A SURVEY ON ADAPTIVE NOISE CANCELLATION TECHNIQUE & ADAPTIVE ALGORITHMS

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***Abstract*:** Adaptive Filters finds applications in various areas of signal processing. Adaptive filters are commonly used in system identification, noise cancellation (white and colored noise), and also in many applications of biomedical signal processing by the help of various optimization algorithms. The choice of an algorithm is dependent on the requirement of the algorithms in certain environment. In this paper we will discuss about the adaptive noise cancellation (ANC) with use of adaptive filters and its various applications.

Keywords: Adaptive Noise Cancellation (ANC), Adaptive Filters, Statistical Signal Processing (SSP)

INTRODUCTION

An adaptive filter is a type of linear digital filter that has self-adjusting coefficients according to an optimized algorithm. Its transfer function is controlled by variable adjustable parameters which are controlled by the optimizing algorithms [1]. With increase in number of applications of digital signal processors, adaptive filters are used in many applications involving communication devices like mobile phones, noise cancellation and bio-medical monitoring equipment. Fig 1 shows the closed loop block diagram of an adaptive filter. The basic principle behind the same is that a variable filter is adjusted until the error is as minimum as possible.

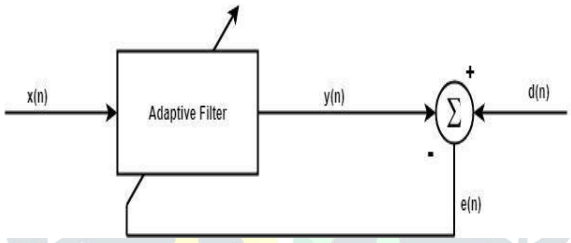

Fig 1: Basic Structure of Adaptive Filter

In this paper we will discuss about Noise Cancellation technique as an application of Adaptive Filters along with the algorithms of the same. Noise cancellation as the name suggest, involves the techniques and procedures which cancels noise in a given system, which can be done by superimposing an "anti-noise" wave through secondary source which are interconnected through an electronic system using a specific adaptive or optimized algorithm. Adaptive filters are best suited for Noise Cancellation which has the ability to configure themselves automatically to block the passing of undesired signals

ADAPTIVE NOISE CANCELLATION

Adaptive Noise Cancellation (ANC) is also called as noise control which is a method for reducing unwanted noise signal by adding second signal [2]. The basic principle behind Adaptive Noise Cancellation is to pass the corrupted signal or the signal consisting noise through filter which tends to suppress the noise while leaving the signal unchanged. The basic principle used for the analysis of Adaptive Noise Cancellation is shown in the Fig 2 which uses two inputs along with an adaptive filter. The first input which is the primary input is signal corrupted by noise. The other input is the noise reference input which contains noise related in some way to that in the main input. An output is produced when a noise reference signal input is passed through the adaptive filter. The filter readjusts itself continuously in order to minimize the error during this process. When the filter is adjusted the error is minimized. So the system output can serve as the error signal for the adaptive filter.

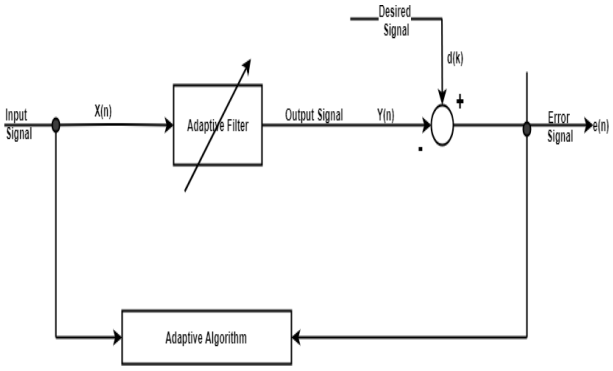

Fig 2: Adaptive Noise Canceller

ADAPTIVE FILTER ALGORITHM

Figure 3 Shows the various types of algorithms which can be implemented to the adaptive filters. the algorithms can be classified into two categories namely the Least Square Estimation (Recursive Least Square Algorithms RLS) and Stochastic Gradient Approach (Least Mean Square Algorithms LMS, NLMS, TVLMS etc.) . In this paper we will briefly discuss about the LMS and RLS algorithms and compare the performance of the two algorithms [3].

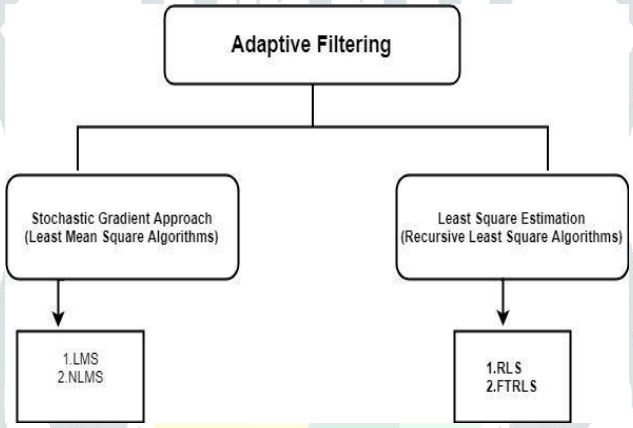

Fig 3: Various Adaptive Algorithms

LMS

The LMS algorithm relates to the steepest descent algorithm in which the weighted vector gets updated from sample to sample which does not requires any present knowledge of statistics of the signal, but instantaneous estimates are instead used. The weights thus obtained by the analysis from LMS algorithm
are only estimates, which improves with time[4]. The weights converge as per the condition for convergence which is given by:

(1)

Where is the maximum Eigen value of the input data covariance matrix [6]. LMS Algorithm implementation involves the iterative computations which involves the

Output of filter: (2) Estimated error: (3) Updated filter weights:

(4)

From equations (2), (3) & (4) we see that the algorithm makes it the first choice and easiest approach in many real-time systems because of its lesser complexity and ease of use. For each new set of samples involving input and output, the computational complexity in case of LMS algorithm requires 2N+1 additions as well as multiplications[8].

RLS

The RLS (recursive least squares) algorithm is another optimized way for determining the adaptive filter coefficients which is based on Least Square Estimation. In comparison to the LMS algorithm, this algorithm make use of past information of input samples for estimation of the autocorrelation matrix of input vector.

This optimized algorithm is based on the principle of least squares method. With recursive least squares algorithm, the estimates gets updated for new set of data. The weighted data can be obtained exponentially from a suitable RLS algorithm to remove the effects of old data gradually and to allow the tracking of slowly varying signal characteristics. Thus,

(5)

] – (6)

(7)

(8)

(9)

In equations (5) to (9) is a recursive way to compute the inverse of the matrix .

The RLS algorithm is more complex as compared to LMS algorithm in terms of computational complexity. Due to recursive updating of data , the inversion of matrix is not required[5]. The RLS algorithm has a faster convergence rate as compared to the LMS algorithm. Other advantages include that RLS algorithm can be used in deterministic signals whereas LMS algorithms are suitable for statistical signals.

CONCLUSION

In this paper we have discussed about adaptive filter and Adaptive Noise Cancellation technique. An adaptive filter is a type of linear digital filter whose transfer function has controllable variable parameters which can be adjusted according to an optimization algorithm. Adaptive filter plays a vital role in Adaptive Noise Cancellation technique. Adaptive Noise Cancellation is also called as noise control which is a method for reducing unwanted noise signal by adding second signal. Two adaptive algorithms were discussed in this paper which is based on least square estimation technique and stochastic gradient approach technique. The difference between the two algorithms is shown in Table 1 which concludes that RLS algorithm is a better approach towards Adaptive Noise Cancellation technique irrespective of its complexity.

TABLE 1: Comparison Between LMS & RLS

S.No	Adaptive Algorithm	Computational Complexity	Stability	Convergence	Limitation
1.	LMS	2N+1 additions as well as multiplications, where N is order of filter	stable	Poor	LMS algorithm can't be used for deterministic signal
2.	RLS	O	More stable in comparison to LMS	Improved convergence in comparison to LMS	More complex & can't be used for statistical signal

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