Speech Enhancement for Cochlear Implants

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The Problem of Noise

Wearers of all types of hearing aids experience difficulty in distinguishing speech in noisy environments. Cochlear implants are no exception, indeed recipients find background noise to be a severely limiting factor in their interactions with others.

The aim of this thesis was to develop an algorithm suitable for Cochlear Ltd. systems which reduce the amount of perceptible noise for the implant user.

1. Cochlear implant systems

Cochlear implants take an audio signal at the ear-level microphone and transform it, via signal processing methods, to electrode stimuli. The electrode array is implanted in the cochlea in the inner ear, and causes nerve endings to fire in a way that simulates the way we hear.

The audio signal is framed, then an FFT is applied to get spectral information. The spectrum is divided into bands corresponding to the electrode array. This is the data used by the enhancement process.

2. How can speech be distinguished from noise?

We only have a single microphone, so a continuous noise estimate must be made. The algorithm looks for an overall ‘noise floor’, through which speech ‘spikes’ can be detected.

The speech enhancement procedure assumes the total signal is noise, until it detects a large, rapid, change in signal power. This is assumed to be speech, so the noise estimate freezes, until the speech ‘spike’ stops. Thereafter the noise estimate updates again.

3. Algorithm Implementation

To implement this we compare the total signal power to a local frequency average of the most recent noise power estimate, obtaining a switching function to decide whether to update the noise or not.

From the noise power estimate the speech power is easily obtained, then an adaptive gain applied using a modified Wiener filter.

Conclusion

Cochlear recipient testing indicated an improvement in objective recognition scores plus positive feedback concerning the subjective quality of the resulting speech.

An average improvement of 30% in spectral distortion terms is obtained using this procedure.

Overall, the system works well, with relative percentage improvement increasing with louder noise levels. Perceptually the procedure is beneficial, meaning that recipients should be able to use it in noisy environments to improve their quality of life.

Low-frequency car noise (above left) is reduced significantly in resulting spectrum (above right).