Using text and acoustic features in predicting glottal excitation waveforms for parametric speech synthesis with recurrent neural networks

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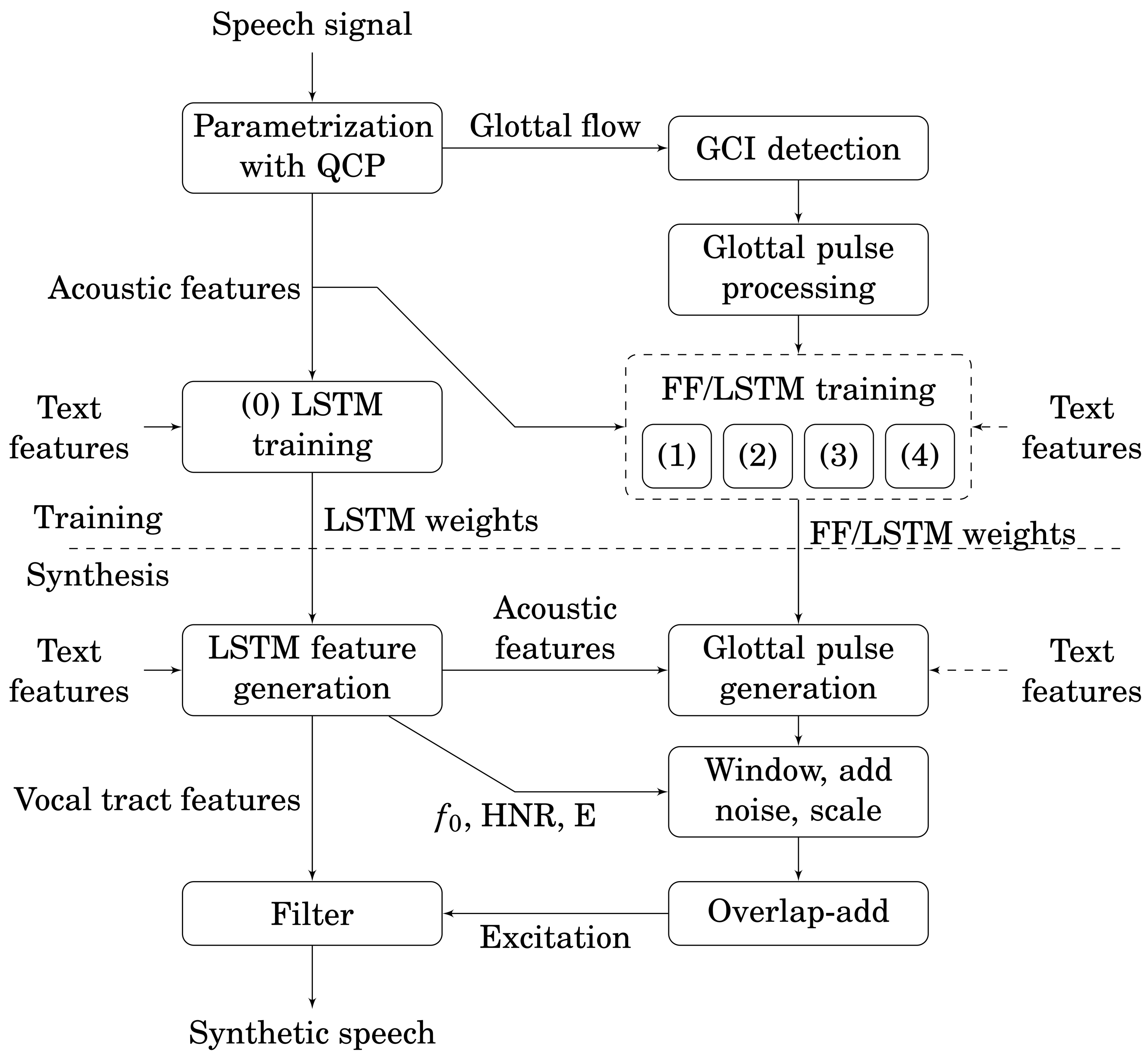
1 Introduction

- Feedforward DNN [1] and LSTM RNN [2] have been successfully used for acoustic modelling in SPSS
- DNN-based excitation models for glottal vocoding [3] have been shown to increase speech quality [4]
- **This work**: Does LSTM improve excitation modelling and can glottal waveforms be predicted directly from text?

2 Speech synthesis system



- Four different networks were trained for modelling glottal waveforms, the acoustic model (text to acoustic) was shared between the systems

ID System	Input	Output	Network
(0) TXT-LSTM-AC	TXT	AC	LSTM
(1) AC-FF-GL	AC	GL	FF
(2) AC-LSTM-GL	AC	GL	LSTM
(3) TXT-LSTM-GL	TXT	GL	LSTM
(4) TXT+AC-LSTM-GL	TXT + AC	GL	LSTM

2.1 Acoustic features

- Acoustic features derived with QCP inverse filtering
- Analysis and synthesis with a modified GlottHMM [5] vocoder
- Dynamic features were used in the neural networks

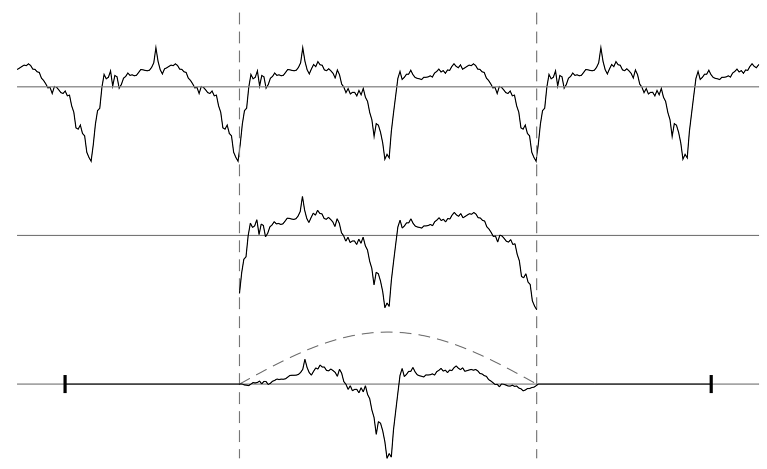
Feature	dim.	Δ dim.
f_0	1	3
VUV	–	1
Energy	1	3
LSF Vocal tract	30	90
LSF Glottal source	10	30
HNR	5	15
total	47	142

2.2 Text features

- Combilex-based linguistic features contain phoneme, syllable, word, phrase, and sentence level information
- 396-dimensional input text features are created with forced alignment

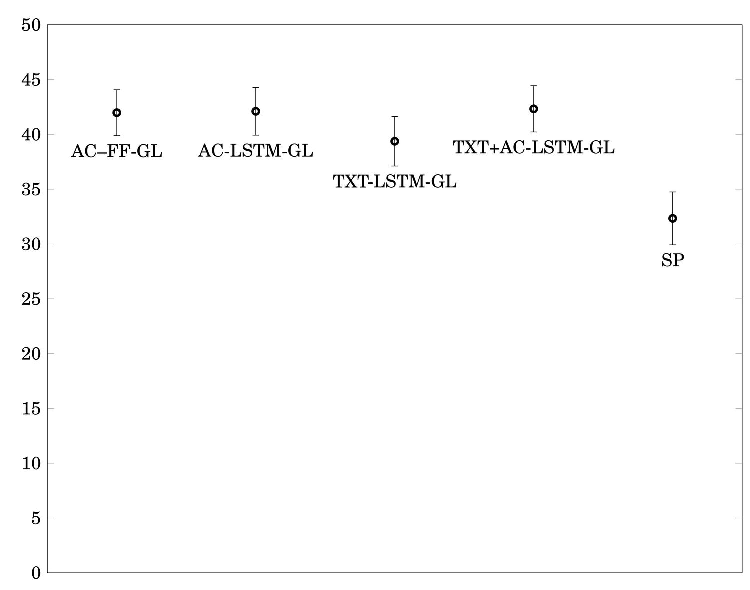
2.3 Glottal waveforms

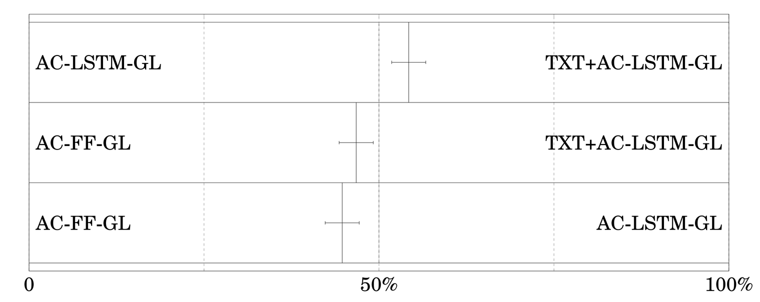
- Obtain glottal flow derivative waveforms with QCP
- Model two-pitch-period segments delimited by GCI
- Window and zero-pad to get fixed length for DNN



3 Listening experiments

- MUSHRA-like test with natural speech with same content as reference
- 30 native English listeners participated
- DNN-based methods outperform single pulse excitation (SP), text-only input is not significantly worse
- Pairwise preference test for the top three methods
- LSTM-based systems outperform the FF-DNN system





4 Summary

- Glottal vocoding was integrated to a framework where text and acoustic features can be used to predict glottal excitation waveforms
- Glottal waveforms can be predicted reasonably well by using only text information
- Use of LSTM slightly improves the excitation modelling performance

References

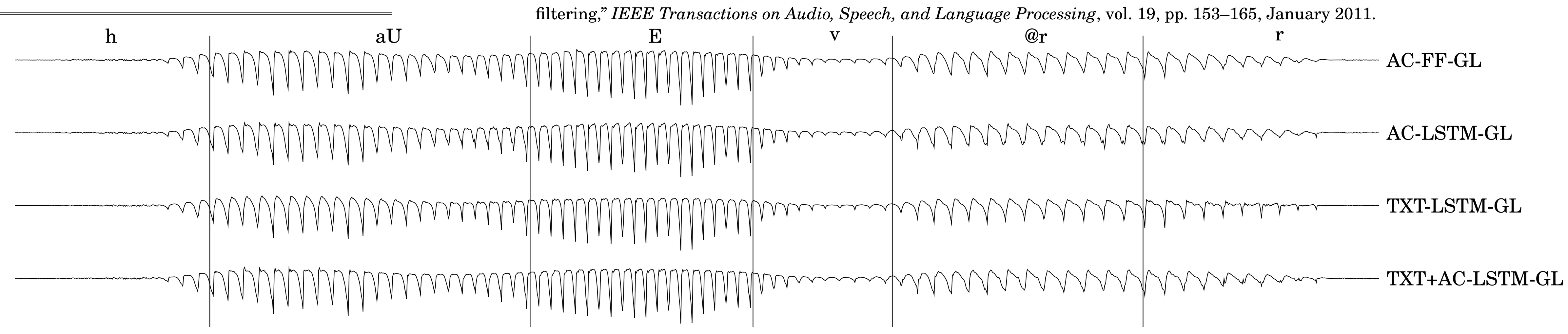
[1] H. Zen, A. Senior, and M. Schuster, "Statistical parametric speech synthesis using deep neural networks," in *Proc. of ICASSP*, pp. 7962–7966, May 2013.

[2] Y. Fan, Y. Qian, F.-L. Xie, and F. K. Soong, "TTS synthesis with bidirectional LSTM based recurrent neural networks.," in *Interspeech*, pp. 1964–1968, 2014.

[3] T. Raitio, H. Lu, J. Kane, A. Suni, M. Vainio, S. King, and P. Alku, "Voice source modelling using deep neural networks for statistical parametric speech synthesis," in *22nd European Signal Processing Conference (EUSIPCO)*, (Lisbon, Portugal), September 2014.

[4] L. Juvela, B. Bollepalli, M. Airaksinen, and P. Alku, "High-pitched excitation generation for glottal vocoding in statistical parametric speech synthesis using a deep neural network," in *"Proc. of ICASSP"*, pp. 5120–5124, Mar. 2016.

[5] T. Raitio, A. Suni, J. Yamagishi, H. Pulakka, J. Nurminen, M. Vainio, and P. Alku, "HMM-based speech synthesis utilizing glottal inverse filtering," *IEEE Transactions on Audio, Speech, and Language Processing*, vol. 19, pp. 153–165, January 2011.



Examples of generated glottal excitation waveforms after overlap-add with the word "however"

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