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Analysis of various active noise control algorithms for cancelling noise using Matlab

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ABSTRACT

This paper represents a short review of active noise control (ANC). In today's world voice communication plays a very vital role in our daily life. The background acoustic noise which is an undesired sound is also transmitted along with the desired voice. This reduces the quality of communication, even if the network signal level is very high. There are various types of noises existed, generally noise has two form electrical and mechanical. Noise of any types are needed to be addressed and removed, else they cause the actual signal to get corrupted. This corrupted signal will not give exact results. Active Noise Control techniques are discussed in detail to cancel the unwanted signal. There are various types of algorithm existed to implemented ANC system. The concept of adaptive filtering along with Sub-band structure can be applied efficiently to remove noise. Now it all depends on the kind of algorithm applied for particular types of noise. Better the flexibility and stability of the algorithm, better will be the result. Mainly algorithms like Filtered-X Least Mean Square algorithm and its family are used for removing noise actively.

Keywords: **Active Noise Control, Active Noise Cancellation, ANC, LMS, FxLMS, NLMS, FuLMS.**

I. INTRODUCTION

Active noise control (ANC) has received considerable research attention in the past decades because of its superior advantages in cancelling low frequency noise than passive methods. ANC has been applied in various industrial applications such as long duct noise cancellation system, car cabin noise cancellation, and active noise reduction headset [3]. Although great progress has been made, there are still some limits on the application of ANC systems, one important challenge is the control of impulsive noises.

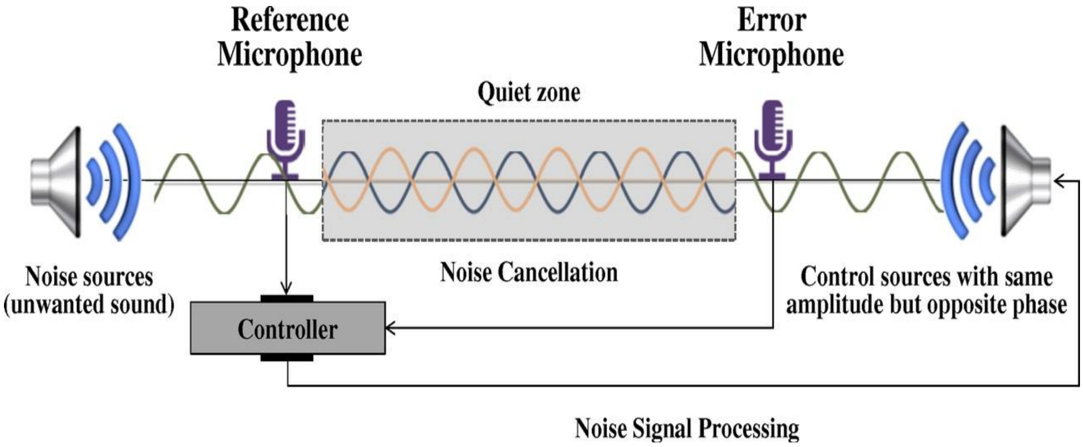

Figure 1 Active noise control system

The active noise control (ANC) is an electroacoustic or electromechanical system which cancels an acoustic noise based on the principle of destructive interference. In ANC, another noise produced by a controller of the same amplitude and frequency as that of original noise with opposite phase. Figure 2 presents the basic principle of the ANC systems where noise, antinoise and residual noise are shown. The ANC system is very effective for reducing low frequency noise in environments where the passive noise control techniques are expensive, bulky, and ineffective.

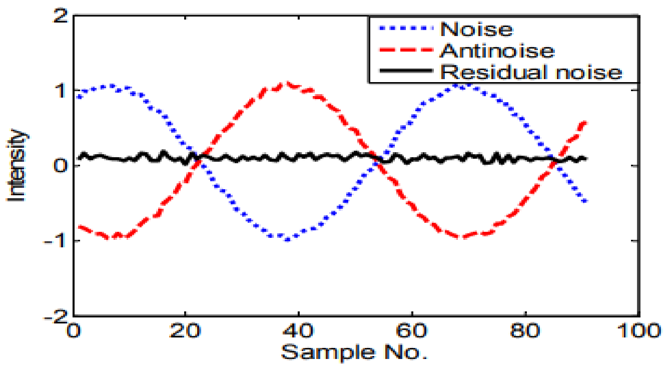

Figure 2: Basic principle of Active Noise Control

Table 1.1 Sources of Noises

Types of Environmental noise sources	Examples
Transportation	Air craft's, trains, road vehicles
Industrial buildings	Factories, machines, air-conditioning systems
Commercial buildings	Office buildings and restaurants, air-conditioning systems, kitchen ventilating systems
Public places	markets, streets, parks
Construction sites	Open Site formation, piling, road work, demolition, renovation

II. NOISE CONTROL

There are two types of noise control which are listed below:

- Passive Noise Control
- Active Noise Control

Passive Noise Control

Modification of the environment where noise propagates is the basic idea of passive noise control method. It is a traditional method, where we aim to reduce the effect of noise by changing the path of energy flow away from humans. This can be accomplished by a numerous ways. One of the methods is to use some materials, which absorb the sound form of energy and convert it into heat. Another method is to reduce the volume velocity by attenuating vibration. Some other techniques are to isolate our place of interest by a wall or barrier [7]. But in this way we isolate ourselves from noise, but we have exposed the whole world to a large amount of noise and it is highly undesired. So research works have been done for more than 70 years on the active control of noise as described below.

Active Noise Control

In this method an electronically synthesized anti-noise, which is equal in magnitude and opposite in phase with noise, is superimposed with it so that destructive interference takes place and the original sound field is exactly cancelled. This is the basic idea of active noise control method. Here we do not modify the environment, rather our work is confined to electronic domain only and this is the main area of interest of our research work.

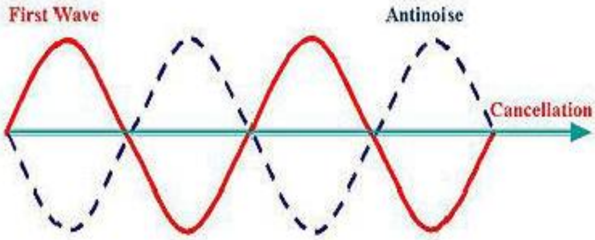

Figure 3: Destructive interference of noise and anti-noise

Physical Mechanisms

The cancelling signal is called the anti-noise, which has equal magnitude and opposite phase with the noise. This is generated electronically and introduced into the acoustic domain so that there is a destructive interference between noise and anti-noise and we get a silent zone. In this method the noise level may be reduced at our desired locations, but according to law of conservation of energy at some other places the noise level is increased considerably. This is known as “Local cancellation”. For example if we have designed an active headset, then near our ear the sound field is cancelled actively, but at other locations the sound level is high.
Except cancellation there are also some mechanisms by which noise can be controlled actively. Due to introduction of anti-noise sources the acoustic radiation impedance of the undesired noise source is changed. The noise field may be absorbed or reflected by the anti-noise sources in some other methods.

III. LITERATURE SURVEY

Muhammad Tahir Akhtar: This paper develops an efficient adaptive filtering algorithm for active impulsive noise control (AINC) systems. For AINC systems, the filtered-x least mean square (Fx-LMS) algorithm fails to converge due to the impulsive nature of the noise source. In previous work, the step-size of the Fx-LMS algorithm was normalized using the power estimate of the error as well as the reference signals, resulting in the improved normalized step size Fx-LMS (INSS-Fx-LMS) algorithm. The INSS-Fx-LMS algorithm exhibits a robust performance for AINC systems; however, it uses a preselected fixed step-size [1].

Priyank H. Prajapati1, Anand D. Darji: Noise reduction is an essential part of the signal processing for error-free analysis and critical measurements of the signal. Various robust mixed norm (RMN)-based adaptive algorithms have been reported to remove Gaussian and impulsive noise together. In this paper, a modified robust mixed norm (MRMN) with step-size scalar-based adaptive filter has been proposed to suppress the impulsive and Gaussian noise in system identification application. Further, an attempt has been made to develop an algorithm that simultaneously improves the rate of convergence and reduce the steady state error (SSE). The proposed adaptive algorithm on an average decreases 13.2% SSE at the same initial rate of convergence, and at the same SSE, the rate of convergence is increased by 43.8% as compared to the existing mixed norm-based adaptive algorithms [2].

Valiantsin Belyi, Woon-Seng Gan: Commercial noise-cancelation headphones are based on active noise control (ANC) algorithm. However, all existing ANC headphones are based on bilateral ANC approach, where two independent monaural ANC systems are used respectively for the left and the right ear cups. In this paper, we first propose a binaural ANC algorithm to evaluate its performance over the bilateral ANC algorithm and subsequently, modify into a combined bilateral-binaural ANC (CBBANC) algorithm for headphones in order to improve noise reduction performance for different cases when there are more than one noise sources and all noise sources are situated at different locations and for diffuse field noise. Experimentation results show that the combined binaural-bilateral ANC has better performance in all our tests compared to the conventional bilateral ANC headphones [3].

Xiaolan Wang, Tongzhou Wang, Lili Su, Yansong Wang, Dongpo Yang, Chao Yang, Ningning Liu: In this study, to reduce secondary sound source pollution in the reference signal of active noise control (ANC), a novel ANC algorithm, based on signal reconstruction, is proposed for vehicle interior noise. This algorithm combines the processes of ear-sides noise reconstruction and ANC. First, to reduce non-stationarity and nonlinearity, multisource noise signals outside the vehicle are decomposed into a finite number of intrinsic mode function (IMF) components by empirical mode decomposition (EMD). Second, the IMFs are reconstructed by the energy-extreme division method into three components: high-frequency, intermediate-frequency and low-frequency. The active control results suggest that the proposed algorithm can not only effectively suppress the interior noise but can also avoid pollution from secondary sound sources [4].

Dinh Cong Le, Defang Li, Jiashu Zhang: To reduce the computational burden of the bilinear FLANN (BFLANN) filter for active noise control (ANC), an M-max partial update leaky bilinear filtered-error least mean square (MmLBFE-LMS) algorithm is proposed in this paper. Unlike the algorithm based on filtered-reference technique in BFLANN-based ANC system, the proposed MmLBFE-LMS algorithm uses the filtered-error method and data-dependence partial update strategy to reduce computational complexity, and employs a leaky technique to mitigate the instability problem as in bilinear filters. The simulation results and computational complexity analysis indicate that the proposed algorithm can significantly reduce the computational burden of the BFLANN-based ANC system without suffering from noise-canceling performance degradation [5].

IV. ANC SYSTEM

Active Noise Control is based on two types of control techniques.

- Feed forward control
- Feedback control

Feed forward ANC is generally more robust as compared to feedback ANC, particularly when the feed forward system has a reference input signal independent of the secondary anti-noise. Noise may be classified into broadband and narrowband noise. Hence, ANC may also be classified:

- Broadband
- Narrowband

Broadband noise generally has stochastic properties and its energy is distributed over a frequency range, etc. In contrast to broadband noise is narrowband noise whose energy is found at discrete frequencies or approx. discrete frequencies.

Broadband Feed forward ANC Systems: A significant amount of broadband noise is produced in Heating, Ventilation and Air conditioning systems. A very simple single channel feed forward ANC control system for a narrow and long duct is illustrated in Figure 4. It has a single reference sensor, a single secondary source and a single error sensor.

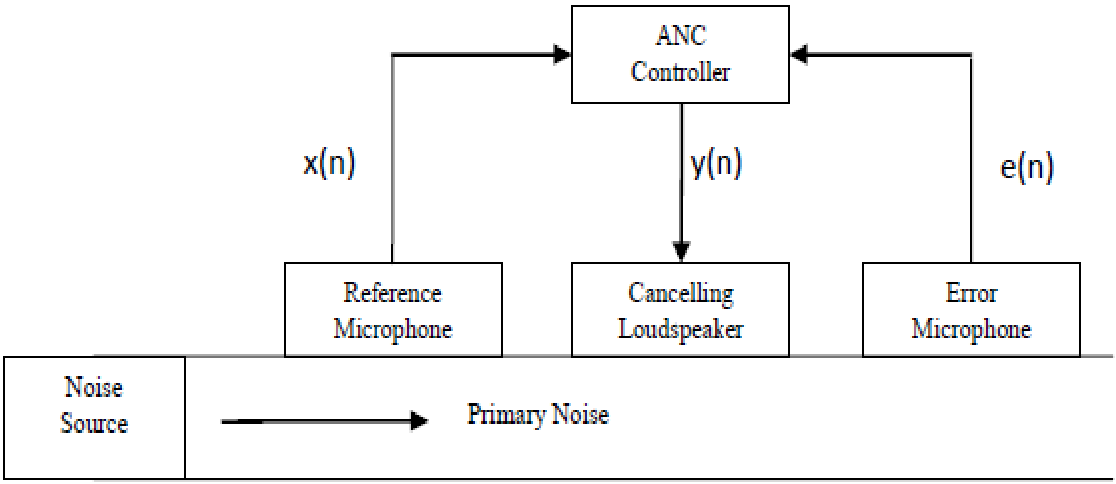

Figure 4: Single Channel Broadband Feed forward ANC systems for Duct noise control

Block diagram is shown in Figure 5, which explains narrowband ANC for attenuating noise in a duct. In narrowband ANC, the reference microphone may favorably be replaced by a non-acoustic sensor which eliminates eventual problems of acoustic feedback. An error microphone is still required to measure the noise to be controlled to adjust the coefficients of the adaptive filter to minimize the mean-square error [2].

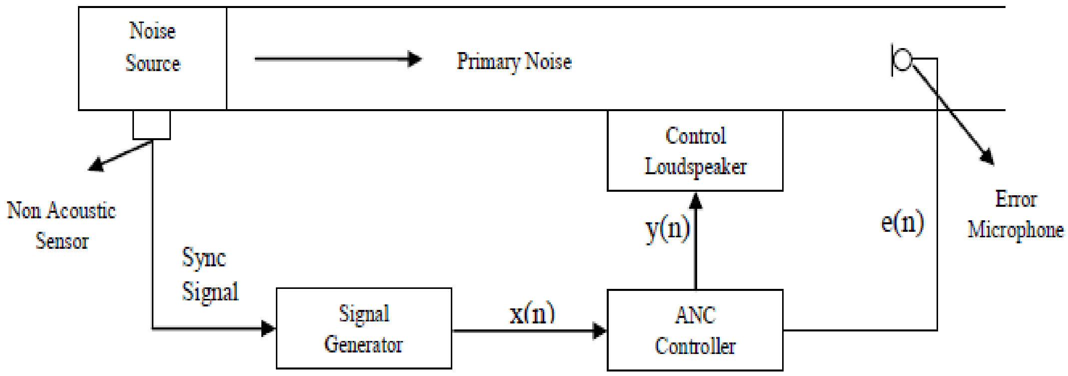

Figure 5: Narrowband Feed forward ANC system for Duct noise control

Feed Back ANC Systems

A Feedback ANC configuration is illustrated in Figure 6. In cases where a suitable reference signal is not available, such configuration may be utilized.

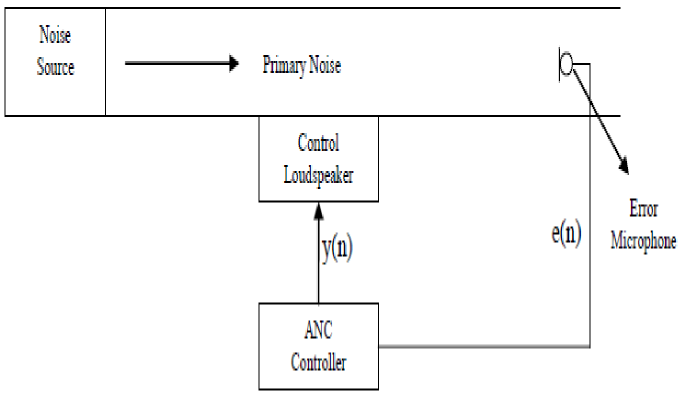

Figure 6: Feedback ANC systems

The algorithms for adaptive signal processing for active noise control applications are listed below:

- LMS
- NLMS
- Fx-LMS
- Fx-NLMS
- Fu-LMS

V. CONCLUSION

The problem of controlling the noise level in the environment has been the focus of tremendous amount of research over the years and noise control has gained considerable importance in the recent years. ANC signal algorithm expanded to multiple channel cases for controlling the noise field in enclosure. Various adaptive algorithms are lattice, frequency domain, sub band and RLS algorithm were also modified for ANC application. Desired active noise control techniques can be applied as per requirement of application with suitable algorithm. The most popular adaptive signal processing algorithm used for ANC applications is the filtered-x least mean square (FxLMS) algorithm which is a modified version of the LMS algorithm. Ease of adaptive filter techniques of its implementation introduces various active noise control (ANC) systems, using different algorithms for efficient and effective acoustic noise control.

REFERENCES

[1]. Muhammad Tahir Akhtar, "Developing a Filtered-Reference Adaptive Algorithm Using a Convex-Combined Normalized Step-Size Approach", Circuits, Systems, and Signal Processing, 5 February 2020, DOI: 10.1007/s00034-020-01368-z.

[2]. Priyank H. Prajapati1 · Anand D. Darji, "FPGA Implementation of MRMN with Step-Size Scaler Adaptive Filter for Impulsive Noise Reduction", Circuits, Systems, and Signal Processing, 04 January 2020, DOI: 10.1007/s00034-019-01339-z.

[3]. Valiantsin Belyi, Woon-Seng Gan, "A combined bilateral and binaural active noise control algorithm for closed-back headphones", Applied Acoustics 160 (2020) 107129, DOI: 10.1016/j.apacoust.2019.107129.

[4]. Xiaolan Wang, Tongzhou Wang, Lili Su, Yansong Wang, Dongpo Yang, Chao Yang, Ningning Liu, "Adaptive Active Vehicle Interior Noise Control Algorithm Based on Nonlinear Signal Reconstruction", 16 April 2020, DOI: 10.1007/s00034-020-01410-0.

[5]. Dinh Cong Le, Defang Li, Jiashu Zhang, "M-max partial update leaky bilinear filter-error least mean square algorithm for nonlinear active noise control", Applied Acoustics 156 (2019) 158–165, 01 July 2019, DOI: 10.1016/j.apacoust.2019.07.006 .

[6]. Pucha Song, Haiquan Zhao, "Filtered-x least mean square/fourth (FXLMS/F) algorithm for active noise control", Mechanical Systems and Signal Processing 120 (2019) 69–82, 10 October 2018, DOI: 10.1016/j.ymssp.2018.10.009.

[7]. ihui Zhang, Thushara D. Abhayapala, Wen Zhang, Prasanga N. Samarasinghe, Shouda Jiang, "Active Noise Control Over Space: A Wave Domain Approach", IEEE/ACM Transactions on Audio, Speech and Language Processing, Vol. 26, No. 4, April 2018.

[8]. Yi-Rou Chen, Cheng Yuan Chang, Sen M. Kuo, "Active Noise Control and Secondary Path Modeling Algorithms for Earphones", 2017 American Control Conference Sheraton Seattle Hotel, May 24–26, 2017, Seattle, USA.

[9]. Jihui Zhang, Thushara D. Abhayapala, Prasanga N. Samarasinghe, Wen Zhang, Shouda Jiang, "Sparse Complex Fxlms for Active Noise Cancellation Over Spatial Regions", IEEE, ICASSP 2016.

[10]. Monali Dhal, Monalish Ghosh, Pankaj Goel, Asutosh Kar, Shibalik Mohapatra and Mahesh Chandra, "An Unique Adaptive Noise Canceller with Advanced Variable-Step BLMS Algorithm", 2015 International Conference on Advances in Computing, Communications and Informatics (ICACCI).

[11]. Abhishek Deb, Asutosh Kar, Mahesh Chandra, "An Efficient Minimum Mean M-Estimate Sub-band Adaptive Active Noise Cancellation Algorithm", 978-1-4799-4075-2/14, © 2014 IEEE.

[12]. Peng Li a, XunYu, "Active noise cancellation algorithms for impulsive noise", Mechanical Systems and Signal Processing 36 (2013) 630–635, DOI: 10.1016/j.ymssp.2012.10.017.