

# Comparison Of Speech Enhancement Algorithms Using Different Parameters

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**Abstract:** In speech communication system, background noise degrades the information or speech signal. For minimizing the effect of background noise different speech enhancement techniques are used. Some speech enhancement techniques are Spectral Subtraction, Wiener Filtering, Two Step Decision Directed Approach, Perceptual Decision Directed Approach. This paper includes the study of these algorithms, and compare the performance using different parameters i.e., signal to noise ratio (SNR), Peak Signal to Noise Ratio (PSNR), Mean Square Error (MSE), Normalized Root Mean Square Error (NRMSE).

**Index Terms:** Speech enhancement, Decision Directed Approach, Noise Masking Threshold, SNR, PSNR, MSE.

## I. INTRODUCTION

Speech plays a major role in speech communication. There are various type of noise present in the environment that degrades the signal. Background noise is a natural part of a conversation. As a result, speech becomes noisy signal. There is a need to improve the quality of speech signal in noisy conditions by developing speech enhancement algorithms to minimize the effect of the background noise. Over the past year, many speech enhancement techniques are developed for this purpose, and these are modified as per the requirement. Some schemes are attempted to reduce the effect of musical residual noise by human auditory system. This auditory system is based on the fact that the human ear cannot perceive residual noise when this level falls below the noise masking threshold (NMT). Only the audible noise components are removed, this results in the reduction of speech distortion[1].

## II. SPEECH ENHANCEMENT TECHNIQUES

### A. SPECTRAL SUBTRACTION ALGORITHM

The spectral subtraction techniques is the most common and widely used method due to its simplicity and easy to implement. In this technique, estimate the magnitude of noise

spectrum and subtract it from the magnitude of noisy spectrum in the absence of speech signal, when only noise is present. The subtraction process needs to be done carefully to avoid speech distortion. If too much is subtracted, then some speech information might be removed, whereas if too short is subtracted, then much of the interfering noise may remains[2].

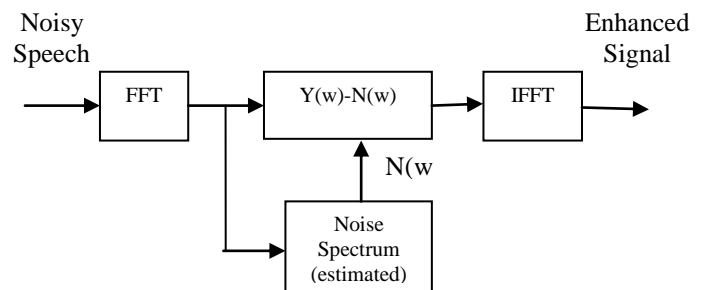


Figure 1: Spectral subtraction technique

### B. WIENER FILTERING

The wiener filter is same as the spectral subtraction in the way that it is derived and makes an attempt to reduce the mean-square error in the frequency domain. These filters involve linear estimation of a desired signal sequence from another related sequence. This method is widely used in the field of signal processing. Based on different application

requirements, a wiener filter is designed to enhance or improve the signal for that very desired frequency response. In this method, the spectral properties of the original signal and noise should be known before the actual processing [3]. The gain function of WF [4] is given by

$$H_{Wiener}(w) = \frac{Ps(w)}{Ps(w) + Pn(w)}$$

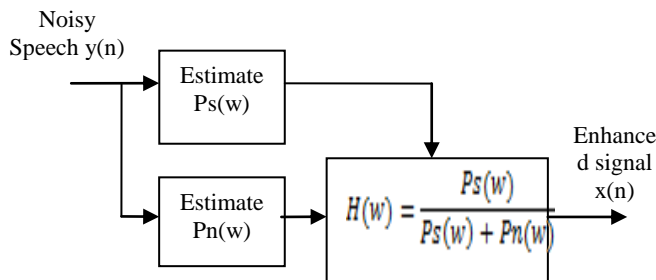


Figure 2: Wiener filtering

### C. TWO-STEP DECISION DIRECTED ALGORITHM

The decision-directed method is better able to minimize the effect of musical residual noise, it introduces a frame delay appeared from the interpolation for estimating the *a priori* SNR. Therefore, a decision-directed method is performed again to enhance the estimated *a priori* SNR by eliminating the frame delay. These procedures develop a two step decision directed (TSDD) algorithm[1].

The gain function of TSDD algorithm is given as:

$$g_{TSDD}(m, w) = \frac{g_{DD} * y_{post}(m, w)}{1 + g_{DD} * y_{post}(m, w)}$$

Where  $y_{post}(m, w)$  is the *posteriori* SNR, and  $g_{DD}$  is the gain factor used to estimate *a priori* SNR[1].

### D. PERCEPTUAL DECISION DIRECTED APPROACH

This technique is modified version of decision directed approach. In this, the main objective is to calculate noise masking threshold (NMT), which is further used to estimate the perceptual gain factor  $G_{per}(m, w)$ . The spectral estimate of a speech signal  $\hat{S}(m, w)$  is obtained by multiplying a perceptual gain factor  $G_{per}(m, w)$  with the noisy spectrum  $Y(m, w)$ [5].

$$\hat{S}(m, w) = G_{per}(m, w) \cdot Y(m, w)$$

Where

$$G_{per}(m, w) = \frac{1}{1 + \max\left(\sqrt{\frac{|D(m, w)|^2}{T}} - 1, 0\right)}$$

## III. EXPERIMENTAL RESULTS

The above mentioned techniques of speech enhancement were applied to the noisy speech input are shown below using cellular noise:

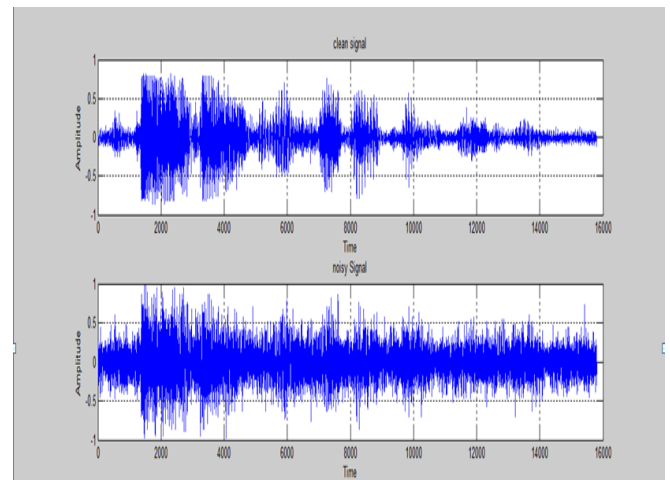


Figure: Clean and noisy speech signal

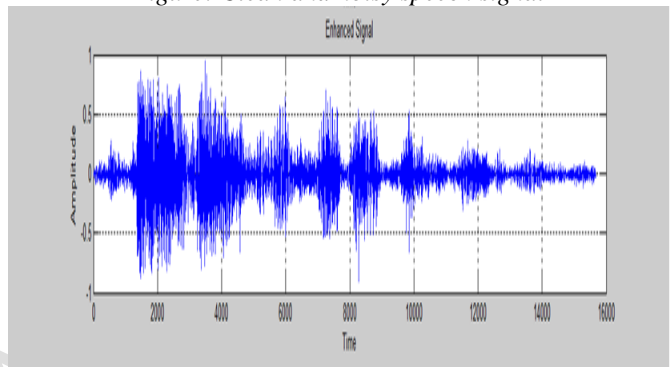


Figure: PDD Output Signal

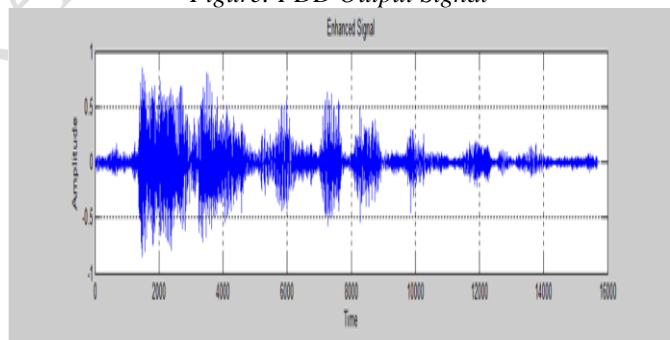


Figure: Wiener Filter Output Signal

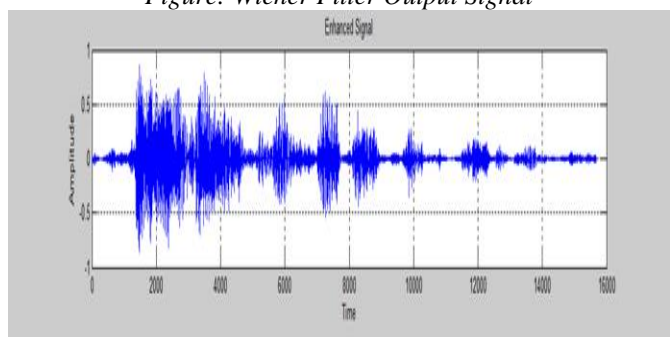


Figure: TSDD Output Signal

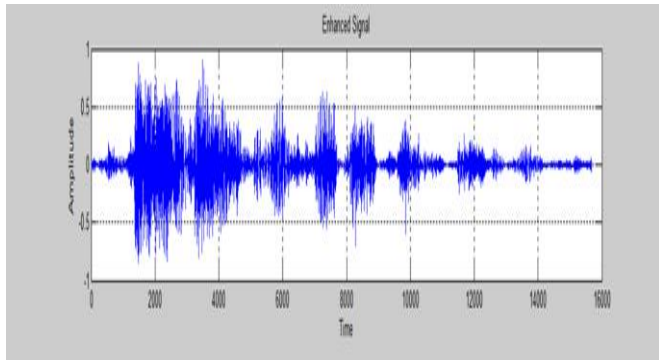


Figure: Spectral Subtraction Output Signal

#### IV. PERFORMANCE EVALUATION

To test the performance of proposed speech enhancement system, the objective quality measurement tests, signal-to-noise ratio (SNR), peak signal-to-noise ratio (PSNR), mean square error (MSE), normalized mean square error (NRMSE) are used.

Table 1 represents the performance comparison of algorithms using cellular noise and figure 3 shows the graph for the evaluation of the algorithms.

Algorithms used	SNR	PSNR	MSE	NRMSE
PDD algorithm	0.365	1.214	1.040	1.570
Wiener algorithm	0.317	1.486	1.042	1.556
TSDD algorithm	0.152	1.073	1.043	1.663
SpecSub algorithm	0.240	1.126	1.037	1.624

Table 1

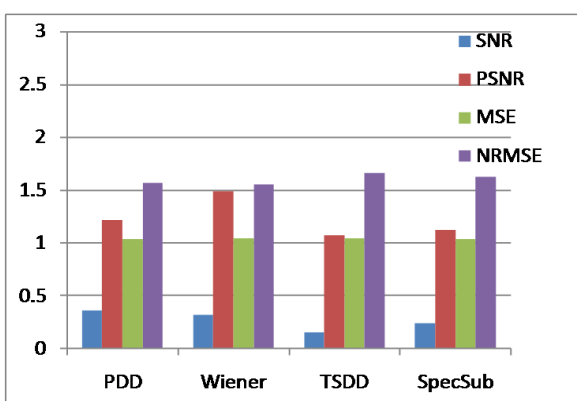


Figure 3: Graph for the evaluation of algorithms

Table 2 shows the performance comparison of algorithms using F16-cockpit noise and figure 4 shows the graph for the evaluation of the algorithms.

Algorithms used	SNR	PSNR	MSE	NRMSE
PDD algorithm	6.173	1.215	0.514	1.021
Wiener algorithm	3.289	1.214	0.516	1.023
TSDD algorithm	1.321	1.213	0.517	1.024
SpecSub algorithm	1.346	1.213	0.519	1.026

Table 2: Parameters measure for F16-cockpit noise

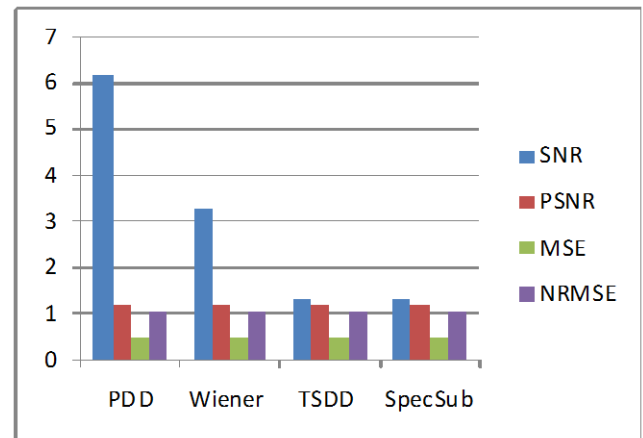


Figure 4: Graph for the evaluation of algorithms

#### V. CONCLUSION

It can be seen from the performance parameters that spectral subtraction method is better for many applications and easy to implement only for stationary noise, but there are some drawbacks of spectral subtraction technique. Wiener filtering is used to provide optimal performance and reduce the mean square error. TSDD method based on decision directed approach which is used to estimate the a priori SNR and it is used twice to reduce frame delay and for better estimation. Perceptual decision directed technique is the modified version of TSDD and it is based on human auditory system. It gives the much better results than the above described algorithms. Perceptual decision directed(PDD) algorithm is used to improve the perceptual gain factor using noise masking threshold. Based on the analysis of the results we concluded that all these algorithms performed well according to the type of signal on different parameters. Based on SNR, PDD is much better than other algorithms. A higher PSNR generally indicates that the reconstruction is of higher quality, in some cases it may not. PSNR should be greater and MSE must be minimize for better estimation of the signal.

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