A correlation metric in the envelope power spectrum domain for speech intelligibility prediction

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Introduction

A powerful tool to investigate speech perception is the use of speech intelligibility prediction models. Recently, a model was presented, termed correlation-based speech-based envelope power spectrum model (sEPSMcorr) [1], based on the auditory processing of the multi-resolution speech-based Envelope Power Spectrum Model (mr-sEPSM) [2], combined with the correlation back-end of the Short-Time Objective Intelligibility measure (STOI) [3]. The sEPSMcorr can accurately predict NH data for a broad range of listening conditions, e.g., additive noise, phase jitter and ideal binary mask processing.

The sEPSMcorr model includes auditory thresholds, such that sensitivity loss can be incorporated based on the audiogram, but other types of impairment (e.g., loss of compression, reduced frequency selectivity) cannot be simulated using this framework. However, it has been shown that speech perception can vary greatly among listeners even when hearing sensitivity is similar.

Therefore, the predictive power of the sEPSMcorr back end was further investigated in combination with a more realistic auditory pre-processing front end adopted from the computational auditory signal processing and perception model (CASP) [4], as its front end can be tuned to individual HI. CASP has been shown to successfully predict behavioral NH data obtained in conditions of, e.g., spectral masking, amplitude-modulation detection, and forward masking [4] as well as individual HI results from simultaneous and forward masking and notched-noise experiments [6].

Evaluation

- Speech mixed with stationary or non-stationary interferers:
  - Speech shaped noise (SSN), which was also used to fit the model
  - Amplitude modulated SSN (SAM) with 8 Hz and modulation depth of 1.0
  - The speech like, but non-semantic international speech test signal (ISTS)
  - The short-time objective intelligibility measure is not very sensitive to speech-in-noise conditions
  - Jittered speech
  - Ideal Binary Masking (8 dB) with four interferers.

- Noise reduction via spectral subtraction:

  \[ S(f) = \frac{P_i(f) - k P_a(f)}{S(f_a)} \]

where \( P_i(f) \) is the input power spectrum, \( P_a(f) \) is the added noise, \( k \) is the gain, and \( S(f_a) \) is the short-time spectrum of the input signal.

The sEPSMcorr model

- The sEPSMcorr model offers more flexibility to model hearing impairments, beyond the audiogram
- Has been shown to account for psychosensory data of individual HI subjects
- Shows great promise in some key conditions but not yet as powerful as sEPSMcorr to generalize across different conditions

Results

- Additive noise
- Reverberant speech
- Spectral Subtraction
- Binary mask processing

Towards realistic cochlear processing

- The CASP model offers more flexibility to model hearing impairments, beyond the audiogram
- Has been shown to account for psychosensory data of individual HI subjects
- Shows great promise in some key conditions but not yet as powerful as sEPSMcorr to generalize across different conditions

Outlook

- Investigate the model’s ability to account for individual hearing impairments, using the parameters available in the CASP framework.
- Consider additional processing stages that could account for inner hair-cell loss and auditory nerve deafferentation (Sumner et al. 2001, López-Poveda and Barrios, 2013), as they are likely to be important in speech-in-noise related tasks.
- Determine the conditions on which the HI model will be tested with special focus on supra-threshold distortions that might be challenging for HI subjects.

References