ELEN E6820:

Speech and Audio Processing and Recognition:

Selected highlights

Columbia University Dept. of Electrical Engineering
Spring 2001

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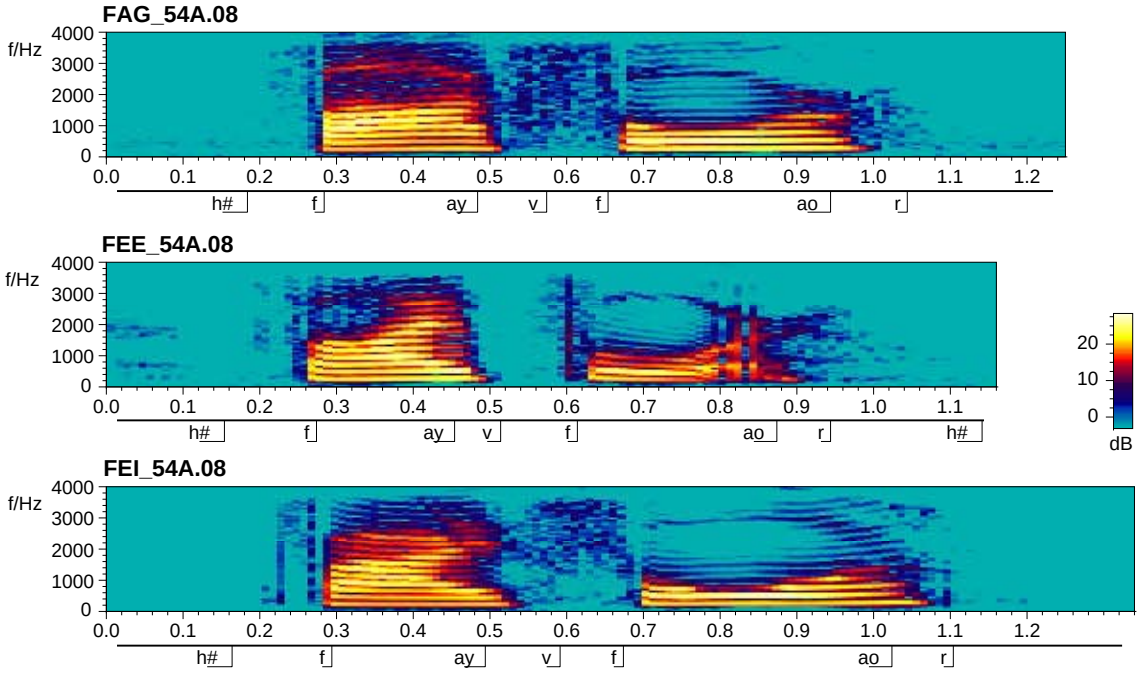
Web site:
http://www.ee.columbia.edu/~dpwe/courses/e6820-2001-01

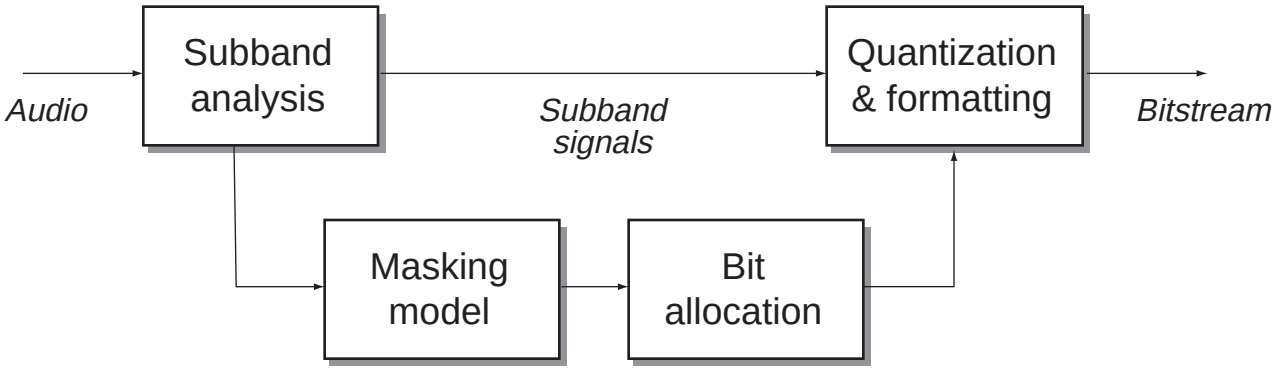
Some aspects of the speech signal

- **Speech is highly redundant**
  - intelligible despite large distortions
  - multiple cues for each phoneme
- **Speech is very variable**
  - redundancy leaves room for variability
  - speakers can use different subsets of cues



Psychoacoustic-based audio compression

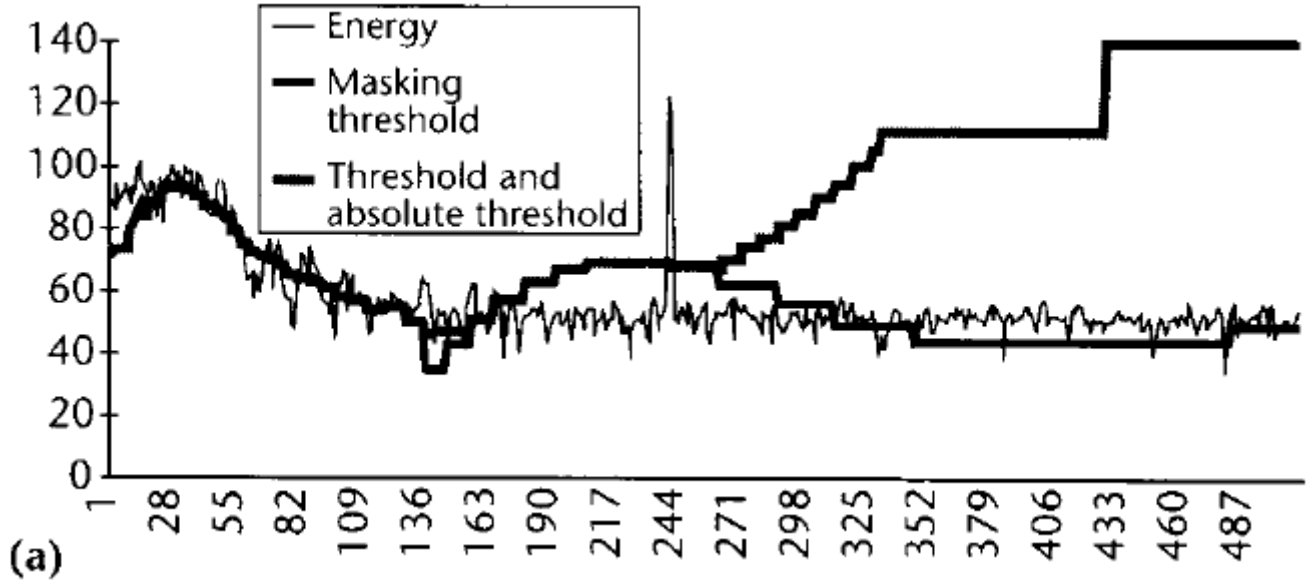
- **Exemplified by MPEG-Audio layer 3 ('MP3')**



→ **From CD rate (1.4 Mbps) to 128 kbps or less (< 1.5 bits/sample)**

Psychoacoustic masking model

- **Based on extensive experiments**



- **Put noise where it can't be heard**

Automatic Speech Recognition (ASR)

- **Observations $X = \{X_1..X_N\} \rightarrow$ States $S = \{S_1..S_N\}$**

$$S^* = \operatorname{argmax}_S P(S|X)$$

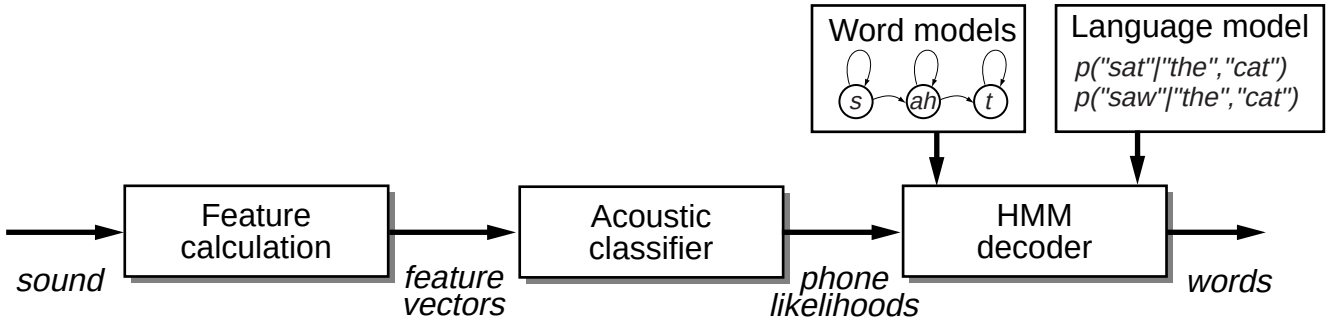
$$= \operatorname{argmax}_S \frac{P(S, X)}{P(X)}$$

Markov assumption

$$= \operatorname{argmax}_S \prod_i P(X_i|S_i) \cdot P(S_i|S_{i-1})$$

acoustic prob. **transition prob.**

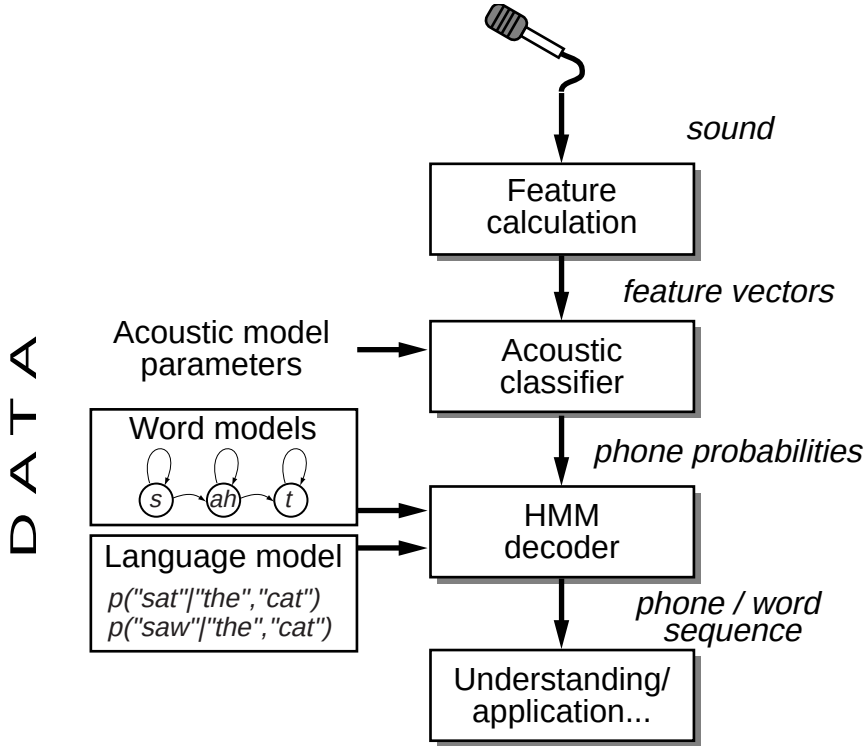
- **State sequence $\{S_i\}$ (e.g. phones) define words**

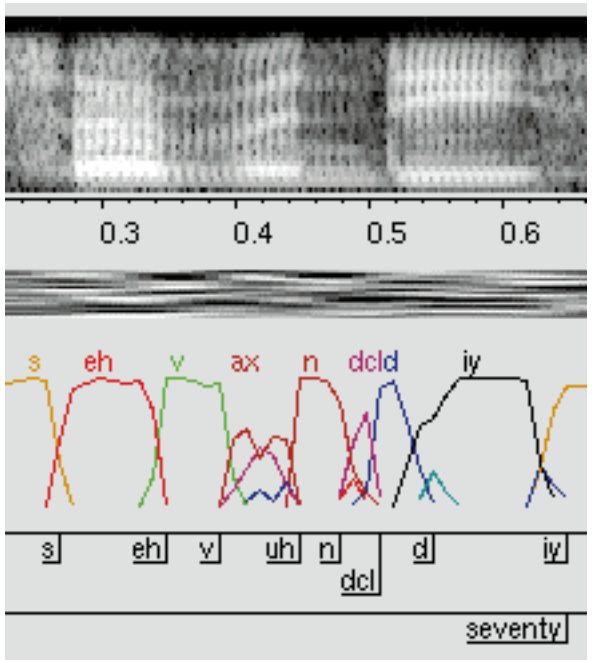


- **Training (on large datasets) is the key**
  - EM iteration for acoustic & transition probs.

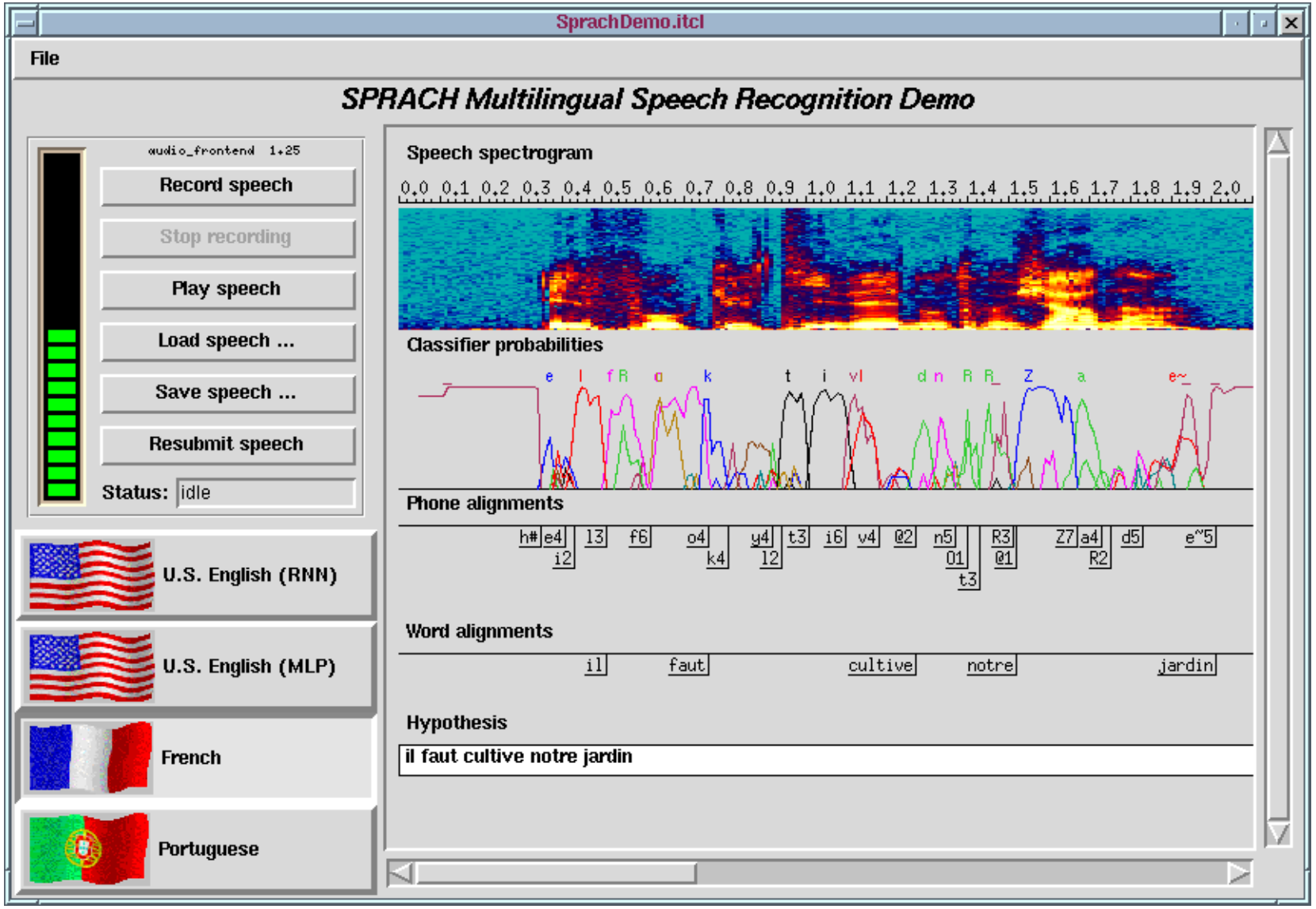
ASR visualization

- **Standard speech recognition structure:**



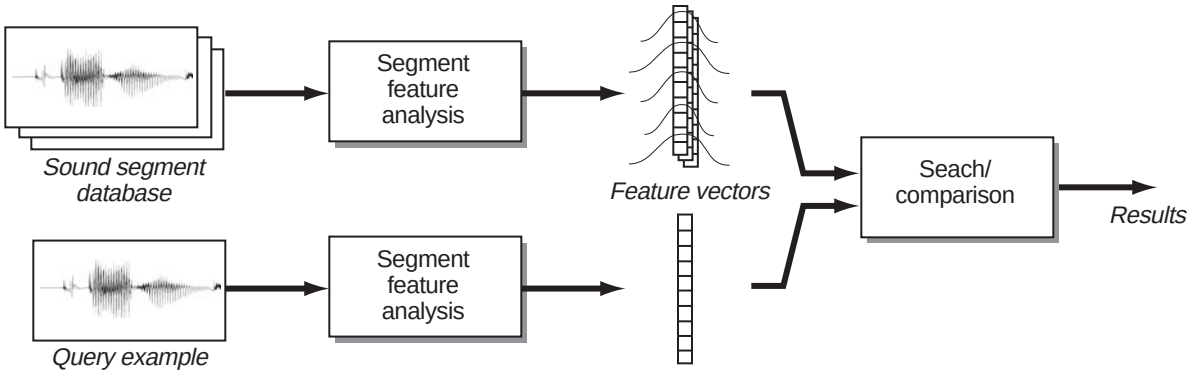


- **'State of the art' word-error rates (WERs):**
  - 2% (dictation) - 30% (telephone conversations)


SprachDemo.itcl
File
SPRACH Multilingual Speech Recognition Demo
audio_frontend 1.25
Record speech
Stop recording
Play speech
Load speech ...
Save speech ...
Resubmit speech
Status: idle
U.S. English (RNN)
U.S. English (MLP)
French
Portuguese
Speech spectrogram
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9 2.0
Classifier probabilities
Phone alignments
Word alignments
il
faut
cultive
notre
jardin
Hypothesis
il faut cultive notre jardin

Element-based audio indexing

- **Search for nonspeech audio databases**
  - e.g. Muscle Fish 'SoundFisher' for SFX libraries
- **Segment-level features**



  - well-performing features: spectral centroid, dynamics, tonality ...
- **Each segment is an object**
  - not applicable to continuous recordings

Audio index features
(Musclefish)

- **Basic features**
  - duration
  - pitch
  - loudness
- **'Timbre' features**
  - brightness
  - cepstra
  - deltas
- **Music-oriented features**
  - rhythm
  - (note) events
  - instruments