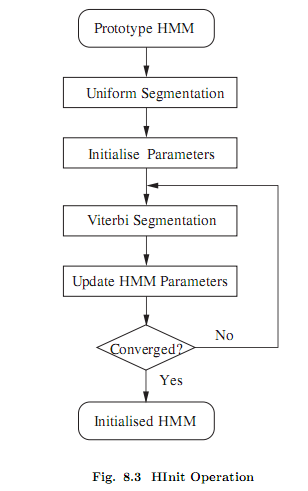
HTK from HTKBook.pdf to HInit.c Code,

Verification using real data

/RESEARCHS/neural\_network\_shmm/logbook\_hinit\_calculation\_verification.doc



# New ideas

## Semi markov to hmm conversion using turin nobelen …. Teori

Well it’s from birth and death ..?

# The data

# Hinit

# The basic principle of HInit depends on the concept of an HMM as a generator of speech vectors. Every training example can be viewed as the output of the HMM whose parameters are to be estimated. [HTKBOOK,sect. 8.2].

# @todo inside htk

## @todo uniform segmentation on hinit

Well actually it’s eems only one segment

### scripts/log\_0001.txt

Just like using only 1 segment contain only 322 observations …

@TODO

- system is PLAIN

Aligning Segment Number 1

1 -87.79 ---- ----

2 -176.60 -173.12 ----

3 -272.34 -263.89 -279.29

4 -380.97 -366.06 -388.23

5 -497.45 -479.17 -501.99

The first line contain only a column ? why ?

@todo whats in a column ? whats is aligning …. Column is an emission state[2,3,4], in column is state probability ? Column contain OutP which is negative by gaussian order.

1 -87.79 ---- ----

@todo where -87.79 come from This is for the first time. The log transp for state 2 is zero, so

2 -176.60 -173.12 ----

@todo Where line 2 come from /

### @todo hinit\_arctic.m log\_htk\_hinit.xls

### @todo, Hinit.c

In HInit, TransP from macro/mmf file is ignored. Because means and vars for states is estimated from mfcc observations directly.

EstimateModel()

🡪UniformSegment()

🡪FlatCluster()

🡪FindCentres () // calculate means, this will get 3x39 means for 3 //clusters ..

🡪FindCovariance()

🡪ViterbiAlign()

🡪getSegobs

🡪OutP()

* UpdateParameters()

Each iteration Parameter is estimated using found/optimate state sequence, see [rabiner,1990, k means viterbi for ahmm]

#### @todo Estimatemodel() explained

IntVec States has size 322 ? why

@todo formulas in [HTKbook3.5] section 8.8.1 Viterbi Training (HInit)

##### HTrain.c: ClusterSet \*ccs, current cluster set

This is the definitions of all cluster in k-means algorithm in HInit

**static** ClusterSet \*ccs; /\* current cluster set \*/

Means is save in ccs->cl[n].vCtr;

ctr = ccs->cl[n].vCtr;

number of cluster, ccs->numClust.  
Cluster size, is the number of element is cluseter, for example cl[1,2].csize=107, cl[3].csize=108

Cl[1].csize

cs = ccs->cl[n].csize;

**for** (j=1; j<=vSize; j++) ctr[j] /= cs;

##### UniformSegment()

This function is called once, when state aligment not yet calculated by viterbi:

**if** (trace&T\_TOP) **printf**("Starting Estimation Process\n");

**if** (newModel){

UniformSegment();

}

Using static variable HTrain.c:: ClusterSet \*ccs to save all clustering segmental k-means information. For example

ccs🡪numClust return 3, for 3 states of HMM, state 2,3 and 4.

ccs->cl[1], will return first cluster

###### UCollect data

For arctic\_a0001.mfc we have 322 observations x(1) to x(322). Which this obs. is divided into 3 states : State2 : 108 observations from x(1) to x(107), state 3 x(108) into x(214), and state 4, x(215) into x(322), 107 observations.

UCollectData will inject Hmm mfcc Observations into cluster datas, by using HTrain.c:: ShortVec cmap, HTrain.c:: Sequence cvp .

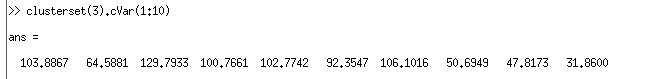
###### FlatCluster()

Flatcluster will calculate, means and covariances for these 3 states. In log\_htk\_hinit.xls:log\_tge we got a mach with from matlab code hinit\_arctic.m

For example in excels for state 4:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| state 4 stream 1 | |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Flat Cluster Set: 1 nodes | | |  |  |  |  |  |  |  |  |  |  |  |  |
| 1. size=107 cost=1.000 | | |  |  |  |  |  |  |  |  |  |  |  |  |
| Mean |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 0.45 -1.62 0.17 -2.62 0.33 0.19 -3.88 -0.36 1.63 1.08 -1.71 -1.59 1.74 0.07 0.01 -0.06 0.01 -0.03 0.02 -0.09 ... | | | | | | | | | | | | | |  |
| diagC |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 103.89 64.59 129.79 100.77 102.77 92.35 106.10 50.69 47.82 31.86 51.59 44.75 72.36 5.64 2.95 3.78 5.92 6.14 5.21 8.73 ... | | | | | | | | | | | | | | |

Which exacts matlab state 4:



So until here matlab and c match correctly…

##### @todo ViterbiAlign() Explained

There are no parameters updating for hmm in Viterbialignment(). We’re just find the best state sequence/path of single invocation of this method. This optimal state sequence is used by UpdateParameters() to update cluster members, transp and means and variances.

hmmLink🡪transP in ViterbiAligned() already contain log e values. For example lastP holding probability until current observations, at observation I, lastP hold probability of

At first observations, all states must traced back to entry state, state1

traceBack[1][currState] = 1;

###### tranP is prioritized, before observations

in calculation of next forward decision of va(), we must take care of *tranP* FIRST, before the obs. Probs. This is done by set

bestP=tranP

and then later we add obs. Probability if we are sure to jump into the next best state.

**for** (segIdx=2; segIdx<=segLen; segIdx++) {

###### Nstates

nstates=5

###### GetSegObs(segStore,segNum,segIdx)

For hartic\_a00001.mfc

There is only 1 segment, so segNum must always be 1, segIdx is observation number from 1 to 322

###### @todo why so many traceback path ? is there eliminations …

###### @todo, dotraceback ?

This function has NO relationship with survival or candidate thing. This is simply reordering back the optimal states sequence. From ‘thisState’ end of viterbi path go to first node of the path. Then save all order in passing by reference parameters ‘states’ .

/\* DoTraceBack: traceBack and set states array \*/

**void** **DoTraceBack**(**int** segLen, IntVec states, **int** thisState)

###### @todo ???

….. Because va() only seen one obs per iterations … current best p may be not survived at end of observations.

###### @todo viterbi traceback matrix

Current single best path now is only candidates. These best paths could be failed, in the next observations ….. So traceback matrix is not intented to to find another path.   
Traceback matrix is SIMPLY a way do keep the all candidate paths. At the end of aligning, one best path in traceback matrix (i.e with MAX probs.) will be chosen. Trace matrix is used to reconstruct the found solution. Traceback matrix is just a convenient way to remember path/trace. We keep all possible values in matrix, at the end one best solutions is reconstructed.

@todo, how many traceback, hinit:va() accommodates ? traceback matrix accommodate all possible solutions from starting state.

@todo is there any missing …

In log.vit

For every iteration there are 3 vectors with long 322. So we have 3 rows x 322 columns for our traceback matrix.

For data

Aligning Segment Number 1

1 -87.79 ---- ----

2 -176.60 -173.12 ----

3 -272.34 -263.89 -279.29

4 -380.97 -366.06 -388.23

5 -497.45 -479.17 -501.99

6 -605.64 -590.66 -600.64

…

We construct traceback matrix

2 1 2 2 …..

3 1 2 3 ….  
 4 1 2 3 …

The first column is a state name not a traceback value, 1 in second column is by

traceBack[1][currState] = 1;

@todo what is the meanings of 3 rows? in relations with bestP?

@todo, is unsurvival path eliminated?

trP=0

=-87.79

btP=pvP+trP= -87.79 + -0.51

currP=LZERO

ltP[2]=LZERO

currP=LZERO

ltP[3]=LZERO

ltP[1]=trP+dgP=-87.79  
-6.6966

4.1143

-2.6649

14.079

…

btP+currP =-176.60

-7.1163   
2.0789   
0.3962   
12.47

……….

Obs 1:

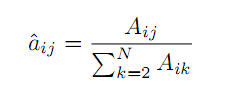
Of course from initial state 1, we go the must state with probability 1 or logp 0, state 2. The total of logsum tranP+DiagP to state 2 is -87.79.

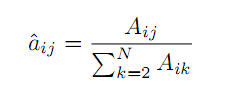
##### @todo UpdateParameters()

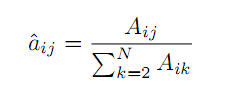
Uptranp, upmean, updprob

###### UpTransP()

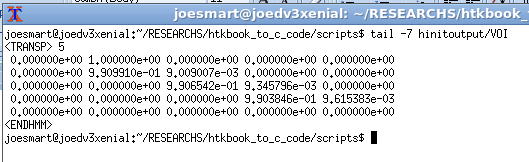
Updating from relative frequency [htkbook8.8]



: TOTAL number of transitions from state i to state j, which can be count after states sequence is aligned

: new transition probability from state i to state j

For arctic\_h0001.mfc after see n, we see in all emission states, 2, 3, 4 the possibility of remain is high, and the possibility of move to right is very low, that it’s happen once in 108/107 obs it’s about 1 to hundred.



###### UpMeans and UPcovR()

Since these are means for states …. Then just averaging observations for the optimized states. This different from first initialization which takes averaging over all 322 observations. In Iteration 2 and next, the means (and vars) for state1 only calculated from 108 first obs. State 2 from 107 middle obs, and state 3 from 107 last obs. Means and variance operations are calculated only for cluster.

###### @todo The relationship of ViterbiAlign() and UPr()?

What output from ViterbiAlign() is used in UpdateParameters()?

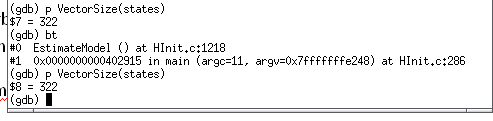
According to [rabiner,1990] parameter is estimated using optimal/state sequence. So viterbialign() find best state sequence based on obs(which is fixed) and current parametes(transp, means and vars).

Then based of this optimal state squence, new hmm paramater (transp, means, and vars) is calculated. This will suggest to probably new state alignment (on next viterbialign()). So we have iterations(repetition of procedures).

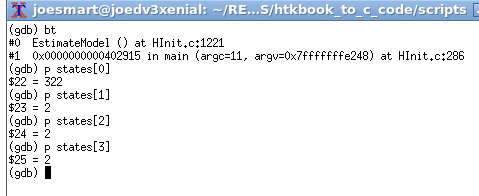
EstimateModel() has states variable that altered by viterbialign() every iterations ….

IntVec states; /\* array[1..numSegs] of State \*/

Well it’s size actually for harctic\_0001.mfc is array of [1][1…322] , 322 hundreds of state sequences. The value is 2s, 3s or 4s because this are the emitting states. And states 1 and 4 do not trigger any observation.



AFTER ViterbiAlignCalled(), the states is filled accordingly.



In updateCount() states is used to alter static HMMLink \*hmmlink. In UpdateParameter() \*hmmlink is used?

#### @todo DOoutP

##### @todo, mp->cov.var[?] error different from file,

@todo EstimateModel()🡪UniformSegment()🡪alter file def. covariances

UniformSegment use it’s own MixPDF \*mp which it’s covariance is estimated from Cluster \*c;

**@todo where variances change ? firstly means are changed in FindCentres(), Covariances() are changed in FindCovariances().**

**HInit.c:595**

**case** *DIAGC*:

**for** (j=1; j<=size; j++){

z= c->cov.var[j];

mp->cov.var[j] = (z<floor[j])?floor[j]:z;

}

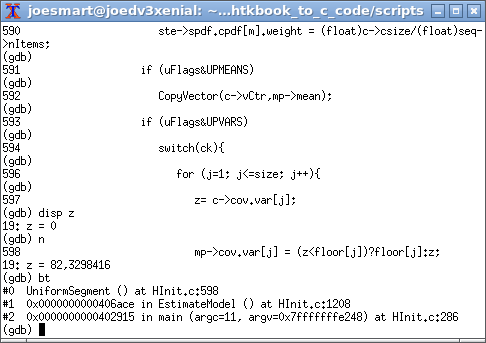


Figure: variances change

**Both FlatClusterSet(), FindCentres() and FindCovariances() using static variables**

**static** ClusterSet \*ccs; /\* current cluster set \*/

#### @todo gconst calc.

Hmodel.c: FixDiagGConst  
Gconst = n\*log(2PI)+sigma(log var)

/\* EXPORT->FixDiagGConst: Sets gConst for given MixPDF in DIAGC case \*/

**void** FixDiagGConst(MixPDF \*mp)

{

**float** sum;

**int** i,n;

LogFloat z;

Vector v;

v = mp->cov.var; n=VectorSize(v); sum = n\*log(TPI);

**for** (i=1; i<=n; i++){

z = (v[i]<=MINLARG)?LZERO:log(v[i]);

sum += z;

}

mp->gConst = sum;

}

/\* DOutP: Log prob of x in given mixture - Diagonal Case \*/

**static** LogFloat DOutP(Vector x, **int** vecSize, MixPDF \*mp)

{

**int** i;

**float** sum,xmm;

sum = mp->gConst;

**for** (i=1;i<=vecSize;i++) {

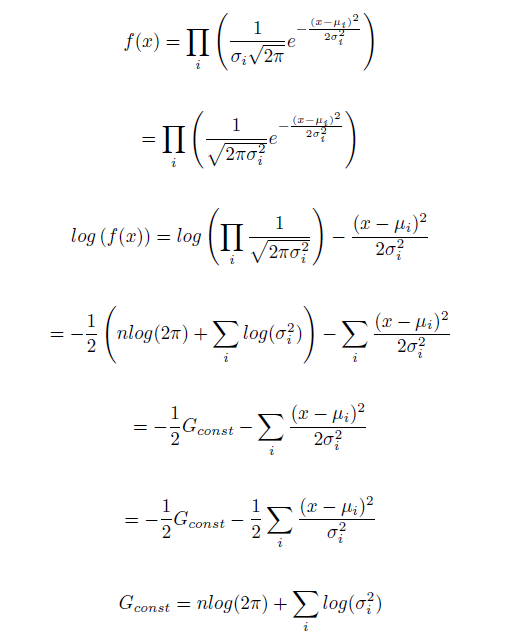
xmm=x[i] - mp->mean[i];

sum += xmm\*xmm/mp->cov.var[i];

}

**return** -0.5\*sum;

}



GConst exist for every state …., so for 3 output state we have 3 GConst.

#### @todo when hmm parameter updated

#### @todo traceback matrix,

Is traceback matrix has relationship with multi viterbi path ? or multi solution ? how many path htk save ?

#### @todo convergence criterion htk hinit?

The convergence of HInit is depend on difference between total Probability every iteration.

HInit.c:1227

Delta=newP-totalP

#### @todo MFCC observations/vectors not clear GetSegObs compare to octave/matlab

….

Must load mfcc from octave/matlab …. And compare to getsegobs

Using hello.m 🡪 arctic\_0001.txt we got

-6.6966 4.1143 -2.6649 14.079 10.799 4.6172 12.076 ……..

-7.1163 2.0789 0.3962 12.47 5.7629 8.6881 17.707 ……….

-5.1815 4.9537 1.2972 9.3509 5.0981 0.93263 15.483 ………..

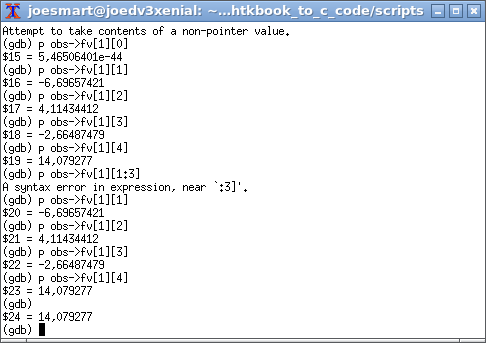
-3.3229 5.59 0.74351 13.567 11.653 5.0787 13.797

….

As We see in HParm.h:printObservations(), Observations->fv is a matrix with two indexes,

obs->fv[s][j];

in our case we have only one mixture 🡪 s=1, and j from 1 (not 0) ,remember htk vector start at 1, 0 for its size, …



#### @todo mfcc file

#### type,

#### @data type

##### HMMSet \*/HLink, HMMDef

HMMDef /HLink

HMMSet

owner\*

##### Observations data type

**typedef** **struct** {

Boolean eSep; /\* Energy is in separate stream \*/

**short** swidth[SMAX]; /\* [0]=num streams,[i]=width of stream i \*/

ParmKind bk; /\* parm kind of the parm buffer \*/

ParmKind pk; /\* parm kind of this obs (bk or DISCRETE) \*/

**short** vq[SMAX]; /\* array[1..swidth[0]] of VQ index \*/

Vector fv[SMAX]; /\* array[1..swidth[0]] of Vector \*/

} Observation;

##### OutP

Outp return log of probs

###### IDOutP

DOutP

For diagonal (non inverse covariance)

LogFloat DOutP(Vector x, **int** vecSize, MixPDF \*mp)

### @todo what is traceback matrix

## @todo segmental k –means ? where in code

## @todo Debug observations into teks ….

In top of htk tools there is tracing level … for example

**#define** T\_VIT 0020 /\* Detailed Viterbi Alignment \*/

Which when executed … using –T switch as in scripts/all.sh

cmd="$HTKTOOLSDIR/HInit -C configtrain.txt -T 20 -m 1 -M hinitoutput VOI arctic\_a0001.mfc"

echo $cmd ; eval $cmd

# @todo, read tutorial uniform segmentation, viterbi training at speech.zone

# @todo, viterbi training?

$pwd

/home/joesmart/RESEARCHS/htkbook\_to\_c\_code/scripts

../../neural\_network\_shmm/htk\_35/HTKTools/HInit -T 3 -m 1 -M hinitoutput VOI arctic\_a0001.mfc

Initialising HMM VOI . . .

States : 2 3 4 (width)

Mixes s1: 1 1 1 ( 39 )

Num Using: 0 0 0

Parm Kind: MFCC\_D\_A\_Z\_0

Number of owners = 1

SegLab : NONE

maxIter : 20

epsilon : 0.000100

minSeg : 1

Updating : Means Variances MixWeights/DProbs TransProbs

- system is PLAIN

322 observations loaded from arctic\_a0001.mfc

1 Observation Sequences Loaded

Starting Estimation Process

Iteration 1: Average LogP =-29415.41797

Iteration 2: Average LogP =-29252.76953 Change = 162.64844

Iteration 3: Average LogP =-29247.36133 Change = 5.40820

Iteration 4: Average LogP =-29247.36133 Change = 0.00000

Estimation converged at iteration 5

Output written to directory hinitoutput

## arctic\_a0001.wav properties

Dump of "D:\RESEARCHS\htkbook\_to\_c\_code\scripts\arctic\_a0001.sfs" on Sat Mar 03 20:39:52 2018

Item 1

Data Type : 1.01 SPEECH

History : slink(file=d:/researchs/htkbook\_to\_c\_code/scripts/arctic\_a0001.wav,headerlen=44,start=0,end=51761,freq=16000,channels=1/1,dc=0,mult=0)

Parameters :

Process Date : Fri Mar 02 21:10:51 2018

Format : 2 byte integer

Frame size : 1 Frame count : 51761

Total Length : 512 Frame Duration : 6.25e-005 (16000 Hz)

Window size : 1 Overlap : 0

Offset : 0 Last Position : 0

Comment :

Linked item :

Filename : d:/researchs/htkbook\_to\_c\_code/scripts/arctic\_a0001.wav

Filepath :

Filetype : 0

Item no. : 0.00

Offset : 44

Multiplex : 0

Byte swap : no

DC offset : 0

Bit shift : 0

Date : Fri Mar 02 21:08:58 2018

lab\_match: out of date labels file 'C:\htk\SFS/data/labels'

file time=1513586305 internal time=1288920030

Total time = 51761 x 6.25e-6 = 3.24

## @todo 322 vs 434 observations

arctic\_a0001.wav

configcopy.txt;TARGETRATE =100 000 =1e5

target rate in s = 1e5x1e-7 = 1e-2 s=10 mili seconds;

jumlah frame = 3.24 s / 1e-2 = 3.24 x 1e2 = 324 obs – 2 (first and last ) = 322 obs.

2 observations is thrown out because of windowing …250

## @todo ron matlab/octave check … on Average LogP

### Debugging

Lunch matlab nodesktop, Using f12 and f5 from editor

Set breakpoint in main source (hello.m) before hit f5. Can’t only set break point in called m files. Matlab won’t stop, must set in MAIN source (hello.m) first, then use step in

F10 (step/next)

## @todo how htk count Average LogP

# journals

## 1990 juang rabiner

State transition probability:

# Installation setup

## Gdb

Remove -02 from

HTKtools/Makefile

HTKLib/Makefile

## Hinit Gdb from shell

Must tell gdb to directory search:

$pwd

/home/joesmart/RESEARCHS/htkbook\_to\_c\_code/scripts

./gdb.sh

In gdb prompt:

gdb>b main

gdb> r `cat arg.txt`

## Eclipse

### Use F3 to see implementation alt 🡨 and alt 🡪 to go back

### Eclipse cdt installed over eclipse

No debugger in eclipse indigo …

Sudo apt-get install eclipse-cdt

Now create project htk\_35

Debugger failed no HInit.c

Using eclipse only for editing … using gdb in bash for debugging …

## Octave and gnuplot installed, ron htk c downloaded

## Matlab r2015

~/ bin/matlab\_2015

Failed, segmentation fault core dumped

Using arg “-nodesktop”, ~/bin/matlab\_r2015 –nodesktop –nojvm

To able to use plot/figure , “remove -nojvm”, only use –nodesktop options …

We can still plot and edit source code. To edit matlab source code just type edit hinit\_arctic.m

### Segmentation fault in browser, doc

### Reading mfcc htkbook\_to\_c\_code/mscripts/hello.m

### Command line mode getplot ?

### Command line mode path

Use rmpath, addpath, path to remove, add, and show search path.

## Initial

3/2/2018 9:41:21 PM

htkbook\_to\_c\_code/scripts/all.sh

3/1/2018 10:13:29 PM  
Project dir. Created ~/RESEARCHS/htkbook\_to\_c\_code/  
HInit.c