Nasal spectra for Forensic Voice Comparison

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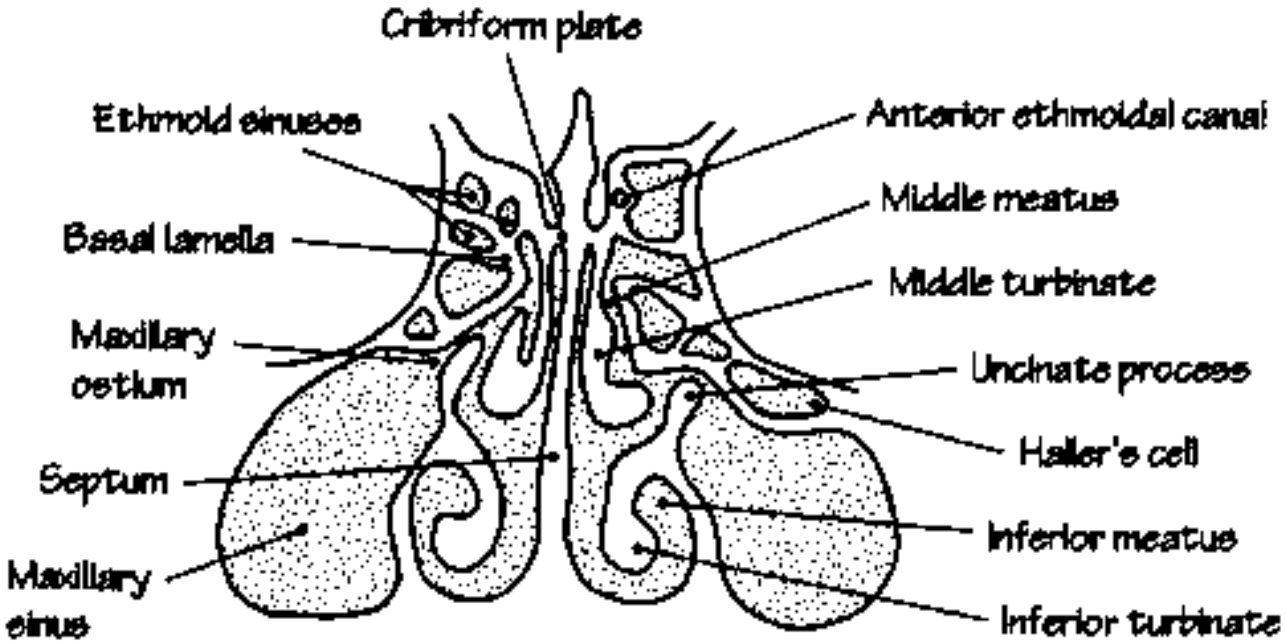
Why nasal consonants for FVC?

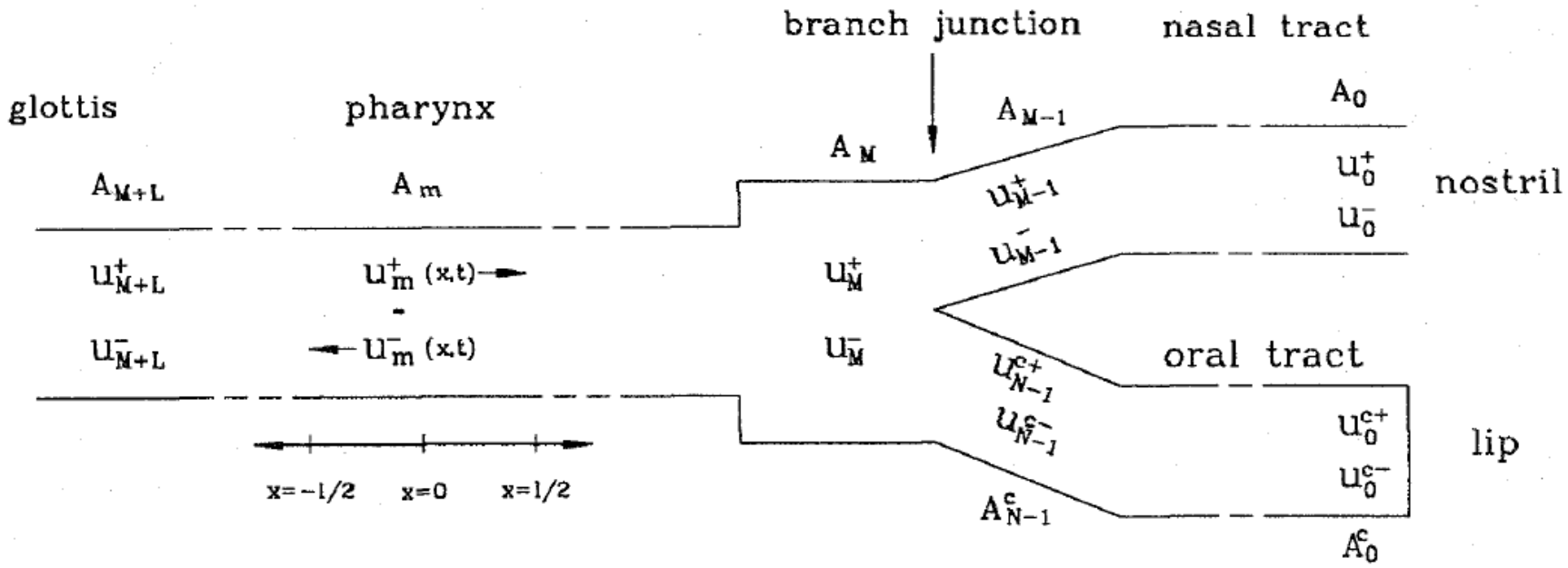
- Relatively fixed nasal and paranasal cavities
  ➡ potentially low within-speaker variability
- Complicated structure of nasal cavity
- Asymmetries in paranasal cavities (sinuses)
  ➡ potentially high between-speaker variability



(Stevens, 1999, p.19)

Representations of nasals

- Branch in oral and nasal cavity as well as sinuses cause zeros

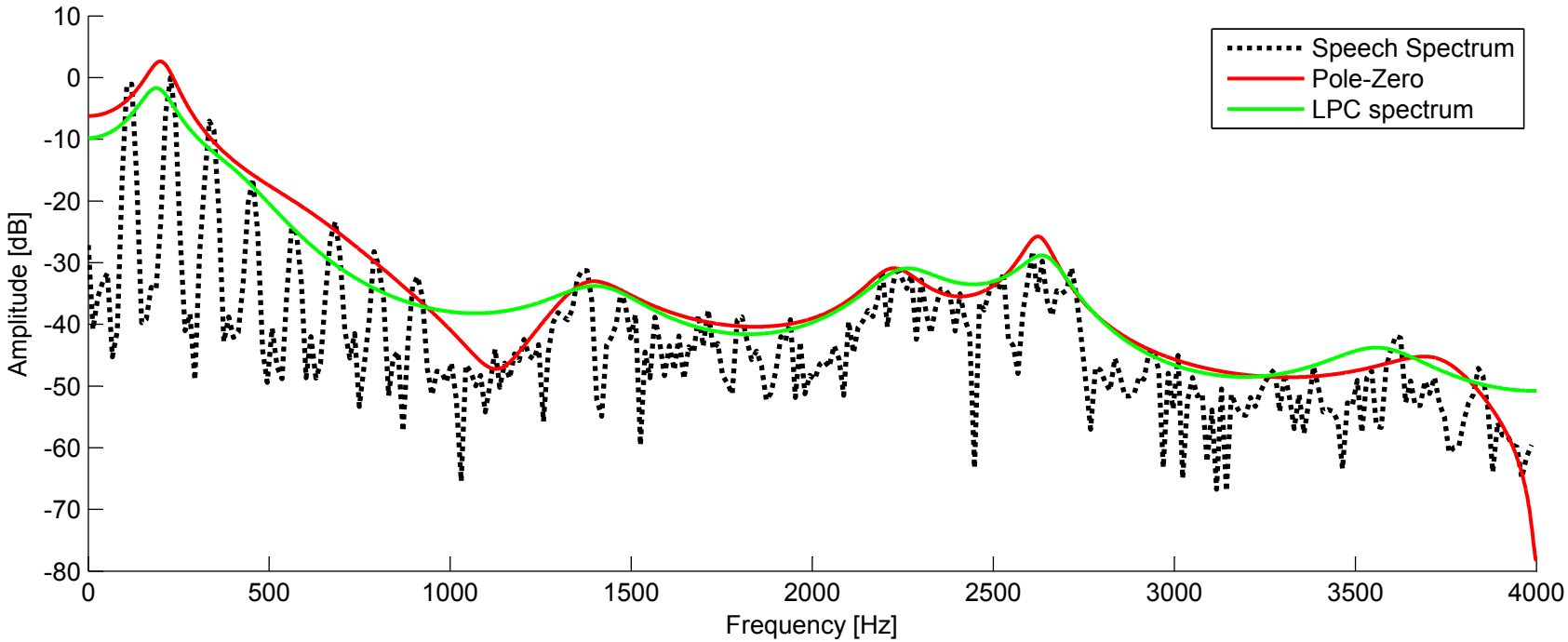


(Lim & Lee, 1996)

Representations of nasals

- Transfer function is adequately represented by a Pole-Zero model

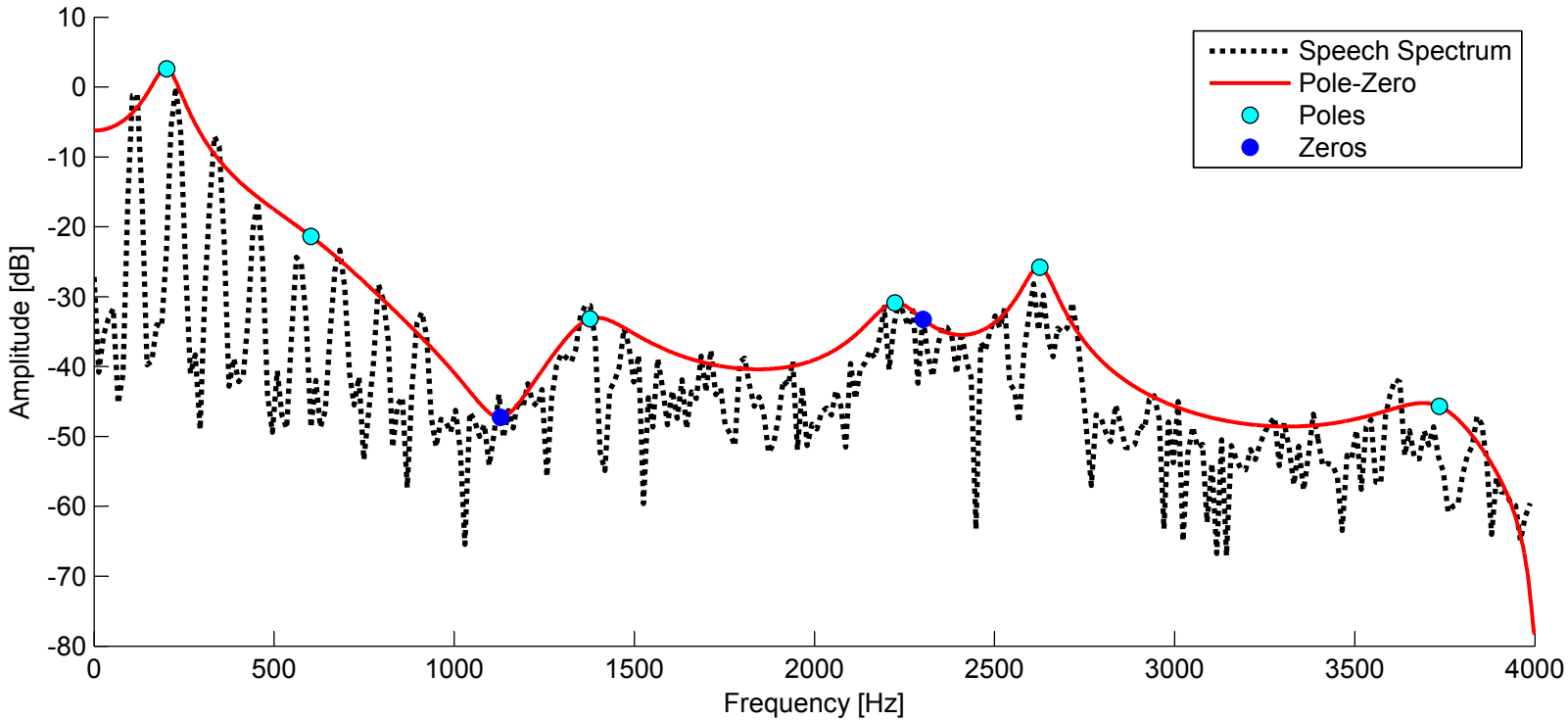
$$G(z,\theta) = \frac{B(z,\theta)}{A(z,\theta)} = \frac{\sum_{l=0}^{n} b_l z^{-l}}{\sum_{l=0}^{m} a_l z^{-l}}$$



Representations of nasals

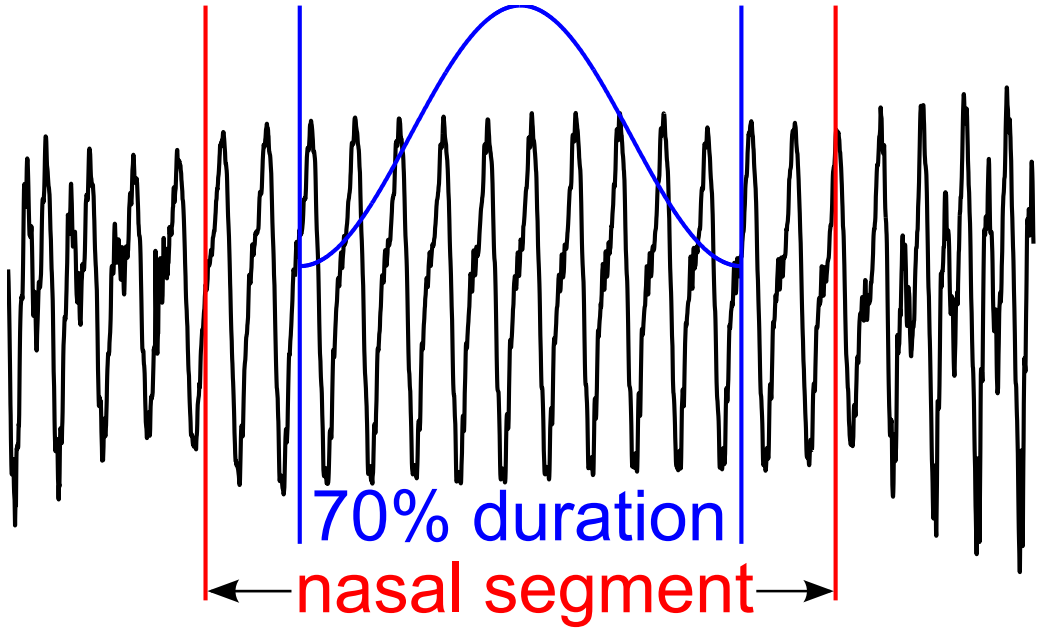
- Cepstral features
  - Mel-frequency cepstral coefficients (MFCCs)
  - Linear Prediction cepstral coefficients (LPCC)
  - Pole/Zero cepstral coefficients (PZCC)
- Angular positions of roots of numerator/denominator polynomials

(Enzinger et al., 2011, Enzinger & Balazs, 2011)



Representations of nasals

- Unsupervised (automatic) feature extraction
- Features obtained from window of 70% segment duration



Likelihood ratio calculation

- Multi-variate kernel density (Aitken & Lucy, 2004)
- Logistic-regression calibration and fusion
- MFCC-based GMM-UBM system
  ➡ Entire speech-active portion of recording

Data

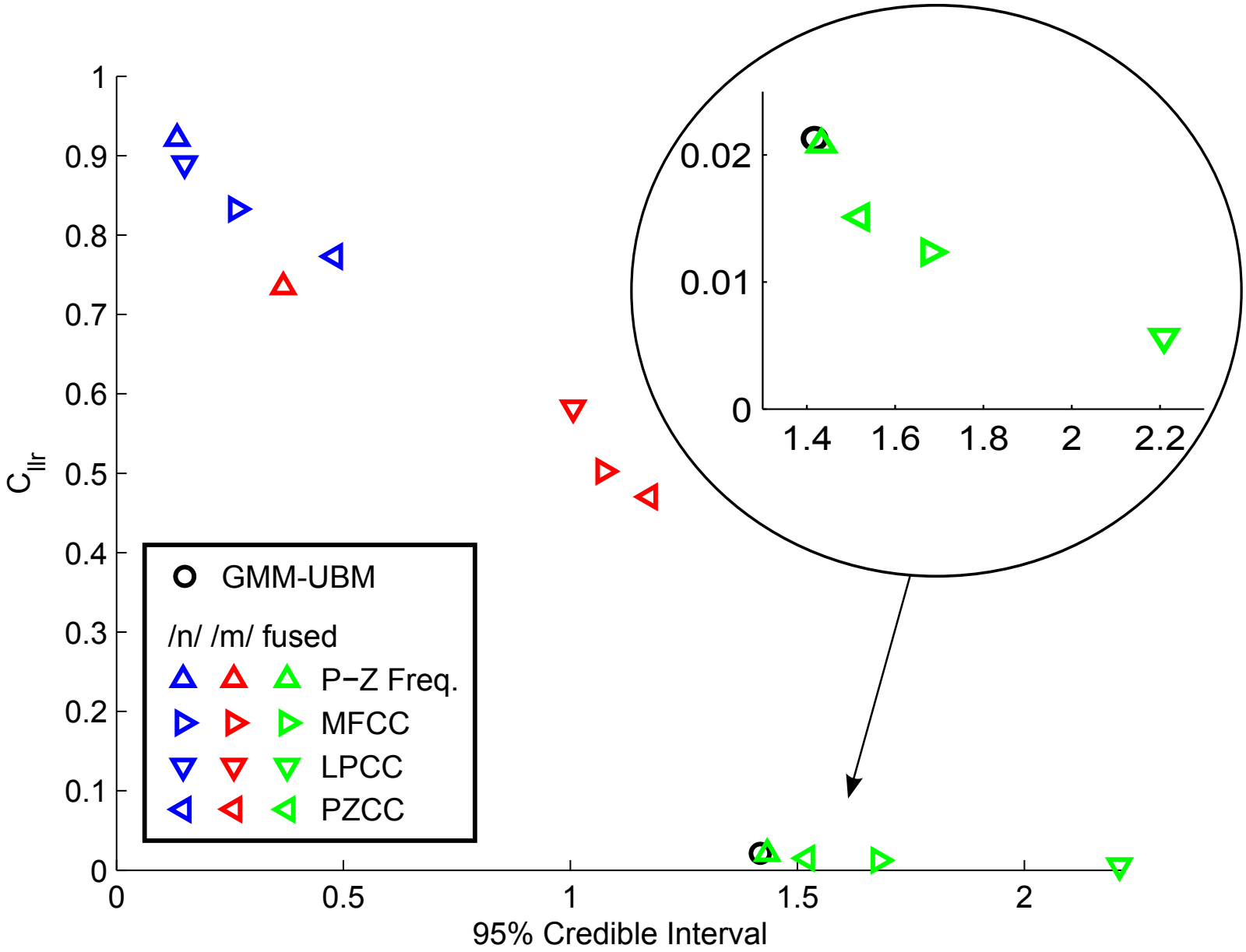
- 60 female Standard Chinese speakers
- Split into 3 groups of 20 speakers
  - background database
  - development set
  - evaluation set
- Information-exchange task over the telephone
- Two recording sessions separated by 2–3 weeks
- High quality data
- /n/ and /m/ tokens analyzed

`http://databases.forensic-voice-comparison.net/`

Evaluation measures

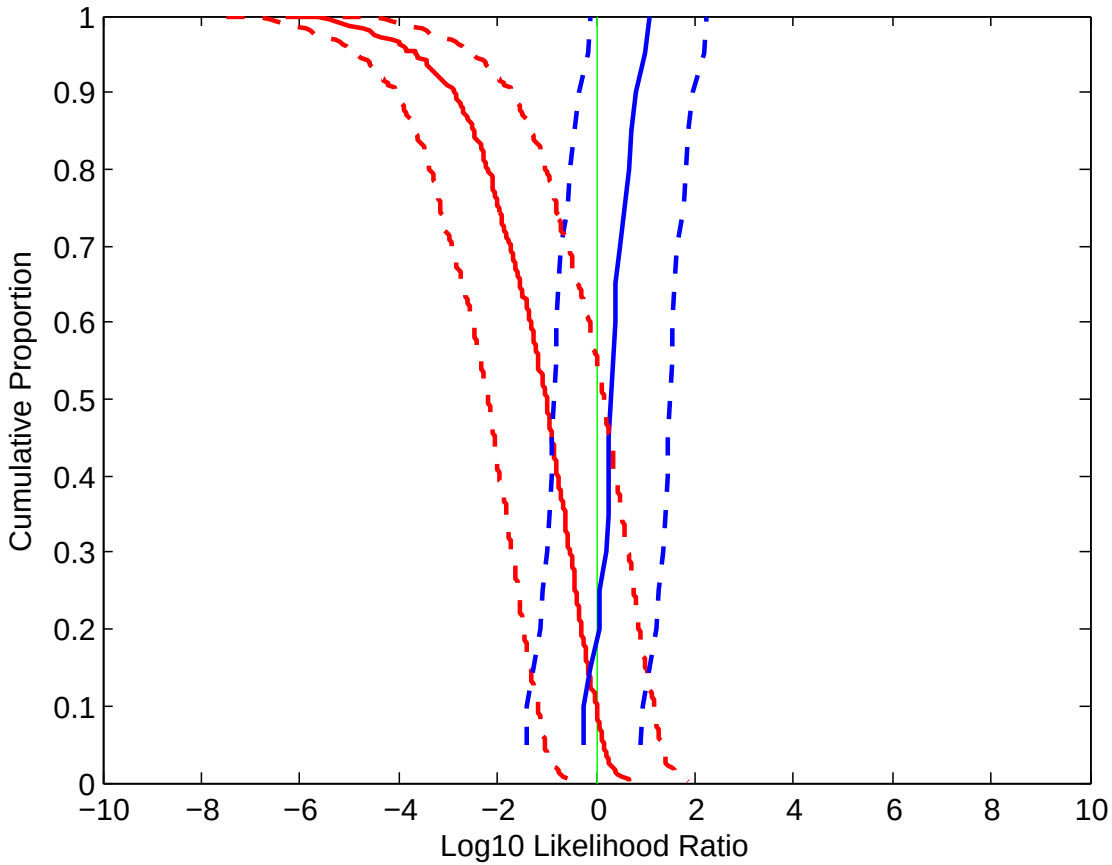
- Validity / Accuracy
  - Log-likelihood ratio cost (C_{llr}) metric
- Reliability / Precision
  - 95% credible interval (Morrison, 2011)
  - Parametric estimation method

Results


1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
C_{llr}
0
0.5
1
1.5
2
95% Credible Interval
GMM-UBM
/n/ /m/ fused
P−Z Freq.
MFCC
LPCC
PZCC
0.02
0.01
0
1.4
1.6
1.8
2
2.2

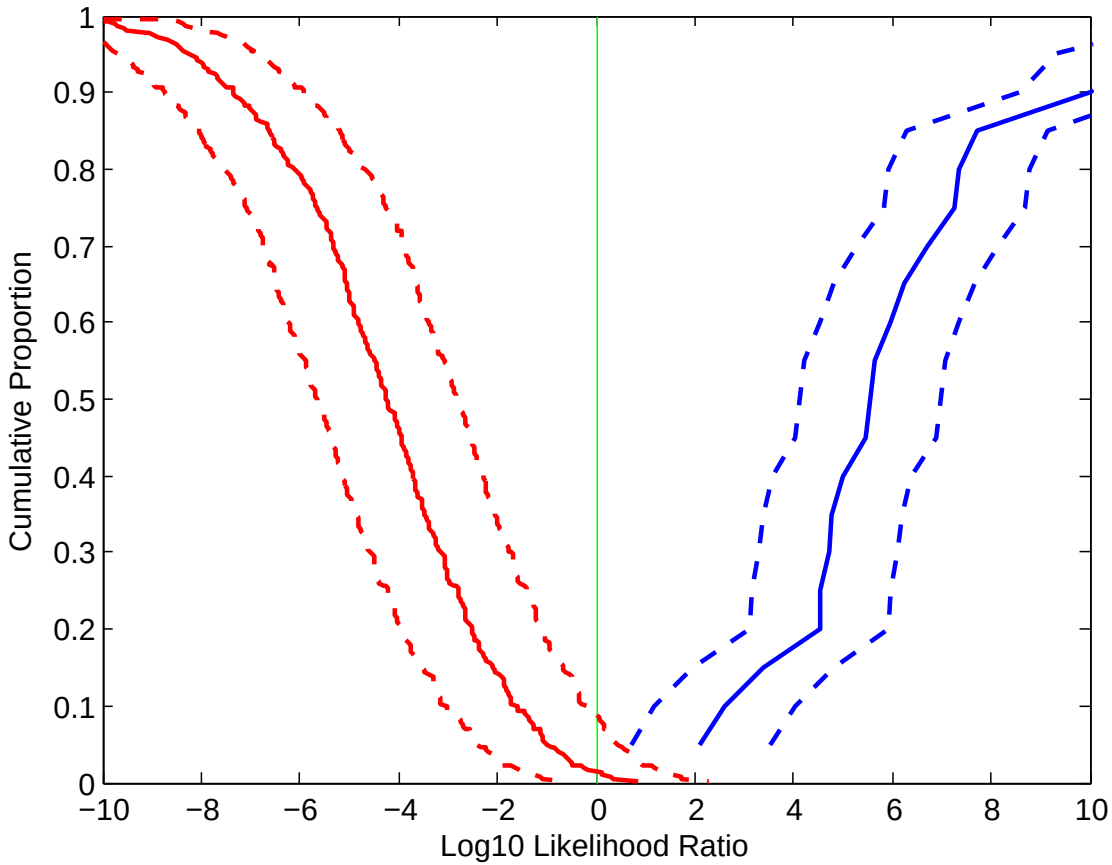
Results

PZCC /m/



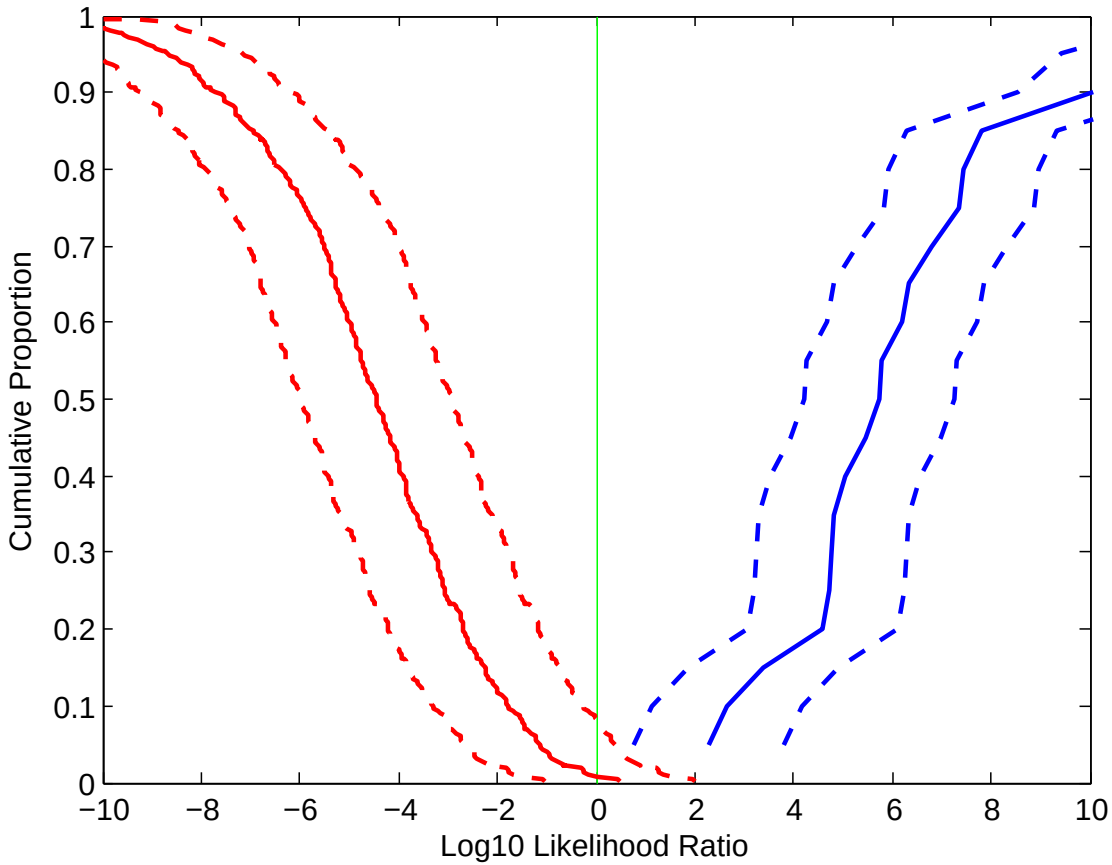
Results

Baseline GMM-UBM



Results

Baseline GMM-UBM + PZCC /m/



Conclusion

Pole/Zero features for nasals

- Theoretically well motivated
- Poor performance of /n/ compared to /m/
  - Low number of tokens per speaker
- Fusion with baseline increases accuracy with a loss in precision

Open issue: Channel mismatch

- GSM: LPC (all-pole) in Adaptive Multi-Rate codec

Thanks!

References

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