865
at  18200 epochs the total loss is 0.215448
at  18400 epochs the total loss is 0.214057
at  18600 epochs the total loss is 0.212691
at  18800 epochs the total loss is 0.211350
at  19000 epochs the total loss is 0.210033
at  19200 epochs the total loss is 0.208739
at  19400 epochs the total loss is 0.207468
at  19600 epochs the total loss is 0.206218
at  19800 epochs the total loss is 0.204990
at  20000 epochs the total loss is 0.203782
```

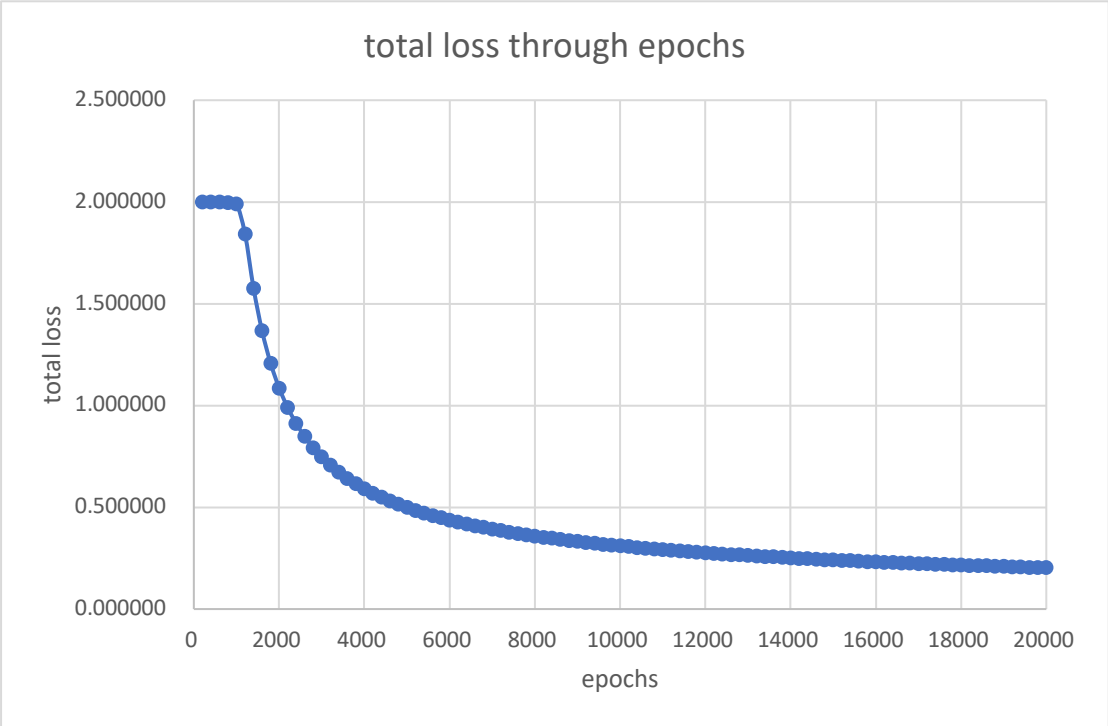
```
-------NN training complete with 20000 epochs-------

for train input [0,0]the  compute output is: 0
the abosolute error of this set is 0.023764

for train input [0,1]the  compute output is: 1
the abosolute error of this set is 0.053956

for train input [1,0]the  compute output is: 1
the abosolute error of this set is 0.053956

for train input [1,1]the  compute output is: 0
the abosolute error of this set is 0.072106
```

訓練模型
結果及誤差



3. 分析

透過(Y_output - Y_expected)作為 loss function，並將每一組 training set 的 loss value 取絕對值(absolute error)並加總，將之稱為 total loss，進行總共 20000 epochs 的學習，並以每 200 epochs 做一次 total loss 的統計共 100 筆資料。以下為這 100 筆 total loss 的資料以 epochs 做橫軸，total loss 為縱軸，以 excel 做圖



本程式的 training set 共四組，可以從圖表及執行結果發現在 0 至 1000 epochs，total loss 約為 2 左右（平均每組 set 的 absolute error 約為 0.5）1200 次世代後開始下降，到了 20000 epochs 已降至約 0.2（平均每組 set 的 absolute error 約為 0.05）從圖表及數據分析可看出此神經網路具備學習 loss 收斂。

另外，處理多 bit XOR 的方法為先計算頭兩個 bit 的 XOR 再以此結果跟下一個 bit 做 XOR，之後依此類推：
例如：輸入為 1101，頭兩個 bit 做 XOR 為 0（有偶數個 1），以此結果與下一個 bit 的 0 做 XOR 會因為還是維持偶數個 1 所以輸出為 0，再以此結果與下一個 bit 做 XOR 會因為變成總共有奇數個 1 所以輸出變成 1（偶數+1 為奇數）最後得到結果為 1

本程式可處理 2 至 100 bits 的 XOR，執行結果截圖以 2 及 8 bits 作為範例。

第二階段完成：
1. 將 array 以 pointer 置換