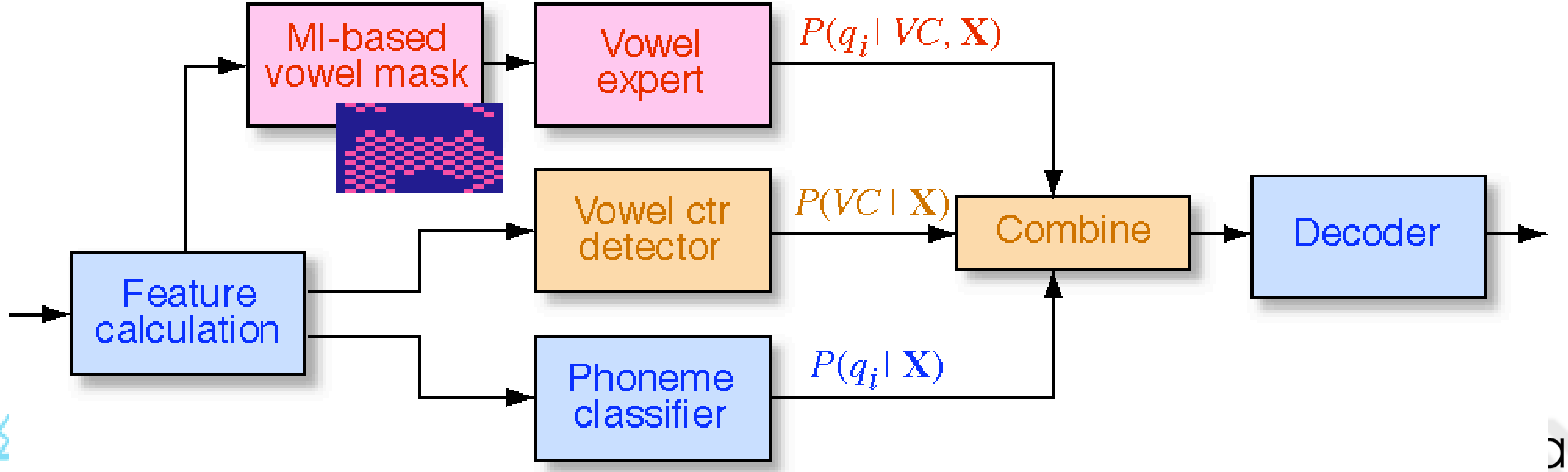
Columbia: Recent + Future

- More information
  - FDLP / PLP2 features
- Better classifiers
  - MI-based broad-class experts
- Reducing variability
  - Temporal variation
  - Formant “automatic gain control” (AGC)
- Signal model
  - “Deformable spectrograms”

Broad-Class Experts

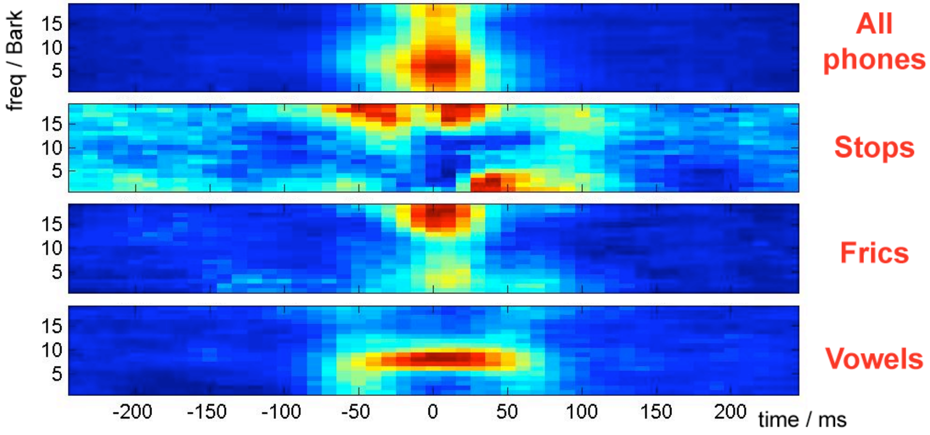
Patricia Scanlon

- MI-based feature masks make superior class-specific classifiers (vowels, stops...)
  - smaller models: good for data-limited case
- Apply to ASR by 'patching in' probabilities via separate broad-class center detector

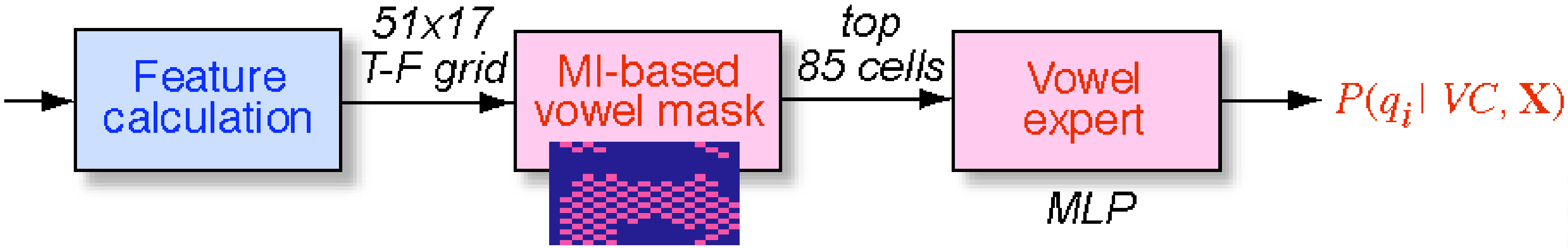


MI-Based Class Experts

- Idea: Different speech sounds have different information distribution
  - .. as identified by MI to phone | class

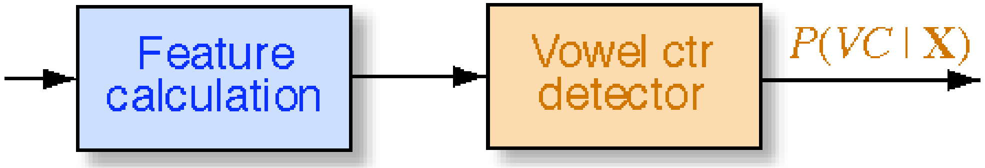


- Good for reducing model complexity
  - benefits disappear given enough data
- Not measuring joint MI
  - quick hack: checkerboard



Broad-Class Detector

- Expert gives Pr(phone | class, features)
  - still need Pr(class | features)
- Repeat same approach
  - separate detectors for each broad class
  - measure MI from TF cell to class
  - train MLP from those features
- False accept/false detect tradeoff
  - try to detect only center of phone
  - reasonable vowel recognition with 10% insertions (6.3% deletions) of centers

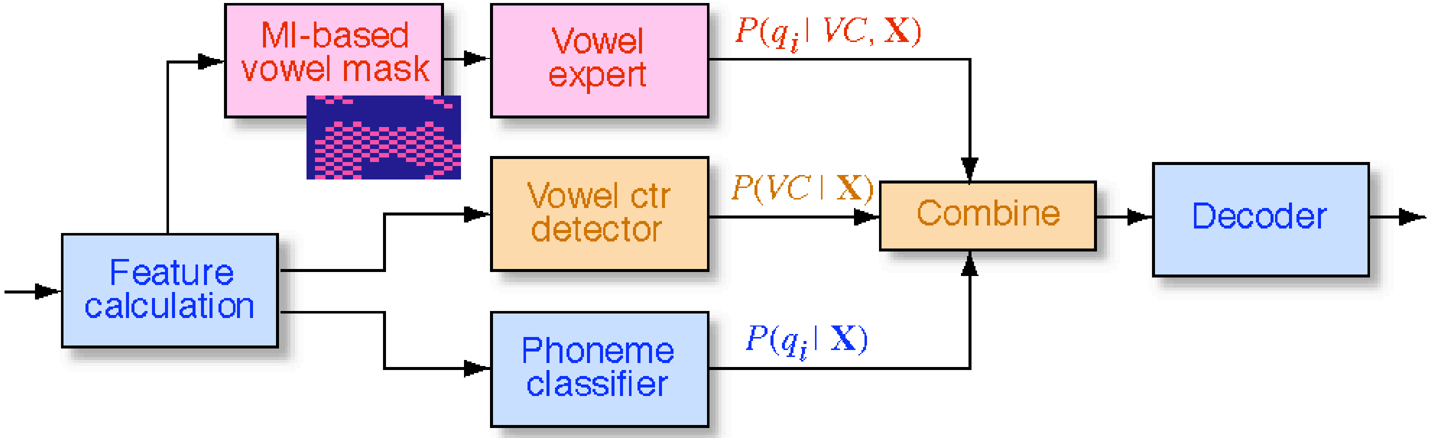


Overall System

- 'Patch in' expert's posteriors:

$$P(q_i|X) = \sum_{class} P(q_i|class, X) \cdot P(class|X)$$

  - 'non-expert' MLP for when $P(class|X)$ are small



TIMIT phone err rate

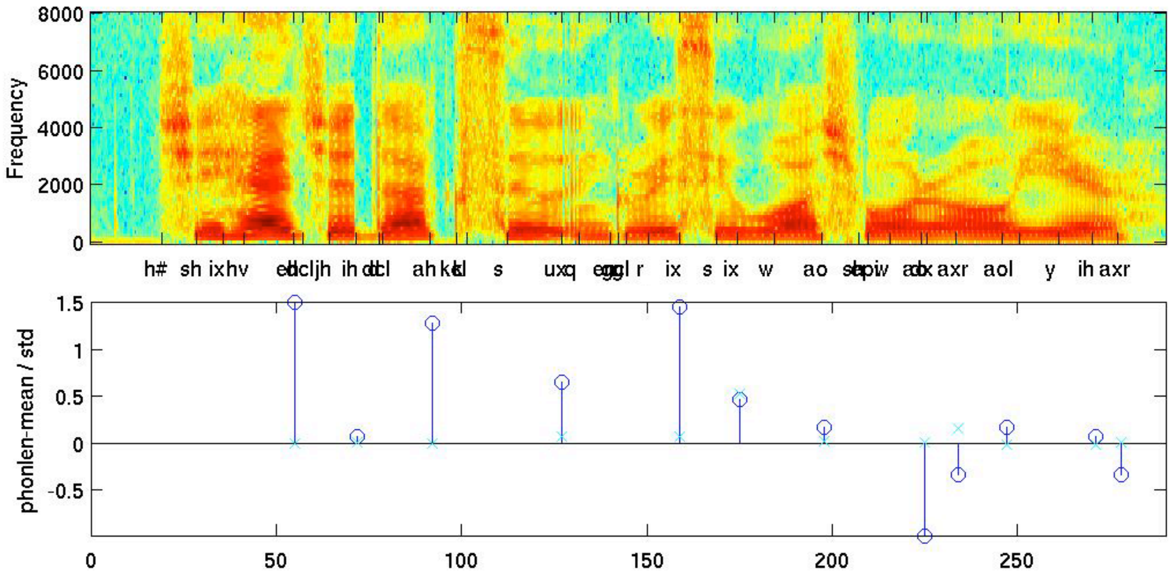
Baseline:	28.4%
Oracle P(VC):	26.9%
Real P(VC):	28.0%
Vowels+Frics:	27.6%

- Still looking at:
  - using more experts
  - better $P(class|X)$

Temporal Variation

Sambarta Bhattacharjee
Banky Omodunbi

- Idea:
  Normalize phone durations by averages
  - .. to reveal per-speaker bias
  - .. and timing variation within phrases
- Focus on vowels
  - per-phone deviations are very noisy

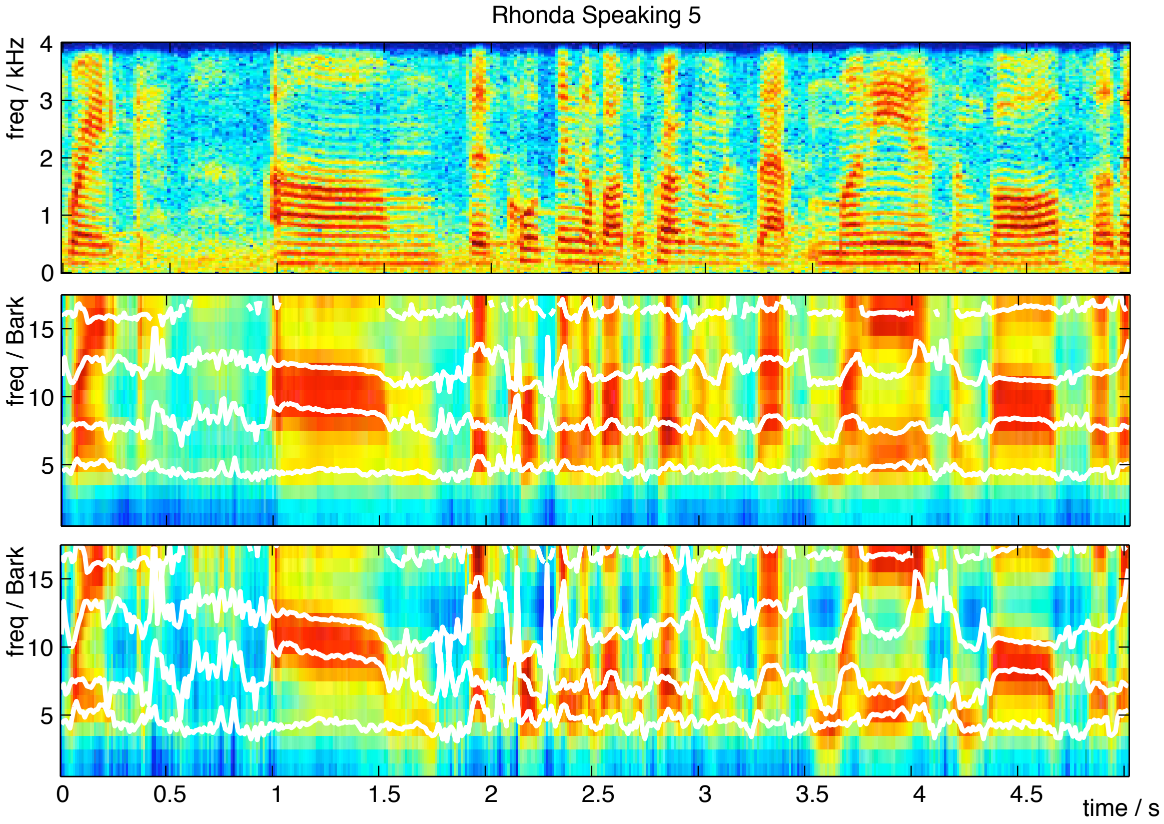


- Use to vary sampling/modeling?

Formant AGC

Eric Fuller
Sambarta Bhattacharjee

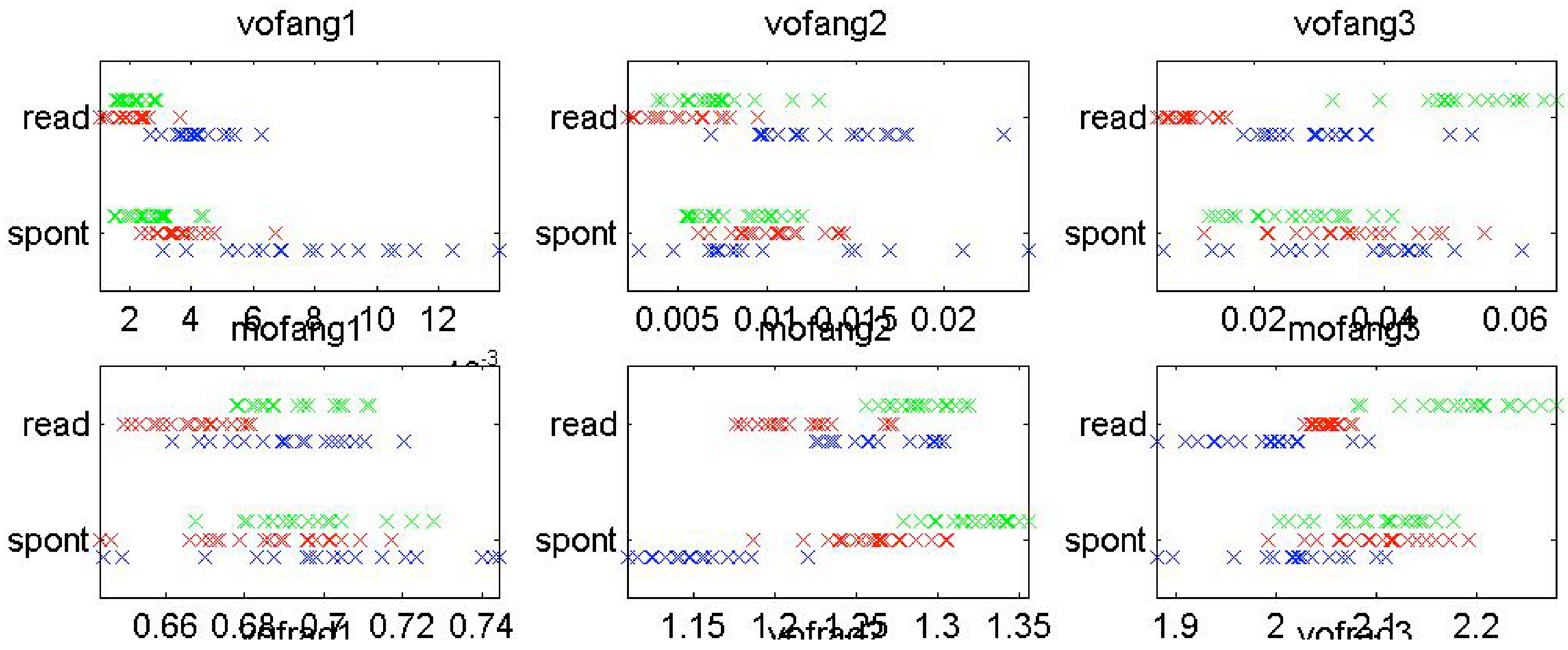
- **Hypothesis:**
  Casual speech has 'compressed' formant motion
  - can we 'enhance' format motions
    to make speech more canonical / read-like?



Lab ROSA
Laboratory for the Recognition and Organization of Speech and Audio

Read vs. Spontaneous

- Speaker-dependent means, vars of PLP pole locations in read vs. spontaneous speech

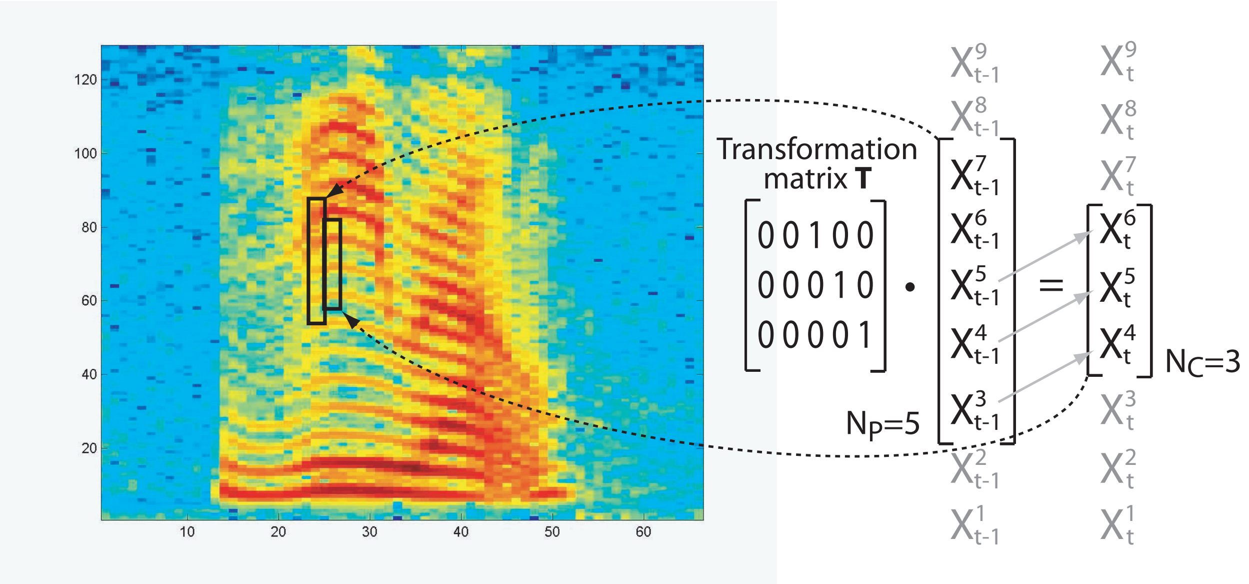


  - variance of angle of pole 3 discriminates well for red and green speakers - but opposite changes!

Deformable Spectra

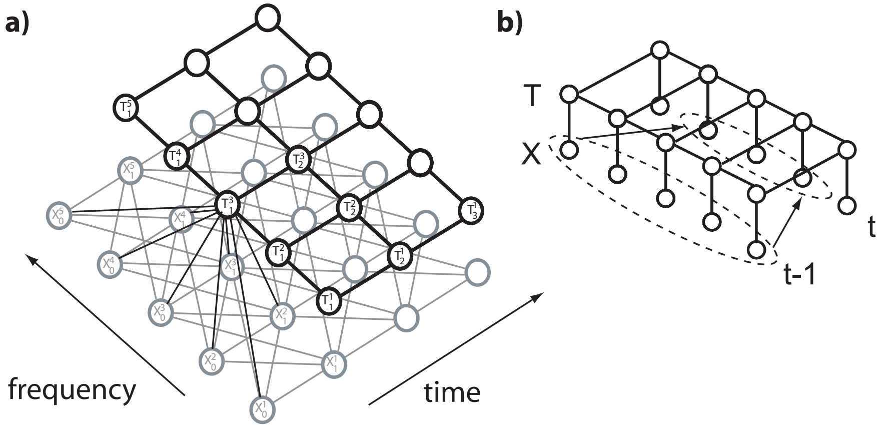
Nebojsa Jojic (MSR)
Manuel Reyes

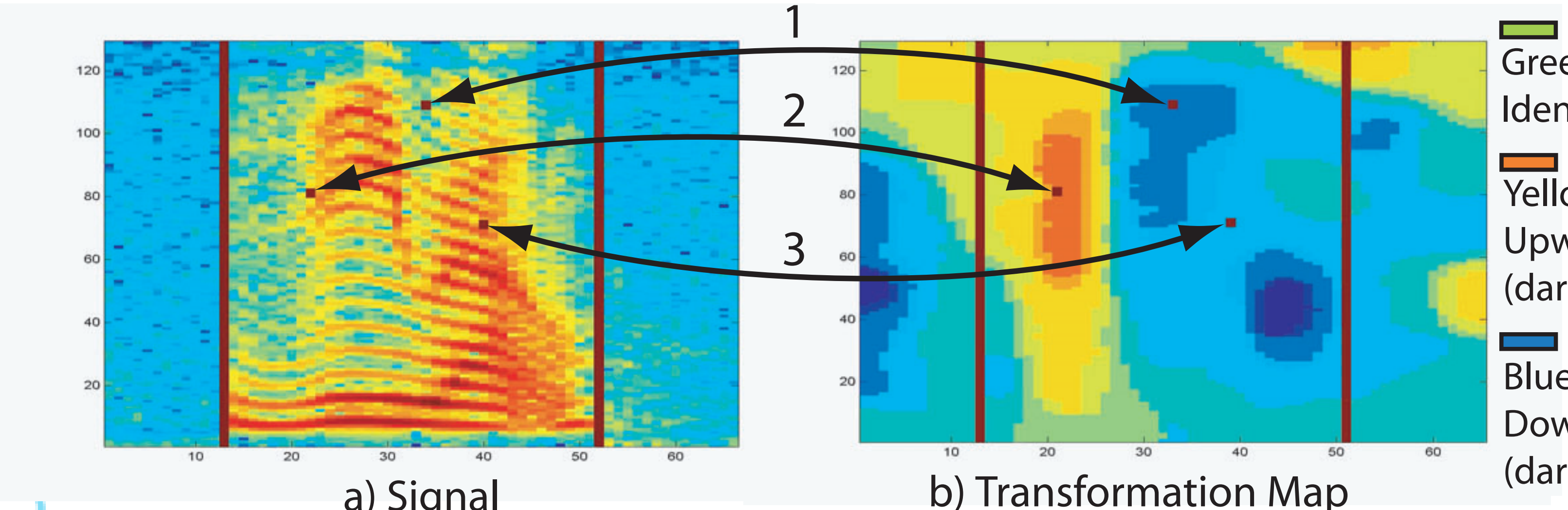
- Accurate spectral modeling in conventional HMMs requires 1000s of states
  - cumbersome, especially transition matrices
- Observation:
  Speech spectra undergo minor deformations
  - suggests a different generative model:



States+Transformation Model

- Time-frequency state grid
- State →
  - explicit prototype
  - or a transformation on prior frame
- Infer underlying states





a) Signal

b) Transformation Map

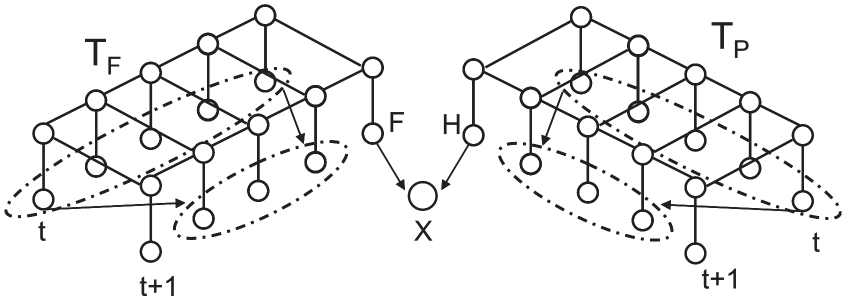
🟩 Green:
Identity transform

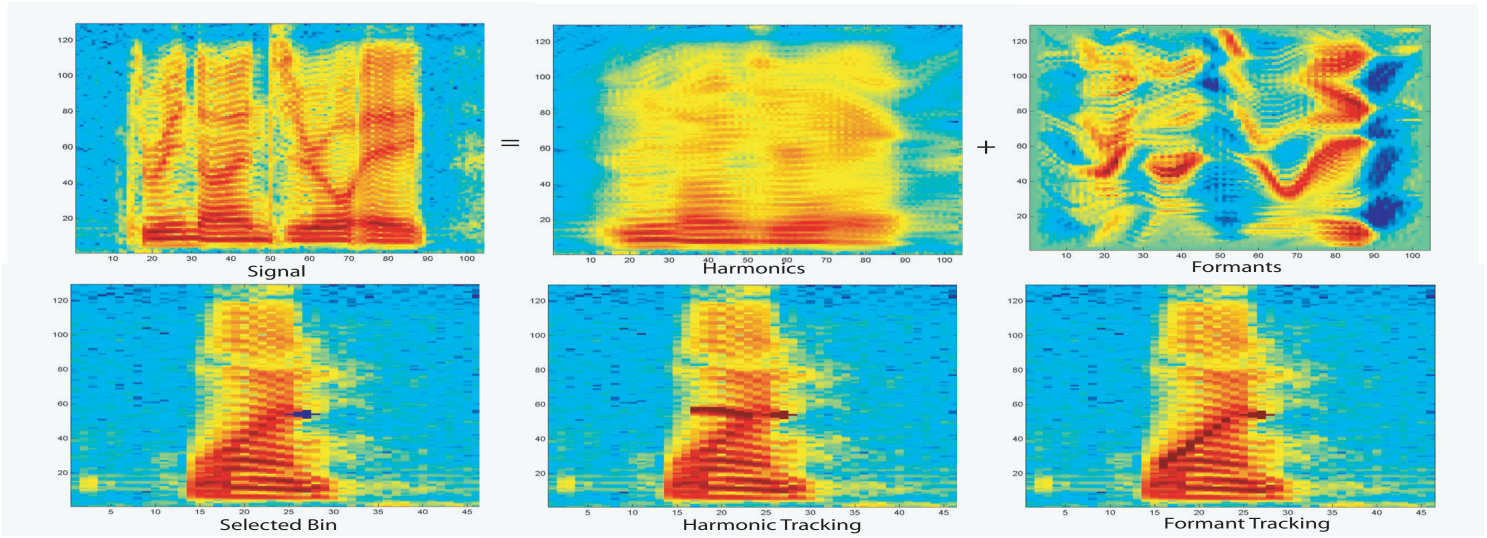
🟧 Yellow/Orange:
Upward motion
(darker is steeper)

🟦 Blue:
Downward motion
(darker is steeper)

Two-layer model

- **Source-filter decomposition**
  - pitch and formants have different dynamics
- **Apply transformation models for both**
  - log-spectra:
    sum of excitation & filter
  - inference does separation


T_F
F
H
T_P
X
t
t+1
t+1
t


Signal
=
Harmonics
Formants
Selected Bin
Harmonic Tracking
Formant Tracking