Review Paper on Performance Analysis of LMS Based Active Noise Cancellation Algorithms

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Abstract - *In a noisy environment, every signal whether it is audio signal or video signal, is highly affected by additive random noise. Noise is any unwanted signal which gets mixed with the desired signal, corrupts it. It is very important to remove noise signal so as to obtain the signal in its clear form. This literature review focuses on the removal of the noise corrupting the original signal using adaptive noise cancellation. The algorithm is first implemented in MATLAB M-file.*

***Key Words*: Adaptive filter, LMS, Active Noise Cancellation**

1. INTRODUCTION

In communication system, noise is considered as a unwanted signal which is the result of distorted signal being communicated. Acoustic noise problems become more serious as increased number of industrial equipment such as engines, fan, generators etc. Passive noise cancellation technique is used for broad band frequency range.[1] In ANC system two possible control strategies are included that is feed forward and feedback. Noise to be cancelled is often stationary and strictly related to the environment changes, for this adaptive algorithms are used.[2]

In noise cancellation process reduce the effect of noise in the desired output of any system.in passive technique high quality absorbing materials are used to reduce the noise. In active noise cancellation electromechanical system is used to reject the unwanted noise using superposition principle.in that principle the antinoise has same amplitude and reverse phase and it is added to the unwanted noise thus noise cancel each other. Passive noise cancellation is not suitable for low frequency, it is costly.[3] ANC is used to remove the noise from ECG and improve the signal quality.to achieve better noise removal from non-stationary signal like ECG adaptive filter algorithm is used.[5]

ANC system attenuates low frequency noise where passive techniques are ineffective. The finite impulse response FIR filters adapted by Filtered X least mean square algorithms are used .the RLS algorithm provide better noise reduction performance at the expense of more computational cost. The advantages of FxLMS algorithms is faster convergence rate.[7]

2. THE ADAPTIVE NOISE CANCELLER:

To remove the various noises and improve the signal quality, adaptive noise canceller is used. Noise cancelling depends upon subtraction of noise from a received signal which is controlled in an adaptive filter. The simplified block diagram of an adaptive filter used in the adaptive noise canceller setting is given in Fig. 1. [5]

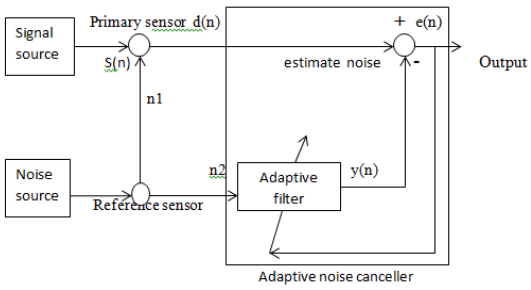

Fig 1.Adaptive Noise Canceller

The primary sensor receives the corrupted signal d (n), which contains the signal from signal source s(n) and additive noise from noise sources n1(n). The signals s(n) and

n1(n) are uncorrelated. The primary input of the adaptive noise canceller is written as.[5]

$$d(n)=s(n)+n1(n) \quad \text{..... (1)}$$

The reference sensor receives a noise n2 (n) which is uncorrelated with signal s (n) but is correlated with noise signal produced from noise sources n1 (n). The reference signal is given by the adaptive filter to produce an output y(n), which is the estimate of noise. This y(n) is given

$$y(n)=\sum_{k=0}^{M-1} w_k v_2(n-k) \quad \text{..... (2)}$$

Here, wk is the adjustable tap weights or filter coefficients. The filter output y(n) is subtracted from the primary signal d(n) and produces the error signal e(n). The error signal e(n) is defined as,

$$e(n)=d(n)-y(n) \quad \text{..... (3)}$$

By substituting Eq. (1) into Eq. (3) we get,

$$e(n)=s(n)+v_1(n)-y(n) \quad \text{..... (4)}$$

To update the filter coefficients of the adaptive filter by using this error signal. From Eq. (4) the noise component present in the system output is n1 (n) – y (n). The adaptive filter attempts to minimize the average power of the error signal e(n). [5]

3. Literature review:

Different types of noises present in the environment these noises are removed by using active noise cancellation system using different LMS based algorithm.

In this paper noise reduction headset is designed for the audio and communication application. For more accurate noise cancellation adaptive feedback noise control technique is used. In this system single microphone is used per ear cup, it produce low power consumption, cheaper and integration is easy.in active noise cancellation super position principle is used, because of this primary noise is not present during operation because it cancel by secondary noise. In this system integrate the feedback ANC with receiving audio input.by using FxLMS algorithm adaptive filter coefficients are updated. The remaining noise picked by the error microphone it is used to synthesize the primary noise foe updating filter coefficient. The advantages of integrated feedback ANC system are good estimation if true residual noise without interfering with the audio signal, large step size can be used in adapting filter. The adaptive feedback ANC system is more accurate for noise cancellation since the microphone is placed inside the ear cup of headset. The audio signal can be used to drive both on line and offline modeling of the secondary path transfer function.[1]

In this paper, in yacht cabin high frequency noises can be reduced by high absorbing materials but in yacht low frequency noises such as engines, air conditioning and electrical generator.in yacht the noise signals are time variant due to change in cruising speed or sea condition. Frequency behavior in terms of amplitude and phase cannot be considered stationary. Each yacht is exclusive and specifically developed for the final user .each environment is developed differently with several architectural constrains. Analyze environment under bedroom and aim is quite the area closed to the bed pillow to make sleeping more comfortable. Due to long length of yacht feed forward control cannot use. The error microphone is placed in the head of bed. Subwoofers are used to generate anti-noise and microphones analyze the noise produced by yacht. In this system FxLMS algorithm is used for psychoacoustic correction. [2]

In this paper, there are different noises under seminar hall produced from fan, air conditioning, cough, shoe noise etc.. These noises create the disturbance while seminar is going on. To reduce such annoying noises by using ANC system with FxLMS algorithm. The conventional LMS algorithm has slow convergence rate, when the environment is changed quickely,it is not work very well.to avoid drawback of LMS

algorithm FxLMS algorithms implemented. The several microphones are used to increases the performance of ANC system.[3]

In this paper to implement the adaptive algorithm like LMS&NLMS in frequency domain.in frequency domain adaptive filtering using adaptive algorithm. Frequency domain can be done by taking Fourier transform of input signal and independent weight coeffient.the adaptive filter suppress the noise without changing the input signal.in LMS algorithm changed its behavior due to changing the step size parameter. Less step size the convergence time is high and it leads the instability of the adaptive filter. In NLMS algorithm standard equation of step size is used using two constant. In time domain result of these algorithms is less SNR and more noise in output signal.so implement LMS and NLMS in frequency domain increase the signal to noise ratio around 8-9 times. It will give good quality of reconstructed signal as compared to time domain.[4].

In this system ECG is a recording of the electrical activities of the heart .the requirement of the ECG signals are accurate. Even small distortions in ECG waveforms impair the understanding of the patient heart condition. But due to some instrumentation faults some noises get added in ECG signal.to remove non stationary signal like ECG various adaptive algorithms are used.in this system RLS and LMS algorithm are used to remove ECG noise. The filtered signals are compaired by using different parameter like signal to noise ratio, minimum square error, percentage root mean square difference, plots of power spectral density. Using these performance criteria it has been observed that RLS algorithm has removed all type of noises more effectively but it is more complex.[5]

In this paper ANC system with online secondary path modeling uses modified FxLMS algorithm for adapting noise control and VSS LMS algorithm is used in the secondary path modeling filter. In FxLMS algorithm slow convergence speed introduce delay in secondary path.in modified FxLMS algorithm two extra filters are used one for the secondary path modeling .another for the control filter. The secondary path modeling filter generate error signal and control filter is used to avoid adaption using FxLMS algorithm. Control filter uses LMS algorithm and upper bound step size parameter is large than FxLMS algorithm. Larger step can be selected for faster converengece.step size is varied accordance with the power of error signal. In this paper improve the performance of online secondary path identification in single channel feed forward ANC system without using third adaptive filter. [6]

In this paper FxLMS algorithm is applied for narrowband noise. Variable step size is used to improve the convergence speed and reduce noise .In variable step size FxLMS algorithm narrowband noise is taken as sources and it is controlled by FxLMS algorithm. This system controls harmonic source by adaptively filtering a synthesized reference signal.varible step size function is used in this algorithm. The step size contains the parameter a and B .the a parameters control the shape and speed of step size of the algorithm. But B control the value range of the function. a and B are the function of error ratio. When the ratio is large the error change is large and VSFxLMS algorithm will be in the convergence stage. If the error ratio is small the step size is small and VSFxLMS algorithm will be in the steady state. The performance is analyzed by using the convergence rate parameter. Variable step size FxLMS with narrow band noise produce better noise reduction and convergence speed when compared with the fixed step FxLMS algorithm.in this technique the feedback is used from cancelling loudspeaker to reference microphone.[7]

4. Summary of reviewed algorithm:

Sr.No	Title of the paper	Algorithm used	Types of noise	Input parameter	Output parameter	
1.	An integrated audio and active noise control headset	FxLMS	siren noise, engine noise	Sampling frequency= 775H Frequency= 122 Hz	SNR=40dB SNR=30dB	
2.	Adaptive feedback active noise control for yacht environments	FxLMS	engines, air conditioning, electrical generator	frequency rang: 20–100 Hz	SNR =15 dB	
3.	A new application of FxLMS Algorithm and designing of a silent seminar room using Active Noise Cancellation	FxLMS	fan, air conditioning, cough, shoe noise	Max frequency rang=120Hz	SNR=50dB	
4.	An Approach to Implement LMS and NLMS Adaptive Noise Cancellation Algorithm in Frequency domain	LMS and NLMS	Adaptive		LMS	NLMS
				Output power	0.2534	0.0082
				Error power	-4.4409	2.3875
				SNR input	7.56 db	7.55 db
				SNR output	25.92 db	4.11 db
				SNR(After Iteration)	26.91 db	28.83 db
5.	Active Noise Control System for Narrowband Noise Using FxLMS Algorithm	VS FxLMS FS FxLMS	Narrowband noise		VS FxLMS	FS FxLMS
				Noise reduction	22 dB	25 Iterations
				Convergence rate	196dB	750 Iterations

Table -1. Comparison of different noises with different algorithm

Sr.No	Algorithm	Findings
1	LMS	• In LMS the coefficients are adjusted from sample to sample in such a way as to minimize the MSE • Low convergence speed • Variable step size
2	NLMS	• Moderate convergence speed • The step size of NLMS algorithm is varied according to the energy of the input signal
3	RLS	• High convergence speed and tracking ability • HIGH computational cost • High degree of complexity. • RLS uses the present and past values to predict its future values
4	FXLMS	• Becomes Unstable Under Highly Impulsive Circumstance. • Work well in primary noise and environment is stationary • Larger impulsive turbulence might cause FXLMS become unstable
5	MODIFIED FXLMM ALGORITHM	• Modified FXLMM algorithm had better stability in coefficient updating • Better stability without sacrificing the performance of residual noise when encountering impulses

Table 2. Different Algorithm with their findings

CONCLUSION:

To cancel the unwanted noise ANC system is useful .in active noise canceller system adaptive filter is used to analyze real time signal continueasouly vary with respect to time. ANC involves many algorithms to cancel the noise. This paper focus on different LMS based algorithms like:

- Least Mean Square (LMS)
- Normalized Least Mean Square (NLMS)
- Recursive Least Square (RLS)
- Filtered X LMS algorithm (FxLMS)
- Modified Filtered X LMS algorithm (Modified FxLMS)

These algorithm optimize several parameter related to the signal making it more suitable for the noise cancellation.

References:

1. W. S. Gan and S. M. Kuo, "An integrated audio and active noise control headset,"IEEE Trans. Consum. Electron, vol. 48, no. 2, pp. 242–247, May 2002
2. Peretti, Paolo, et al. "Adaptive feedback active noise control for yacht environments." IEEE transactions on control systems technology 22.2 (2014): 737-744.
3. Md. Makid Md. Al-Amin Howlader "A new application of FxLMS Algorithm and designing of a silent seminar room using Active Noise Cancellation"
4. Rachana Nagal Pradeep Kumar Poonam Bansal, "An Approach to Implement LMS and NLMS Adaptive Noise Cancellation Algorithm in Frequency domain"
5. Arya Chowdhury Mugdha, Ferdousi Sabera Wanaque, Mosabber Uddin Ahmed-"A study of Recursive Least Squares (RLS) adaptive filter algorithm in noise removal from ECG signals
6. Muhammad Tahir Akhtar, Masahide Abe and Masayuki Kawamata "Modified-Filtered-x LMS Algorithm Based Active Noise Control Systems with Improved Online Secondary-Path Modeling "
7. E. Priya, V. Saravanan, and N. Santhiyakumari, Active Noise Control System for Narrowband Noise Using FxLMS Algorithm
8. Pooja G Prajapati, Anupam N Devan: Noise Reduction Using Different Techniques