Forensic voice comparison using voice source features: An evaluation of the GLOTTEX® software package

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Why voice source features for FVC?

- Under-investigated source of features
- Potentially complementary information
  - Most acoustic FVC systems based on spectral envelope (MFCC, formants)
- Closely related to speakers' vocal fold biomechanics
  - laryngeal settings (creaky voice etc.)
  - voice pathologies

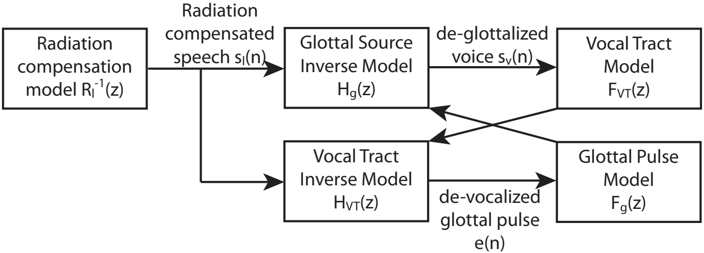
➡ Potentially high between-speaker variability

Voice source features – GLOTTEX®

- Evaluation of the GLOTTEX® software package
  - Originally developed as a non-invasive diagnostic tool for medical applications
  - Provides features related to biomechanics of the vocal folds
- Gómez-Vilda et al. (2008) proposed use in forensic voice comparison
  - Voice source features applied to speaker verification (Mazaira-Fernández et al., 2010)
- Automatic feature extraction from speech segments

Voice source features – GLOTTEX®

Separation of glottal source and vocal tract

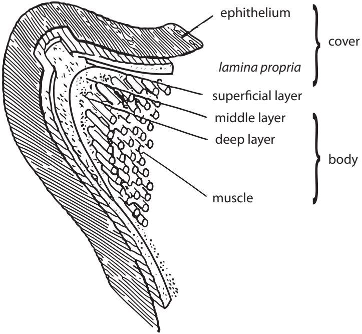


Radiation compensation model $R_l^{-1}(z)$
Radiation compensated speech $s_l(n)$
Glottal Source Inverse Model $H_g(z)$
de-glottalized voice $s_v(n)$
Vocal Tract Model $F_{VT}(z)$
Vocal Tract Inverse Model $H_{VT}(z)$
de-vocalized glottal pulse e(n)
Glottal Pulse Model $F_g(z)$

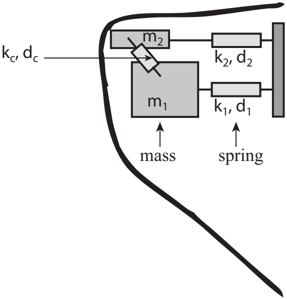
Gómez-Vilda et al. (2009)

Voice source features – GLOTTEX® MWC

- Modeling of vocal fold dynamics using k-mass model
- Decomposition of glottal source signal into
  - average acoustic wave (AAW)
  - mucosal wave correlate (MWC)

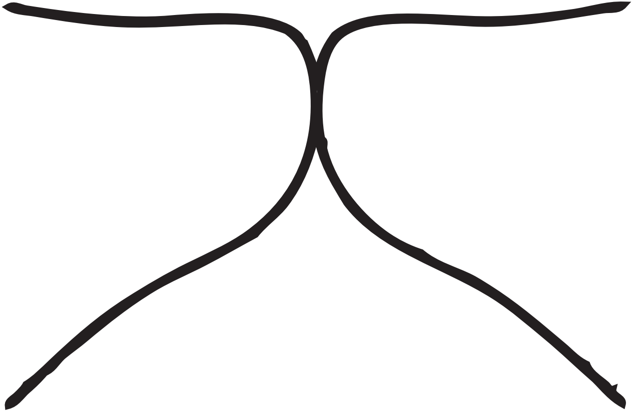


Hirose (2010), p. 140



Two-mass vocal fold model (Story, 2002)

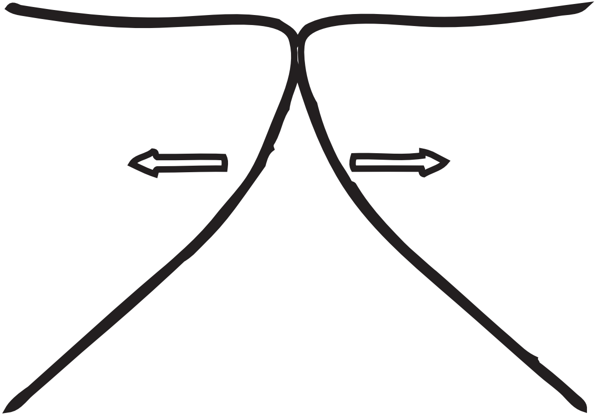
Idealized cycle of vocal fold vibration (Story, 2002, p.197)



(1)

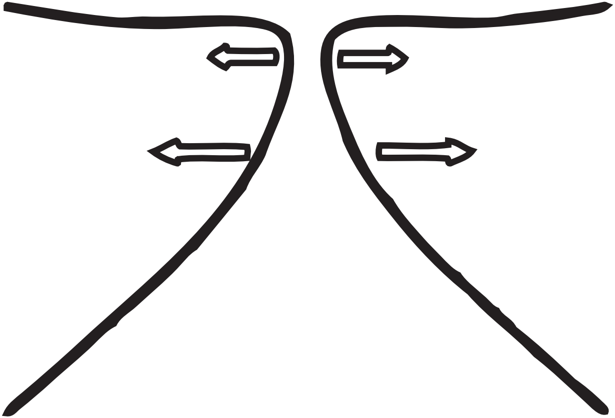
Voice source features – GLOTTEX® MWC

Idealized cycle of vocal fold vibration (Story, 2002, p.197)



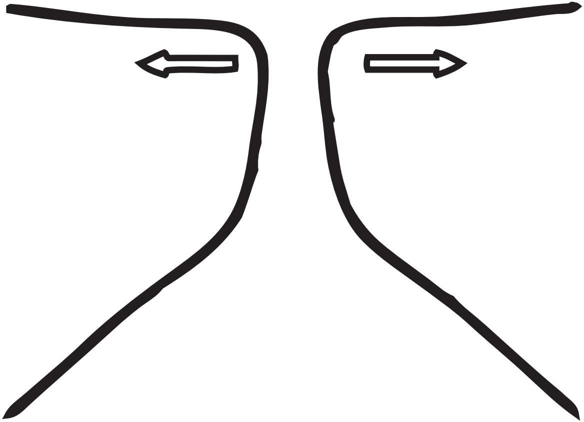
(2)

Idealized cycle of vocal fold vibration (Story, 2002, p.197)



(3)

Idealized cycle of vocal fold vibration (Story, 2002, p.197)



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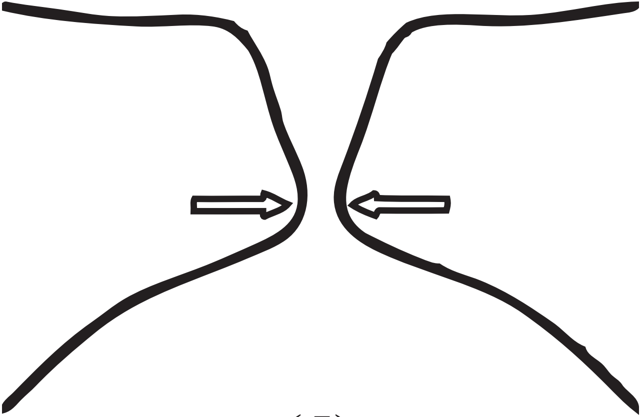
Voice source features – GLOTTEX® MWC

Idealized cycle of vocal fold vibration (Story, 2002, p.197)



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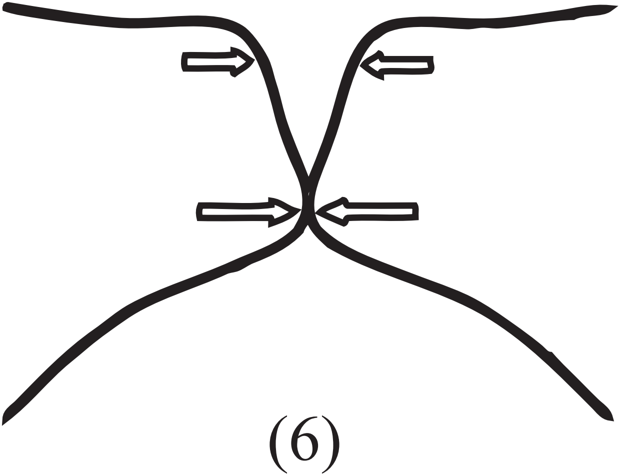
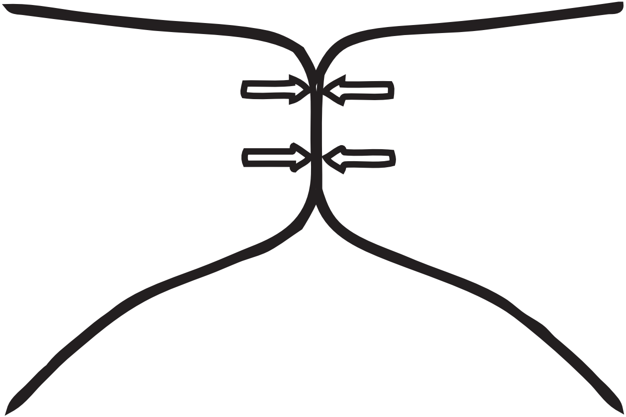
Voice source features – GLOTTEX® MWC

Idealized cycle of vocal fold vibration (Story, 2002, p.197)



Voice source features – GLOTTEX® MWC

Idealized cycle of vocal fold vibration (Story, 2002, p.197)



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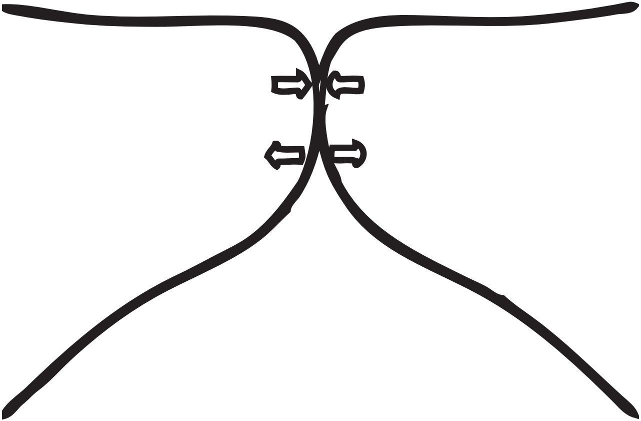
Voice source features – GLOTTEX® MWC

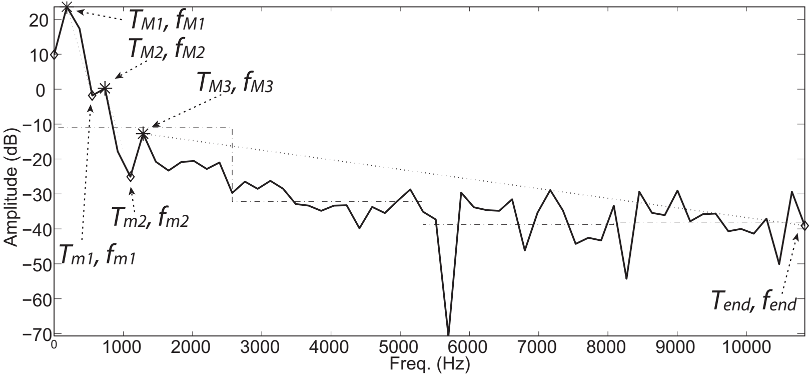
Idealized cycle of vocal fold vibration (Story, 2002, p.197)



(8)

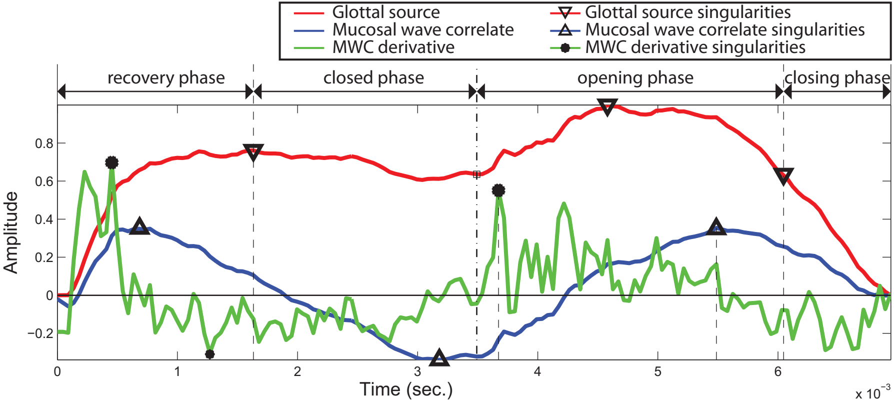
Voice source features – GLOTTEX®

- Mucosal wave correlate (MWC) features:
  - 1-14th cepstral coefficient of MWC power spectrum
  - MWC power spectral singularities (frequencies and amplitudes of minima and maxima):



Voice source features – GLOTTEX® Time-domain

- Relative times of singularities in glottal source, MWC, and MWC derivative time signals



Voice source features – GLOTTEX® f0+Distortion

- Distortion features and fundamental frequency
  - Fundamental frequency (f0)
  - f0 jitter
  - Amplitude shimmer
  - Slenderness shimmer (glottal pulse spike $\frac{height}{width}$)
  - Area shimmer (area under source signal per cycle)
  - Glottal-to-noise excitation ratio

Data

- 60 female Standard Chinese speakers
- Split into 3 groups of 20 speakers
  - background database
  - development set
  - test set
- Information-exchange task over the telephone
- High quality and mobile-to-landline data
- Two recording sessions separated by 2–3 weeks

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

Likelihood ratio calculation

- Score obtained using GMM–UBM system
- Logistic-regression calibration and fusion
- 2 approaches:
  - segmental: pause fillers (sustained /n/ tokens)
  - speech-active portion of recording (200 ms blocks)

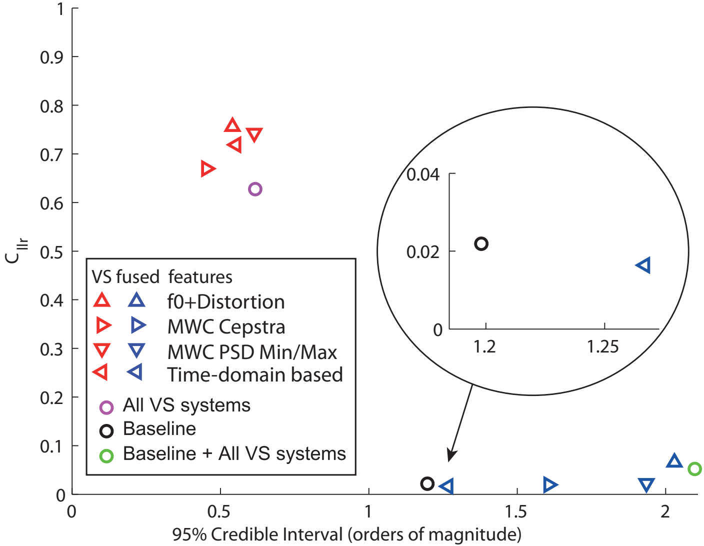
- Baseline MFCC GMM-UBM system (Reynolds et al., 2000)
  - Entire speech-active portion of recording
  - 16 MFCC+Δ, Feature warping
  - 1024 Gaussian mixture components (UBM)

Evaluation measures

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

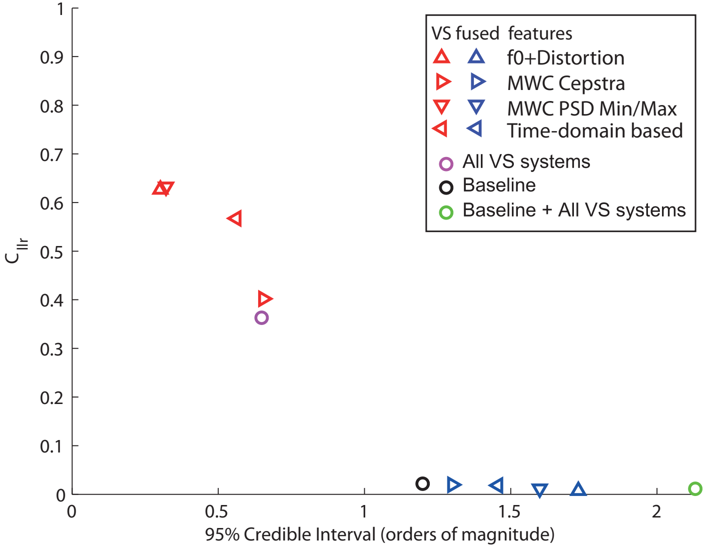
Results - segmental /n/ approach

high-quality v high-quality



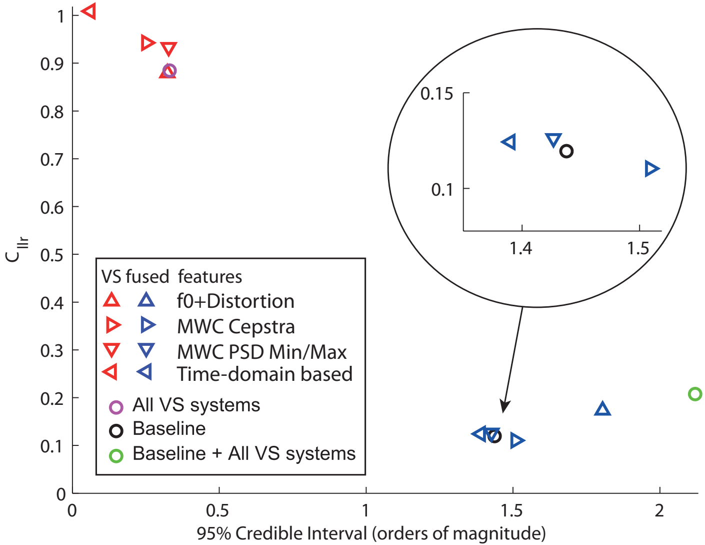
Results - speech-active portion

high-quality v high-quality



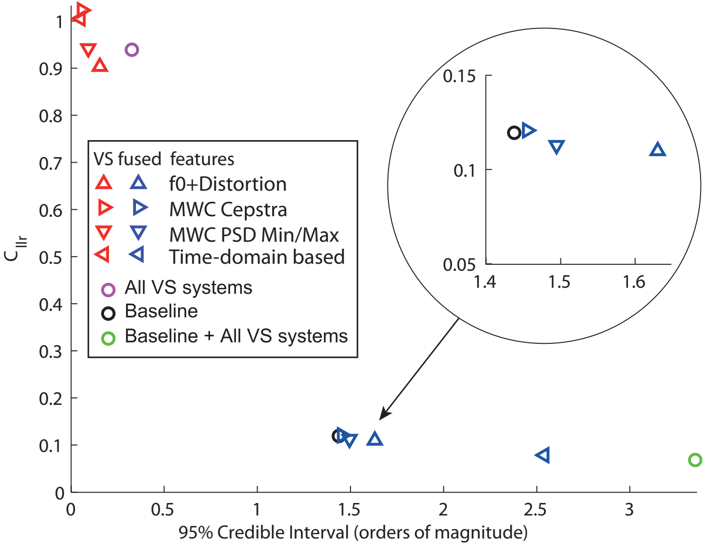
Results - segmental /n/ approach

mobile-to-landline v high-quality



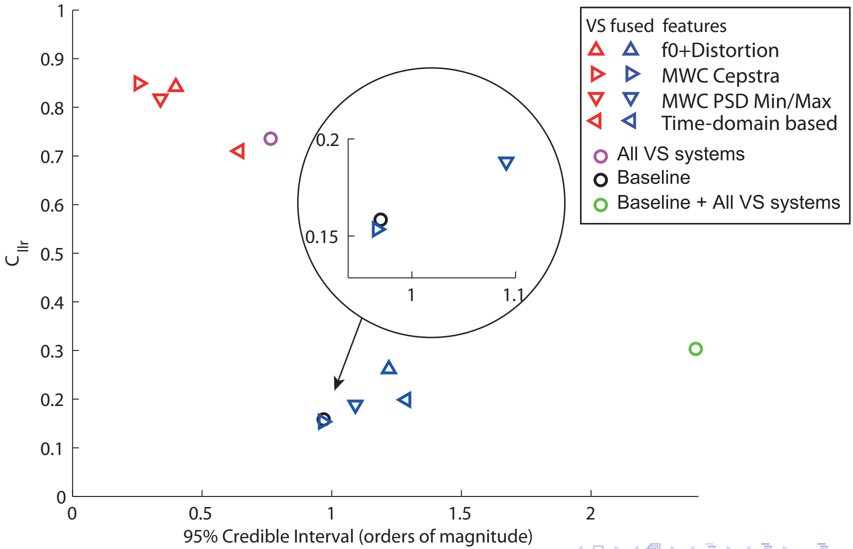
Results - speech-active portion

mobile-to-landline v high-quality



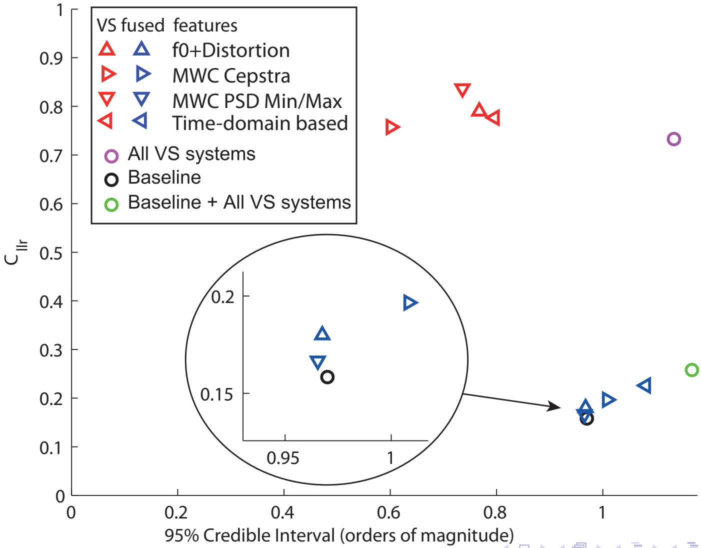
Results - segmental /n/ approach

mobile-to-landline v mobile-to-landline



Results - speech-active portion

mobile-to-landline v mobile-to-landline



Conclusion

- Caveats
  - only one database in one language tested
  - segment tested was a nasal
    (developer said ok)
    (all-speech-active also tested)

- Adding glottal-source features extracted by GLOTTEX® did **not** lead to substantial improvement in performance relative to a baseline forensic-voice-comparison system.

Thanks!

References

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