# AI 應用於醫療分析

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# 資料內容:

- 資料來源: Single Proton Emission Computed Tomography heart diagnosis dataset
- 共有267筆資料，其中有55筆是正常，212筆是不正常，約1:4
- Data有22筆binary 的attributes, Label也是 binary資料
- 其中0為正常，1為不正常
- 本次實驗按8:2分成training data和validation data，隨機產生20組資料。
- 不平均+離群子

# 環境配置

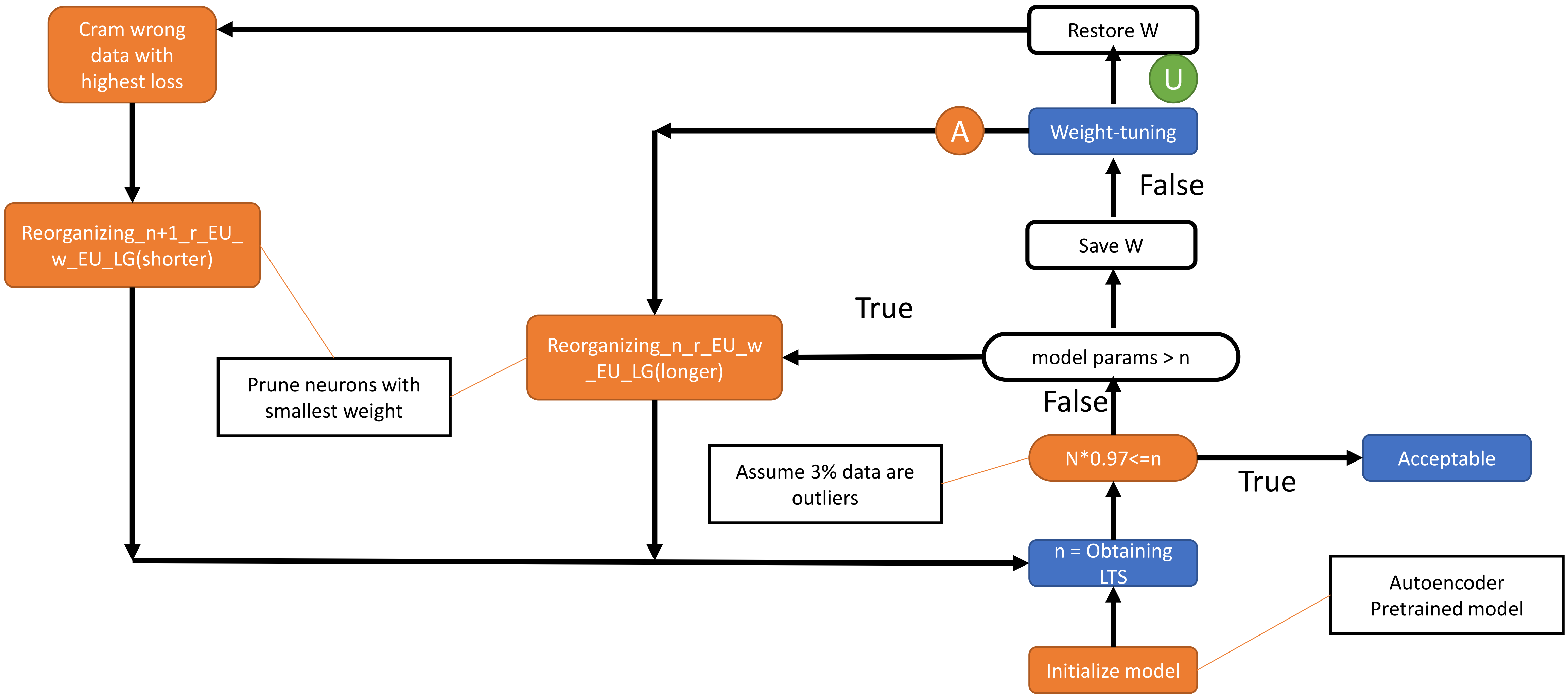
**硬體與python版本:**

- CPU: R5 2400g
- Ram: 32G
- GPU: RTX 3060
- IDE: Vscode
- Python: 3.7.6

**套件:**

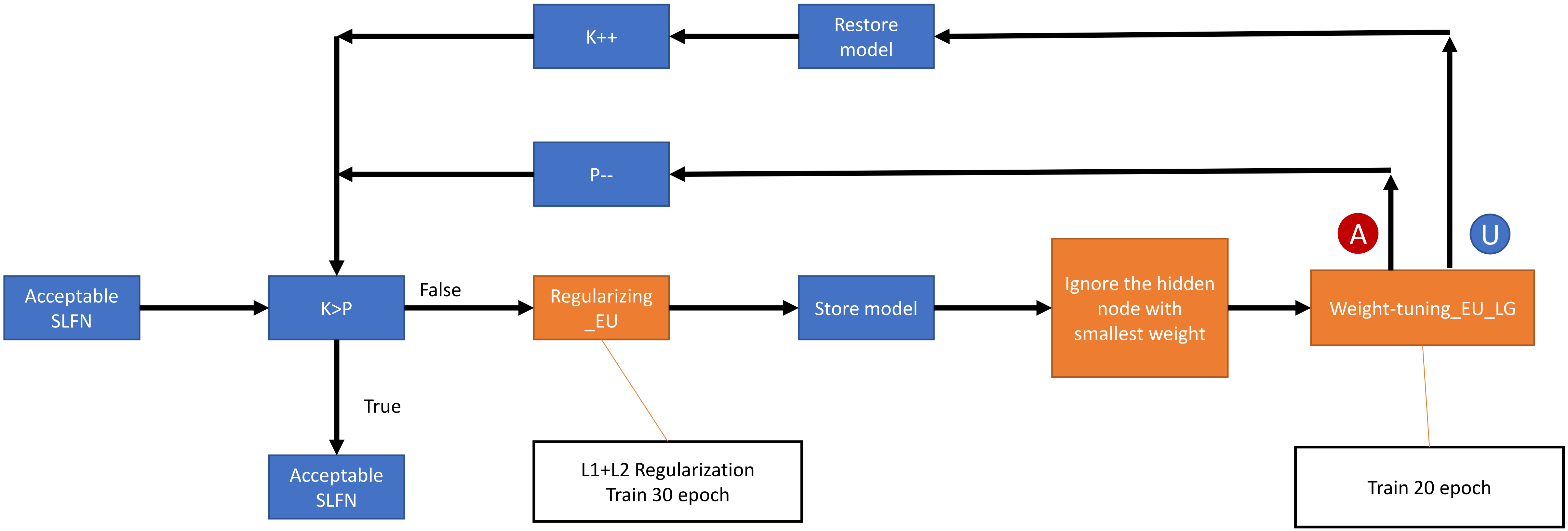
- Pytorch
- Sklearn
- Pandas
- Itertools
- Random
- Copy
- Logging
- OS
- Time

# 新型學習演算法:



Cram wrong data with highest loss
Restore W
U
A
Weight-tuning
False
Save W
True
Reorganizing_n+1_r_EU_w_EU_LG(shorter)
Prune neurons with smallest weight
Reorganizing_n_r_EU_w_EU_LG(longer)
model params > n
False
N*0.97<=n
Acceptable
True
Assume 3% data are outliers
n = Obtaining LTS
Autoencoder Pretrained model
Initialize model

# Reorganizing_ALL_r_EU_w_EU_LG

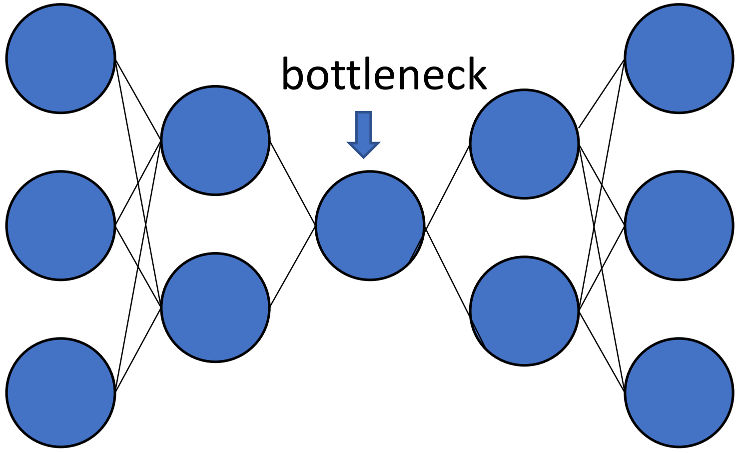


# 模型參數

Input num

Output: as close as input

bottleneck



encoder

decoder

使用這部分的模型

Optimizer:
AdamW

Activation function:
ReLU

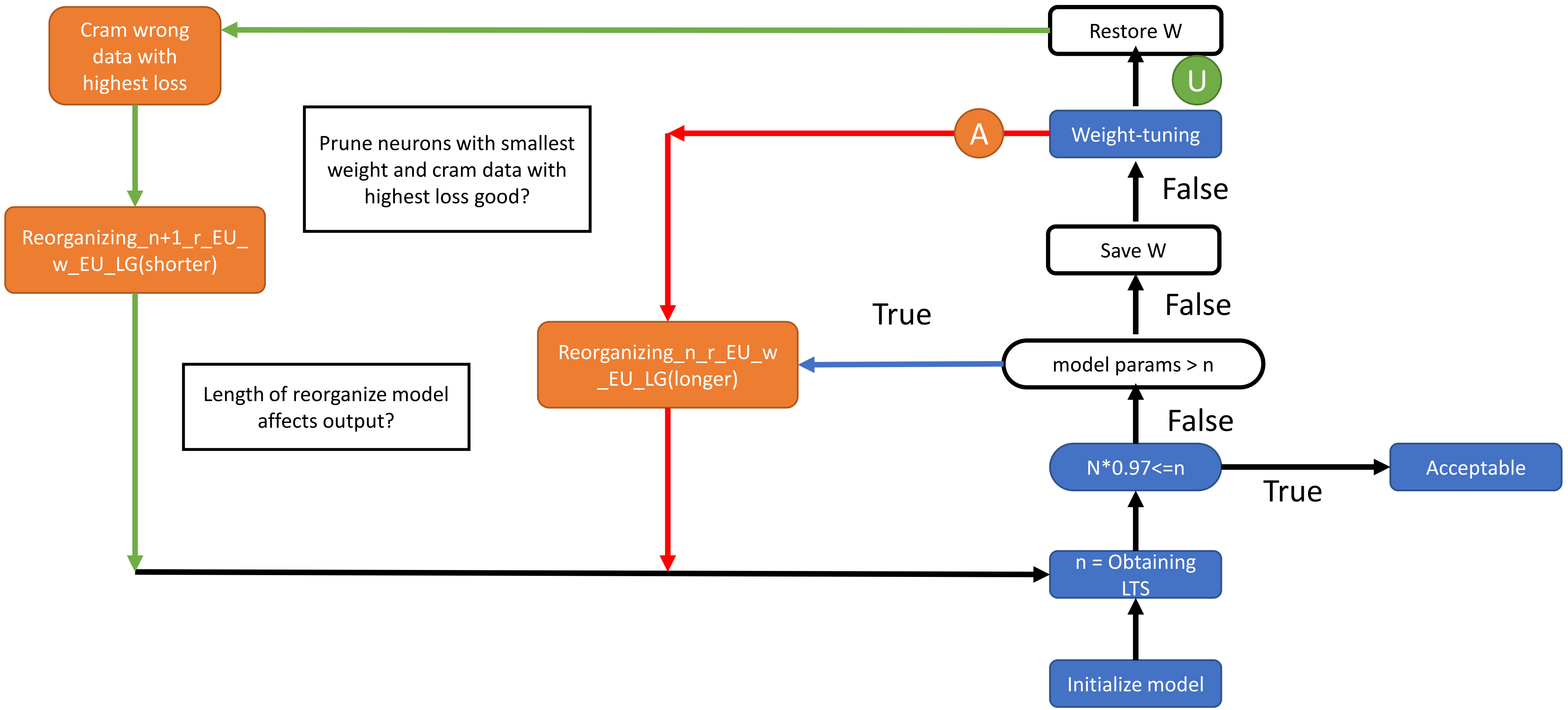
Loss function:
Focal loss

處理樣本不均

$$FL = \begin{cases} -\alpha(1-p)^{\gamma}log(p), & if \quad y=1 \\ -(1-\alpha)p^{\gamma}log(1-p), & if \quad y=0 \end{cases}$$

Focal loss 論文

# Validate the proposed learning mechanism



# Four versions

| Version | Reorganizing Module | Cramming and Pruning |
|---|---|---|
| **Reorganize – 10** | Reorganizing(10, 30) | Cram highest loss, prune smallest weight |
| **Reorganize – 50** | Reorganizing(50, 150) | Cram highest loss, prune smallest weight |
| **Reorganize – 100** | Reorganizing(100, 300) | Cram highest loss, prune smallest weight |
| **Cram min Prune max** | Reorganizing(10, 30) | Cram lowest loss, prune biggest weight |

# Reorganize 10 (baseline)

| Set | Green | Blue | Red |
|---|---|---|---|
| 1 | 6 | 5 | 1 |
| 2 | 0 | 0 | 1 |
| 3 | 8 | 6 | 1 |
| 4 | 3 | 0 | 1 |
| 5 | 5 | 12 | 3 |
| 6 | 0 | 1 | 1 |
| 7 | 0 | 0 | 1 |
| 8 | 13 | 0 | 9 |
| 9 | 8 | 6 | 8 |
| 10 | 4 | 1 | 1 |
| 11 | 0 | 2 | 1 |
| 12 | 3 | 18 | 7 |
| 13 | 3 | 0 | 1 |
| 14 | 8 | 6 | 8 |
| 15 | 4 | 4 | 1 |
| 16 | 13 | 0 | 1 |
| 17 | 18 | 0 | 9 |
| 18 | 0 | 1 | 1 |
| 19 | 13 | 0 | 9 |
| 20 | 6 | 1 | 1 |
| AVG | 5.75 | 3.15 | 3.3 |
| STD | 5.087976 | 4.618171 | 3.348134 |

# Reorganize 50

- Green Average is the highest -> cram more

| Set | Green | Blue | Red |
|---|---|---|---|
| 1 | 1 | 1 | 1 |
| 2 | 3 | 2 | 1 |
| 3 | 0 | 2 | 1 |
| 4 | 2 | 4 | 1 |
| 5 | 1 | 0 | 1 |
| 6 | 19 | 0 | 9 |
| 7 | 15 | 0 | 9 |
| 8 | 0 | 1 | 1 |
| 9 | 13 | 14 | 1 |
| 10 | 1 | 0 | 1 |
| 11 | 35 | 0 | 9 |
| 12 | 4 | 8 | 8 |
| 13 | 12 | 1 | 1 |
| 14 | 7 | 7 | 8 |
| 15 | 6 | 7 | 1 |
| 16 | 6 | 0 | 1 |
| 17 | 11 | 6 | 8 |
| 18 | 5 | 0 | 1 |
| 19 | 4 | 7 | 7 |
| 20 | 9 | 13 | 1 |
| AVG | 7.7 | 3.65 | 3.55 |
| STD | 8.167619 | 4.315959 | 3.499643 |

# Reorganize 100

- Blue Average is the lowest -> no overfitting
- Maybe longer reorganize helps pruning

| Set | Green | Blue | Red |
|---|---|---|---|
| 1 | 2 | 2 | 1 |
| 2 | 25 | 0 | 9 |
| 3 | 0 | 2 | 1 |
| 4 | 0 | 1 | 1 |
| 5 | 0 | 1 | 1 |
| 6 | 8 | 2 | 1 |
| 7 | 1 | 0 | 1 |
| 8 | 11 | 7 | 1 |
| 9 | 8 | 0 | 1 |
| 10 | 7 | 0 | 1 |
| 11 | 0 | 1 | 1 |
| 12 | 14 | 0 | 9 |
| 13 | 4 | 0 | 1 |
| 14 | 0 | 1 | 1 |
| 15 | 7 | 1 | 1 |
| 16 | 14 | 4 | 1 |
| 17 | 3 | 6 | 1 |
| 18 | 18 | 0 | 9 |
| 19 | 14 | 0 | 9 |
| 20 | 0 | 1 | 1 |
| AVG | 6.8 | 1.45 | 2.6 |
| STD | 7.03278 | 1.961505 | 3.2 |

# Cram min Prune max

- Cramming has less effect on model loss, so the number of n come from LTS module increase very slow.

| Set | Green | Blue | Red |
|---|---|---|---|
| 1 | 12 | 10 | 1 |
| 2 | 3 | 4 | 1 |
| 3 | 1 | 10 | 7 |
| 4 | 6 | 9 | 1 |
| 5 | 5 | 10 | 7 |
| 6 | 10 | 2 | 1 |
| 7 | 3 | 12 | 8 |
| 8 | 11 | 8 | 8 |
| 9 | 4 | 3 | 1 |
| 10 | 8 | 9 | 6 |
| 11 | 6 | 8 | 8 |
| 12 | 3 | 8 | 7 |
| 13 | 3 | 5 | 1 |
| 14 | 12 | 0 | 9 |
| 15 | 1 | 8 | 1 |
| 16 | 4 | 8 | 1 |
| 17 | 2 | 8 | 1 |
| 18 | 6 | 8 | 7 |
| 19 | 6 | 9 | 8 |
| 20 | 0 | 2 | 1 |
| AVG | 5.3 | 7.05 | 4.25 |
| STD | 3.565109 | 3.153966 | 3.299621 |

# Green Path: Cramming

- Prune more, cram more

| Set | Reorganize 10 | Reorganize 50 | Reorganize 100 | Cram min Prune max |
|---|---|---|---|---|
| 1 | 6 | 1 | 2 | 12 |
| 2 | 0 | 3 | 25 | 3 |
| 3 | 8 | 0 | 0 | 1 |
| 4 | 3 | 2 | 0 | 6 |
| 5 | 5 | 1 | 0 | 5 |
| 6 | 0 | 19 | 8 | 10 |
| 7 | 0 | 15 | 1 | 3 |
| 8 | 13 | 0 | 11 | 11 |
| 9 | 8 | 13 | 8 | 4 |
| 10 | 4 | 1 | 7 | 8 |
| 11 | 0 | 35 | 0 | 6 |
| 12 | 3 | 4 | 14 | 3 |
| 13 | 3 | 12 | 4 | 3 |
| 14 | 8 | 7 | 0 | 12 |
| 15 | 4 | 6 | 7 | 1 |
| 16 | 13 | 6 | 14 | 4 |
| 17 | 18 | 11 | 3 | 2 |
| 18 | 0 | 5 | 18 | 6 |
| 19 | 13 | 4 | 14 | 6 |
| 20 | 6 | 9 | 0 | 0 |
| AVG | 5.75 | 7.7 | 6.8 | 5.3 |
| STD | 5.087976 | 8.167619 | 7.03278 | 3.565109 |

# Blue Path: Big param

Cram min Prune max:
需要花較多時間才能夠達到Pruning門檻->
沒有頻繁的去Pruning

| Set | Reorganize 10 | Reorganize 50 | Reorganize 100 | Cram min Prune max |
|---|---|---|---|---|
| 1 | 5 | 1 | 2 | 10 |
| 2 | 0 | 2 | 0 | 4 |
| 3 | 6 | 2 | 2 | 10 |
| 4 | 0 | 4 | 1 | 9 |
| 5 | 12 | 0 | 1 | 10 |
| 6 | 1 | 0 | 2 | 2 |
| 7 | 0 | 0 | 0 | 12 |
| 8 | 0 | 1 | 7 | 8 |
| 9 | 6 | 14 | 0 | 3 |
| 10 | 1 | 0 | 0 | 9 |
| 11 | 2 | 0 | 1 | 8 |
| 12 | 18 | 8 | 0 | 8 |
| 13 | 0 | 1 | 0 | 5 |
| 14 | 6 | 7 | 1 | 0 |
| 15 | 4 | 7 | 1 | 8 |
| 16 | 0 | 0 | 4 | 8 |
| 17 | 0 | 6 | 6 | 8 |
| 18 | 1 | 0 | 0 | 8 |
| 19 | 0 | 7 | 0 | 9 |
| 20 | 1 | 13 | 1 | 2 |
| AVG | 3.15 | 3.65 | 1.45 | 7.05 |
| STD | 4.618171 | 4.315959 | 1.961505 | 3.153966 |

# Red Path: Weight-tune

Cram min Prune max:
比起cramming，更常使用weight-tuning
-> 也許在cramming和pruning時更加精確?

| Set | Reorganize 10 | Reorganize 50 | Reorganize 100 | Cram min Prune max |
|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 |
| 2 | 1 | 1 | 9 | 1 |
| 3 | 1 | 1 | 1 | 7 |
| 4 | 1 | 1 | 1 | 1 |
| 5 | 3 | 1 | 1 | 7 |
| 6 | 1 | 9 | 1 | 1 |
| 7 | 1 | 9 | 1 | 8 |
| 8 | 9 | 1 | 1 | 8 |
| 9 | 8 | 1 | 1 | 1 |
| 10 | 1 | 1 | 1 | 6 |
| 11 | 1 | 9 | 1 | 8 |
| 12 | 7 | 8 | 9 | 7 |
| 13 | 1 | 1 | 1 | 1 |
| 14 | 8 | 8 | 1 | 9 |
| 15 | 1 | 1 | 1 | 1 |
| 16 | 1 | 1 | 1 | 1 |
| 17 | 9 | 8 | 1 | 1 |
| 18 | 1 | 1 | 9 | 7 |
| 19 | 9 | 7 | 9 | 8 |
| 20 | 1 | 1 | 1 | 1 |
| AVG | 3.3 | 3.55 | 2.6 | 4.25 |
| STD | 3.348134 | 3.499643 | 3.2 | 3.299621 |

# Accuracy

Average:
[55+(267-55)*0.784]/267 = 82.8%

Best:
[55+(267-55)*0.871]/267 = 89.7%

Original paper:
Rule based model: 84%

Maybe…

Cram highest loss ->
Reach the learning goal too fast?

Prune smallest weight ->
Prune the well learned node?

| Set | Reorganize 10 | | reorganize 50 | | reorganize 100 | | Cram min prune max | |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.5548 | 0.5455 | 0.8051 | 0.7159 | 0.5236 | 0.5085 | 0.8029 | 0.7528 |
| 2 | 0.7963 | 0.7912 | 0.7898 | 0.8153 | 0.8501 | 0.8224 | 0.8656 | 0.8068 |
| 3 | 0.8031 | 0.7614 | 0.7827 | 0.8011 | 0.6023 | 0.6378 | 0.7874 | 0.7443 |
| 4 | 0.7876 | 0.8452 | 0.5236 | 0.4929 | 0.5032 | 0.5369 | 0.8727 | 0.7528 |
| 5 | 0.642 | 0.5625 | 0.5412 | 0.5767 | 0.7944 | 0.8224 | 0.875 | 0.8707 |
| 6 | 0.8031 | 0.7543 | 0.8478 | 0.8608 | 0.8142 | 0.7216 | 0.7785 | 0.7628 |
| 7 | 0.5884 | 0.6151 | 0.8478 | 0.8452 | 0.8006 | 0.7457 | 0.8412 | 0.8224 |
| 8 | 0.8299 | 0.8011 | 0.7989 | 0.7997 | 0.5548 | 0.5284 | 0.8548 | 0.8537 |
| 9 | 0.8255 | 0.669 | 0.8168 | 0.7301 | 0.8051 | 0.7301 | 0.8433 | 0.8395 |
| 10 | 0.5236 | 0.608 | 0.5278 | 0.4858 | 0.6025 | 0.5085 | 0.8163 | 0.6392 |
| 11 | 0.8121 | 0.7088 | 0.8703 | 0.8295 | 0.8031 | 0.7614 | 0.8212 | 0.8466 |
| 12 | 0.8703 | 0.777 | 0.8389 | 0.7926 | 0.8189 | 0.7756 | 0.801 | 0.8551 |
| 13 | 0.7987 | 0.777 | 0.5593 | 0.554 | 0.6241 | 0.5625 | 0.8567 | 0.7685 |
| 14 | 0.8433 | 0.8082 | 0.8793 | 0.7855 | 0.5123 | 0.6605 | 0.7834 | 0.7543 |
| 15 | 0.821 | 0.6918 | 0.5323 | 0.554 | 0.8053 | 0.7173 | 0.8163 | 0.6776 |
| 16 | 0.5548 | 0.4162 | 0.7915 | 0.7472 | 0.8123 | 0.7741 | 0.7942 | 0.7784 |
| 17 | 0.8525 | 0.8537 | 0.801 | 0.7074 | 0.51 | 0.5312 | 0.8793 | 0.8011 |
| 18 | 0.5614 | 0.4915 | 0.1924 | 0.2543 | 0.8391 | 0.8849 | 0.8367 | 0.8466 |
| 19 | 0.8278 | 0.7926 | 0.8299 | 0.8693 | 0.8278 | 0.8139 | 0.8612 | 0.6932 |
| 20 | 0.6108 | 0.6236 | 0.8858 | 0.794 | 0.8102 | 0.7614 | 0.841 | 0.8153 |
| AVG | 0.73535 | 0.694685 | 0.72311 | 0.700565 | 0.710695 | 0.690255 | 0.831435 | 0.784085 |
| STD | 0.120038 | 0.120612 | 0.176686 | 0.157994 | 0.131668 | 0.118312 | 0.031799 | 0.062158 |

# Training Time

- Model initialize後loss值低但accuracy不高
- 也許可以加入正確率做為 learning goal

| Set | reorganize 10 | reorganize 50 | reorganize 100 | cram min prune max |
|---|---|---|---|---|
| 1 | 438.883 | 406.602 | 1615.752 | 768.053 |
| 2 | 9.991 | 959.892 | 10145.78 | 237.832 |
| 3 | 550.653 | 248.09 | 521.86 | 401.002 |
| 4 | 116.621 | 1477.942 | 178.08 | 505.522 |
| 5 | 648.772 | 101.18 | 204.48 | 653.852 |
| 6 | 18 | 3526.704 | 3413.732 | 508.772 |
| 7 | 9.191 | 2842.004 | 176.27 | 651.063 |
| 8 | 543.444 | 88.22 | 6514.463 | 845.483 |
| 9 | 524.163 | 4813.063 | 2948.033 | 253.102 |
| 10 | 167.621 | 87.1 | 2741.074 | 619.523 |
| 11 | 35.63 | 6643.984 | 177.11 | 525.813 |
| 12 | 748.292 | 2192.693 | 5299.884 | 412.652 |
| 13 | 113.301 | 2337.464 | 1339.641 | 263.71 |
| 14 | 517.583 | 2528.103 | 177.32 | 472.444 |
| 15 | 281.572 | 2416.093 | 2981.403 | 324.772 |
| 16 | 475.344 | 1188.903 | 6388.833 | 426.372 |
| 17 | 660.294 | 3269.733 | 3166.002 | 350.052 |
| 18 | 17.97 | 901.061 | 7173.544 | 521.982 |
| 19 | 492.034 | 2260.302 | 5441.534 | 553.783 |
| 20 | 265.093 | 3789.183 | 177.5 | 36.7 |
| AVG | 331.7226 | 2103.916 | 3039.115 | 466.6242 |
| STD | 247.395 | 1696.107 | 2848.452 | 188.5243 |

Thanks for Listening!