DSP HW2-1
HMM Training and Testing

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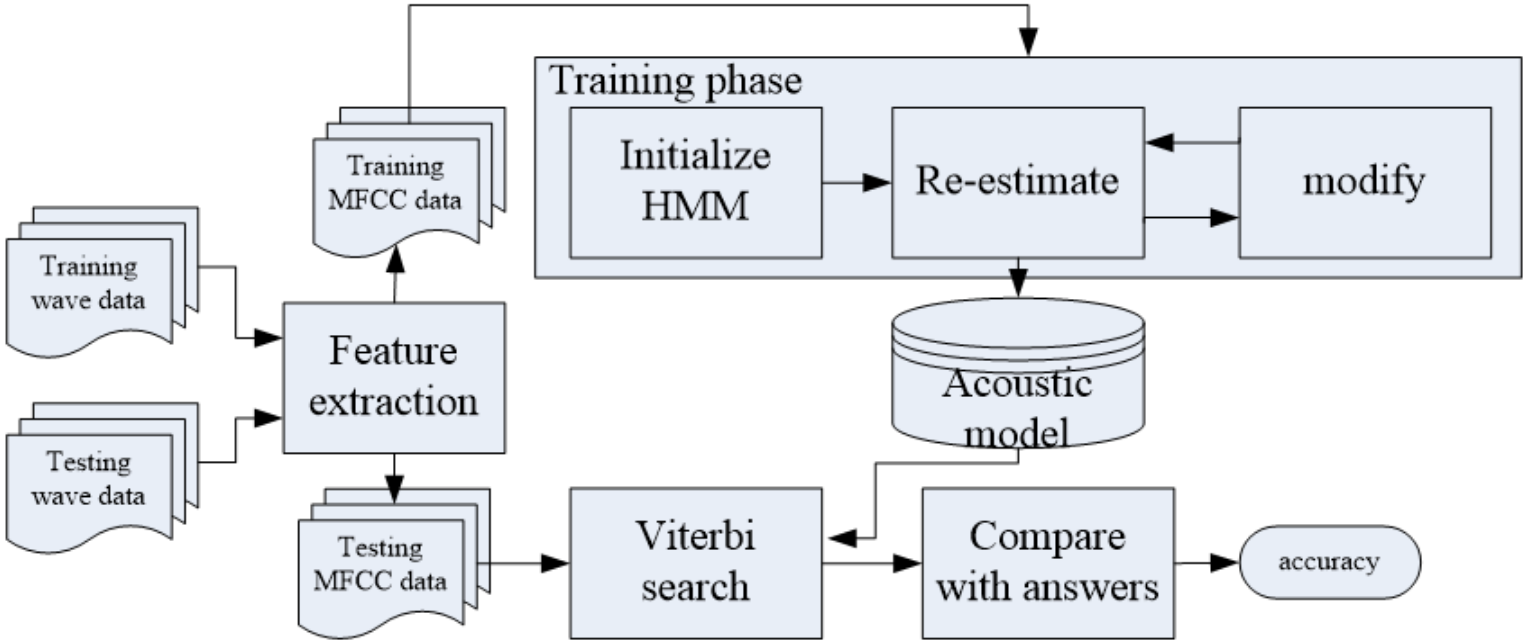
Outline

1. Introduction
2. Hidden Markov Model Toolkit (HTK)
3. Homework Problems
4. Submission Requirements

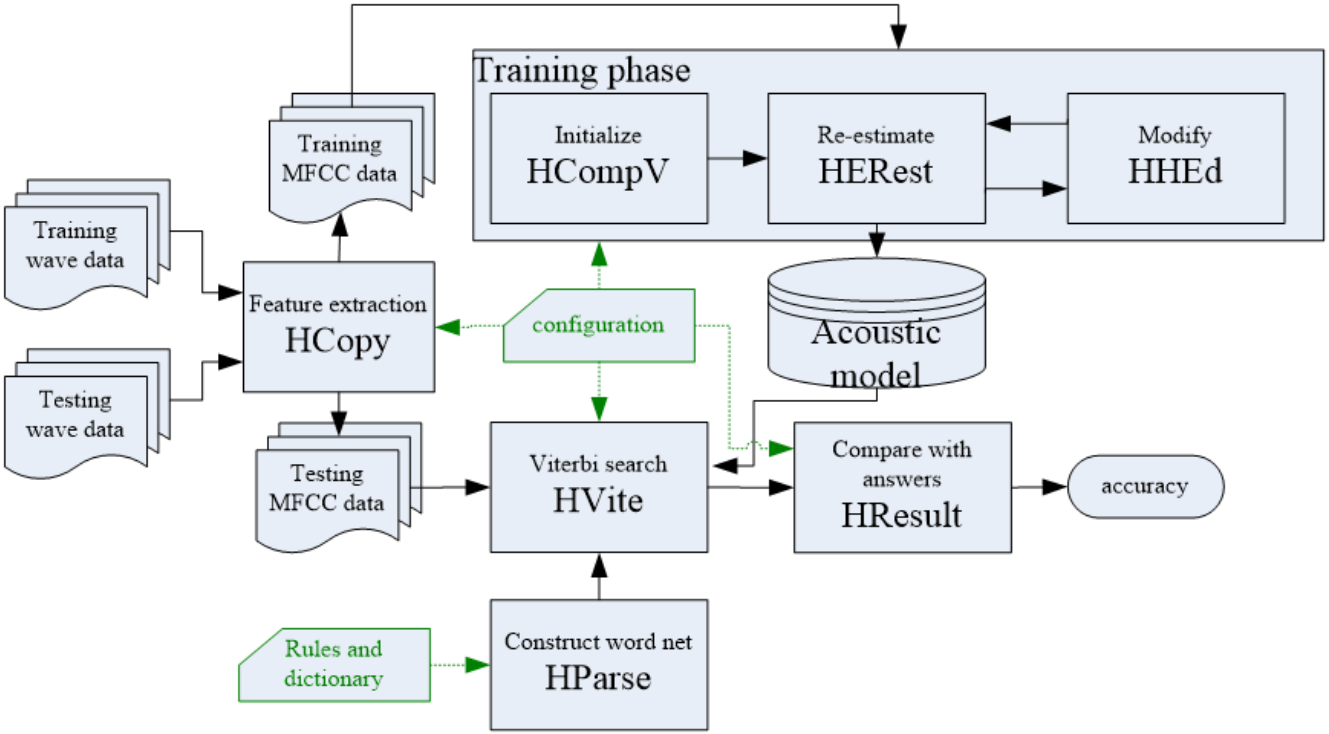
Introduction

- Construct a digit recognizer - monophone
  ling | yi | er | san | si | wu | liu | qi | ba | jiu
- Free tools of HMM: Hidden Markov Toolkit (HTK)
  http://htk.eng.cam.ac.uk/
- Training data, testing data, scripts, and other resources all are available on http://speech.ee.ntu.edu.tw/DSP2017Autumn/

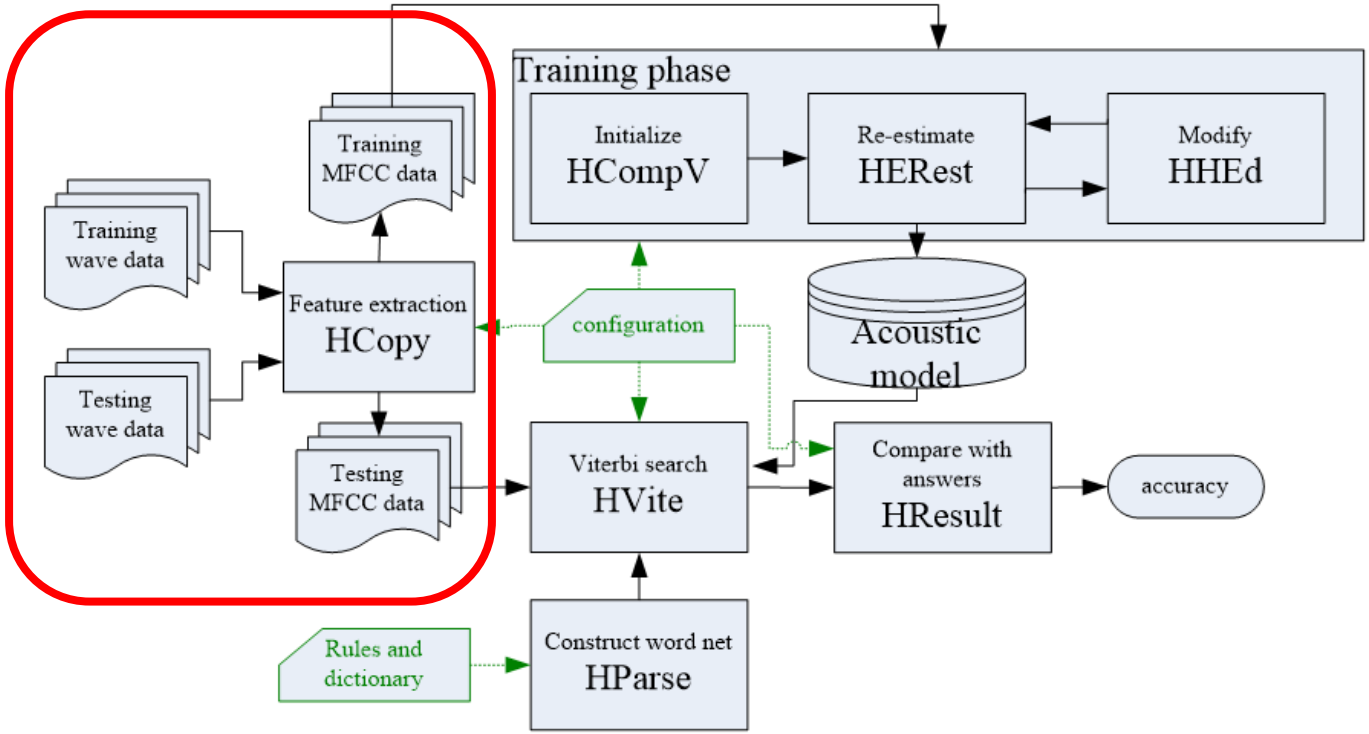
Flowchart


Training phase
Initialize HMM
Re-estimate
modify
Training MFCC data
Training wave data
Feature extraction
Testing wave data
Acoustic model
Testing MFCC data
Viterbi search
Compare with answers
accuracy

Hidden Markov Model Toolkit (HTK)



Feature Extraction



Feature Extraction - HCopy

```
HCopy -C lib/hcopy.cfg -S scripts/training_hcopy.scp
```

Convert wave to 39 dimension MFCC.

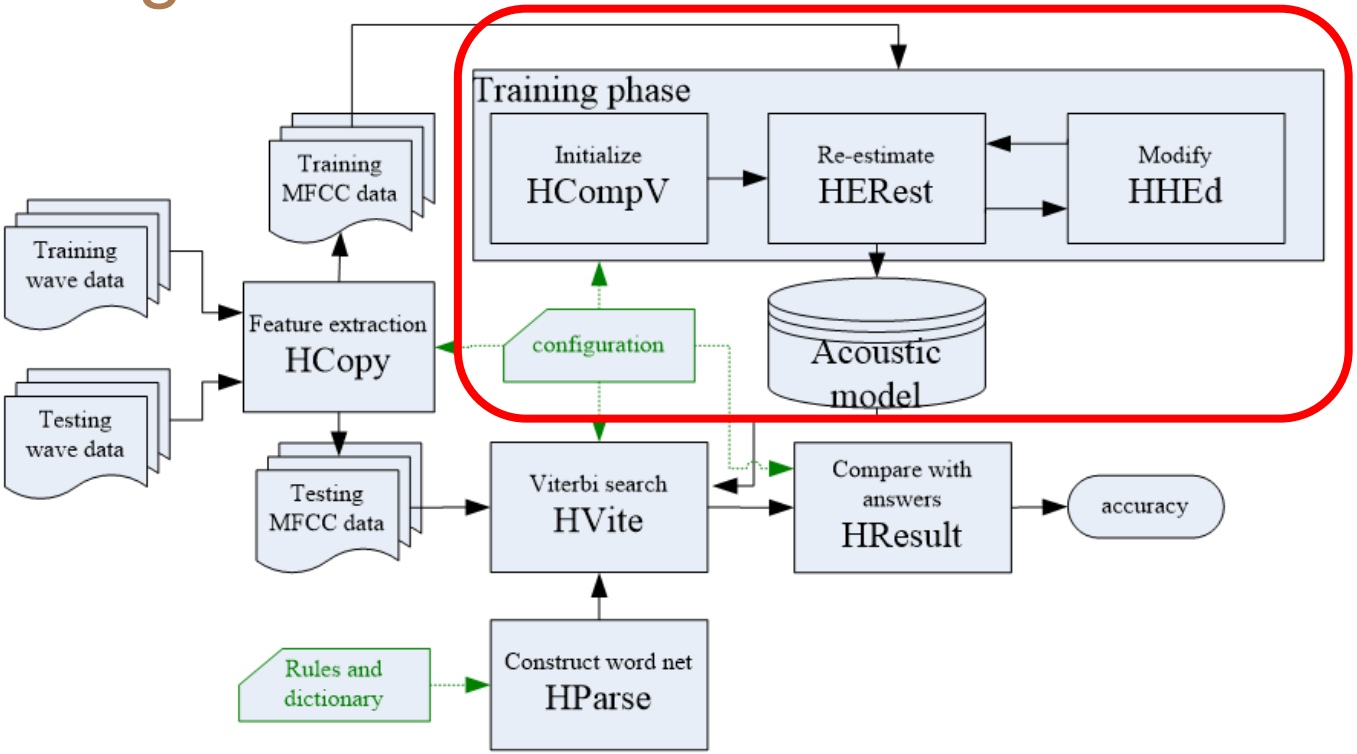
-C lib/hcopy.cfg

- input and output form e.g. wav -> MFCC_Z_E_D_A
- parameters of feature extraction
- Chapter 7 - Speech Signals and Front-end Processing

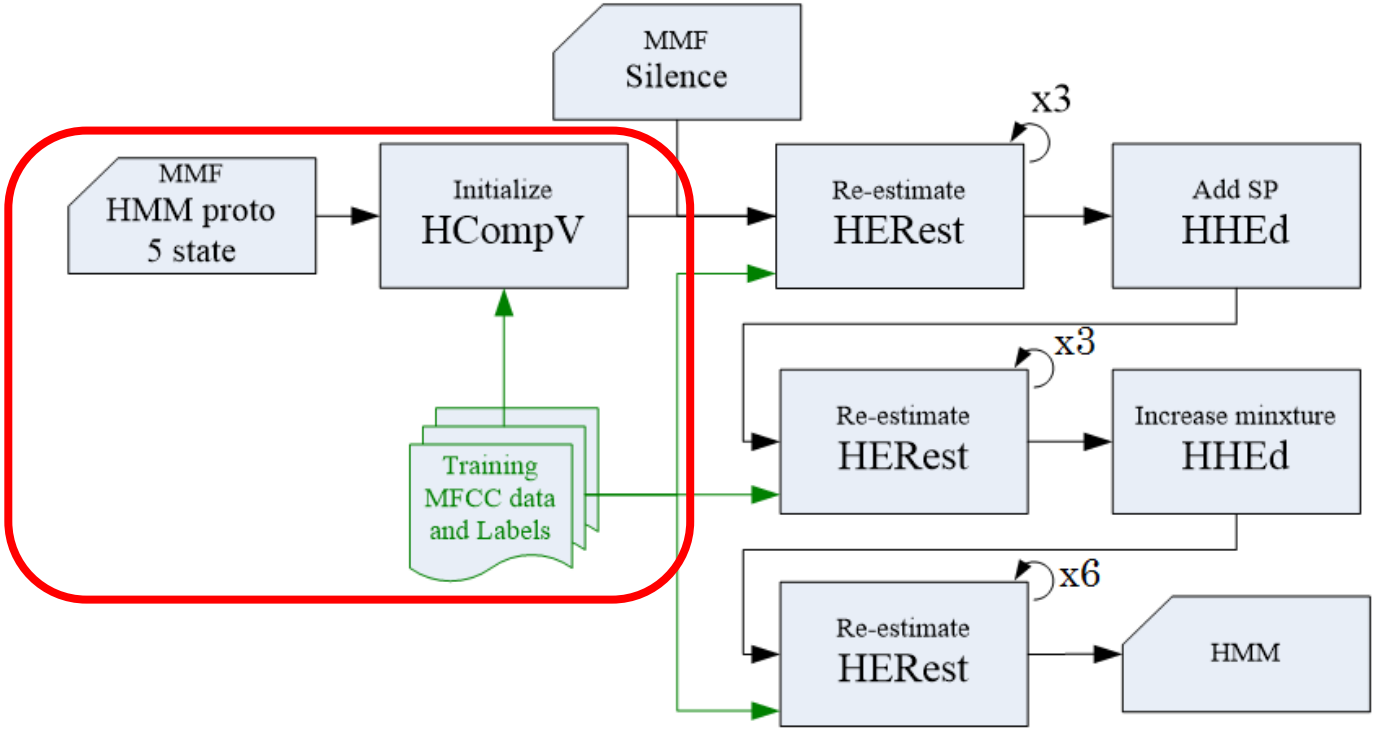
-S scripts/training_hcopy.scp

- a mapping from Input file name to output file name

Training Flowchart



Training Flowchart



Initialize model - HCompV

```
HCompV -C lib/config.cfg -o hmmdef
-M hmm -S scripts/training.scp lib/proto
```

Compute global mean and variance of features

-C lib/config.cfg

- set format of input feature (MFCC_Z_E_D_A)

-o hmmdef -M hmm

- set output name: hmm/hmmdef

-S scripts/training.scp

- a list of training data

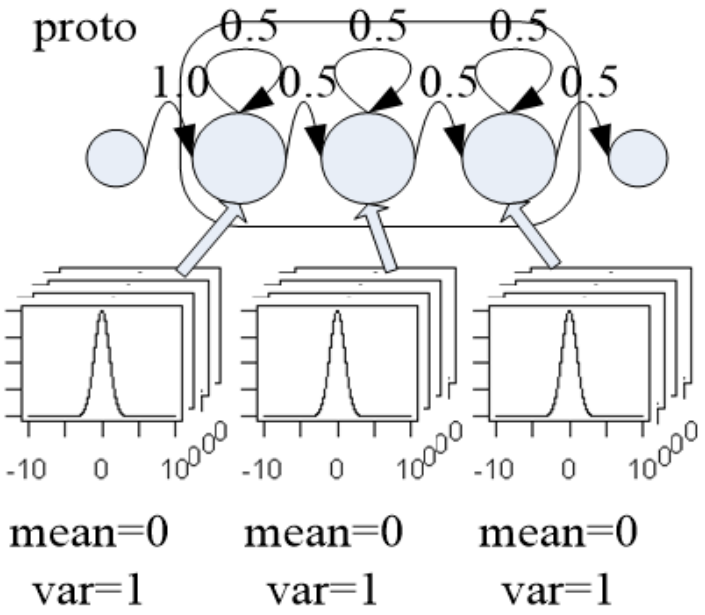
lib/proto

- a description of a HMM model, HTK MMF format

⇨ you can modify the Model Format here (# states) !

Initial MMF Prototype

MMF: HTKBook chapter 7

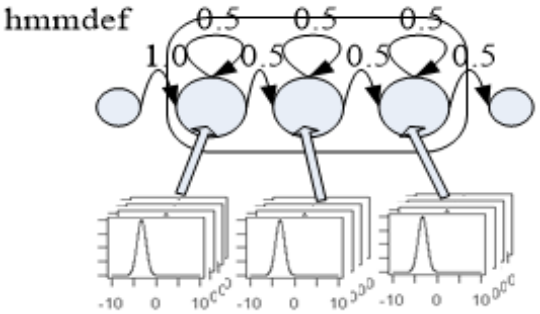



```
~o <VECSIZE> 39 <MFCC_Z_E_D_A>
~h "proto"
<BeginHMM>
<NumStates> 5
<State> 2
<Mean> 39
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 ...
<Variance> 39
1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 ...
<State> 3
<Mean> 39
0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 ...
<Variance> 39
...
<TransP> 5
0.0 1.0 0.0 0.0 0.0 0.0
0.0 0.5 0.5 0.0 0.0 0.0
0.0 0.0 0.5 0.5 0.0 0.0
0.0 0.0 0.0 0.5 0.5 0.0
0.0 0.0 0.0 0.0 0.5 0.5
0.0 0.0 0.0 0.0 0.0 0.0
<EndHMM>
```

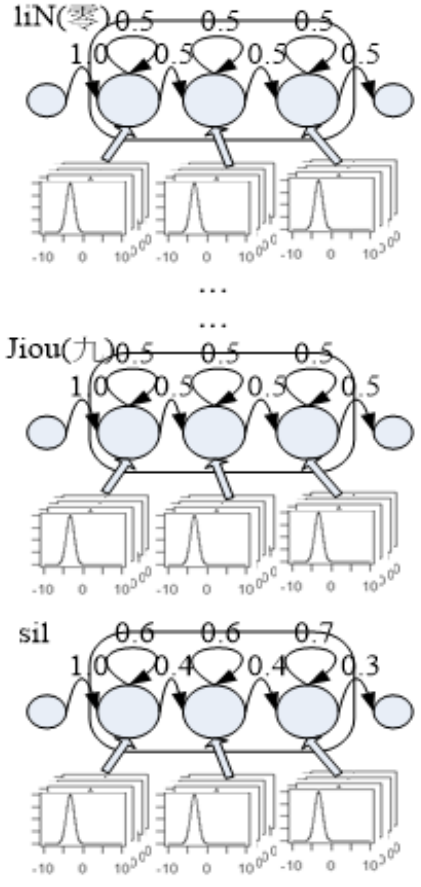
Initial HMM

- bin/macro
  Produce MMF contains vFloor
- bin/models_1mixsil
  add silence HMM

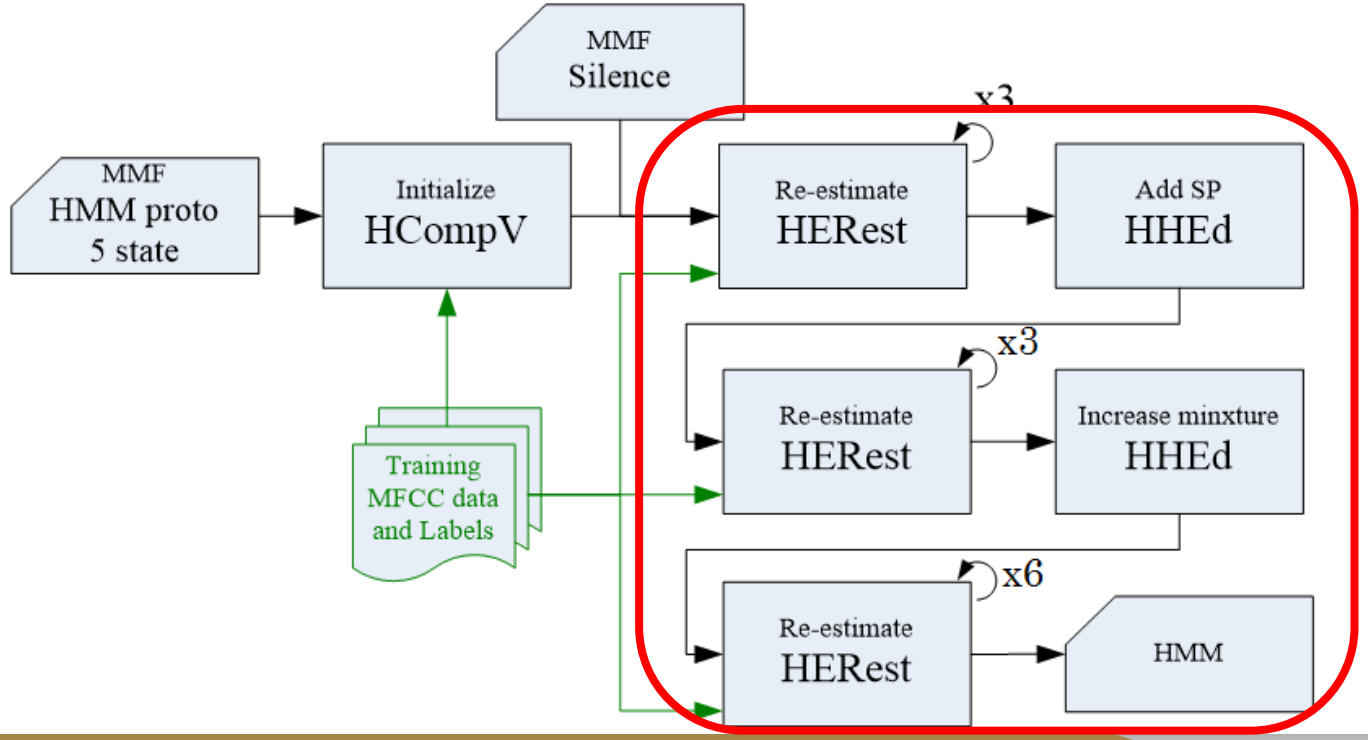
hmm/hmmdef



hmm/models



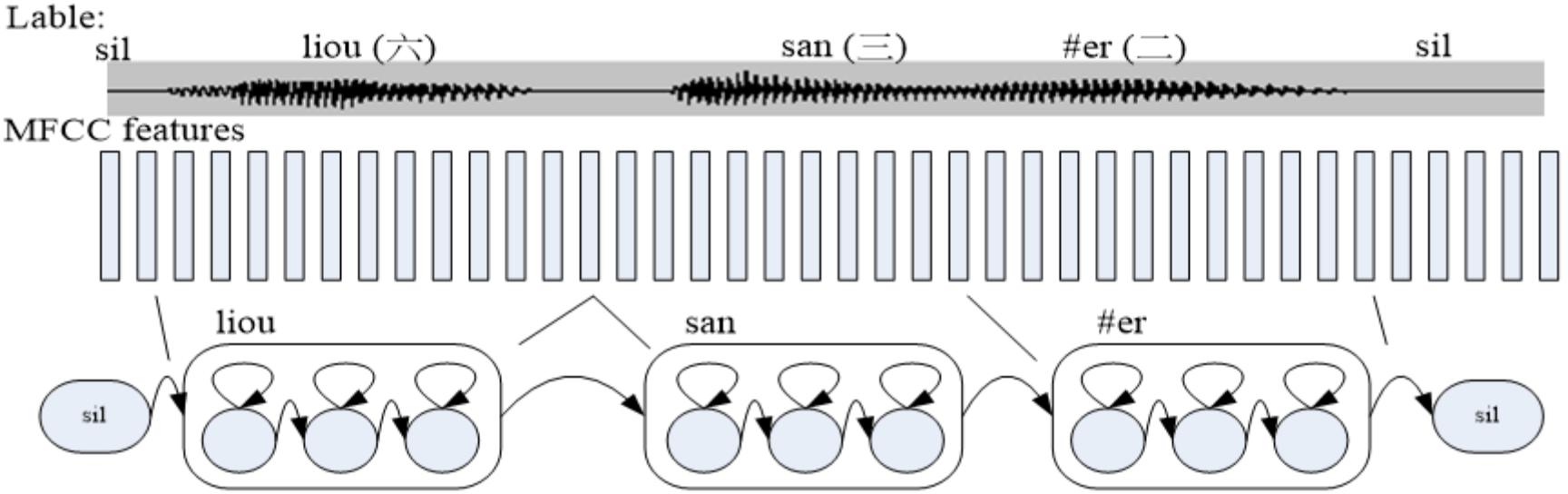
Training Flowchart



Adjust HMMs - HERest

Basic problem 3 for HMM

- Given O and an initial model λ=(A,B, π), adjust λ to maximize P(O|λ)



Adjust HMMs - HERest

```
HERest -C lib/config.cfg -S scripts/training.scp -I labels/Clean08TR.mlf
-H hmm/macros -H hmm/models -M hmm lib/models.lst
```

Adjust parameters λ to maximize P(O|λ)

- one iteration of EM algorithm
- run this command three times => three iterations

–I labels/Clean08TR.mlf

- set label file to “labels/Clean08TR.mlf”

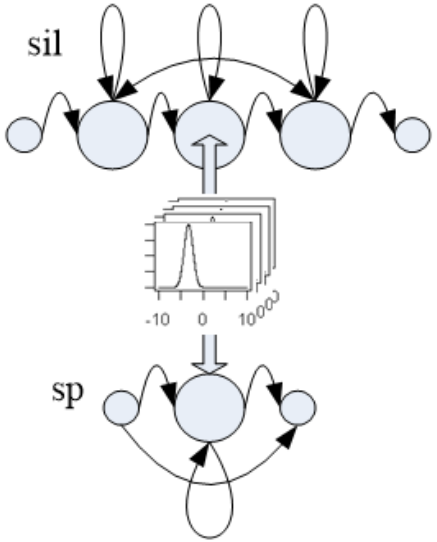
-o lib/models.lst

- a list of word models (liN (零), #i (一), #er (二),… jiou (九), sil)

Add SP Model

```
bin/spmodel_gen hmm/models hmm/models
```

Add ”sp”(short pause) HMM definition to MMF file “hmm/hmmdef”



Modify HMMs - HHEd

```
HHEd -H hmm/macros -H hmm/models
-M hmm lib/sil1.hed lib/models_sp.lst
```

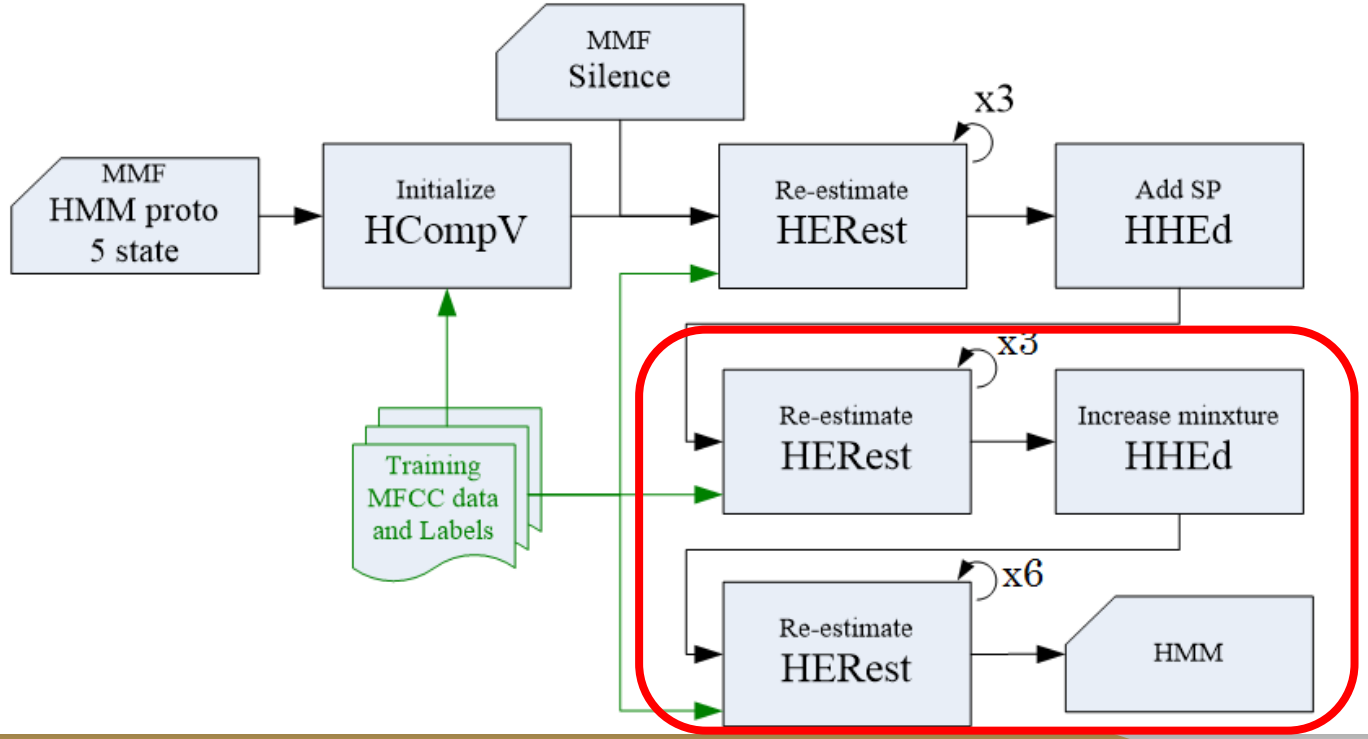
lib/sil1.hed

- a list of command to modify HMM definitions

lib/models_sp.lst

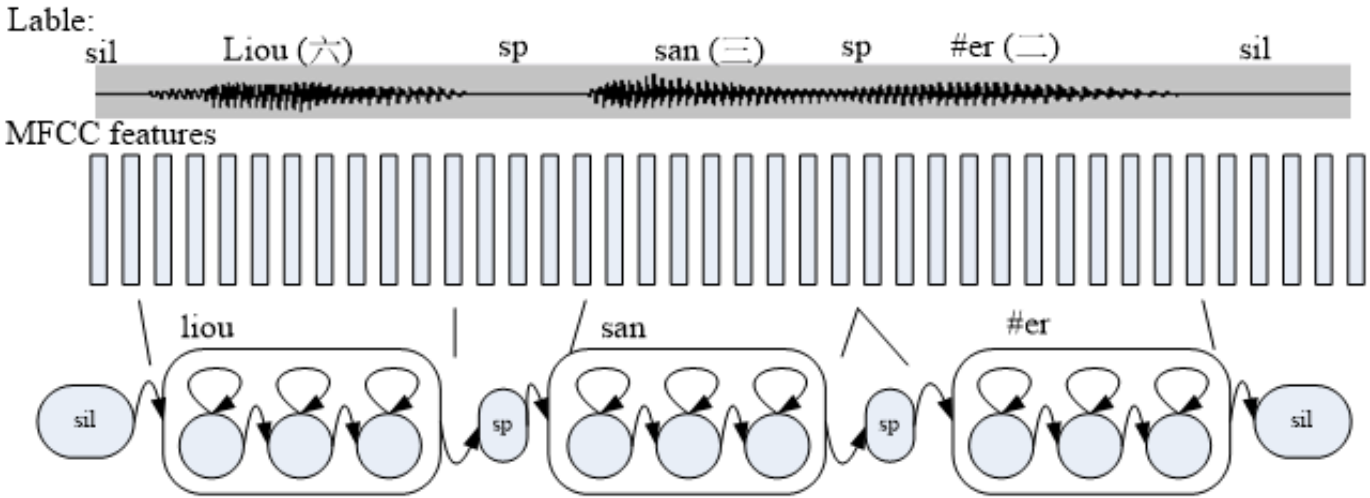
- a new list of model (liN (零), #i (一), #er (二),… jiou (九), sil, sp)

Training Flowchart



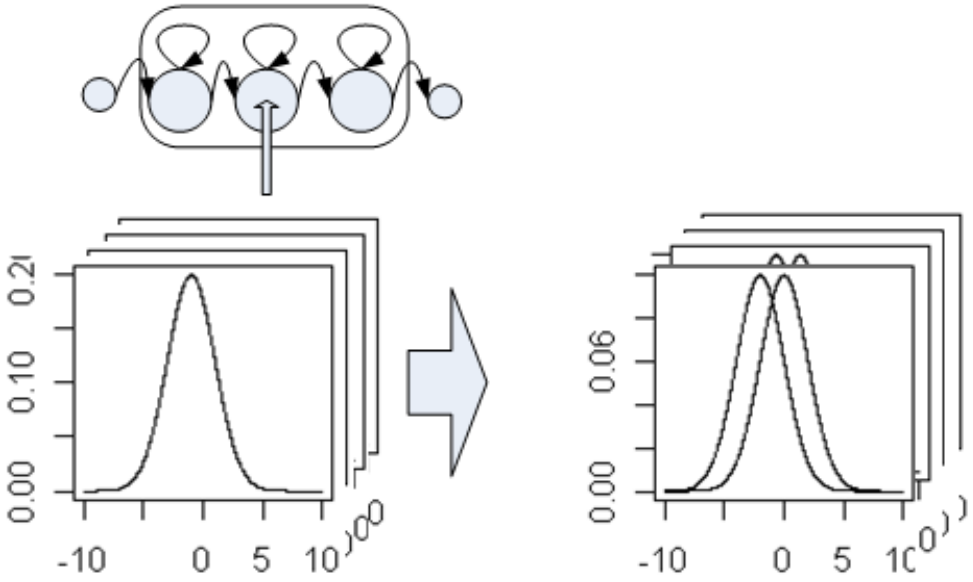
Adjust HMMs Again - HERest

```
HERest -C lib/config.cfg -S scripts/training.scp
-I labels/Clean08TR_sp.mlf -H hmm/macros
-H hmm/models -M hmm lib/models_sp.lst
```



Increase Number of Mixtures - HHEd

```
HHEd -H hmm/macros -H hmm/models
-M hmm  lib/mix2_10.hed lib/models_sp.lst
```



Modification of Models

lib/mix2_10.hed

```
MU 2 {liN.state[2-4].mix}
MU 2 {#i.state[2-4].mix}
MU 2 {#er.state[2-4].mix}
MU 2 {san.state[2-4].mix}
MU 2 {sy.state[2-4].mix}
...
MU 3 {sil.state[2-4].mix}

MU +2 {san.state[2-9].mix}
```

You can modify # of Gaussian mixture here.

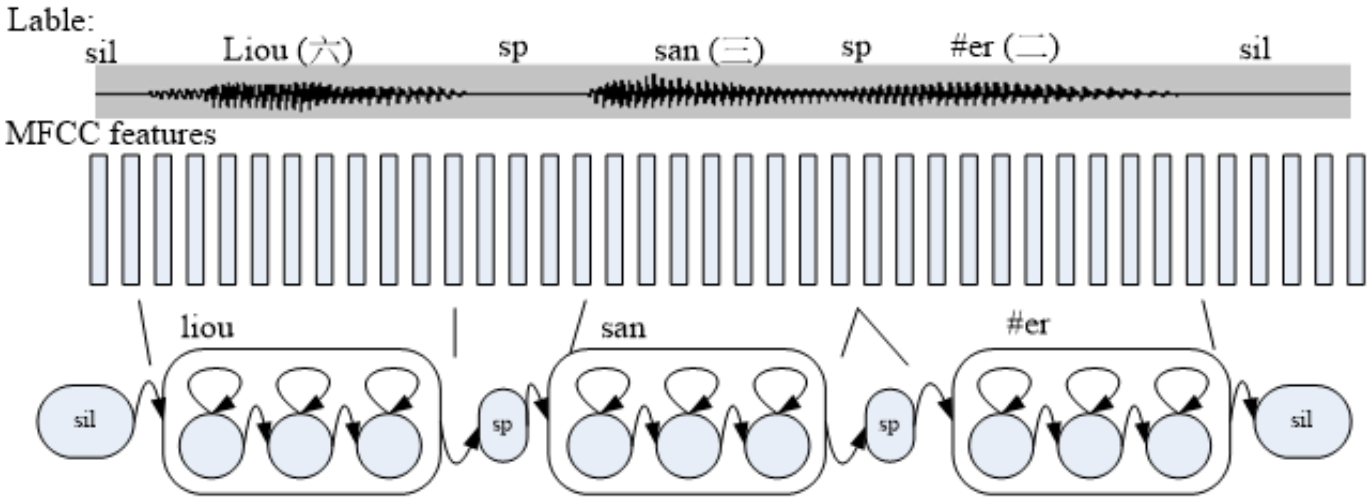
This value tells HTK to change the mixture number from state 2 to state 4. If you want to change # state, check lib/proto.

You can increase # Gaussian mixture here.

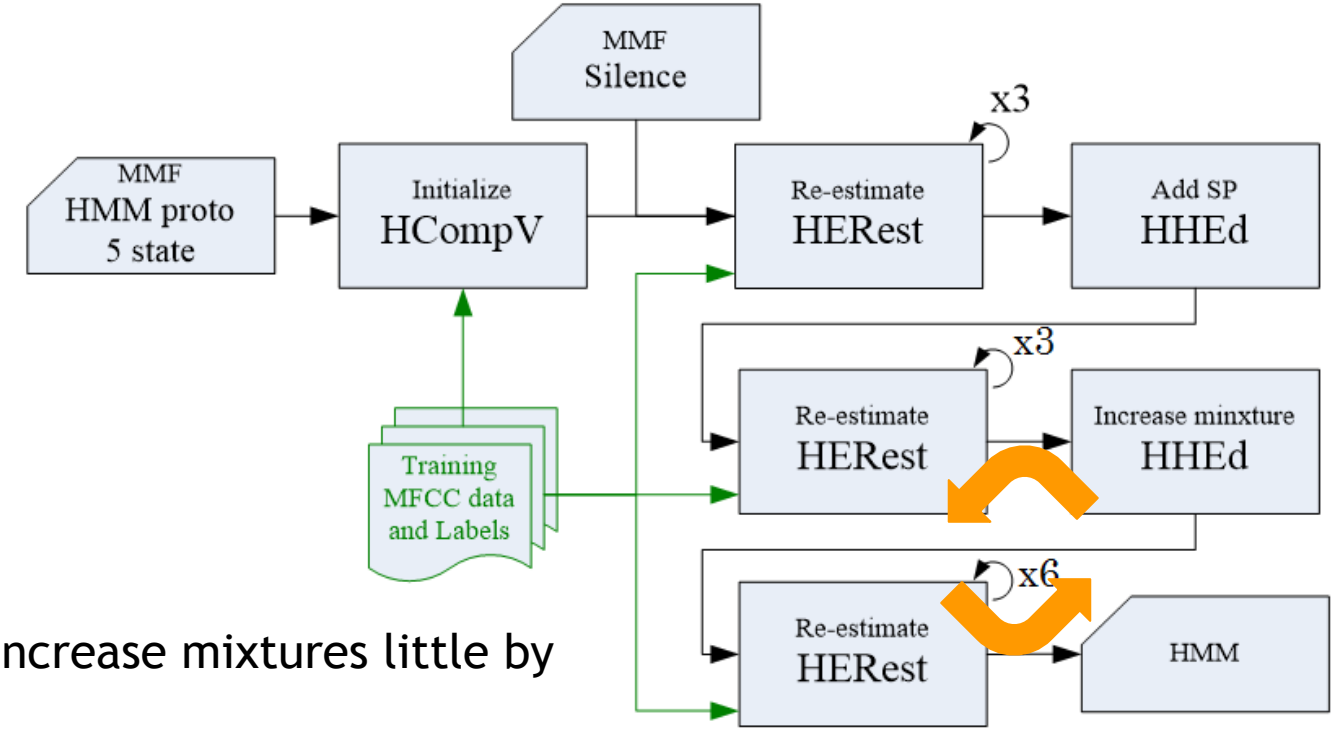
Check HTKBook 17.8 HHEd for more details

Adjust HMMs Again - HERest

```
HERest -C lib/config.cfg -S scripts/training.scp
-I labels/Clean08TR_sp.mlf -H hmm/macros
-H hmm/models -M hmm lib/models_sp.lst
```

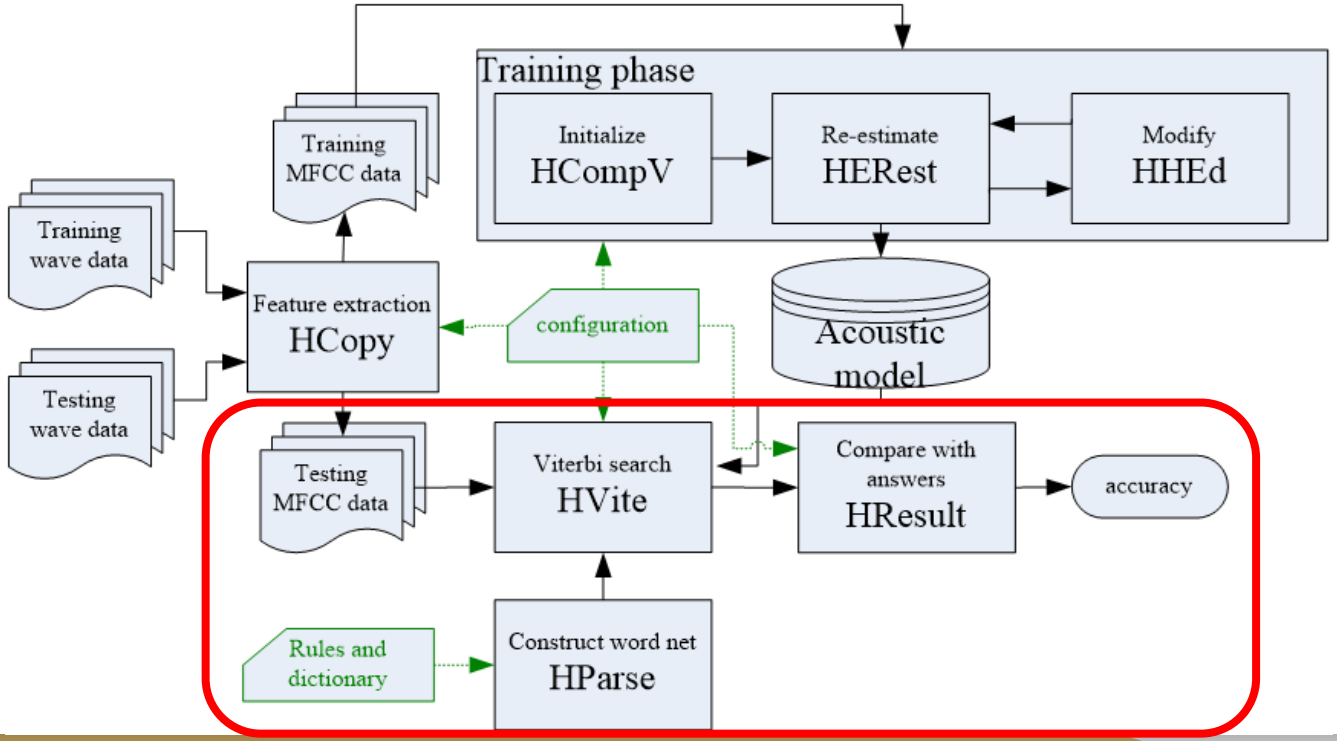


Training Flowchart



Hint：Increase mixtures little by little !

Testing Flowchart

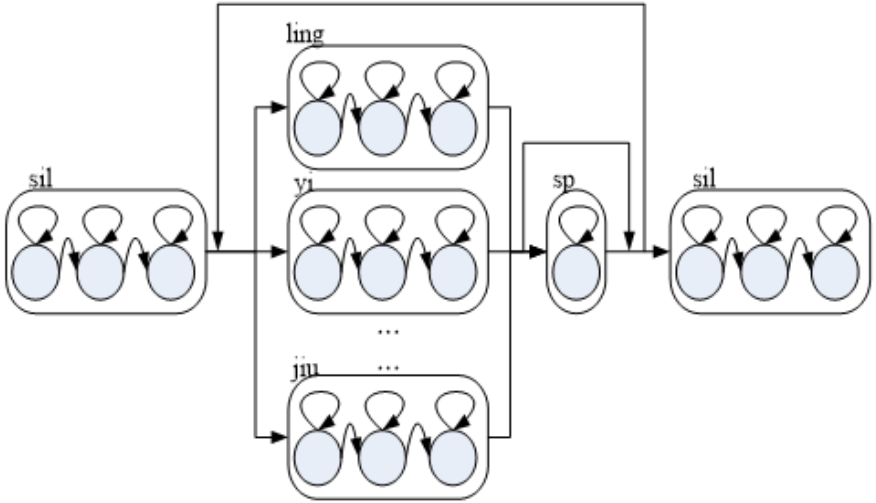


Construct Word Net - HParse

HParse lib/grammar_sp lib/wdnet_sp

lib/grammar_sp
- regular expression
- easy for user to construct

lib/wdnet_sp
- output word net
- the format that HTK understand



Viterbi Search - HVite

```
HVite -H hmm/macros -H hmm/models -S scripts/testing.scp
-C lib/config.cfg -w lib/wdnet_sp -l '*' -i result/result.mlf
-p 0.0 -s 0.0 lib/dict lib/models_sp.lst
```

-w lib/wdnet_sp

- input word net

-i result/result.mlf

- output MLF file

lib/dict

- dictionary: a mapping from word to phone sequences

  ling -> liN, er -> #er, … . 一 -> sic_i i, 七-> chi_i i

Don't worry

```
WARNING [-8232]  ExpandWordNet: Pronunciation 1 of sp is 'tee' word in HVite
```

Compared With Answer - HResults

```
HResults -e "???" sil -e "???" sp
-I labels/answer.mlf lib/models_sp.lst result/result.mlf
```

Longest Common Subsequence (LCS)

```
====================== HTK Results Analysis =======================
  Date: Wed Apr 17 00:26:54 2013
  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]
===================================================================
```

Report - Part 1 (40%) - Run Baseline

1. Download HTK tools and homework package
2. Set PATH for HTK tools：*set_htk_path.sh*
3. Execute (bash shell script)
   01_run_HCopy.sh
   02_run_HCompV.sh
   03_training.sh
   04_testing.sh
4. You can find accuracy in “result/accuracy”
   the baseline accuracy is 74.34%
5. Put the screenshot of your result on the report.

Useful tips

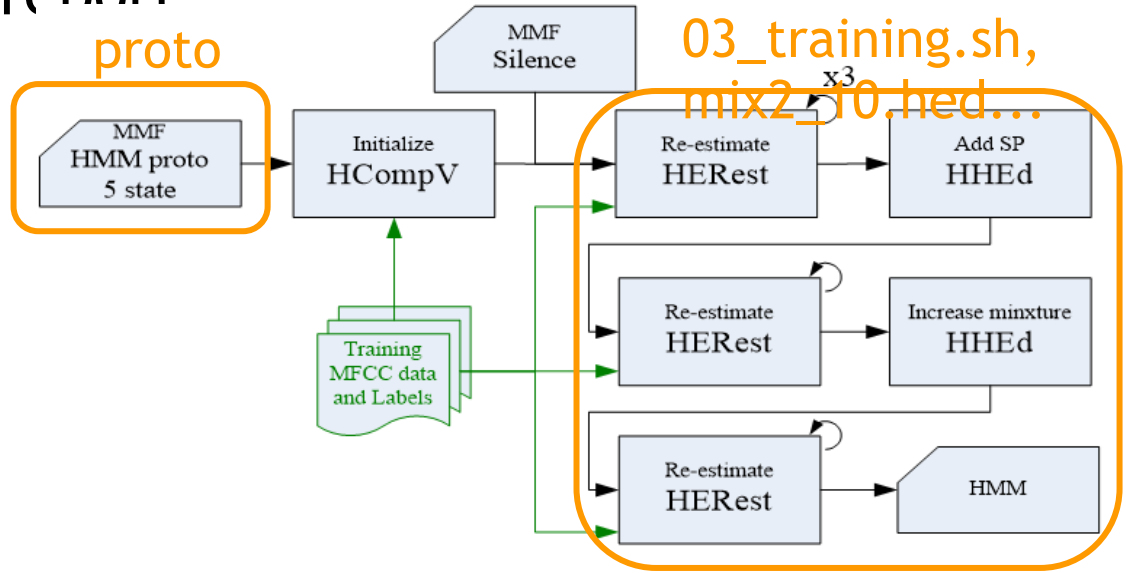
1. To unzip files
   unzip XXXX.zip
   tar -zxvf XXXX.tar.gz

2. To set path in “set_htk_path.sh”
   PATH=$PATH:“~/XXXX/XXXX”

3. In case shell script is not permitted to run…
   chmod 744 XXXX.sh

Report - Part 2 (40%) - Improve Accuracy

- Acc > 95% for full credit ; 90~95% for partial credit and put the screenshot of your result on the report



Part 2 - Attention 1

- Executing 03_training.sh twice is different from doubling the number of training iterations.
  To increase the number of training iterations, please modify the script, rather than run it many times.

```
for i in 0 1 2 ;
do
    echo "iteration $i"
    HERest -C $config -I $label \
        -t 250.0 150.0 1000.0 -S $data_list \
        -H $macro -H $model -M $mmf_dir $model_list
done
```

Part 2 - Attention 2

- Every time you modified ***any parameter or file***, you should run ***00_clean_all.sh*** to remove all the files that were produced before, and restart all the procedures. If not, the new settings will be performed on the previous files, and hence you will be not able to analyze the new results.
  (Of course, you should record your current results before starting the next experiment.)

Report - Part 3 (30%)

- Write a report describing your training process and accuracy.
  Number of states, Gaussian mixtures, iterations, …
  How some changes effect the performance
  Other interesting discoveries
- Well-written report may get +10% bonus.

Submission Requirements

- 4 shell scripts
  your modified 01~04_XXXX.sh
- 1 accuracy file
  with only your best accuracy (The baseline result is not needed.)
- proto, mix2_10.hed
  your modified hmm prototype and *file which specifies the number of GMMs of each state*
- 1 report (in PDF format)
  the filename should be hw2-1_bXXXXXXXX.pdf (your student ID)
- Put above 8 files in a folder (named after your student ID), and compress into 1 zip file and upload it to Ceiba.

If you have any problem…

- Check for hints in the linux and shell scripts. ex 鳥哥
- Check the HTK book.
- Ask friends who are familiar with Linux commands or Cygwin. (link：how to HTK on Cygwin)
- Contact the TA :
  email：ntudigitalspeechprocessingta@gmail.com
  title: [HW2-1] bxxxxxxxx (your student number)