Algorithms on Noisy Speech for Hearing-Aid Users

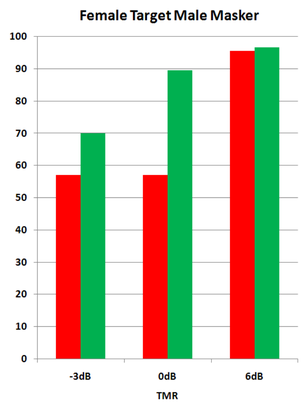
MERIT FAIR
BIEN 2010

Nicholas Prior, Dr. Carol Espy-Wilson, Srikanth Vishnubhotla

Introduction:

• An algorithm has been developed by the Speech Communication Lab that is able to reduce background noise in a signal, even when the noise is the speech of a competing talker.

• Our objective is to see if this algorithm can improve the performance of hearing-aids, making speech more intelligible for hearing-aid users.



The algorithm showed improvement in intelligibility (from red to green) in experiments involving normal hearing listeners. However due to the properties of hearing loss and hearing-aids, this trend may not follow for hearing-aid users.

Speech Properties:

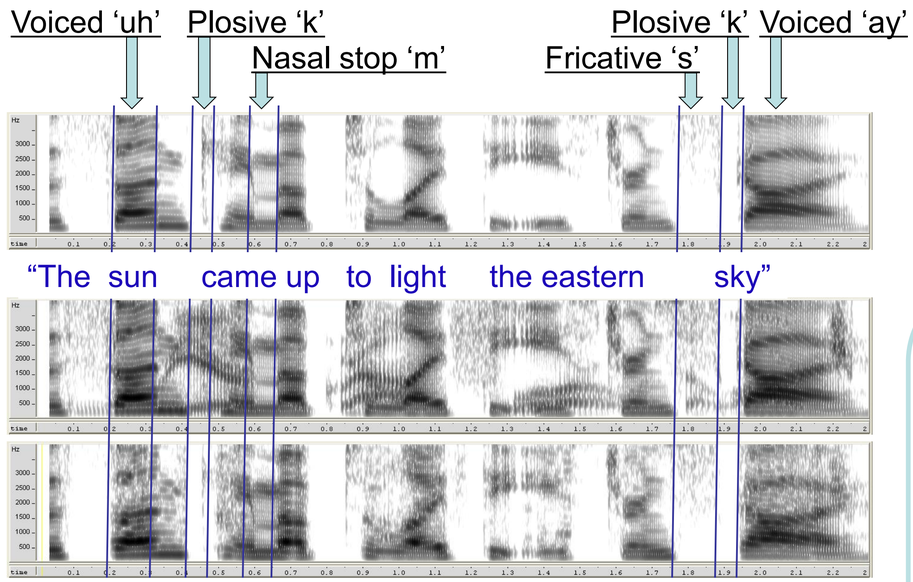
• Vocal cords open and close very rapidly for the voiced periodic sounds including vowels, nasals, semivowels and voiced consonants.
• Tongue, lips and teeth temporarily constrict or block air flow for consonant sounds generating frication noise and/or transients.
• The dark horizontal bands in the spectrogram correspond to formant frequencies.

➢ **Voiced speech** (e.g. vowels) – Periodic waveform. Formants at lower frequencies stronger than formants at higher frequencies.
➢ **Unvoiced speech** (e.g. most consonants) – Aperiodic waveform. Formants at higher frequencies stronger than formants at lower frequencies.

Algorithm:

• The algorithm extracts the voiced and unvoiced regions of the signal, and selectively amplifies or reduces these sections to try and isolate the target speaker.

• The important physical properties for the perception of consonant sounds consist of the transient or frication noise produced from the constriction(s), and the formant transitions of the neighboring voiced region.



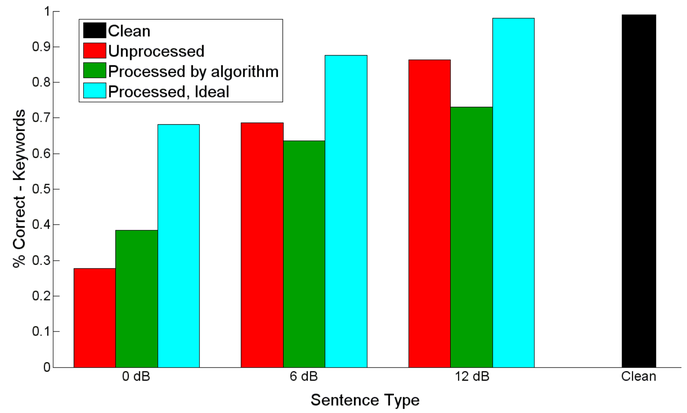
(1) Original Signal (2) Mixed Signal (3) Processed Signal

Listener Tests:

• 5 hearing-impaired (HI) subjects were presented with clean, noisy, and processed sentences to listen to and repeat as best they could.
• Their responses were scored based on the number of keywords correctly repeated.
• Listeners wore their hearing-aids during the tests.
• In one case, near perfect information is given to the listeners which provides a ceiling for its performance.
• The relative strengths of the target and masker speakers (TMR) were also varied.

Results:

• The blue sentences demonstrate the potential for success of the algorithm, as correct consonant information is provided for the target speaker.
• Further analysis of the green processed sentences is needed to see why the automatic consonant information results in lower intelligibility at 6 &12 dB.



Conclusions & Future Work:

• The algorithm demonstrates the potential for improvement in HI listeners, but results are not entirely consistent. If particular regions of the target speaker can be better isolated (blue), then the algorithm will produce significant improvement in intelligibility.
• Future work will look at and isolate the high energy regions of the speech signals to observe and improve the preservation of speech properties during processing in these areas.