ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 5, Issue 7, July 2016

Performance Comparison of Speech Enhancement Algorithms Using Different Parameters

Ambalika, Er. Sonia Saini

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). From the results we conclude that the performance of PDD approach is better than other described algorithms.**

***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].

Manuscript received July, 2016.

First Author name- *Ambalika M.Tech student in electronics and communication department of Seth Jai Parkash Mukand Lal Institute of Engineering & Technology.*

Second Author name- *Er. Sonia Saini Lecturer in electronics and communication of Seth Jai Parkash Mukand Lal Institute of Engineering & Technology.*

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].

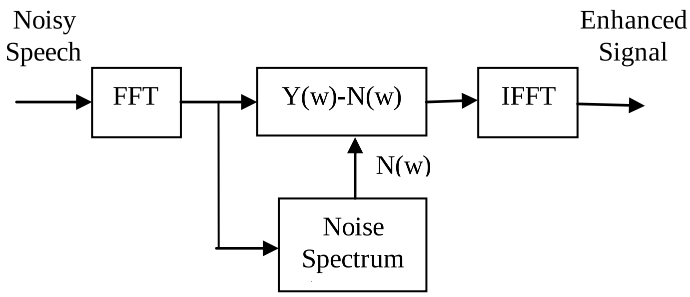

Fig1. Spectral subtraction technique

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

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

ISSN: 2278 – 909X
International Journal of Advanced Research in Electronics and Communication Engineering (IJARECE)
Volume 5, Issue 7, July 2016

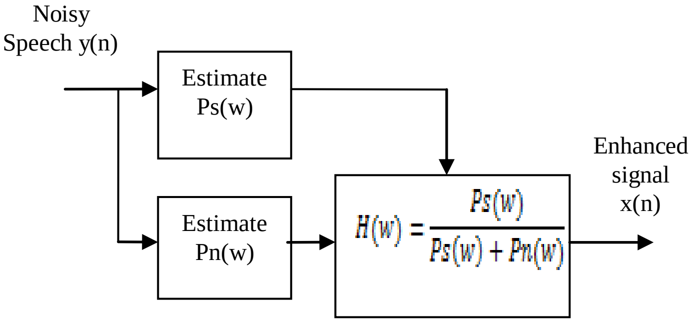

Fig 2. Wiener filtering

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].

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

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:

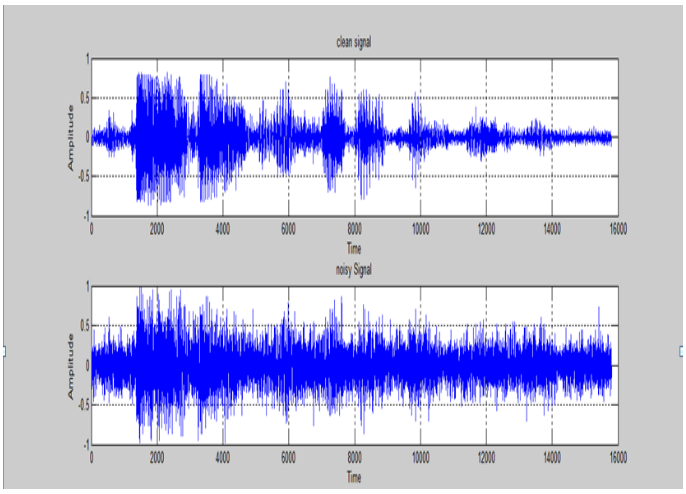

Fig.3 Clean and noisy speech signal

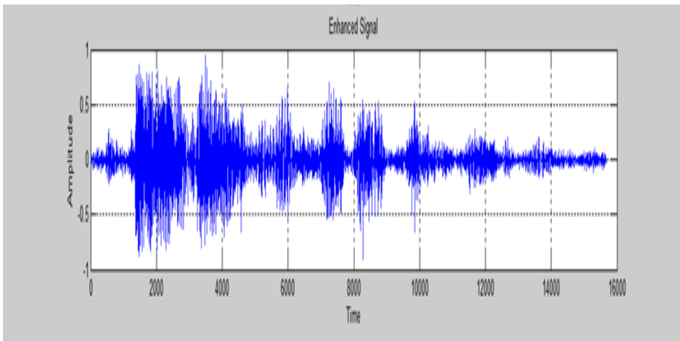

Fig.4 PDD Output Signal

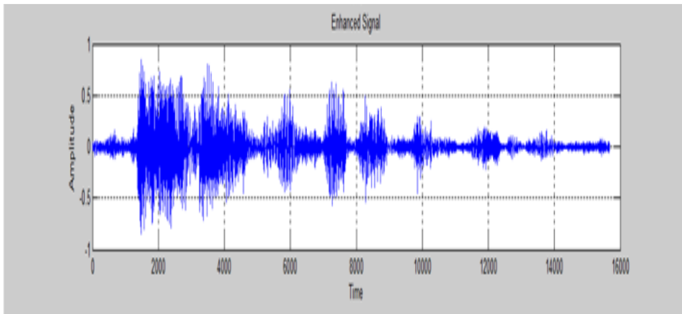

Fig.5 Wiener Filter Output Signal

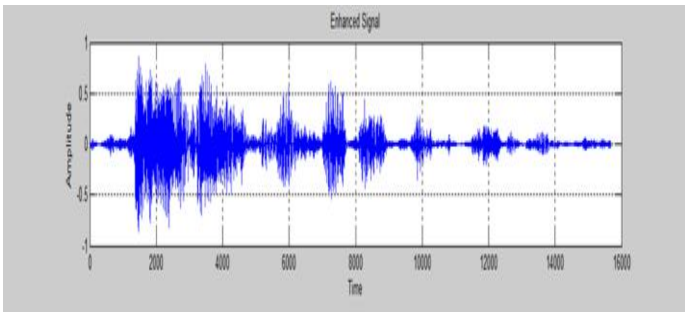

Fig.6 TSDD Output Signal

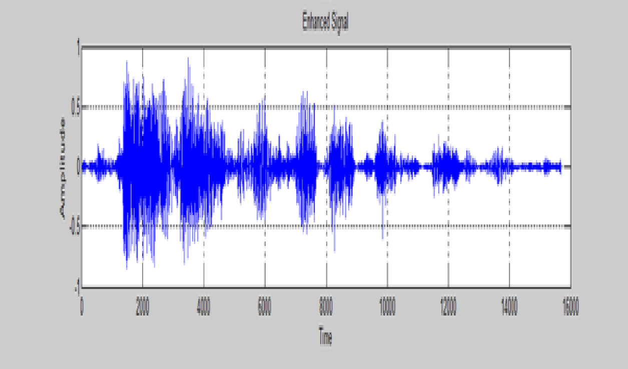

Fig.7 Spectral Subtraction Output Signal

Spectrogram: The spectrogram is a graphical display of the power spectrum of speech as a function of time. The spectrogram of these algorithms are shown below:

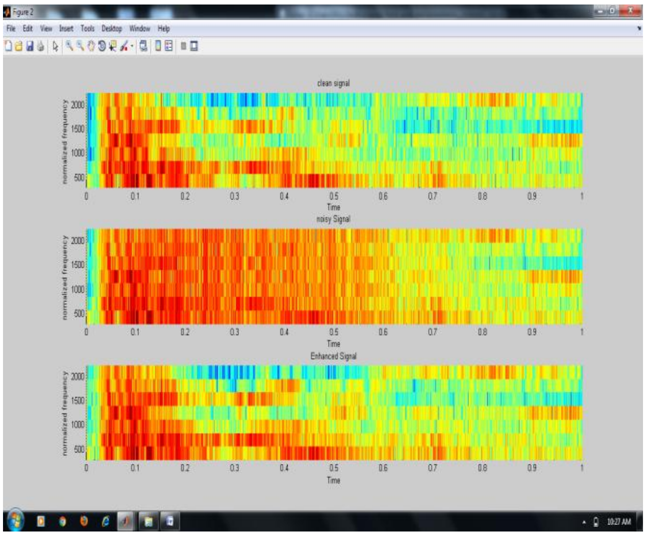

Fig.8 Spectrogram of perceptual decision directed algorithm

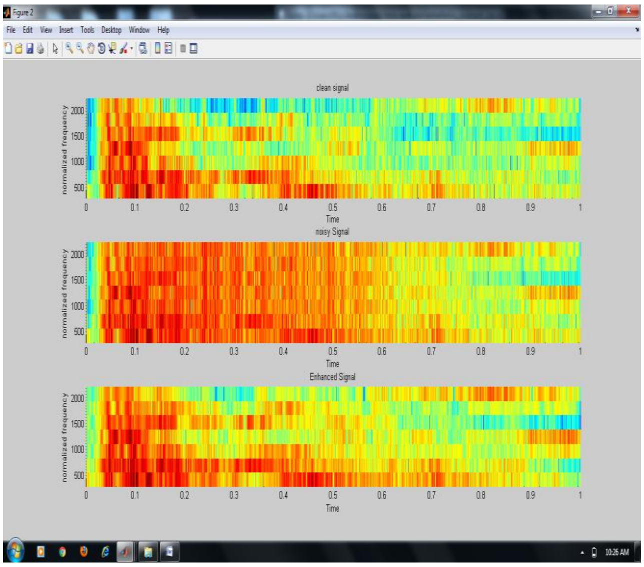

Fig.9 Spectrogram of wiener filtering algorithm

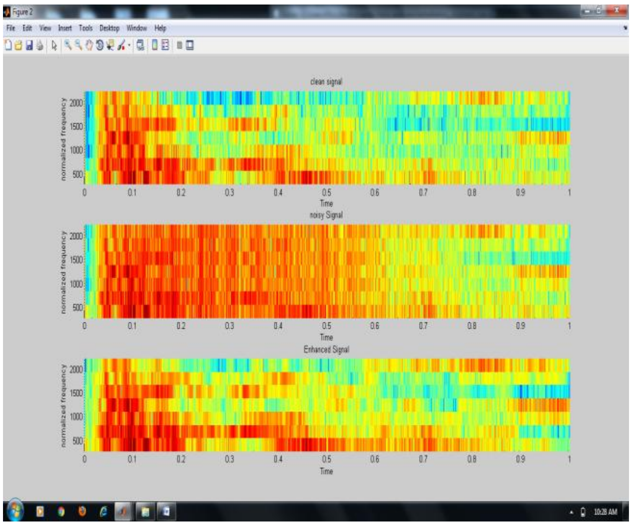

Fig.10 Spectrogram of TSDD algorithm

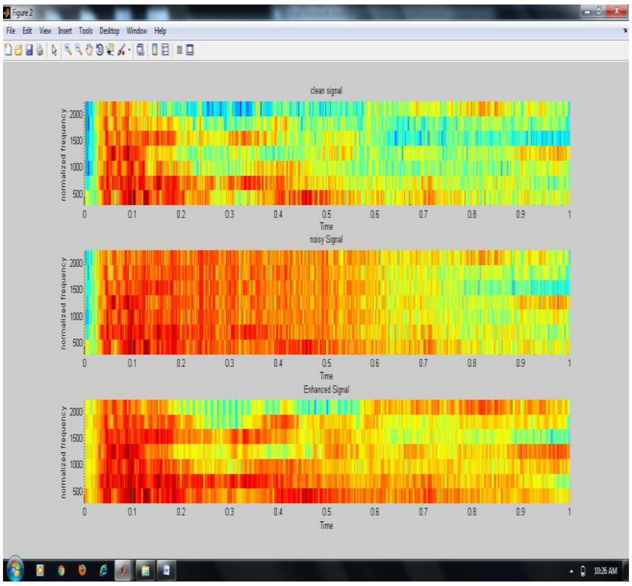

Fig.11 Spectrogram of Spectral subtraction algorithm

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 fig.12 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

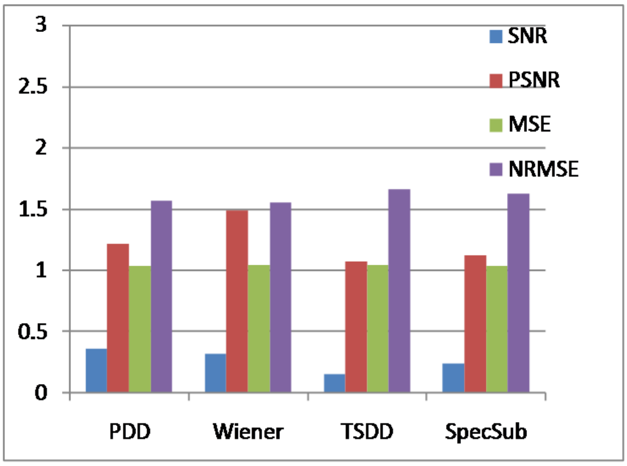

Fig.12 Graph for the evaluation of algorithms

Table 2 shows the performance comparison of algorithms using F16-cockpit noise and fig.13 shows the graph for the evaluation of the algorithms.

Table 2: Parameters measure for F16-cockpit noise

Algorithms used	SNR	PSNR	MSE	NRMSE
PDD algorithm	6.436	8.366	0.526	0.873
Wiener algorithm	2.566	8.361	0.526	0.874
TSDD algorithm	3.121	8.359	0.527	0.875
SpecSub algorithm	4.647	8.364	0.527	0.875

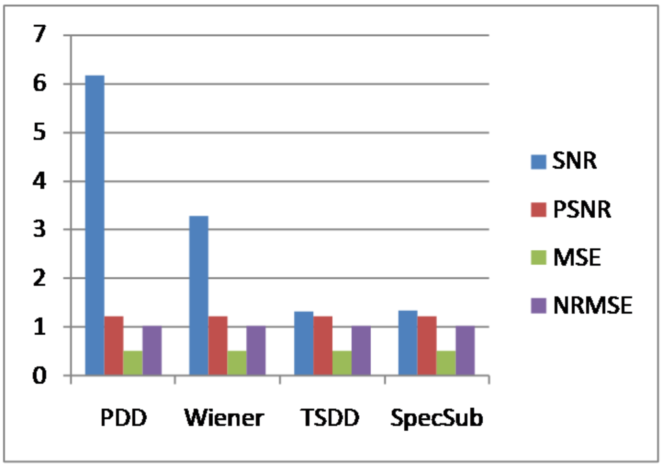

Fig.13- Graph for the evaluation of algorithms

Table 3 shows the performance comparison of algorithms using babble noise and fig.14 shows the graph for the evaluation of the algorithms.

Table 3: Parameters measure for babble noise signal

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

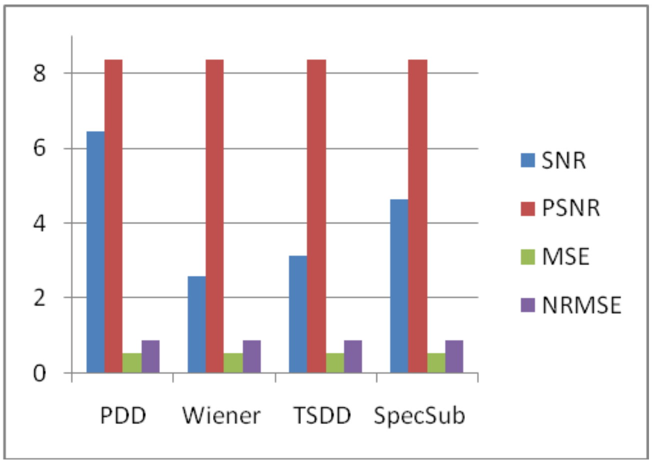

Fig.14- Graph for the evaluation of algorithms

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.

REFERENCES

[1] Ching-Ta Lu, "Enhancement of Single Channel Speech Using Perceptual Decision Directed Approach", Science Direct of Speech Communication, Vol 53, pp 495-507, 2011.

[2] Philips C. Loizou, "Speech Enhancement: Theory and Practice", 1st edition, Boca Raton, FL.: CRC, 2007.

[3] Jimish Dodia, Darshana Gowda, " GUI Based Performance Analysis of Speech Enhancement Techniques", International Journal of Scientific and Research Publications, Volume 3, Issue 9, pp.1-7, September 2013.

[4] Navneet Upadhyay, Abhijit Karmakar, "Speech Enhancement using Spectral Subtraction-type Algorithms: A Comparison and Simulation Study", Science Direct, Eleventh International Multi-Conference on Information Processing-2015, vol. 54 pp. 574-584.

[5] Deepa Dhanaskodi, Shanmugam Arumugam, "Speech Enhancement Algorithm Using Sub band Two Step Decision Directed Approach with Adaptive Weighting factor and Noise Masking Threshold", Journal of Computer Science vol. 6, pp. 941-948, 2011.

[6] Philipos C. Loizou, Gibak Kim, "Reasons why Current Speech-Enhancement Algorithms do not Improve Speech Intelligibility and Suggested Solutions", IEEE Transactions on Audio, Speech, and Language Processing, Vol. 19, Issue 1, pp. 47-56, January 2011.

[7] Anuradha R. Fukane, Shashikant L. Sahare, "Noise estimation Algorithms for Speech Enhancement in highly non-stationary Environments", IJCSI International Journal of Computer Science Issues, Vol. 8, Issue 2, pp. 39-44, March 2011.

[8] Premananda B S and Dr. Uma B V, "Speech Enhancement Algorithm to Reduce the Effect of Background Noise in Mobile Phones", International Journal of Wireless & Mobile Networks (IJWMN) Vol. 5, Issue 1, pp. 177-189, February 2013.

[9] Milind U. Nemade1, Prof. Satish K. Shah, "Performance Comparison of Single Channel Speech Enhancement Techniques for Personal Communication", International Journal of Innovative Research in Computer and Communication Engineering Vol. 1, Issue 1, pp. 67-76, March 2013.

[10] Miss. Anuja Chougule, Dr. Mrs. V. V. Patil, "Survey of Noise Estimation Algorithms for Speech Enhancement Using Spectral Subtraction", International Journal on Recent and Innovation Trends in Computing and Communication, Volume: 2 Issue-12, pp. 4156-4160, December 2014.

[11] Yang Lu, Philipos C. Loizou, "A geometric approach to spectral subtraction", Science Direct, Speech Communication, Vol. 50, pp. 453-466, January 2008.

[12] Teddy Surya Gunawan, "Perceptual Speech Enhancement Exploiting Temporal Masking Properties of Human Auditory System", Science Direct of Speech Communication, Vol. 52, pp. 381-393 (2010).

[13] Philipos C. Loizou, Israel Cohen, "Special issue on Speech Enhancement", Science Direct of Speech Communication, Vol. 49, pp 527-529 (2007).

[14] Yi Hu, Philipos C. Loizou, "Subjective comparison and evaluation of speech enhancement algorithms", Science Direct of Speech Communication, Vol. 49, pp. 588-601 (2007).

[15] [15] Nathalie Virag, "Single Channel Speech Enhancement Based on Masking Properties of the Human Auditory System", IEEE Transactions on Speech and Audio Processing, Vol. 7, No. 2, pp. 126-137, March 1999.

First Author *Ambalika M.Tech student in electronics and communication department of Seth Jai Parkash Mukand Lal Institute of Engineering & Technology.*
Second Author *Er. Sonia Saini Lecturer in electronics and communication of Seth Jai Parkash Mukand Lal Institute of Engineering & Technology.*