DSP HW2-1
HMM Training and Testing
資工碩二 R05922038 黃郁庭

Part 1：baseline accuracy = 74.34%

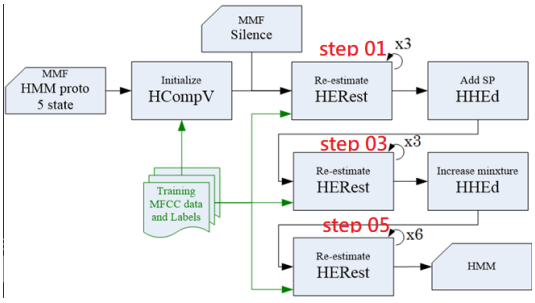
```
====================== HTK Results Analysis =======================
  Date: Wed Nov 22 19:48:42 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=38.54 [H=185, S=295, N=480]
WORD: %Corr=96.61, Acc=74.34 [H=1679, D=13, S=46, I=387, N=1738]
===================================================================
```

上圖為 baseline accuracy 的截圖。設定 set_htk_path.sh 將 path 指到 htk 的 code 後，我依序執行 01_run_HCopy.sh、02_run_HCompV.sh、03_training.sh、04_testing.sh 這幾個腳本後可以得到 74.34%的 accuracy。

P.S.另外雖然預設是 5 個 states，但是 mix2_10.hed 裡數字 0~9 的 states 卻設定成 2~9 個 states 都是 2 個 gaussian，應該 HTK 有判斷處理超過的 states。

Part 2 & 3：the best accuracy = 97.81%

1. Iteration : 03_training.sh



首先我嘗試各自調整上圖中 step 01、03、05 三處的 iteration 數，並固定其他參數，得到的結果如下表。調整的方法是手動更改 03_training.sh 中對應到的 for loop 次數。

Accuracy(%)	10	20	50	100	200	500
Step 01	76.93	75.37	**77.79**	77.79	-	-
Step 03	77.79	77.16	78.65	78.88	**79.00**	79.00
Step 05	74.57	74.22	**75.66**	-	-	-

上表分別記錄著針對各 step 01、03、05 三處跑不同 iteration 數(10,20,50,100,200,500)所對應到的 accuracy。不論是哪個 step，跑 10 iterations 的 accuracy 皆會上升，但到了 20 iterations 的 accuracy 皆會下降，但到了 50

iterations 的 accuracy 又皆會再度上升。此外當 iteration 超過一定數量後 accuracy 幾乎不太會再發生變化。

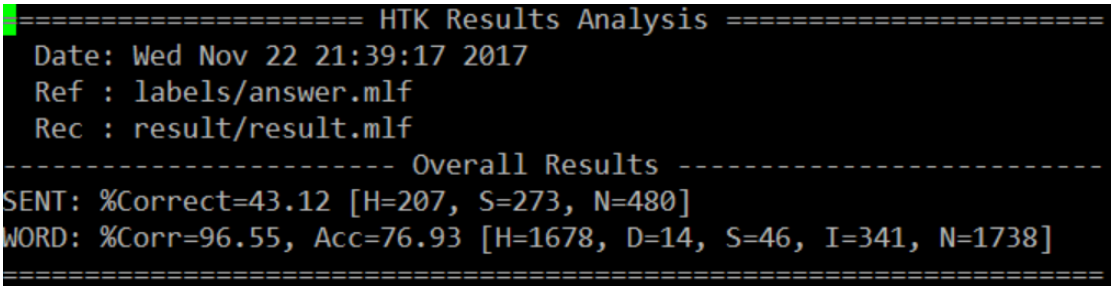
由上表可知，調整 Step 01 的 iteration 數至 50 時 accuracy 會達到 77.49%(此時其他參數皆與 baseline 設定相同，其他 step 的 iteration 數也不變)；而調整 Step 03 的 iteration 數至 200 時 accuracy 可以達到 79.00%，此為"各自調整 step 01、03、05 三處的 iteration 數"這項實驗中能達到的最好的結果；調整 Step 03 的 iteration 數至 100 時 accuracy 會達到 75.66%。

# of iteration			accuracy
Step 01	Step 03	Step 05	
50	200	50	77.22
50	200	6	77.79
10	200	6	78.88
10	100	6	78.83

上表記錄著同時調整 step 01、03、05 三處的 iteration 數時所對應的 accuracy。當 step 01 的 iteration=50、step 03 的 iteration=200、step 05 的 iteration=50 時 accuracy=77.22%，前一段已知當 Step 03 的 iteration 數至 200 時 accuracy 時可以達到 79.00%，可見同時調整三處的 iteration 反而會使 accuracy 下降。但若調降 step 05 的 iteration=6 時(step 01 的 iteration=50、step 03 的 iteration=200)accuracy 可以提高至 77.79%，可見 Step 05 的 iteration 數不一定越高能使 accuracy 越高。同樣的情況發生在 step 01，若調降 step 01 的 iteration=10 時(step 05 的 iteration=6、step 03 的 iteration=200)accuracy 可以提高至 78.88%，可見 Step 01 的 iteration 數不一定越高能使 accuracy 越高。然而若調降 step 03 的 iteration=100 時(step 01 的 iteration=10、step 05 的 iteration=6)accuracy 反而略降至 78.83%，可知 Step 03 的 iteration 數越高可能使 accuracy 越高。

下列為以上結果的截圖：

Only adjusting step 01：10 iterations



Only adjusting step 01：20 iterations

```
====================== HTK Results Analysis =======================
  Date: Thu Nov 23 09:39:47 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=41.25 [H=198, S=282, N=480]
WORD: %Corr=96.14, Acc=75.37 [H=1671, D=14, S=53, I=361, N=1738]
===================================================================
```

Only adjusting step 01：50 iterations

```
====================== HTK Results Analysis =======================
  Date: Wed Nov 22 22:11:06 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=44.79 [H=215, S=265, N=480]
WORD: %Corr=96.32, Acc=77.79 [H=1674, D=16, S=48, I=322, N=1738]
===================================================================
```

Only adjusting step 01：100 iterations

```
====================== HTK Results Analysis =======================
  Date: Wed Nov 22 23:44:51 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=44.79 [H=215, S=265, N=480]
WORD: %Corr=96.32, Acc=77.79 [H=1674, D=16, S=48, I=322, N=1738]
===================================================================
```

Only adjusting step 03：10 iterations

```
====================== HTK Results Analysis =======================
  Date: Thu Nov 23 10:36:17 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=43.96 [H=211, S=269, N=480]
WORD: %Corr=96.84, Acc=77.79 [H=1683, D=12, S=43, I=331, N=1738]
===================================================================
```

Only adjusting step 03：20 iterations

```
====================== HTK Results Analysis =======================
  Date: Thu Nov 23 11:07:47 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=42.29 [H=203, S=277, N=480]
WORD: %Corr=96.66, Acc=77.16 [H=1680, D=10, S=48, I=339, N=1738]
===================================================================
```

Only adjusting step 03：50 iterations

```
====================== HTK Results Analysis =======================
  Date: Thu Nov 23 11:26:03 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=45.62 [H=219, S=261, N=480]
WORD: %Corr=96.78, Acc=78.65 [H=1682, D=14, S=42, I=315, N=1738]
===================================================================
```

Only adjusting step 03：100 iterations

```
====================== HTK Results Analysis =======================
  Date: Thu Nov 23 11:47:07 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=45.83 [H=220, S=260, N=480]
WORD: %Corr=96.78, Acc=78.88 [H=1682, D=14, S=42, I=311, N=1738]
===================================================================
```

Only adjusting step 03：200 iterations

```
====================== HTK Results Analysis =======================
  Date: Thu Nov 23 12:51:00 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=46.04 [H=221, S=259, N=480]
WORD: %Corr=96.78, Acc=79.00 [H=1682, D=14, S=42, I=309, N=1738]
===================================================================
```

Only adjusting step 03：500 iterations

```
====================== HTK Results Analysis =======================
  Date: Thu Nov 23 13:49:01 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=46.04 [H=221, S=259, N=480]
WORD: %Corr=96.78, Acc=79.00 [H=1682, D=14, S=42, I=309, N=1738]
===================================================================
```

Only adjusting step 05：10 iterations

```
====================== HTK Results Analysis =======================
  Date: Thu Nov 23 13:56:38 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=40.62 [H=195, S=285, N=480]
WORD: %Corr=96.55, Acc=74.57 [H=1678, D=10, S=50, I=382, N=1738]
===================================================================
```

Only adjusting step 05：20 iterations

```
====================== HTK Results Analysis =======================
  Date: Thu Nov 23 14:04:49 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=40.00 [H=192, S=288, N=480]
WORD: %Corr=96.78, Acc=74.22 [H=1682, D=10, S=46, I=392, N=1738]
===================================================================
```

Only adjusting step 05：50 iterations

```
====================== HTK Results Analysis =======================
  Date: Thu Nov 23 14:31:31 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=42.50 [H=204, S=276, N=480]
WORD: %Corr=96.78, Acc=75.66 [H=1682, D=12, S=44, I=367, N=1738]
===================================================================
```

(Step01,step03,step05)=(50,200,50)

```
====================== HTK Results Analysis =======================
  Date: Thu Nov 23 15:26:59 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=44.58 [H=214, S=266, N=480]
WORD: %Corr=96.89, Acc=77.22 [H=1684, D=11, S=43, I=342, N=1738]
===================================================================
```

(Step01,step03,step05)=(50,200,6)

```
====================== HTK Results Analysis =======================
  Date: Thu Nov 23 16:46:58 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=43.75 [H=210, S=270, N=480]
WORD: %Corr=96.66, Acc=77.79 [H=1680, D=15, S=43, I=328, N=1738]
===================================================================
```

(Step01,step03,step05)=(10,200,6)

```
====================== HTK Results Analysis =======================
  Date: Thu Nov 23 17:57:18 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=45.83 [H=220, S=260, N=480]
WORD: %Corr=96.78, Acc=78.88 [H=1682, D=14, S=42, I=311, N=1738]
===================================================================
```

(Step01,step03,step05)=(10,100,6)

```
====================== HTK Results Analysis =======================
  Date: Thu Nov 23 19:04:11 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=45.83 [H=220, S=260, N=480]
WORD: %Corr=96.78, Acc=78.83 [H=1682, D=14, S=42, I=312, N=1738]
===================================================================
```

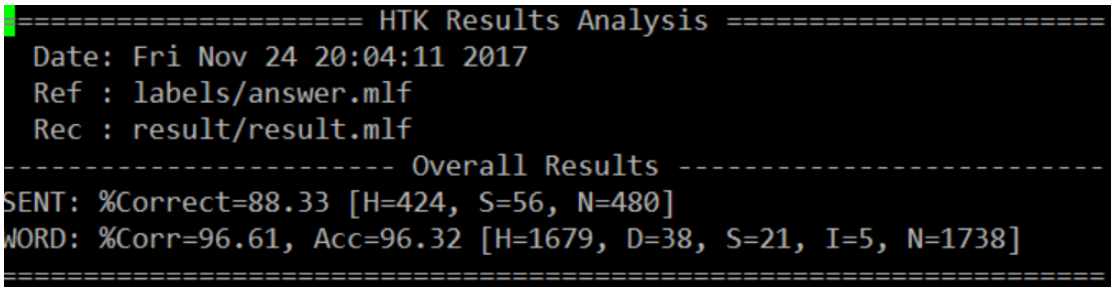
2. State : Proto (mix2_10.hed)

在這裡我嘗試改變 state 數，方法為將 proto 的 NumStates 更改，然後設定每個 state 的 mean 為 0、variance 為 1，TransP 改為 NumStates*NumStates 大小。

我嘗試將 state 數改為 10，accuracy 大幅改善至 93.67%：

```
====================== HTK Results Analysis =======================
  Date: Thu Nov 23 19:23:44 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=80.83 [H=388, S=92, N=480]
WORD: %Corr=96.61, Acc=93.67 [H=1679, D=26, S=33, I=51, N=1738]
===================================================================
```

再將 state 數改為 15，accuracy 能達到 96.32%：



State 數對 accuracy 的影響非常大，我覺得這是有道理的，因為 state 越多越能抓到更多每個音的細節，因此更能準確預測每個 data 正確的音。

3. Gaussian : mix2_10.hed

我嘗試只調整 mix2_10.hed 中 0~9 與 sil 的 gaussian 數而固定其他參數，結果如下表：

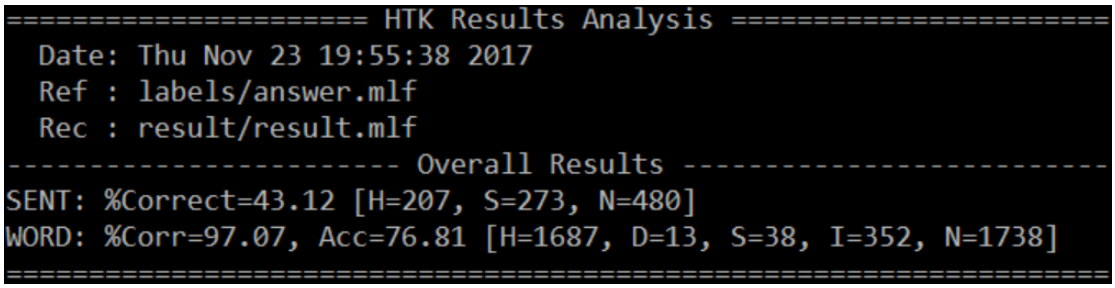
Method	# of Gaussian mixture											acc
	0	1	2	3	4	5	6	7	8	9	sil	
a	2										3	74.34
b	5										3	76.81
c	5										6	76.35
d	10										3	79.57
e	10										10	**81.59**
f	10										11	81.42
g	15										3	77.16
h	15										11	78.65
i	5	10	5	5	5	5	5	10	5	5	3	76.81

當 0~9 每個 state 的 gaussian mixture 數從 2 改為 5 時(此時 silence 的 gaussian mixture 數皆為 3)acuuracy 進步 2.47% (也就是從 method a 改為 b)，再從 5 改為 10 時 acuuracy 則進步 2.76% (從 method b 改為 d)，但是 0~9 每個 state 的 gaussian mixture 數從 10 改為 15 時(此時 silence 的 gaussian mixture 數皆為 3)accuracy 卻下降 2.41% (從 method d 改為 g)，可知剛開始 0~9 每個 state 的 gaussian mixture 數越多越能進步，但是若數量過多則有可能使 accuracy 下降。當 0~9 每個 state 的 gaussian mixture 數皆為 10 時，若 silence 的 gaussian mixture 數從 3 改為 10 時 accuracy 會上升 2.02% (從 method d 改為 e)；然而若 silence 的 gaussian mixture 數從 10 改為 11 時 accuracy 則會下降 0.17% (從 method e 改為 f)。當 0~9 每個 state 的 gaussian mixture 數皆為 5 時，若 silence 的 gaussian mixture 數從 3 改為 6 時 accuracy 會下降 0.46% (從 method b 改為 c)。當 0~9 每個 state 的 gaussian mixture 數皆為 15 時，若 silence 的 gaussian mixture 數從 3 改為 11 時 accuracy 則會上升 1. 5% (從 method g 改為 h)。可知

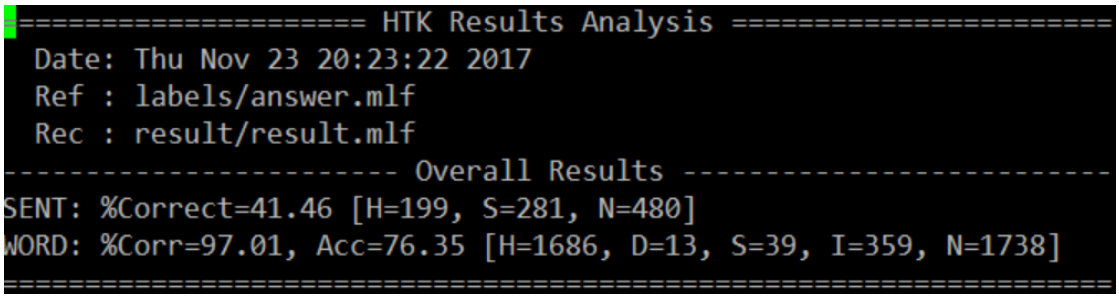
silence 的 gaussian mixture 數不一定越多越好。
比較有趣的是，我因為覺得 1 與 7 的發音比較像，所以猜想是否有可能藉由調高 1 與 7 的 gaussian mixture 數來增加 accuracy。因此嘗試將 1 與 7 的 gaussian mixture 數改為 10、其他數字則設為 5、silence 設為 3，這些設定的結果與所有數字的 gaussian mixture 數皆設為 5、silence 設為 3 相比，accuracy 皆為 76.81% (從 method b 改為 i)。可知雖然 1 與 7 的發音相似，但是若只增加 1 與 7 的 gaussian mixture 數無法直接改善 accuracy。

下列為以上結果的截圖：

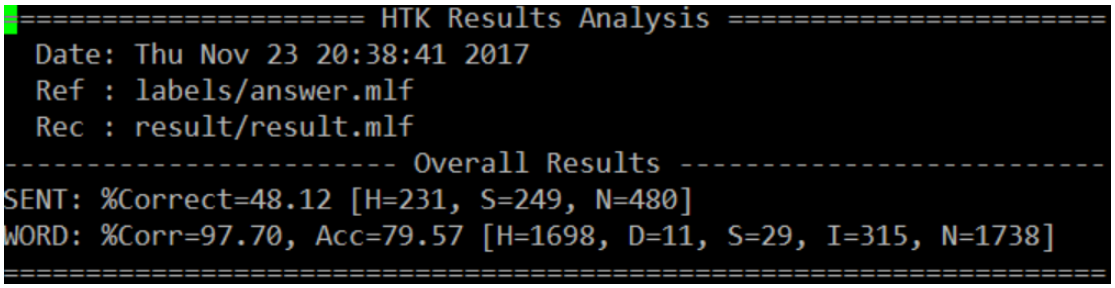
Method b



Method c



Method d



Method f

```
====================== HTK Results Analysis =======================
  Date: Thu Nov 23 20:47:04 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=52.29 [H=251, S=229, N=480]
WORD: %Corr=97.41, Acc=81.42 [H=1693, D=12, S=33, I=278, N=1738]
===================================================================
```

Method h

```
====================== HTK Results Analysis =======================
  Date: Thu Nov 23 20:57:55 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=46.67 [H=224, S=256, N=480]
WORD: %Corr=97.12, Acc=78.65 [H=1688, D=14, S=36, I=321, N=1738]
===================================================================
```

Method g

```
====================== HTK Results Analysis =======================
  Date: Thu Nov 23 21:09:44 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=43.96 [H=211, S=269, N=480]
WORD: %Corr=97.24, Acc=77.16 [H=1690, D=13, S=35, I=349, N=1738]
===================================================================
```

Method i

```
====================== HTK Results Analysis =======================
  Date: Thu Nov 23 21:18:06 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=43.75 [H=210, S=270, N=480]
WORD: %Corr=97.24, Acc=76.81 [H=1690, D=13, S=35, I=355, N=1738]
===================================================================
```

Method f

```
====================== HTK Results Analysis =======================
  Date: Thu Nov 23 21:27:14 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=52.92 [H=254, S=226, N=480]
WORD: %Corr=97.41, Acc=81.59 [H=1693, D=13, S=32, I=275, N=1738]
===================================================================
```

4. 同時調整 iteration、gaussian、states 數以獲得>95%的 accuracy

method	# of iteration			# of Gaussian mixture		# of state	accuracy
	Step 01	Step 03	Step 05	Digit 0~9	silence		
A	3	200	6	10	10	10	95.86
B	3	100	6	10	10	10	95.68
C	10	200	6	10	10	10	96.20
D	20	200	6	10	10	10	95.74
E	50	200	6	10	10	10	95.91
F	3	200	10	10	10	10	96.09
G	10	200	10	10	10	10	96.20
H	3	200	6	10	8	10	95.74
I	3	200	6	8	8	10	95.34
J	3	200	6	10	10	15	97.47
K	10	200	6	10	10	15	97.07
L	3	200	10	10	10	15	**97.81**
M	3	200	6	12	10	15	97.47
N	3	400	6	10	10	15	97.35
O	3	100	6	10	10	15	97.35

當 step03 的 iteration 改到 200、0~9 與 sil 的 gaussian 數改成 10、states 數改成 10 時 accuracy 可以達 95.86% (method A)：

1) 當 step03 iteration 數調降成 100 則 accuracy 會降至 95.68% (method B)，可知 step03 數越高越能改善 accuracy；
2) 若將 step01 iteration 數增加至 10 則 accuracy 增加為 96.20% (method C)，但若再將 step01 iteration 數增加至 20 時 accuracy 卻會降為 95.74% (method D)，不過若再將 step01 iteration 數增加至 50 時 accuracy 會上升至 95.91% (method E)，可見增加 Step 01 不一定會改善 accuracy；
3) 當 step05 iteration 數改成 10 則 accuracy 可以進步至 96.09% (method F)，

此時若再進一步將 step01 iteration 數改成 10 時 accuracy 又可以再進步至 96.20% (method G)，但是此 accuracy 與 step05 iteration=6 的 accuracy 相同，可能 step01 與 step05 對 accuracy 的影響有重疊；

4) 若將 sil 的 gaussian 數改成 8 則 accuracy 會下降至 95.74% (method H)，若再進一步調降 0~9 的 gaussian 數改成 8 則 accuracy 會繼續下降至 95.34% (method I)，可知 gaussian 數越多確實能增進 accuracy；

若將 state 數改為 15 則 accuracy 會明顯上升、可達 97.47% (method J)：

1) 若此時將 step01 iteration 數增至 10 則 accuracy 會下降至 97.07% (method K)；
2) 但若是將 step05 iteration 數增至 10 則 accuracy 會上升至 97.81% (method L)；
3) 若將 0~9 的 gaussian 數改成 12 時 accuracy 不會改變(method M)，可見 gaussian 數不是越多 accuracy 就會越好，可能會有瓶頸或是到達穩定狀態；
4) 若將 step03 iteration 數增至 400 則 accuracy 會略降至 97.35% (method N)，若減至 100 時也會降至一樣的 accuracy(97.35%) (method O)，可見 step03 iteration 數雖然能大幅提升 accuracy (當從 iteration=3 改至 iteration=200 時能大幅提升 accuracy)，但是不是越多越好。

下列為以上結果的截圖：

Method a

```
====================== HTK Results Analysis =======================
  Date: Thu Nov 23 22:13:39 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
---------------------- Overall Results --------------------------
SENT: %Correct=87.50 [H=420, S=60, N=480]
WORD: %Corr=97.58, Acc=95.86 [H=1696, D=21, S=21, I=30, N=1738]
===================================================================
```

Method b

```
====================== HTK Results Analysis =======================
  Date: Thu Nov 23 22:30:11 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
---------------------- Overall Results --------------------------
SENT: %Correct=86.88 [H=417, S=63, N=480]
WORD: %Corr=97.41, Acc=95.68 [H=1693, D=23, S=22, I=30, N=1738]
===================================================================
```

Method c

```
====================== HTK Results Analysis =======================
  Date: Thu Nov 23 23:41:35 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=88.33 [H=424, S=56, N=480]
WORD: %Corr=97.70, Acc=96.20 [H=1698, D=21, S=19, I=26, N=1738]
===================================================================
```

Method d

```
====================== HTK Results Analysis =======================
  Date: Thu Nov 23 22:50:26 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=87.08 [H=418, S=62, N=480]
WORD: %Corr=97.58, Acc=95.74 [H=1696, D=21, S=21, I=32, N=1738]
===================================================================
```

Method e

```
====================== HTK Results Analysis =======================
  Date: Fri Nov 24 02:21:28 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=87.29 [H=419, S=61, N=480]
WORD: %Corr=97.47, Acc=95.91 [H=1694, D=22, S=22, I=27, N=1738]
===================================================================
```

Method f

```
====================== HTK Results Analysis =======================
  Date: Fri Nov 24 00:02:20 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=87.92 [H=422, S=58, N=480]
WORD: %Corr=97.58, Acc=96.09 [H=1696, D=23, S=19, I=26, N=1738]
===================================================================
```

Method g

```
====================== HTK Results Analysis =======================
  Date: Fri Nov 24 02:55:14 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=88.33 [H=424, S=56, N=480]
WORD: %Corr=97.53, Acc=96.20 [H=1695, D=23, S=20, I=23, N=1738]
===================================================================
```

Method h

```
====================== HTK Results Analysis =======================
  Date: Fri Nov 24 01:40:32 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=86.67 [H=416, S=64, N=480]
WORD: %Corr=97.35, Acc=95.74 [H=1692, D=22, S=24, I=28, N=1738]
===================================================================
```

Method i

```
====================== HTK Results Analysis =======================
  Date: Thu Nov 23 23:14:35 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=86.04 [H=413, S=67, N=480]
WORD: %Corr=97.53, Acc=95.34 [H=1695, D=21, S=22, I=38, N=1738]
===================================================================
```

Method j

```
====================== HTK Results Analysis =======================
  Date: Fri Nov 24 13:46:21 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=92.08 [H=442, S=38, N=480]
WORD: %Corr=97.53, Acc=97.47 [H=1695, D=32, S=11, I=1, N=1738]
===================================================================
```

Method k

```
====================== HTK Results Analysis =======================
  Date: Fri Nov 24 14:43:11 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=91.25 [H=438, S=42, N=480]
WORD: %Corr=97.18, Acc=97.07 [H=1689, D=35, S=14, I=2, N=1738]
===================================================================
```

Method l

```
====================== HTK Results Analysis =======================
  Date: Fri Nov 24 18:45:17 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=93.33 [H=448, S=32, N=480]
WORD: %Corr=97.87, Acc=97.81 [H=1701, D=30, S=7, I=1, N=1738]
===================================================================
```

Method m

```
====================== HTK Results Analysis =======================
  Date: Fri Nov 24 15:21:35 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=92.08 [H=442, S=38, N=480]
WORD: %Corr=97.53, Acc=97.47 [H=1695, D=32, S=11, I=1, N=1738]
===================================================================
```

Method n

```
====================== HTK Results Analysis =======================
  Date: Fri Nov 24 17:38:34 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=91.67 [H=440, S=40, N=480]
WORD: %Corr=97.41, Acc=97.35 [H=1693, D=33, S=12, I=1, N=1738]
===================================================================
```

Method o

```
====================== HTK Results Analysis =======================
  Date: Fri Nov 24 18:03:41 2017
  Ref : labels/answer.mlf
  Rec : result/result.mlf
------------------------ Overall Results --------------------------
SENT: %Correct=91.88 [H=441, S=39, N=480]
WORD: %Corr=97.53, Acc=97.35 [H=1695, D=35, S=8, I=3, N=1738]
===================================================================
```

Conclusion

State 數對 accuracy 的影響最顯著，這是有道理的，因為 state 越多越能抓到更多每個音的細節，因此更能準確預測每個 data 正確的音。而 iteration 數越多效果通常越好，但常常 iteration 太多反而會使 accuracy 下降；另外 step01、03、05 中，step03 對 accuracy 的影響較明顯。Gaussian 數越多越能改善 accuracy，但改善幅度相對小一點，且 Gaussian 數多到一定程度後可能使 accuracy 下降。