Waveform Generation

From phones, durations, F0 to waveforms

Types of synthesis

- Articulartory: model the human vocal tract
- Formant: model the voice signal
- Concatenative: diphones, unit selection
- Statistical Parametric Synthesis
- Canned speech

Waveform generation

- Formant synthesis
- Random word/phrase concatenation
- Phone concatenation
- Diphone concatenation
- Sub-word unit selection
- Cluster based unit selection
- Clustergen SPS synthesis

Concatenative synthesis

- ☐ Select appropriate speech unit
- ☐ Impose desired prosody
- ☐ Reconstruct signal from modifed parts

Quality is usually good, but less flexible than formant or articulatory.

Diphone synthesis

- mid-phone is more stable than edge
- Need phone^2 number of units:
  - some combinations don't exist (hopefully)
  - may include stress, consonant clusters
  - lots of phonetic knowledge in design
- Database relatively small (by today's standards)
  - around 8 meg for English (16KHz 16bit)

Designing a diphone inventory

Nonsense words

- Build set of carrier words:
  - pau t aa b aa b aa pau
  - pau t aa m aa m aa pau
  - pau t aa m iy m aa pau
  - pau t aa m ih m aa pau
- Advantages:
  - easy to get all diphones
  - will be pronounced consistently
  - (no lexical interferance)
- Disadvantages:
  - (possibly) bigger db
  - will be pronounced consistently
  - (speaker becomes bored)

As we will be randomly joining these units consistency is probably key

Designing a diphone inventory

Natural words

- Greedily select sentences/words:
  - quebecois arguments (19)
  - brouhaha abstractions (18)
  - arkansas arranging (11)
- Advantages:
  - will be pronounced naturally
  - easier for speaker to pronounce
  - smaller db ? (505 pairs vs 1345 words)
- Disadvantages:
  - will be pronounced naturally
  - may not be pronounced correctly

Diphone distribution in natural text is very variable

Making recordings consistent

Natural words

- ☐ Diphone should come from mid-word
  - – help ensure full articulation
- ☐ Performed consistently
  - – constant pitch, power, duration
- ☐ Use (synthesized) prompts:
  - – help avoid pronunciation problems
  - – keep speaker consistent
  - – used for alignment in labelling

Building diphone schema

- Find list of phones in language:
  - plus interesting allophones
  - stress, tones, clusters, onset/coda etc
  - foreign (rare) phones,
- Build carriers for:
  - consonant-vowel, vowel-consonant,
  - vowel-vowel, consonant-consonant,
  - silence-phone, phone-silence,
  - other special cases
- Check the output:
  - list *all* diphones and justify missing ones
  - *every* diphone list has mistakes

Recording conditions

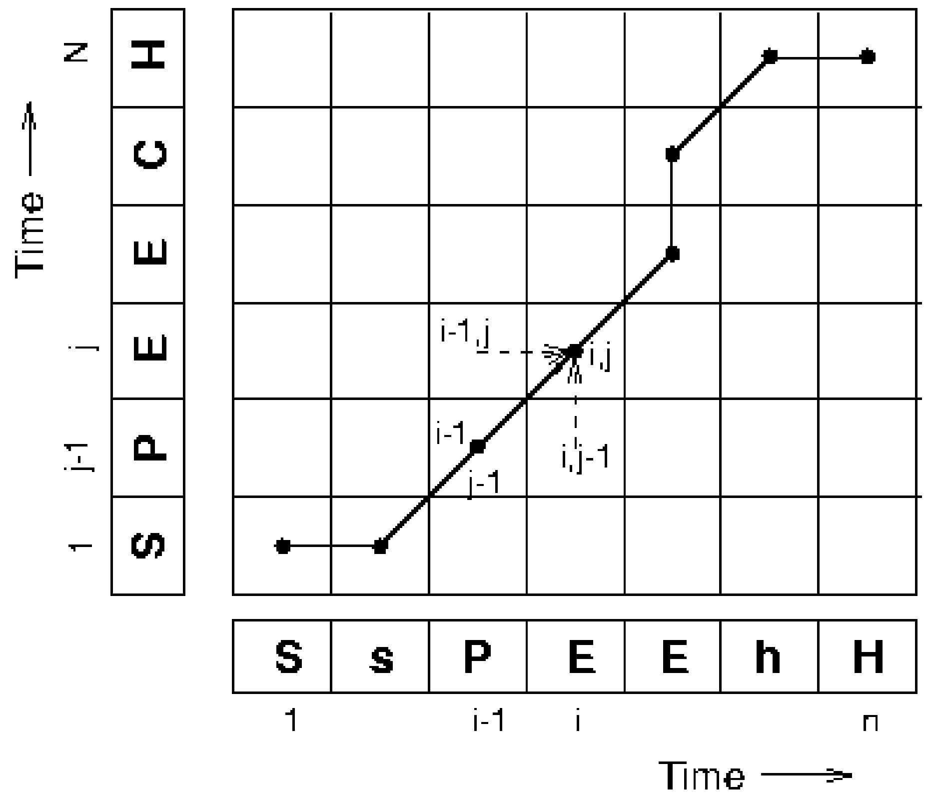
- Ideal:
  - anechoic chamber
  - studio quality recording
  - EGG signal
- What we put up with:
  - quiet room
  - cheap microphone/sound blaster
  - no EGG
  - headmounted microphone
- What we can do
  - repeatable conditions
  - careful setting on audio levels

Labelling Diphones

- *Much* easier than phonetic labelling:
  - the phone sequence is defined
  - they are clearly articulated
  - if its wrong, its wrong
- Phone boundaries less important
  - +/- 10ms is okay.
- Midphone boundaries important
  - where is the stable part
  - can it be automatically found

Dynamic Time Warping

Find shortest euclidean distance through table



Simple autoalignment

Much easier than full autolabelling

- ☐ Synthesizer phone string
- ☐ Time align prompt to spoken form
  - using euclidean distance
- ☐ Works very well 95%+
  - errors are typically large (easy to fix)
  - maybe even automatically detected
- ☐ This works cross-language too:
  - even when phones don't exist
  - e.g. English prompts with Korean spoken form

Malfrere and Dutoit 97

Diphone alignment

Does it work?

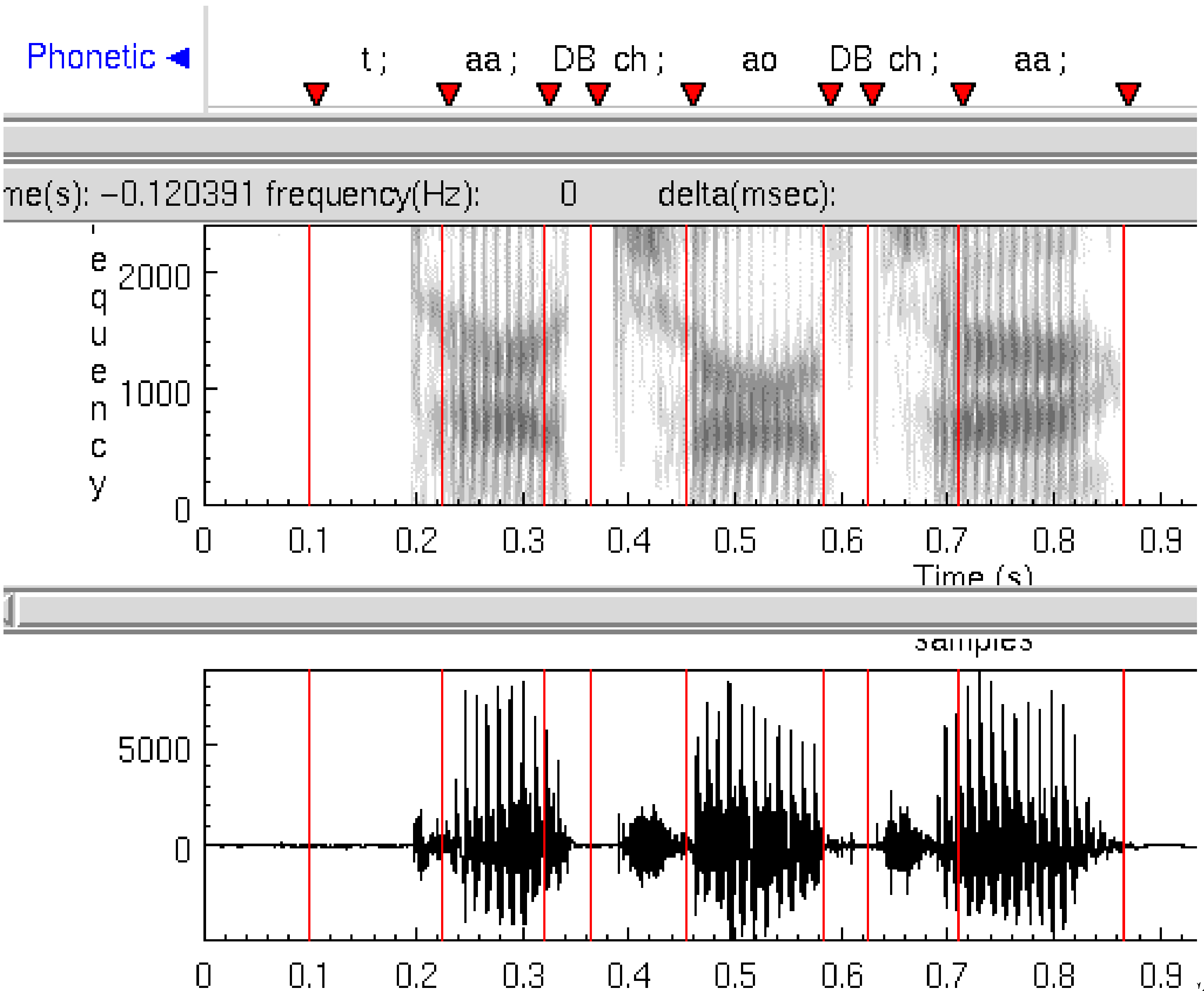
- DP align MFCC prompt to spoken word
- test against hand labelled

	type	RMSE	stddev
KED-KED	self	14.77ms	17.08
MWM-KED	US-US	27.23ms	28.95
GSW-KED	UK-US	25.25ms	23.92
KED-WHY	US-Kor	28.34ms	27.52

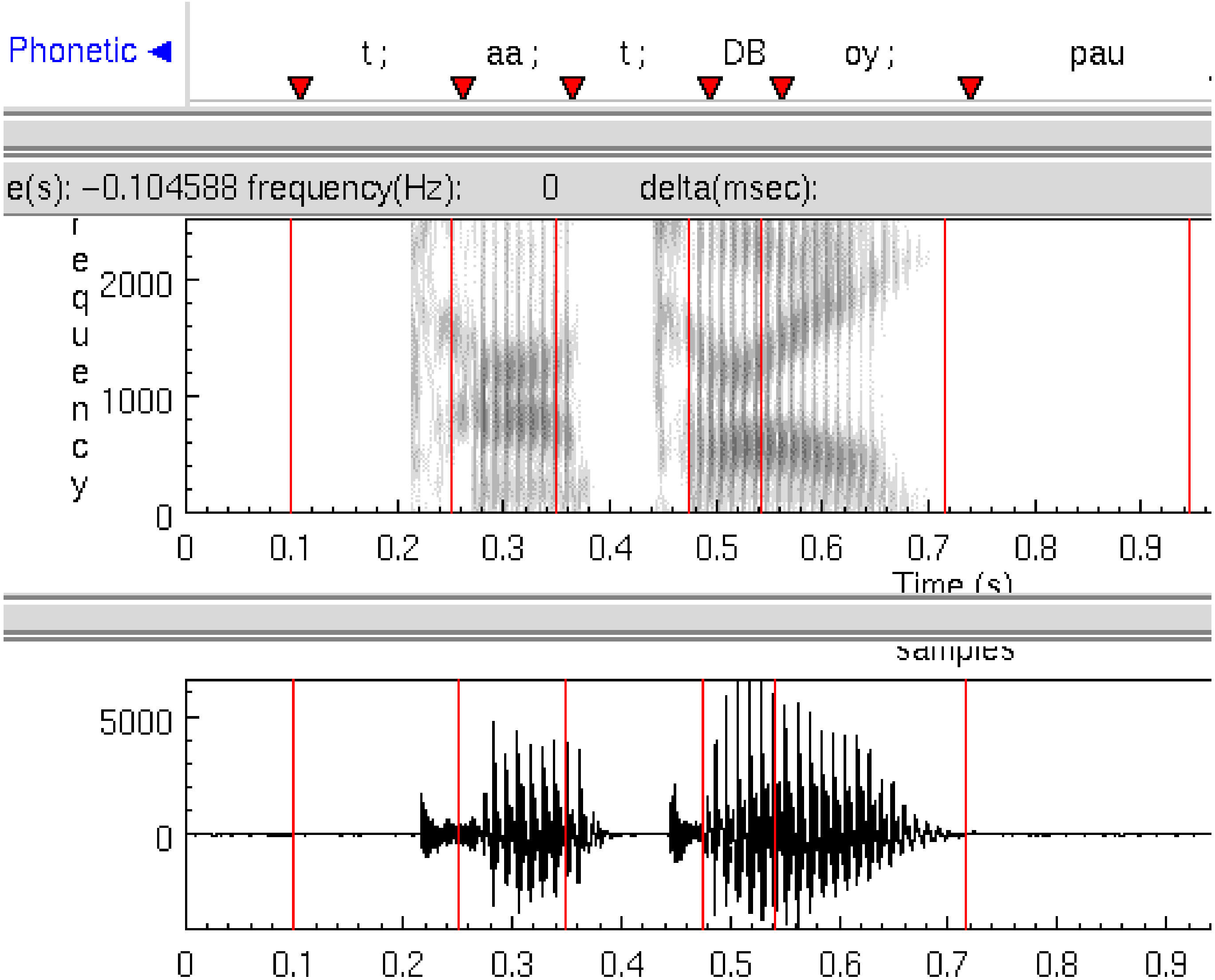
Stable part in phones

- Middle of phone:
  - one third in for stops
  - one quarter in for phone-silence
  - half way for rest
- In time alignment case:
  - Add explicit diphone boundaries
  - (only need to hand correct once)
- Optimal coupling (Conkie and Isard 96)
  - automatically find them
  - using Euclidean distance of cepstrum
  - find minimum join point over all phone-phone
  - or find best for each phone-phone
- Hand check each one:
  - what "real" companies do

Diphone boundaries in stops



Diphone boundaries at end phones



Autolabelling vs Hand labelling

Recorded KAL (US male)

- around 15-20 examples *wrong* (KED-KAL)
- As good as first pass by human labellers
- 45 mins vs 2 weeks hand labelling
- Whole voice in under 2 days
  - recording 3-4 hours
  - pitch mark extraction 3 hours
  - alignment 1 hour
  - hand correction and tuning (3 hours)