# DSP HW2-1
HMM Training and Testing

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Outline

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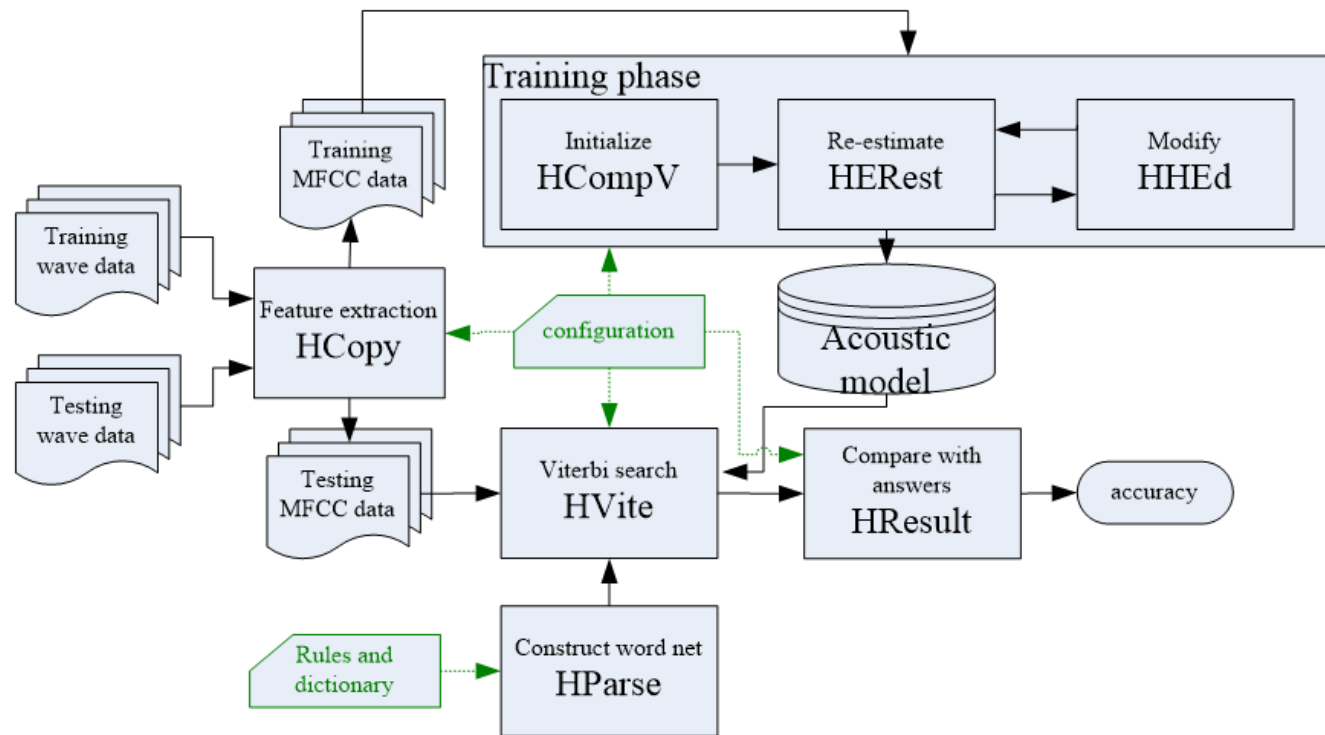3. Homework Problems
4. Submission Requirements

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/DSP2019Spring/

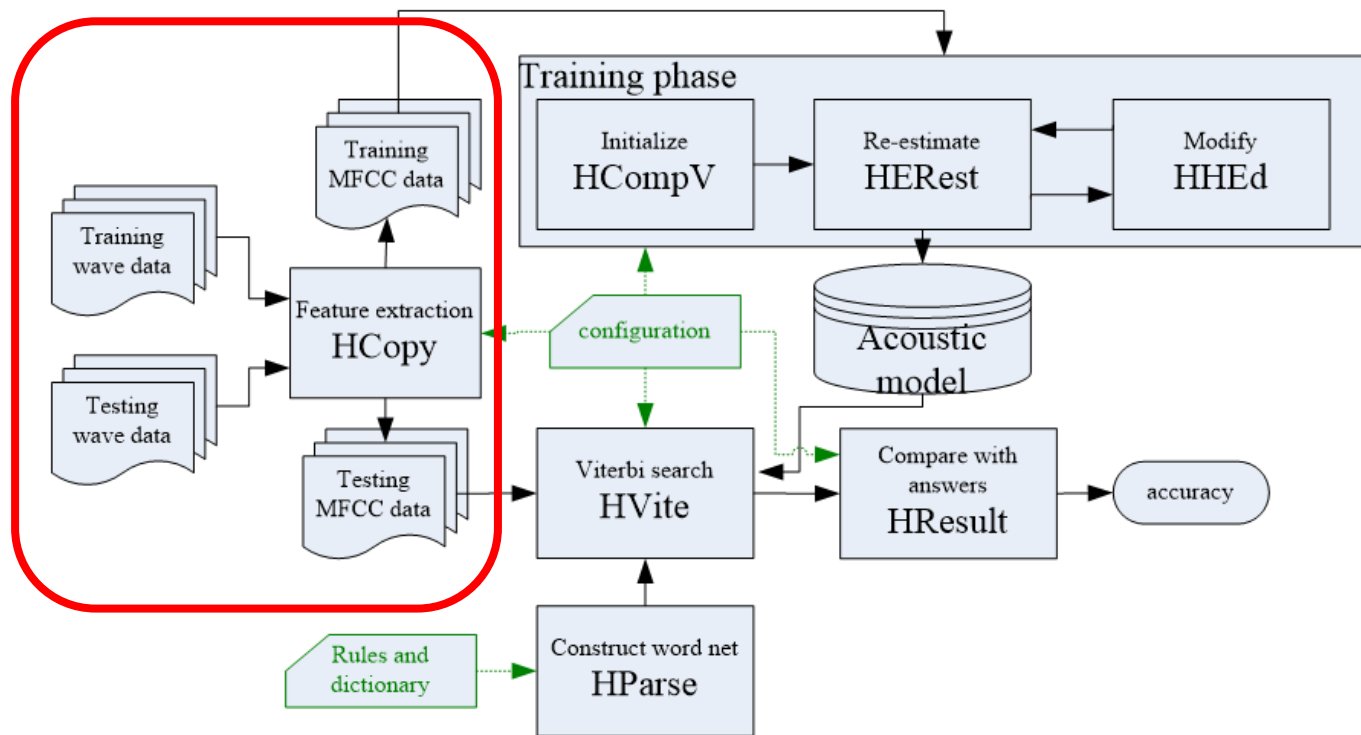# Flowchart
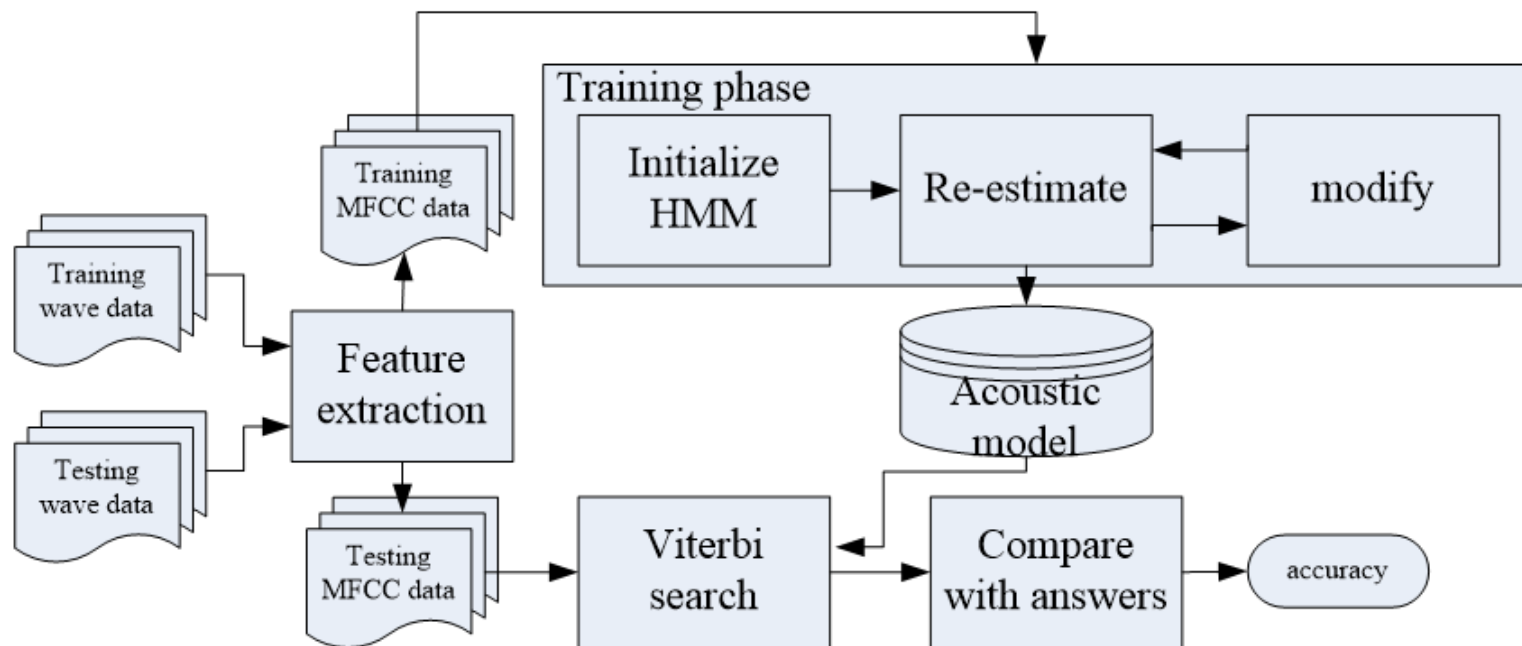
Hidden Markov Model Toolkit (HTK)

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 format   e.g. wav -> MFCC_Z_E_D_A
- ● parameters of feature extraction
- ● [Chapter 7 - Speech Signals and Front-end Processing](#)
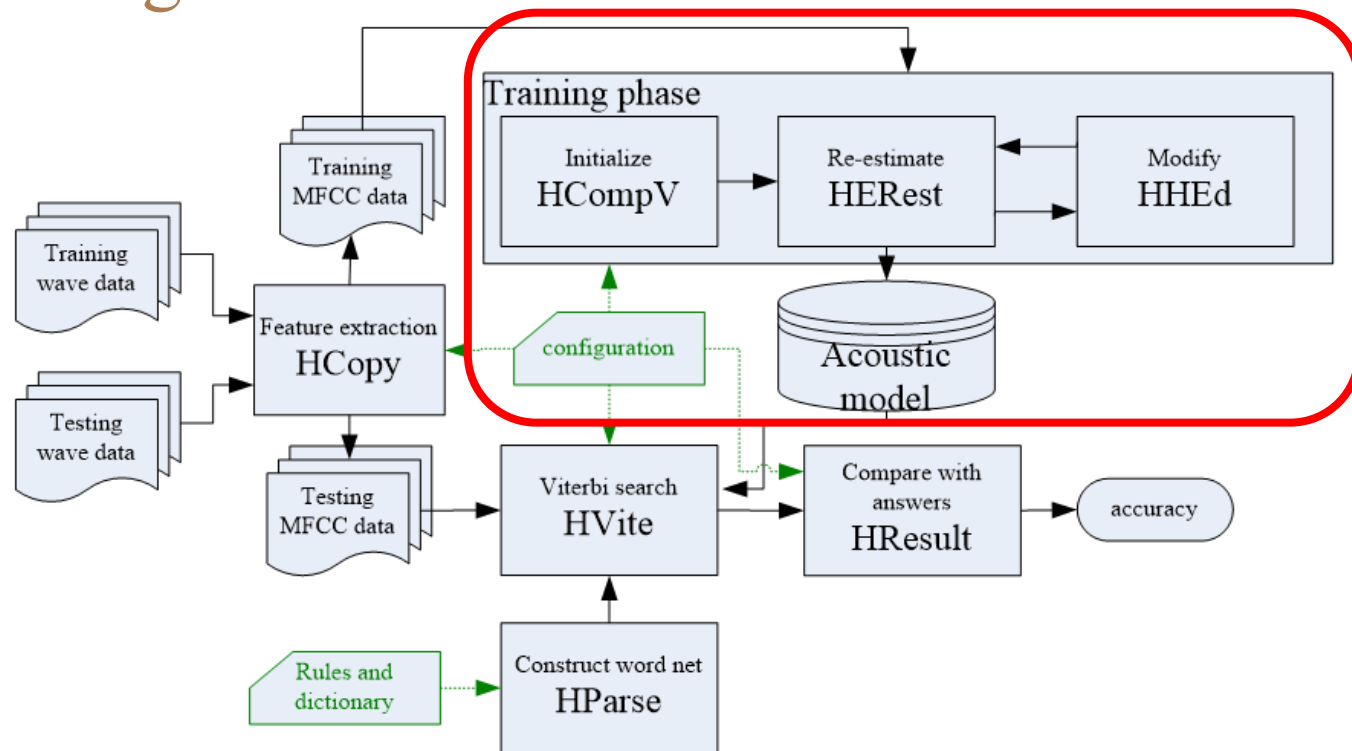
 -S scripts/training_hcopy.scp
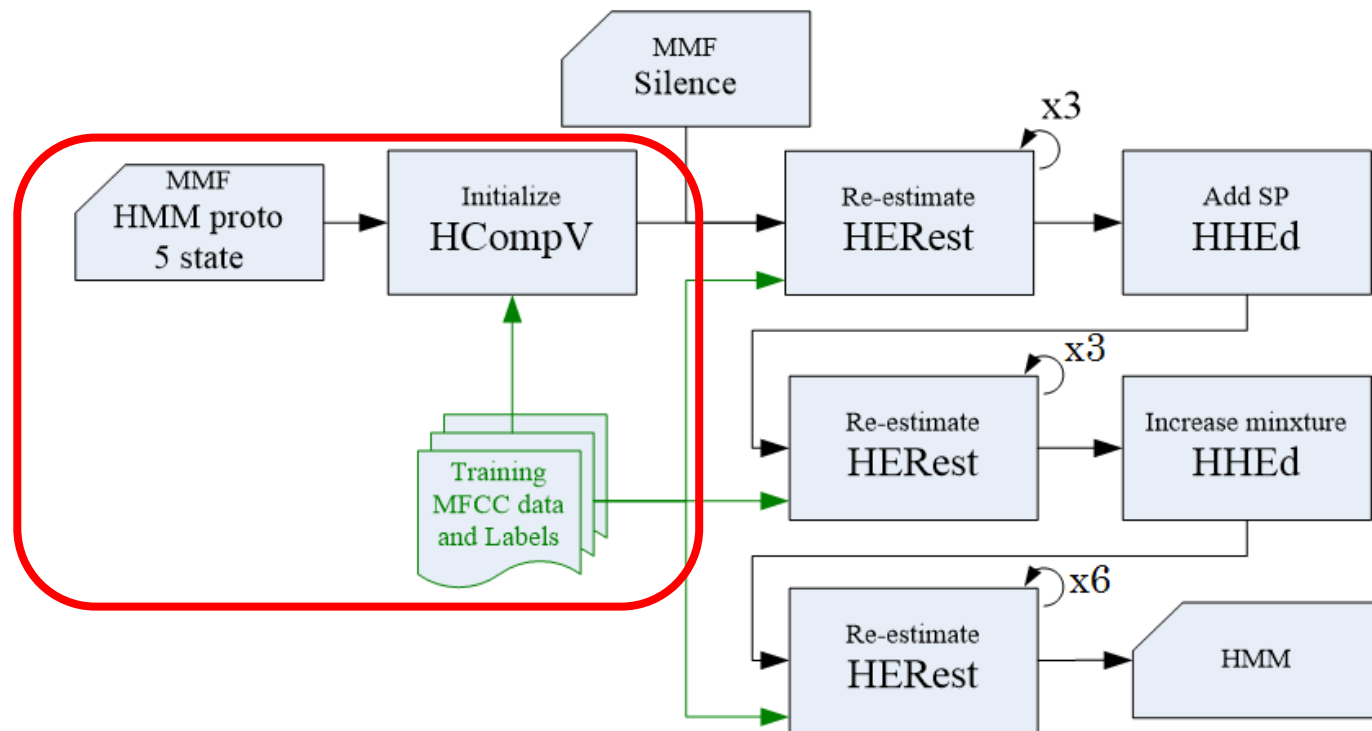- ● a mapping from Input file name to output file name

speechdata/training/ N110022.wav	→	MFCC/training/ N110022.mfc

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
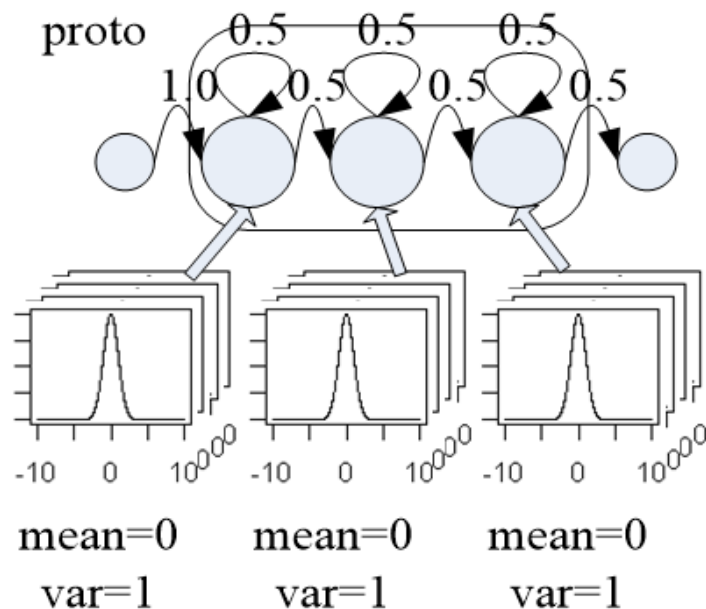
-S scripts/training.scp

- ● a list of training data

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

- ● a description of a HMM model, HTK MMF format
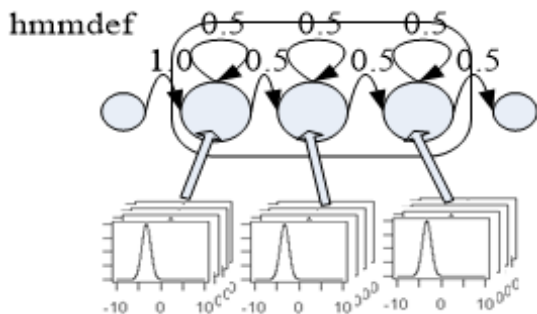
Initial MMF Prototype

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...
<Variance> 39
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...
<Variance> 39

...
<TransP> 5
0.0 1.0 0.0 0.0 0.0
0.0 0.5 0.5 0.0 0.0
0.0 0.0 0.5 0.5 0.0
0.0 0.0 0.0 0.5 0.5
0.0 0.0 0.0 0.0 0.0
<EndHMM>
```
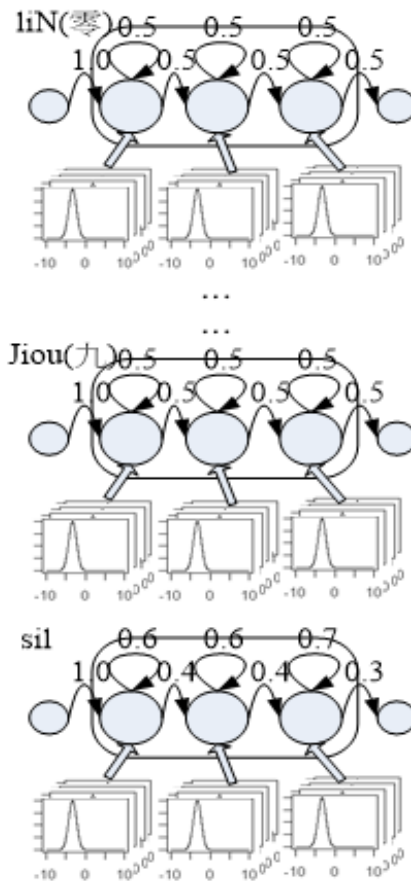
Initial HMM

- ## bin/macro
  Produce MMF contains vFloor

- ## bin/models_1mixsil
  add silence HMM

hmm/models

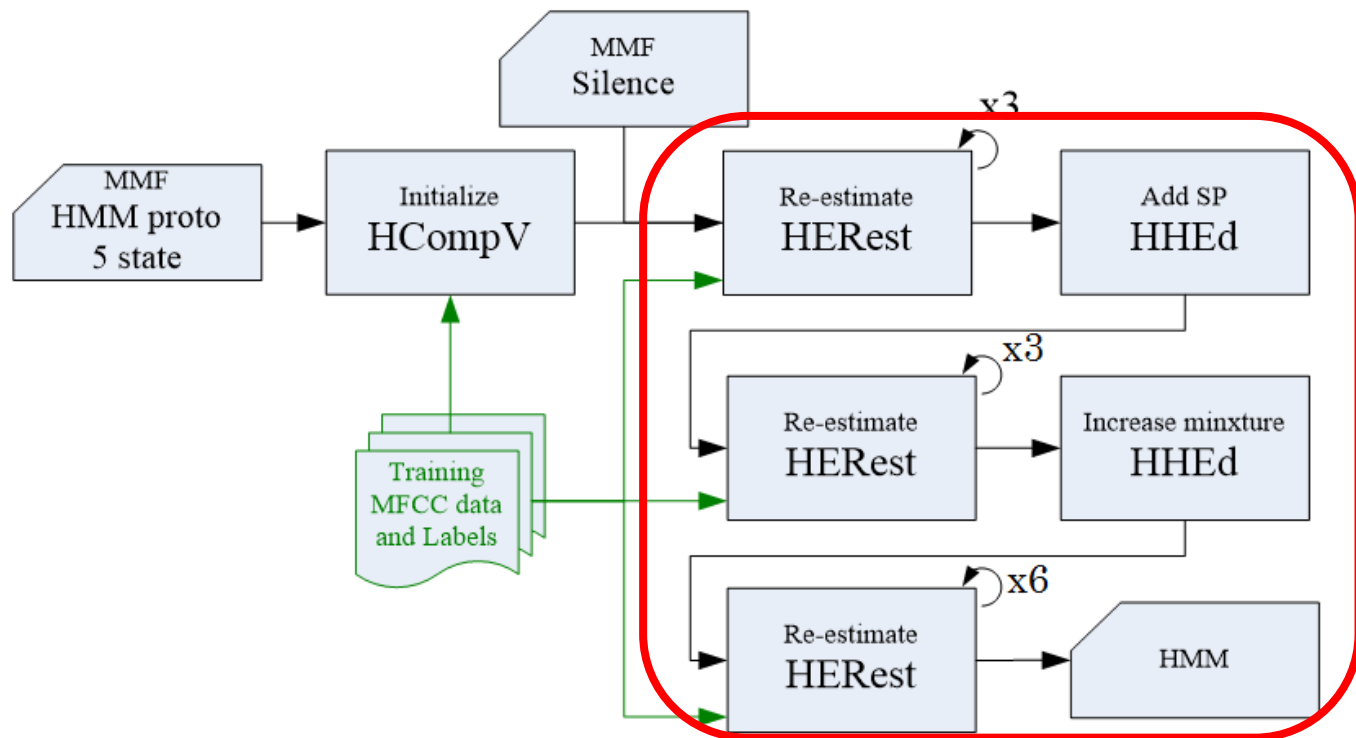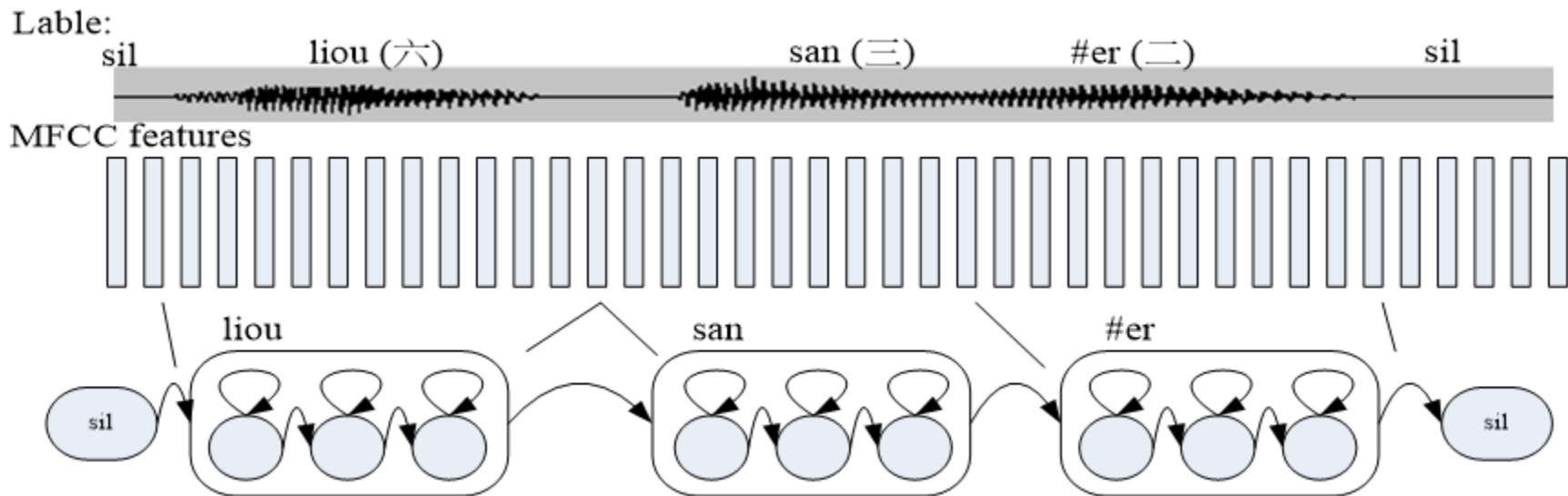
hmm/hmmdef

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"
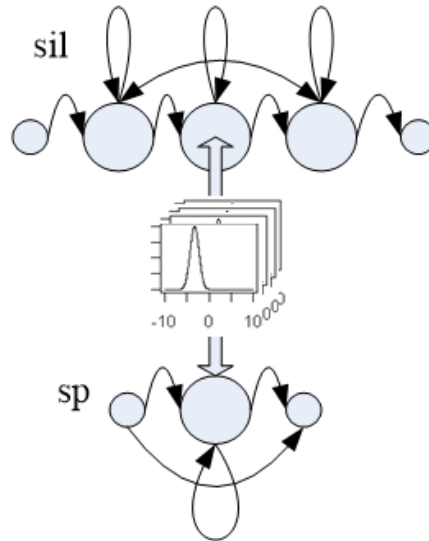
Modify HMMs - HHEd

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
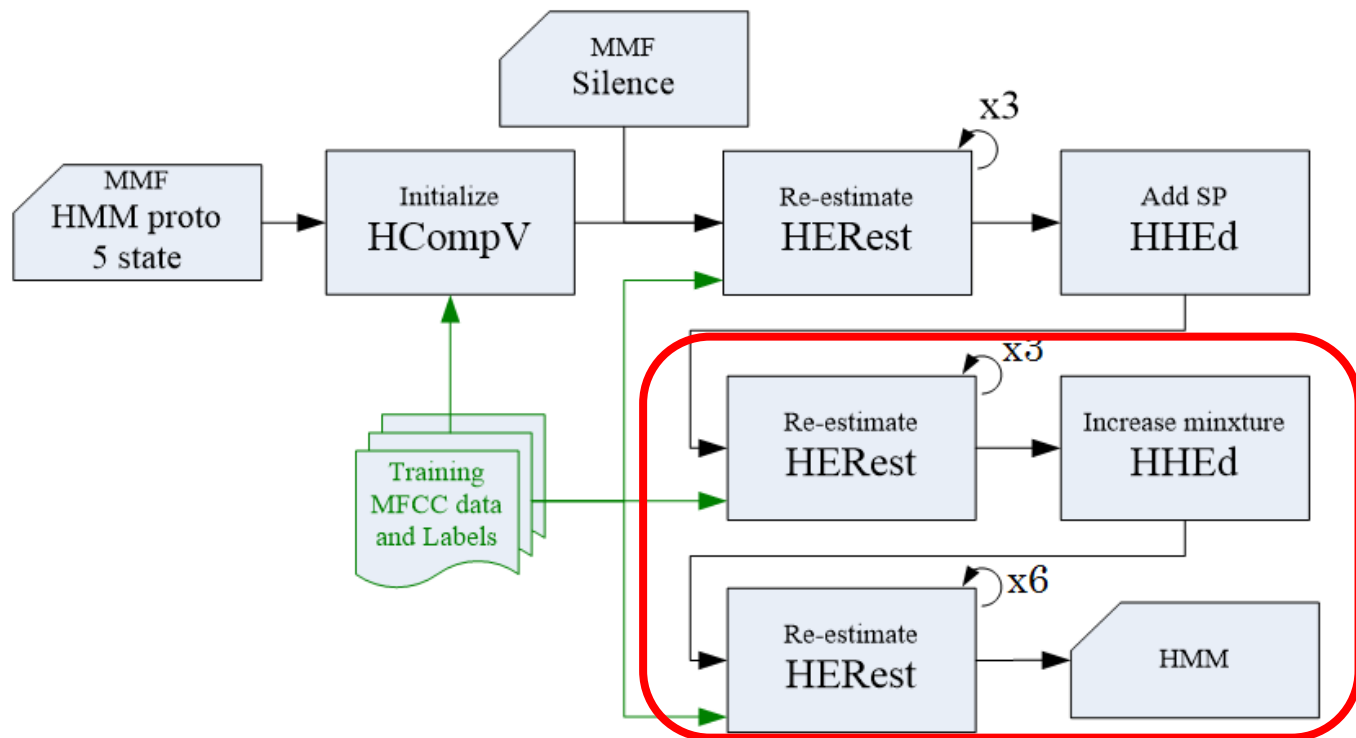
Adjust HMMs Again - HERest

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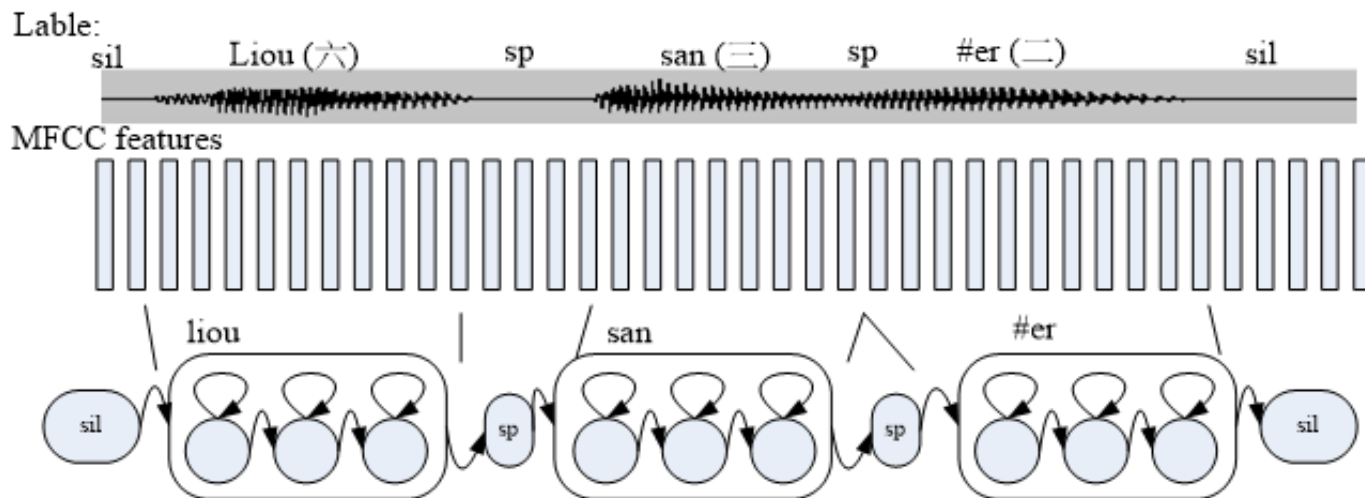-H hmm/models -M hmm lib/models_sp.lst

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}

Check HTKBook 17.8 HHEd for more details

> 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.
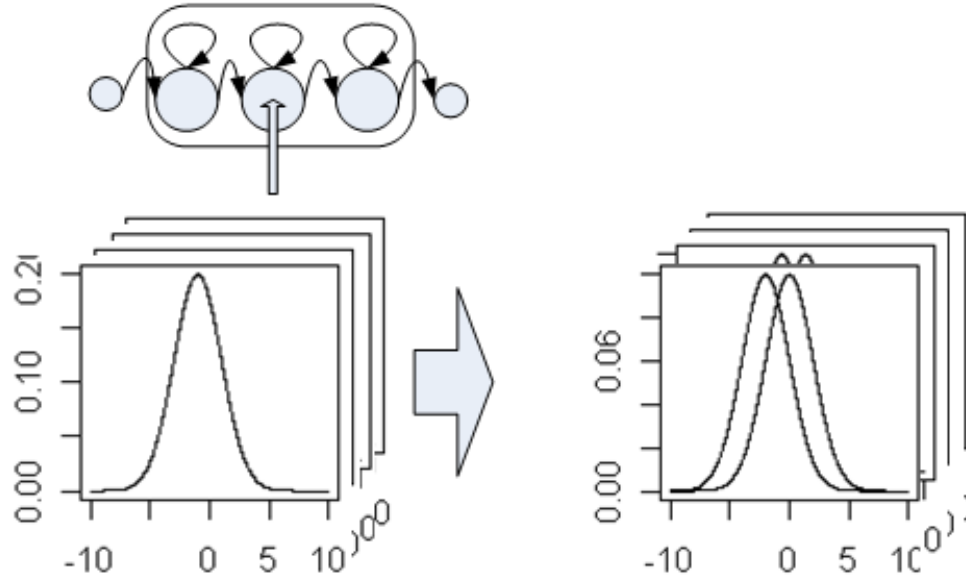
> You can increase # Gaussian mixture here.

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
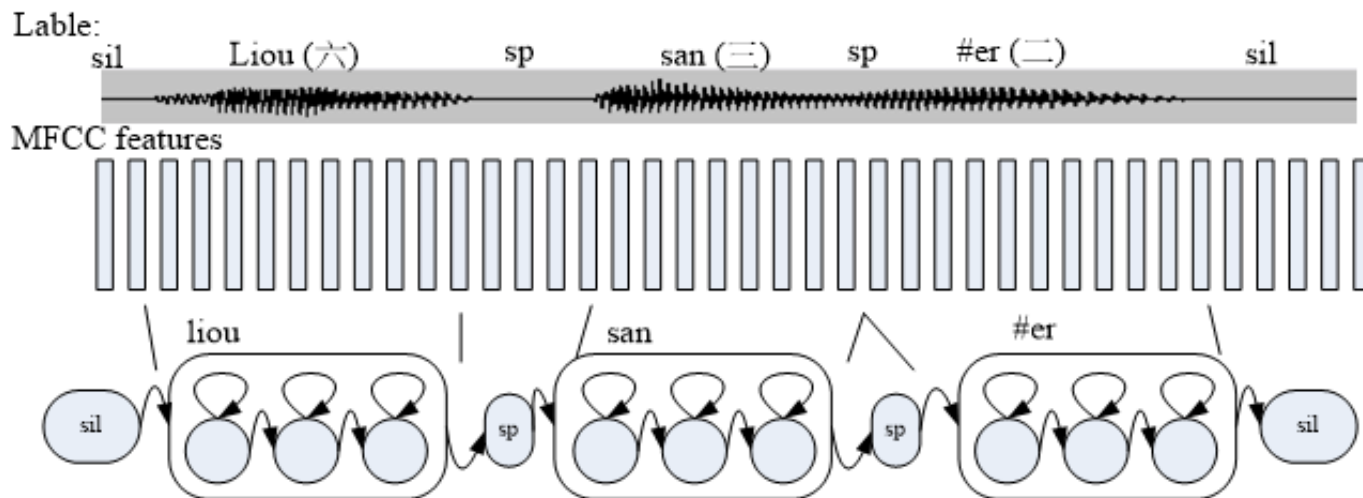
Training Flowchart
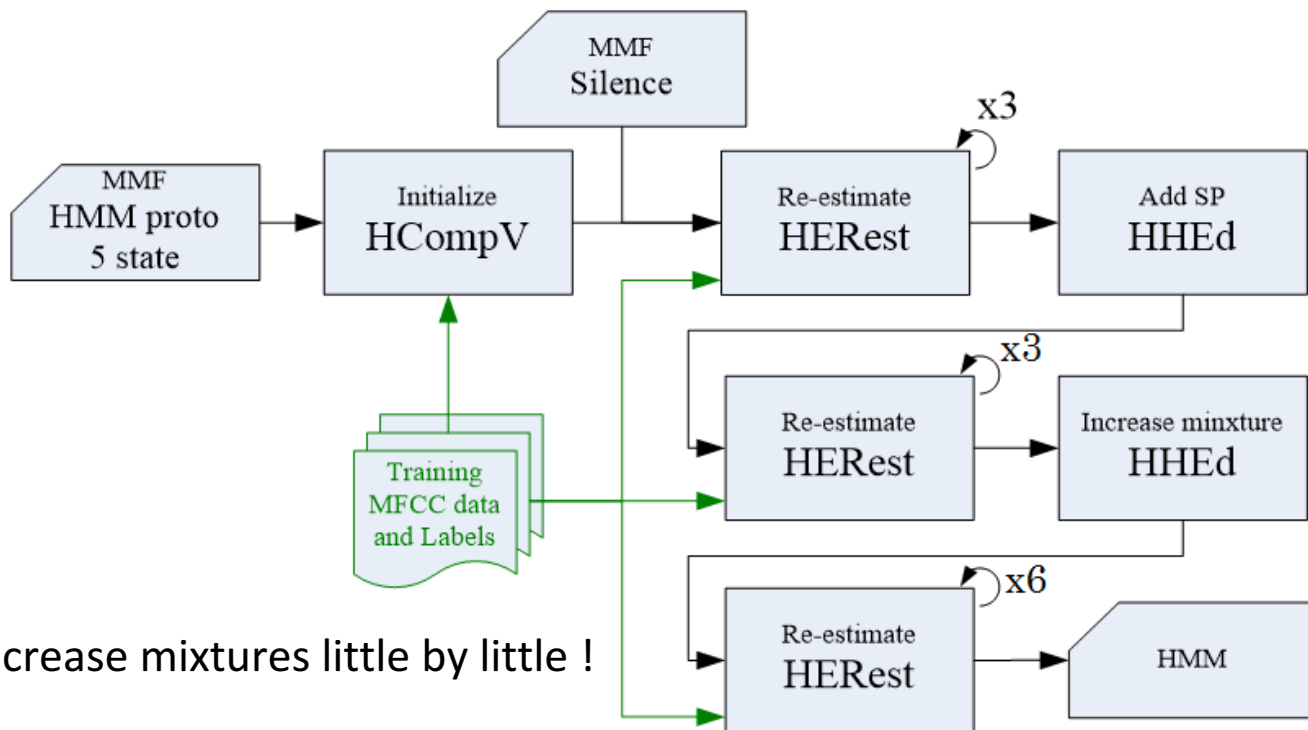
Hint：Increase mixtures little by little !

Testing Flowchart
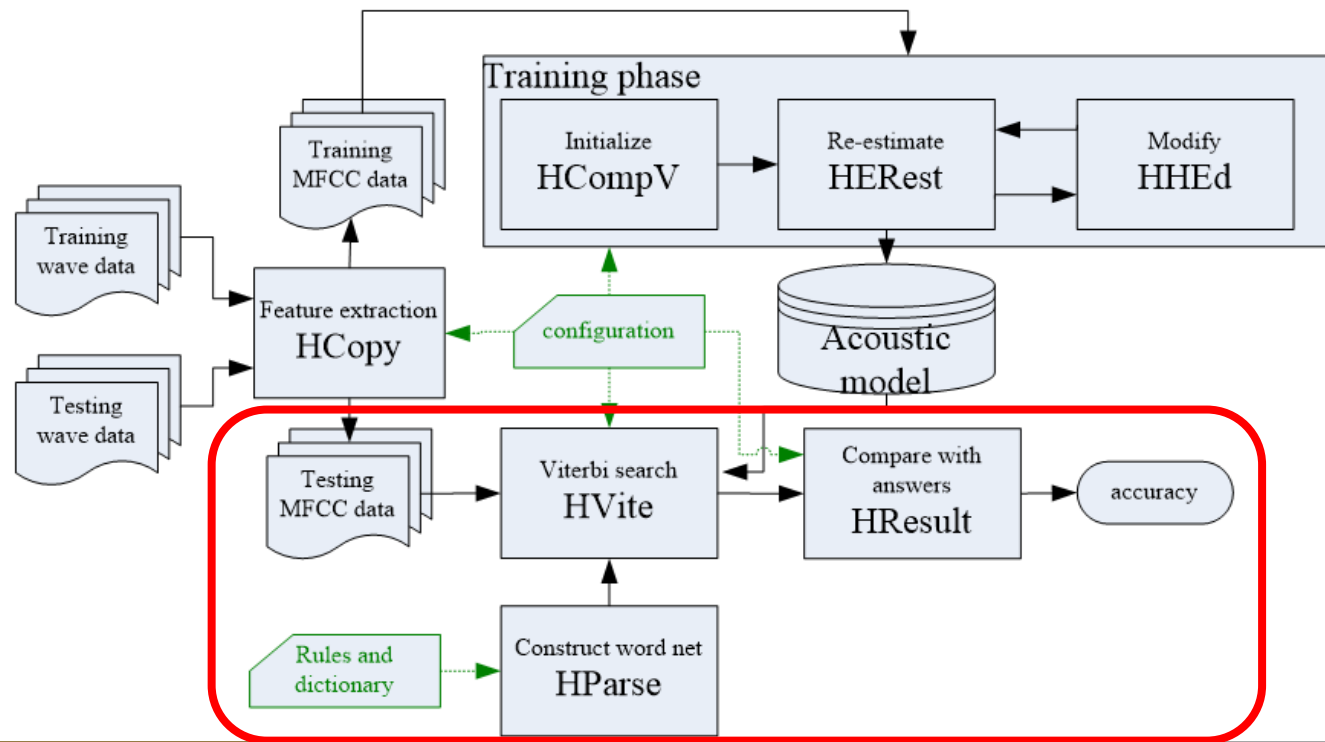
Construct Word Net - HParse

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
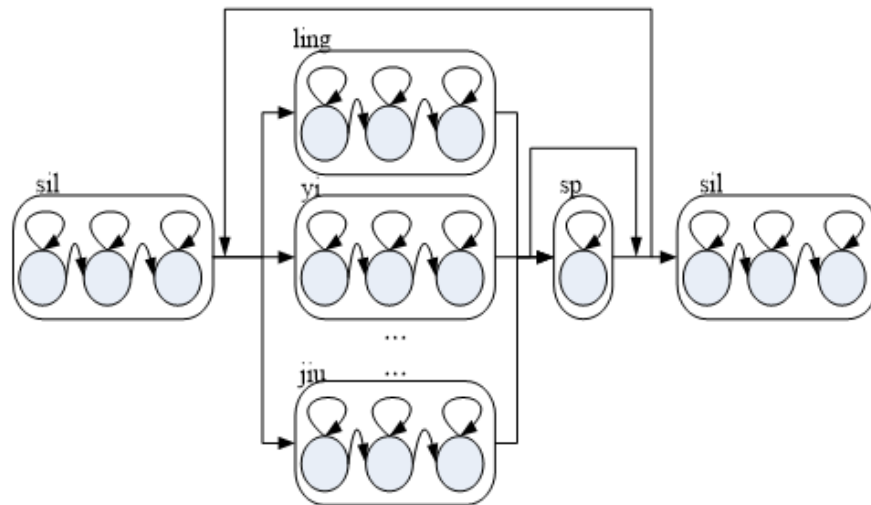
Viterbi Search - HVite

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 (recommend: compiled binary) 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

Report - Part 1 (40%) - Run Baseline (cont.)

3. You can find accuracy in "result/accuracy"

    the baseline accuracy is 74.34%

4. 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

Useful tips

4. If you encounter *No such file or directory* on the compiled binary files, it is because you are trying to run a 32-bit binary on a 64-bit system that doesn't have 32-bit support installed. You may need to install library packages such as *libc6:i386, libncurses5:i386,* and *libstdc++6:i386*.

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.
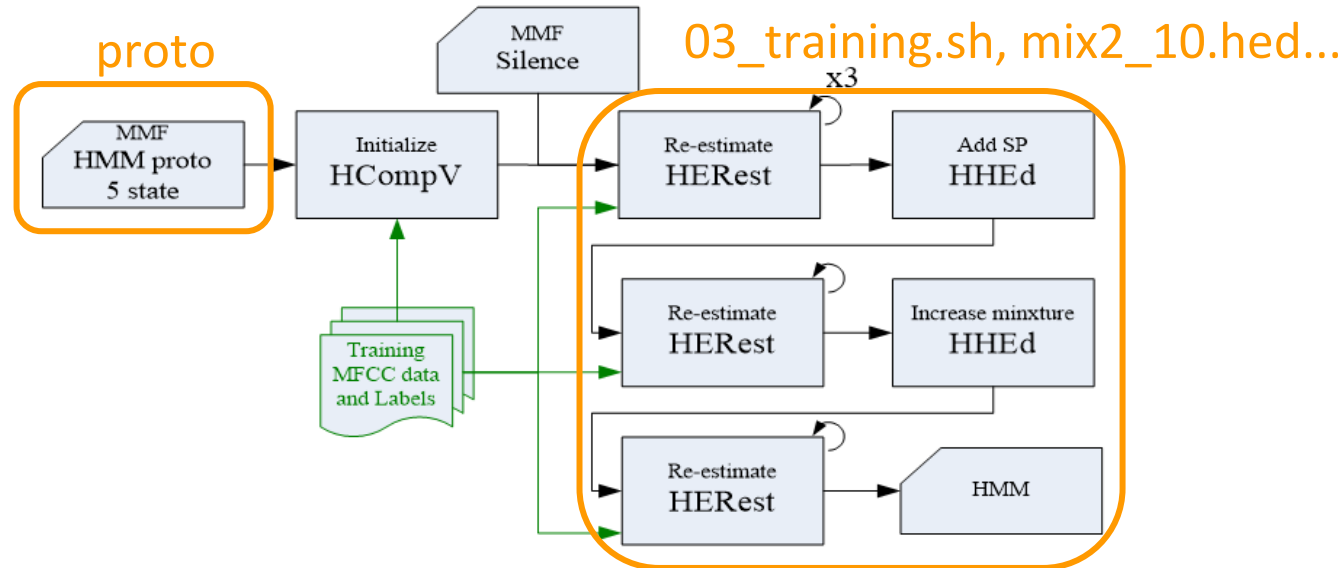
Part 2 - Attention 1

- 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

1. 4 shell scripts

   your modified 01~04_XXXX.sh

2. 1 accuracy file

   with only your best accuracy (The baseline result is not needed.)

3. proto, mix2_10.hed

   your modified hmm prototype and *file which specifies the number of GMMs of each state*

4. hw2-1_bXXXXXXXX.pdf

   screenshot for baseline and the best result, or other interesting.

Submission Requirements (cont.)

5. Put those 8 files in a folder, compress the folder to 1 zip file and upload it to CEIBA.

   - Folder name should be bXXXXXXXX (e.g. b04901000 or r07922000)
   - .zip only
   - 20% of the final score will be taken off for wrong format

6. Deadline: 2019/5/3 23:59:59

   - Late Penalty: 10% off every 24 hours after deadline
                       (less than 24 hours will be viewed as 24 hours).
   - Submission after 3 days will get zero point.

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 TA

- email：ntudigitalspeechprocessingta@gmail.com

  title：[HW2-1] Problem Description

- Office Hour: Monday 14:30-15:30 電二531 王君璇

  (Please send an email before coming!)