

Assignment #1

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1. 編譯結果

```
● (base) youjinyang@youjinyangdeMacBook-Pro 110503517_assignment_1 % cd src
● (base) youjinyang@youjinyangdeMacBook-Pro src % gcc -o runme 110503517_assignment_1.c
```

2. 執行結果

```
● (base) youjinyang@youjinyangdeMacBook-Pro src % ./runme
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
```

Loss
convergence

```
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 absolute error of this set is 0.023764

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

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

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

訓練模型
結果及誤差

```
Please enter testing set with binary numbers(2-100bit):0
Input error,try again

Please enter testing set with binary numbers(2-100bit):1030
Input error,try again

Please enter testing set with binary numbers(2-100bit):10
The output is: 1
type $ if you want to exit the program

Please enter testing set with binary numbers(2-100bit):10110100
The output is: 0
type $ if you want to exit the program

Please enter testing set with binary numbers(2-100bit):$
(base) youjinyang@youjinyangdeMacBook-Pro src %
```

輸入/
2 bit input →

輸入/
8(多) bit input →

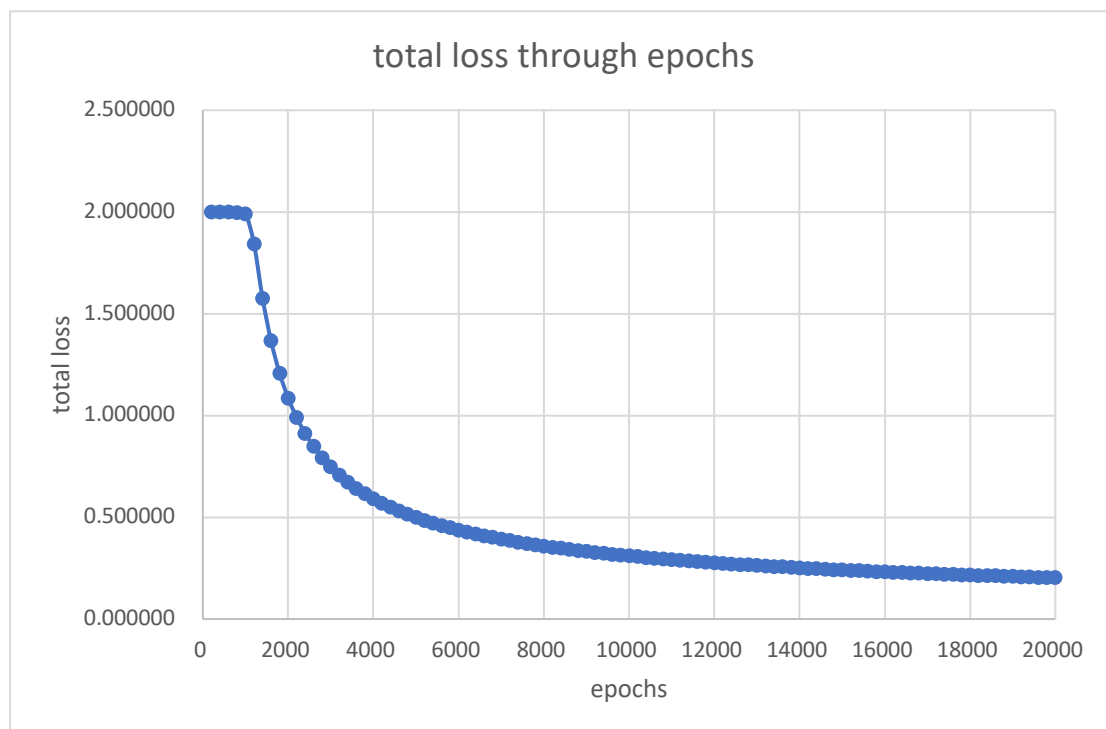
錯誤/只有 1 bit

錯誤/
非 binary number

停止輸入/
輸入 \$

3. 分析

透過 $(Y_{\text{output}} - Y_{\text{expected}})$ 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