Michael Pucher, Dietmar Schabus, Gregor Hofer

From Viennese to Austrian German and back again - An algorithm for the realization of a variety-slider

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What do we mean by “variety”?

- We are mainly interested in social (sociolects) and regional varieties (dialects).
  - where sociolects are defined by education and age.
  - and dialects are defined by geographic region.
- But the interpolation methods can also be applied to other language variations like accents of non-native speakers.

Interpolation - Why it works

- Interpolation can be best explained in the low-dimensional space of F1 and F2.
- Linear interpolation of formants leads to non-linear changes in the auditory-articulatory space.
- Mel-frequency cepstral coefficients (MFCC) are a representation of the spectral envelope.
- We interpolate between MFCCs to interpolate the whole acoustic model.

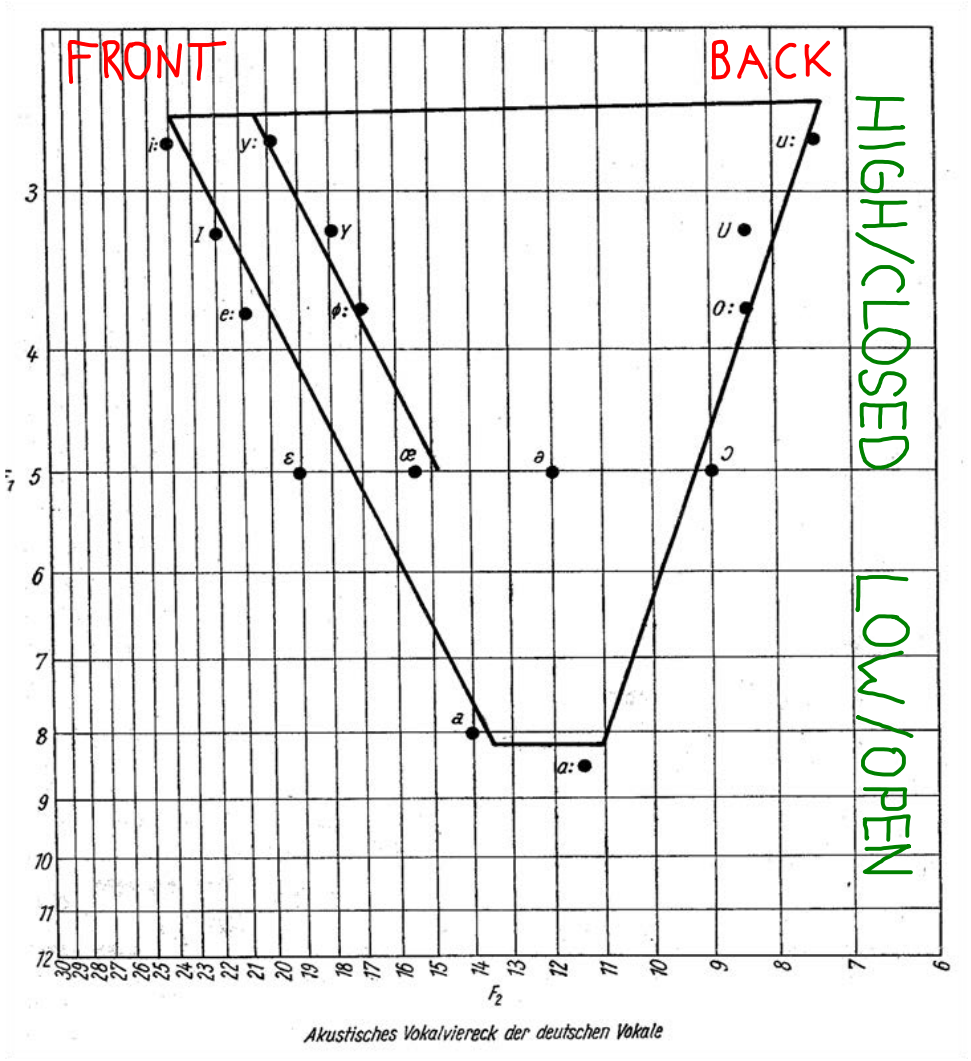
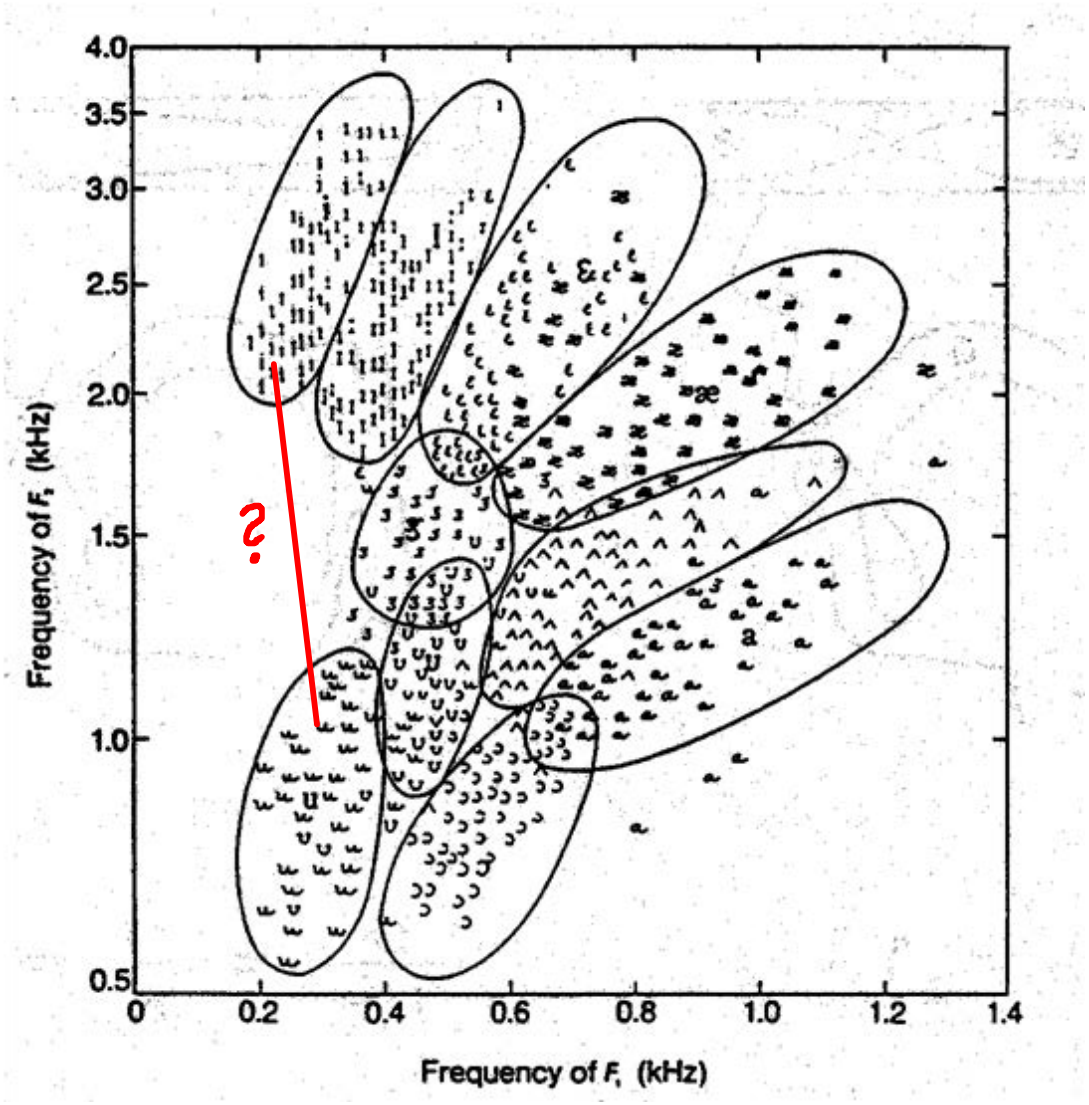


Figure: Hans-Heinrich Wängler, *Atlas deutscher Sprachlaute*, Akademie-Verlag Berlin 1981.

Interpolation - Problems

- But interpolated vowels (in-between) vowels may not exist.
- In-between vowels may not exist in a specific linguistic context (e.g. [ə] in stressed position in German).
- The transition between consecutive phones may be different in speed.
- This can lead to linguistically invalid models.
- Restriction of interpolation to certain phonological processes.



Speaker dependent Hidden Markov model (HMM) based speech synthesis system

- Training of models for spectral (Mel-cepstrum), excitation parameters (F0), and duration.
- Generation of parameters from trained models.
- Synthesis from parameters.
- Austrian German voice trained with 3000 utterances `audio1/at-spkdep.wav` (Voices in Edinburgh HTS library 0.99).

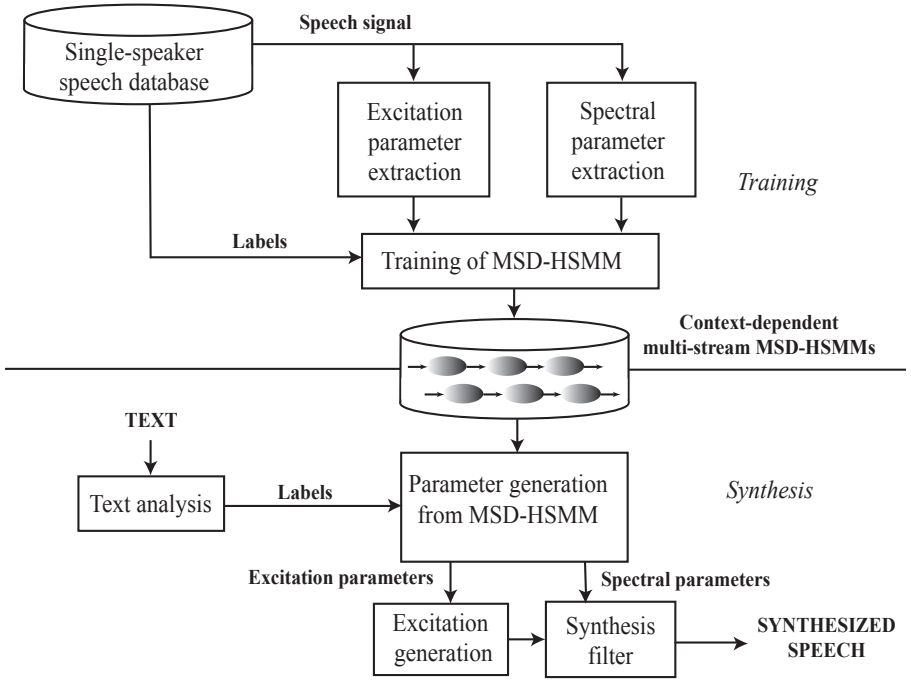


Figure: Speaker dependent HMM-based speech synthesis system.

Interpolation - Methods

Interpolation of HMMs can be used for

- generation of emotional speech
- generation of in-between varieties
- generation of fast speech.

Interpolation methods (Yoshimura et al. 2000):

- Interpolation among observations

$$\hat{\mu} = \sum_{k=1}^{n} a_k \mu_k, \quad \hat{\Sigma} = \sum_{k=1}^{n} a_k^2 \Sigma_k, \quad \sum a_k = 1, \quad (\hat{\mu} = a\mu_1 + (1-a)\mu_2)$$

- Interpolation among output distributions

$$\hat{\Sigma} = \sum_{k=1}^{n} a_k (\Sigma_k + \mu_k \mu_k^T) - \hat{\mu}\hat{\mu}^T$$

- Interpolation based on KL-divergence

Interpolation of varieties

- Interpolation between Austrian German and Viennese sociolect (Pucher et al. 2010).
- Alignment on phone level.
- One interpolation parameter for the whole utterance.
- Missing phones are mapped to source phone with zero duration.

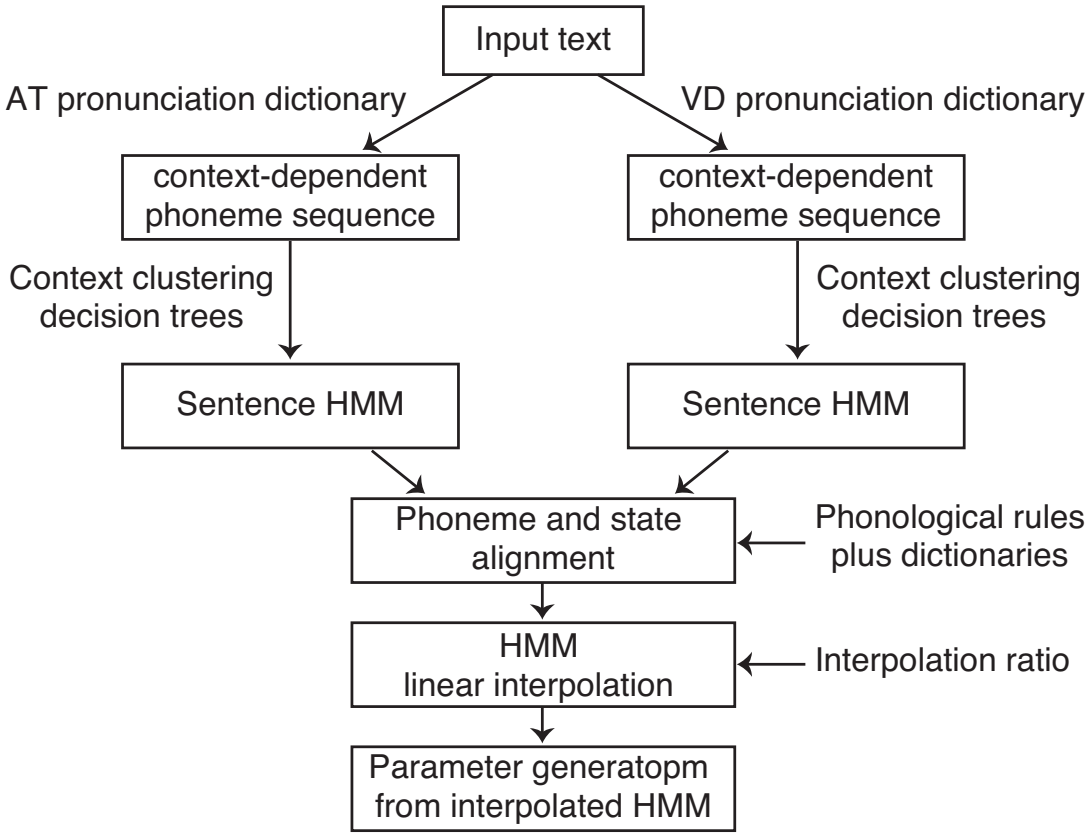
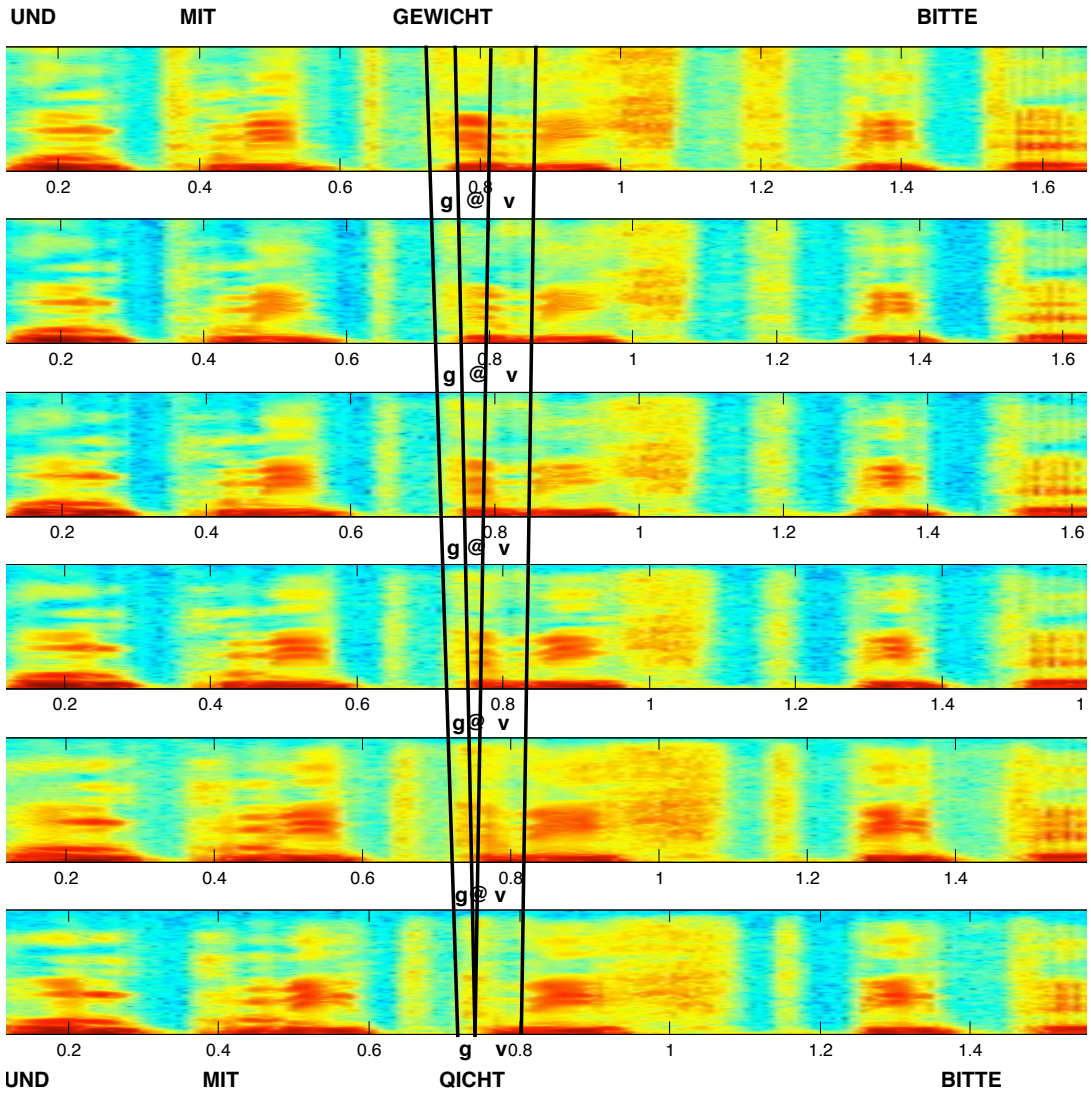


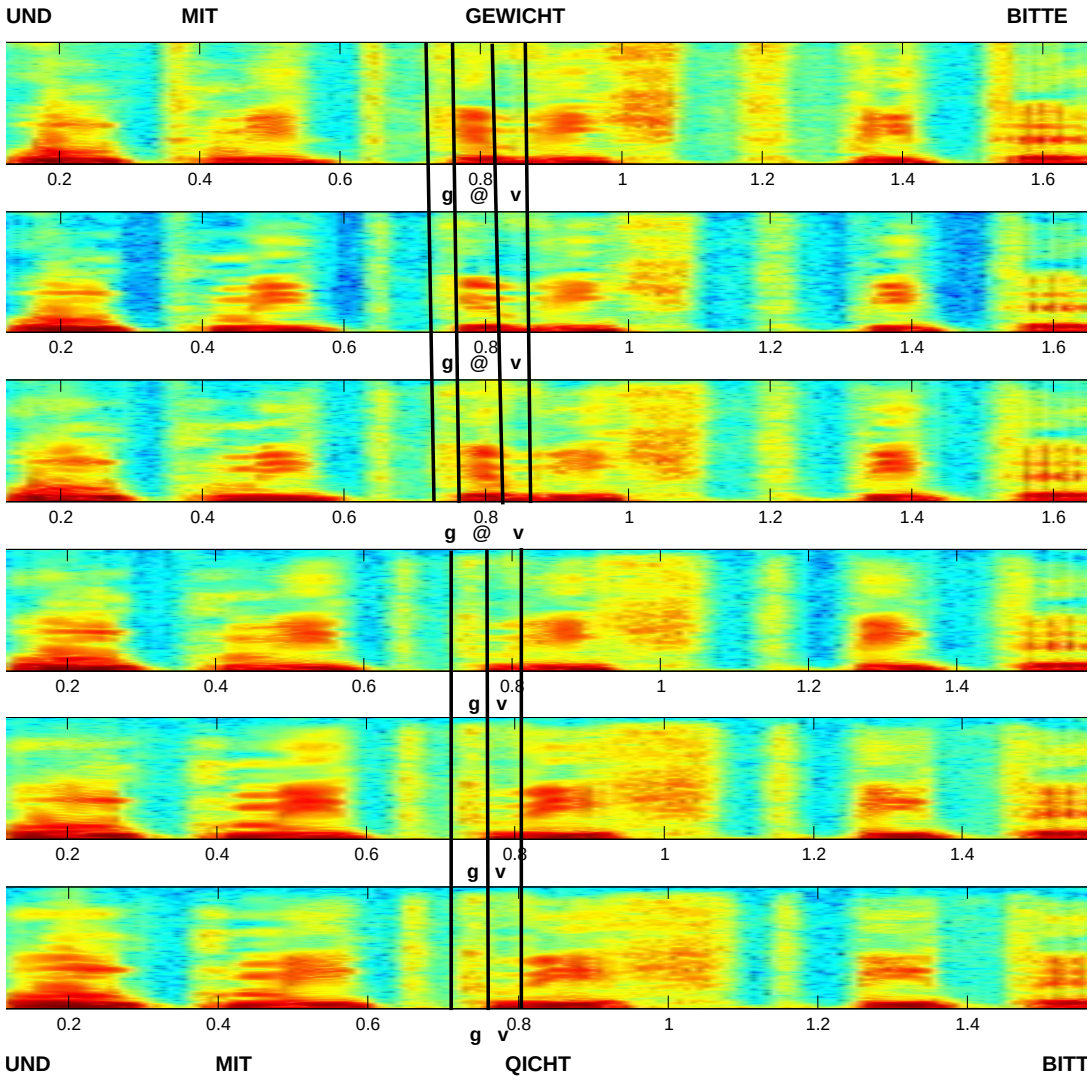
Figure: Flow of dialect interpolation.

Schwa ([@], [ə])-deletion [gəviçt] - [gviçt]



audio1/und_mit_gewicht_bitte.wav

Schwa ([@], [ə])-deletion [gəviçt] - [gviçt]



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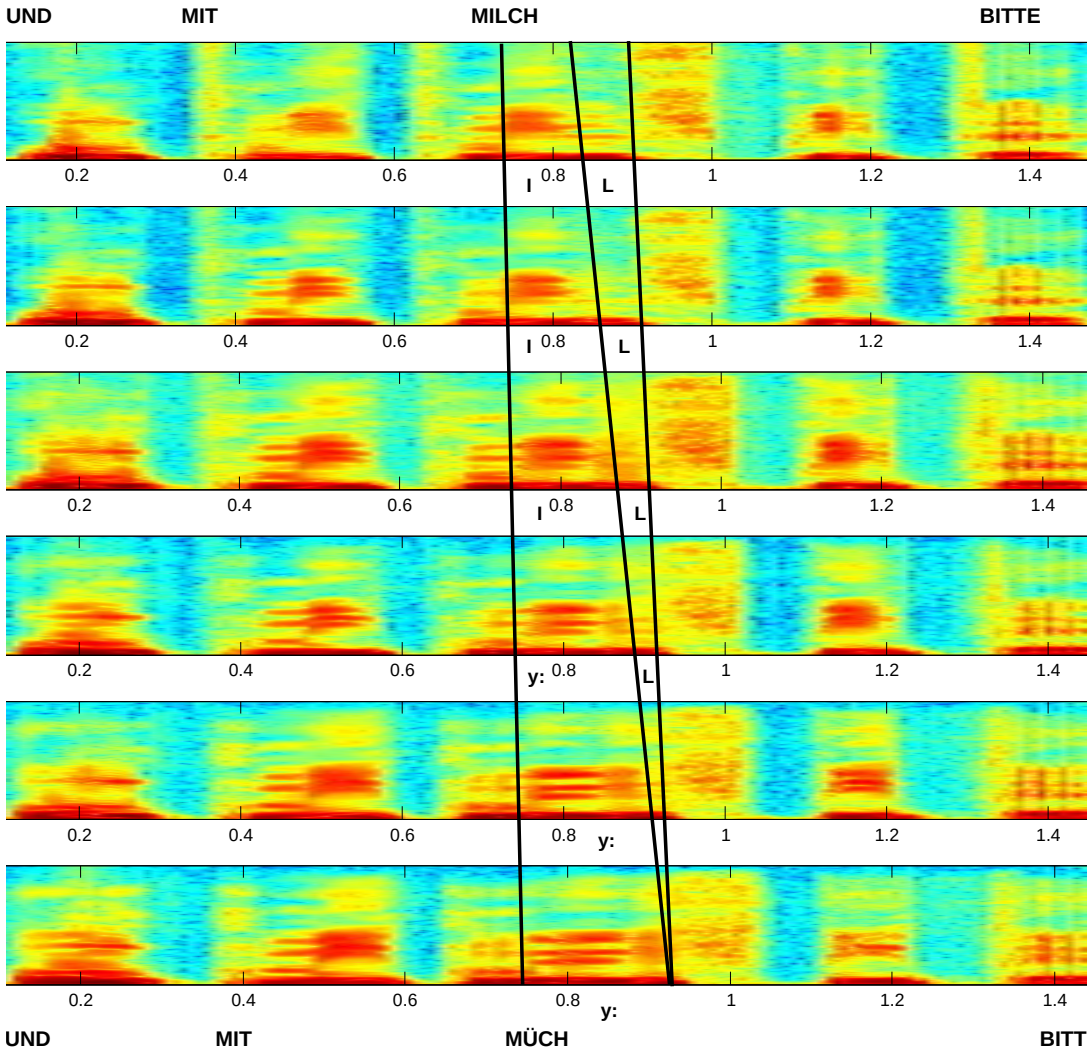
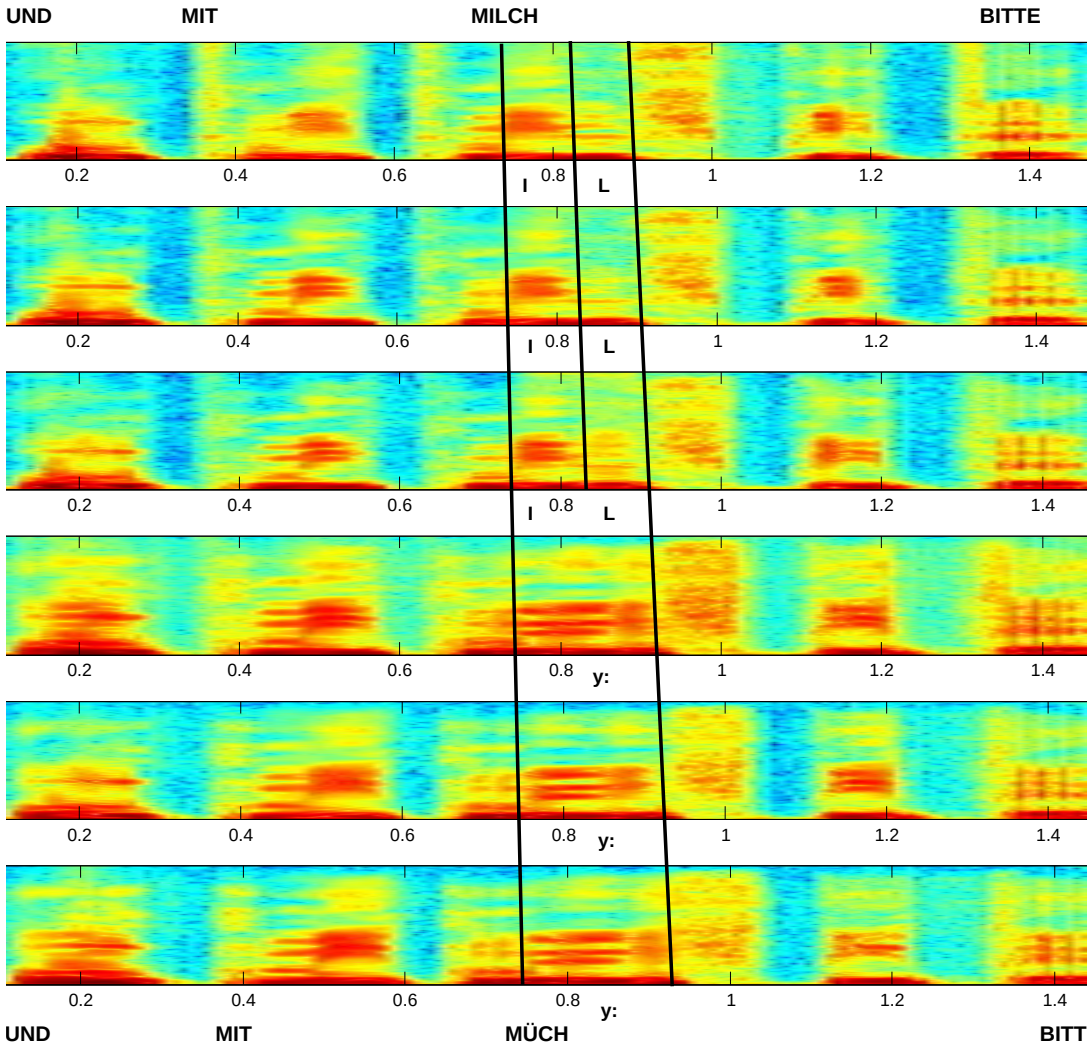
l-vocalization [milç] - [myːç]



audio1/und_mit_milch_bitte.wav

l-vocalization [milç̩] - [myːç̩]



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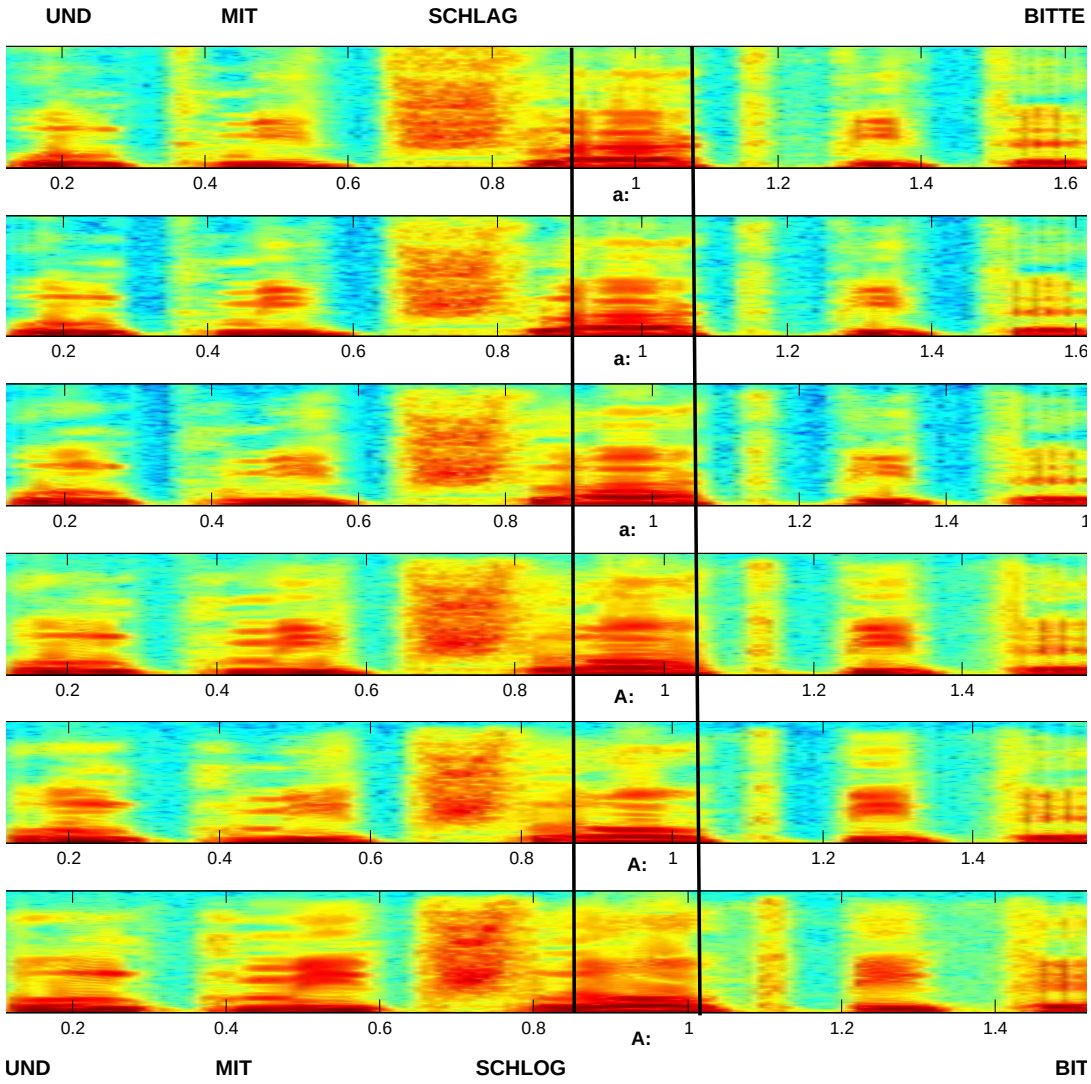
Input shift [ʃlaːk] - [ʃlɔ̝ːk]



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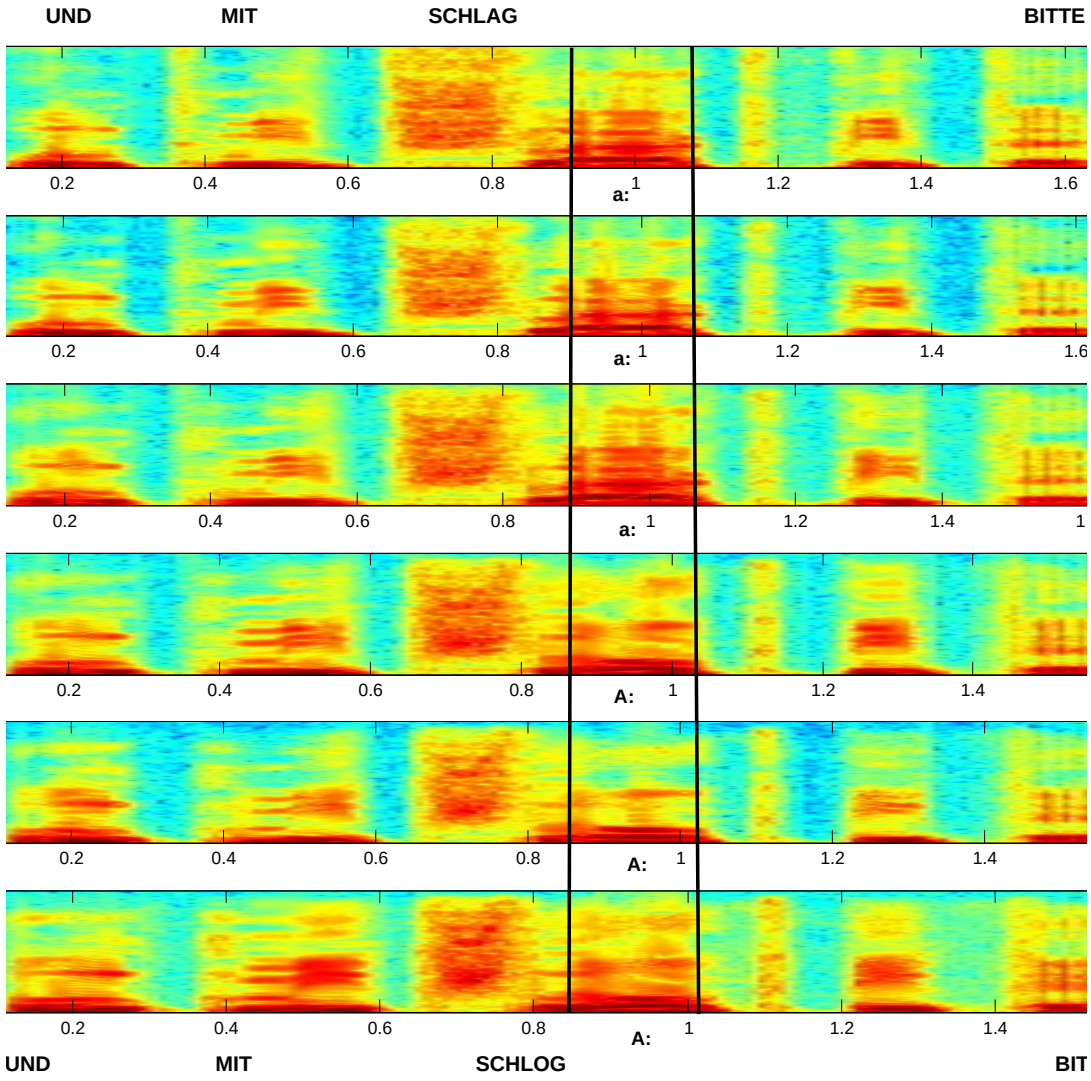
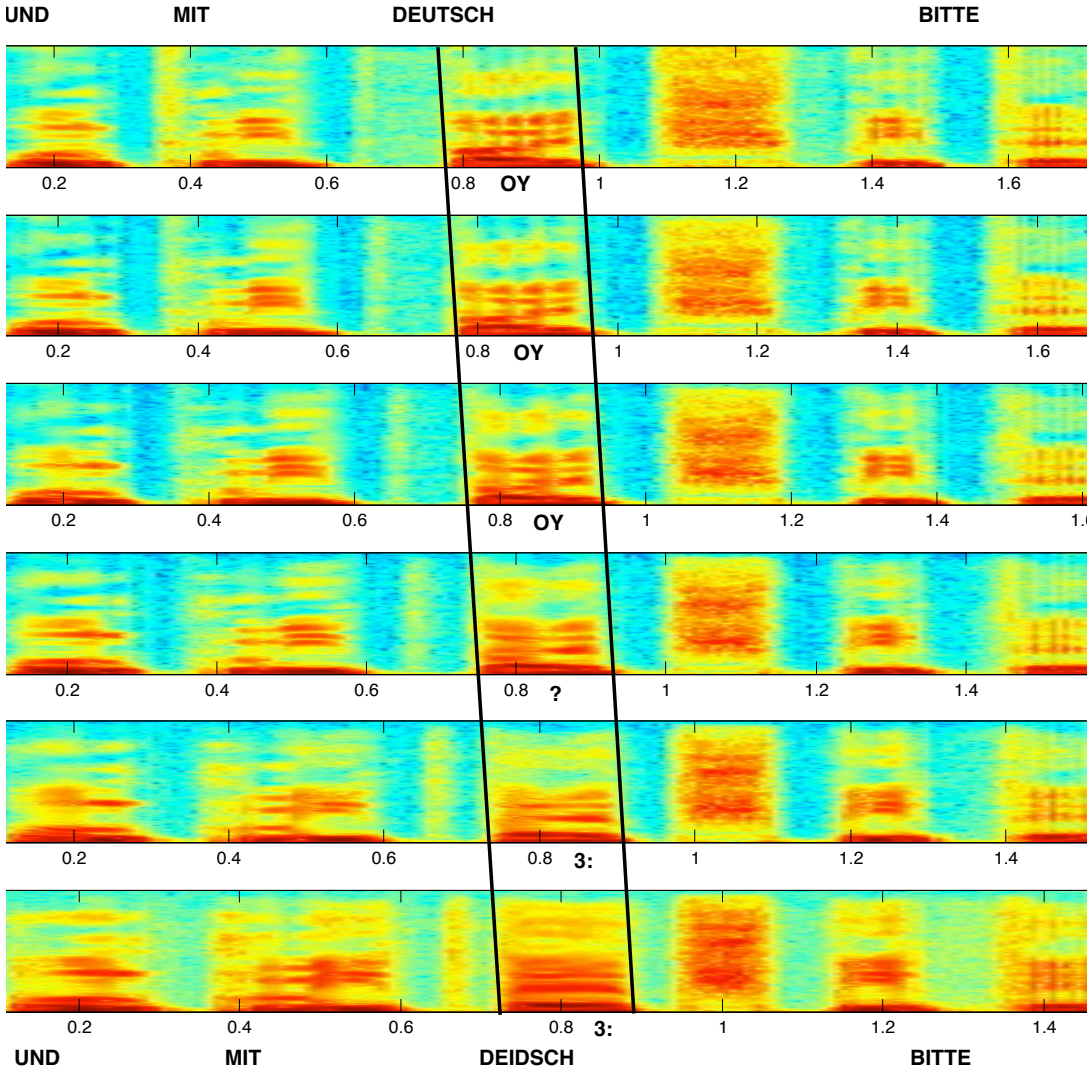
Input shift [ʃlaːk] - [ʃlɔ̝ːk]



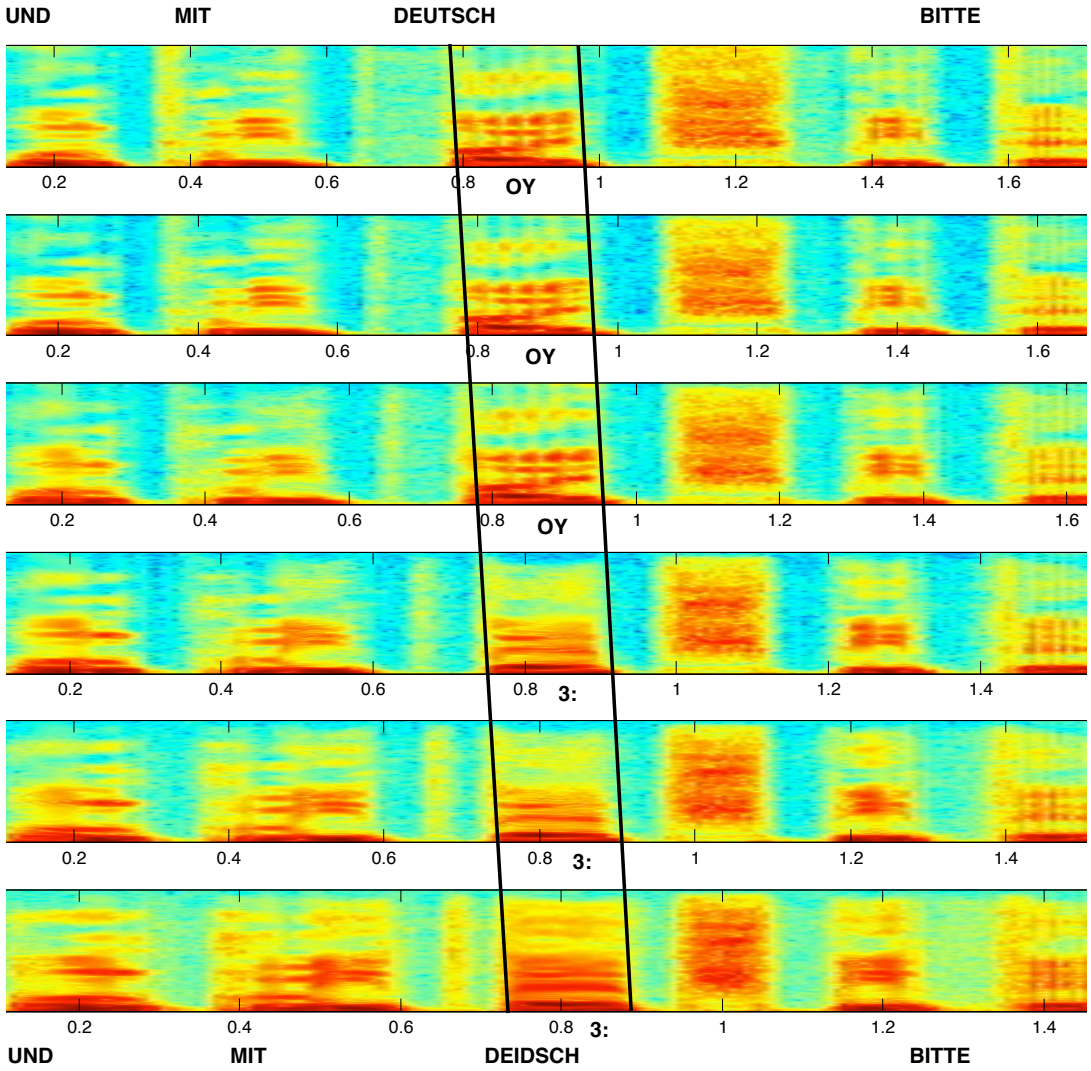
audio1/und_mit_schlag_bitte_inputswitch.wav

Monophthongization [do̯͡etʃ] - [dæːtʃ]



audio1/und_mit_deutsch_bitte.wav

Monophthongization [dɔ̯͡ɐtʃ] - [dæːtʃ]



audio1/und_mit_deutsch_bitte_inputswitch.wav

Evaluation results

- Listeners had to rate synthesized samples between 1 (‘strongly Viennese’) and 6 (‘strongly standard’).
- Interpolation without switching rules created a more continuous transition.
- Interpolation with switching rules led to a categorical difference.

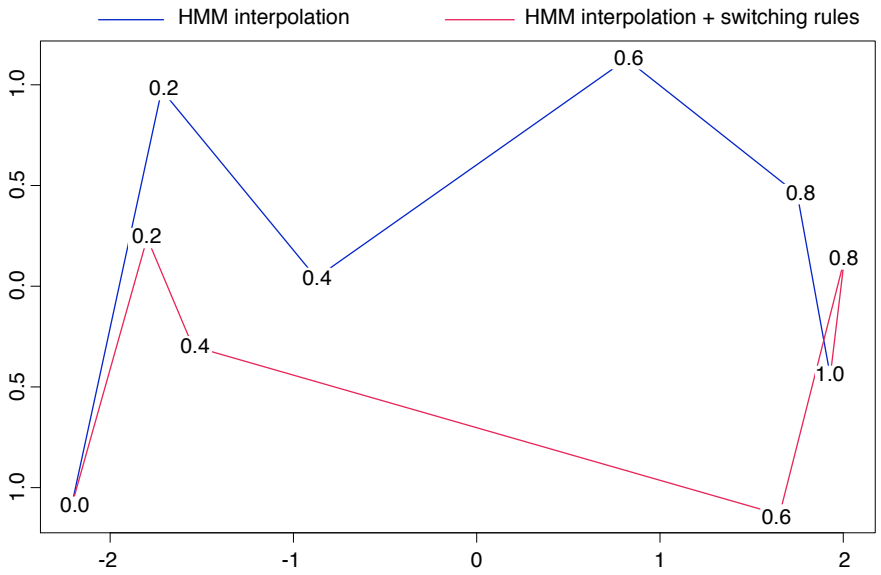


Figure: Evaluation of similarity in terms of dialect. Multidimensional scaling is used for 2D visualization of evaluation results.

Interpolation of duration models

Interpolation between normal and fast speaking rate (`audio1/spo_rho_070_00.wav`,`audio1/spo_rho_070_14.wav`,`audio1/spo_spospo+f_070_14.wav`) (Pucher et al. 2010).

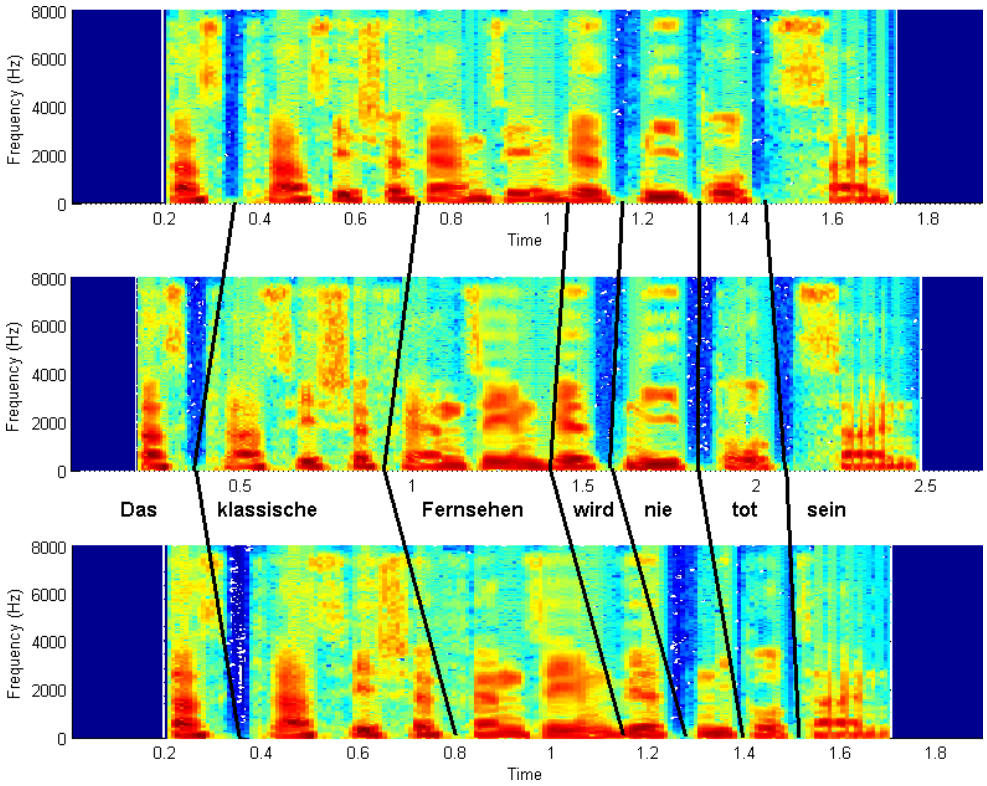


Figure: Interpolation between normal and fast speech models.

Advanced interpolation

- The proposed method needs a manual alignment of phonemes.
- States are interpolated per phoneme.
- A more flexible approach finds an alignment between states automatically
  - using dynamic programming and similarities between acoustic models.

Applications

- Spoken dialog systems
  - Use language recognition to detect the speaker's variety.
  - Select a voice in a variety that is closest to the speaker's variety,
  - or select a variety that is related to the speaker's variety.
- Dialectology
  - Comparison of spoken dialect maps and interpolated synthetic speech.

Conclusion

- We explained interpolation of varieties in formant space.
- Described a method for performing linear interpolation with HMM-based speech synthesis.
- Performed sample interpolations for several phonological processes of Austrian German / Viennese.
- Showed that interpolation is able to produce in-between varieties.

References and Acknowledgements

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- M. Pucher, D. Schabus, J. Yamagishi (2010), *Synthesis of fast speech with interpolation of adapted HSMMs and its evaluation by blind and sighted listeners*. INTERSPEECH 2010.
- T. Yoshimura, T. Masuko, K. Tokuda, T. Kobayashi, T. Kitamura (2000), *Speaker interpolation for HMM-based speech synthesis system*. J. Acoust. Soc. Jpn., 21(4).

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