Introduction to Digital Speech Processing
2019 Spring
Homework 1 - Hidden Markov Model

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Description
Using simplified discrete models, the algorithms solving the three basic problems (evaluation, decoding, and training) are implemented. Details of the algorithms can be found in lecture 4.0.

Summary
Maximum testing accuracy of **0.8272** is obtained after **54 iterations** of training.

Environment
All code is written in C, using the default compiler settings.
They are compiled and run on *linux9.csie.ntu.edu.tw*.

Execution
Please arrange the files as follows:
  dsp_hw1/
  +-- c_cpp/
  | +-- hmm.h
  | +-- Makefile
  | +-- test.c
  | +-- train.c
  +-- model_init.txt
  +-- modellist.txt
  +-- seq_model_01~05.txt
  +-- testing_answer.txt
  +-- testing_data1~2.txt

To **compile, train and test**, execute:
  $ make
All the resulting files will be generated in *c_cpp/*.

To log the accuracies while training, execute:
  $ make log
Iteration and accuracy will be stored in *c_cpp/log.txt*.
figures.m can be used to plot figures on the next page.

To clean up executables, execute:
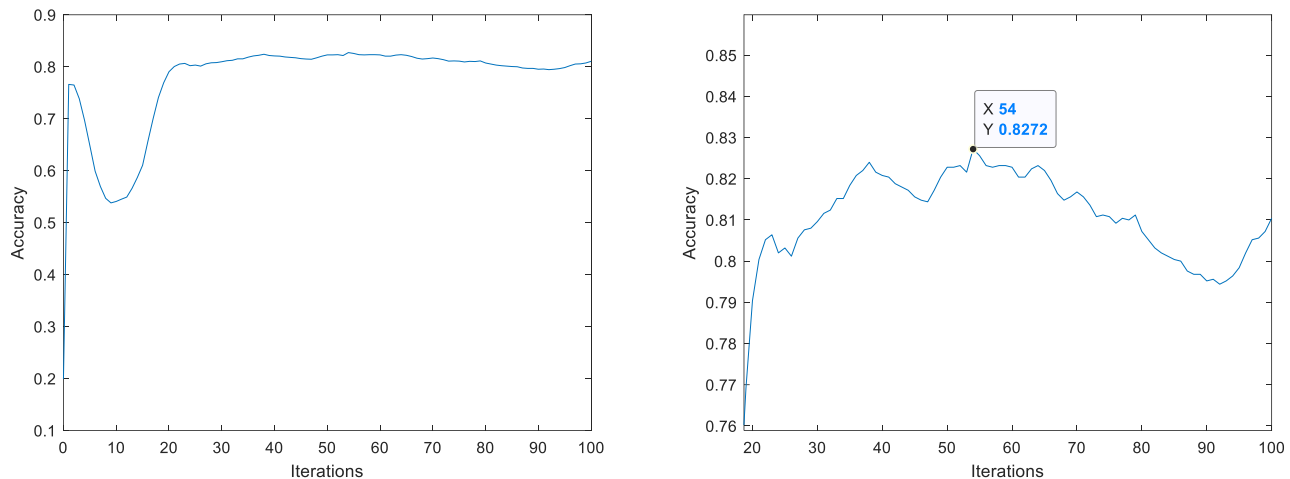 *$ make clean*

To clean up data, execute:
  $ make clean_data

To change number of iterations, change the 6th line in *Makefile*:
  iter=54

Discussion

The accuracies in 100 iterations of training is shown in the figures below. The figure on the right is a zoomed version.

According to the trend of accuracy changes, the process of training can be segmented into several stages:
(1) 1~9 iterations:
     Accuracy gets worse before they converge to better models.
(2) 10~21 iteration:
     Accuracy gets better quickly.
(3) 22~100 iteration:
     Accuracy become stable but tend to get worse very slowly.
In the (1) stage, the model started to fit to the patterns in the training data and a watershed might be encountered.
In the (2) stage the model converged to a local optimum, and as Baum–Welch algorithm doesn't guarantee to find global optimum, there could be better results if a different initial model is given.
In the (3) stage, overfitting might occur as the accuracy begin to degenerate. To check if it is the case, the accuracy of the model against training data set is plotted in the figure below:
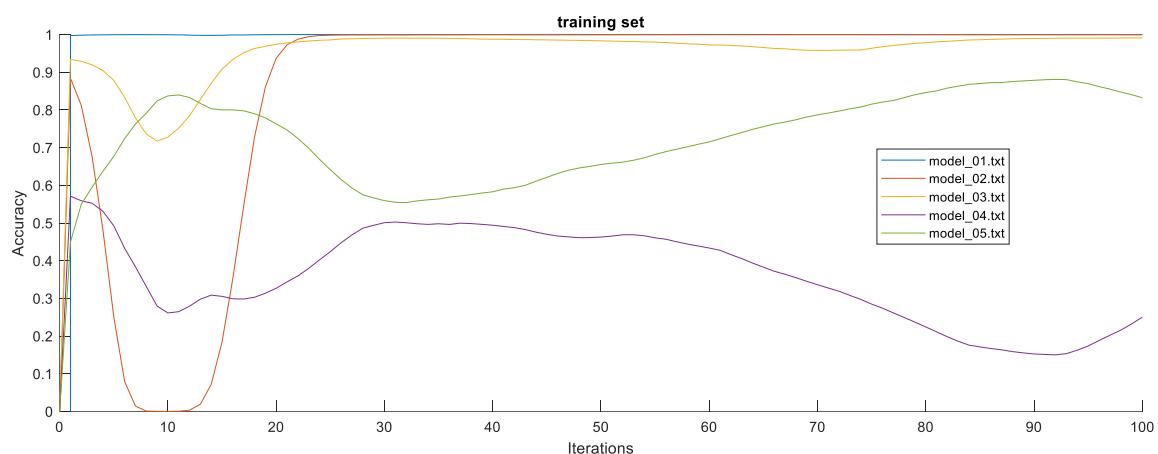
It can be easily seen that model 01, 02 and 03 are overfitted.

Another observation is that some probability values in the models converges to 0, suggesting that a left-to-right model may be compatible for this data.

Lessons learnt

Makefiles can automate compiling and testing, but the interaction between the makefile expansion and the invoked shell is a little tricky, so care needs to be taken.