*IMPERIAL COLLEGE LONDON*

Real-Time Digital Signal Processing

*Speech Enhancement Project*

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Real-Time Digital Signal Processing

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# Introduction

# Basic Implementation

The basic implementation includes filtering the signal in the frequency domain using spectral subtraction. The method used initially will take N samples of an input signal () and multiplying with a windowing function. Windowing is used to reduce the effects of spectral leakage in the frequency domain causing large discontinuities. The full signal that is to be processed in the time domain can be represented by the required speech signal with noise added:

|  |  |  |
| --- | --- | --- |
|  |  |  |

Windowing the signal:

|  |  |  |
| --- | --- | --- |
|  |  |  |

The Fourier Transform of the signal can be taken:

|  |  |  |
| --- | --- | --- |
|  |  |  |

Assuming the signals are windowed. The process for performing the speech enhancement in high level is shown in Figure 1.

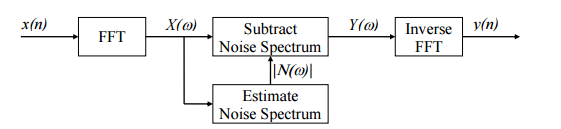


Figure 1 The high level proves for preforming speech enhancement

From the high level diagram it can be seen that after the FFT is taken the magnitude of the noise spectrum is estimated and subtracted from the input noise spectrum. The magnitude of the noise away as the phase of the required signal is not known. The initial operation uses frame processing for windowing.

## 2.1 Frame Processing

## 2.2 Spectral Subtraction

### 2.2.1 Spectral Estimation

To estimate the noise, an initial assumption is made. The assumption is that the speaker will speak for no more than 10 seconds at one time. After the speech has been paused, it is assumed that the only input to the program will be noise. During this 10 second window, the minimum of the input spectrum can be found. This will give an estimated value of the noise spectrum. To lower the complexity of this operation, the 10 second time period of speech and noise is converted into 4, 2.5 second blocks. For each frequency bin in these 10 second blocks, the spectral minimum will correspond to the noise amplitude during non-speech intervals ( , where ) . The overall minimum of these

### 2.2.2 Noise Subtraction

As the phase of the signal is not known, the magnitude of the input can only be manipulated. The estimated noise, (as found in section 2.2.1) can be taken away from the input signal to give an output signal i.e.

Taking the magnitude:

The above expression can also be expressed as where. is set to this as spectral subtraction will sometimes result in negative estimates in the magnitude. To counteract this, the is non-linearly mapped to if the noise is over estimated and otherwise. The value of is set very close to zero to counteract the effect of musical noise. Musical noise artifacts occur due to isolated peaks in the noise spectrum occurring from the imperfect noise estimation. If there are trough’s with peaks in the noise spectrum, when subtracting the estimated noise spectrum the trough’s may reach less than zero and as a result will cause some frequencies to be isolated in terms of magnitude to adjacent frequencies. The musical noise will be greatly increased if there are adjacent peaks to the valley’s or troughs. This due to as human sound perception being logarithmic and being

Frequency

Magnitude

Isolated ‘peak’

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