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Design of Quantized Least Mean Square Adaptive Filter for Adaptive Noise Cancellation

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Abstract— an adaptive filter finds its application in adaptive noise cancellation where a signal corrupted from noise is extracted and signal free from noise using an adaption algorithm is obtained. There are various types of adaptation algorithms for FIR filters such as least mean square (LMS) and recursive least square (RLS). The performance of these algorithms can be compared according to three parameters which are convergence speed, misadjustment and tracking capability. Convergence speed is simply the number of iterations needed for the filter to converge to its optimum state for a specific desired signal and input signal. in adaption algorithm it is not necessary to have any a priori knowledge of signal or noise characteristics that corrupt the signal. This paper proposes method of noise cancellation using quantized version of least mean square algorithm which provide better result as compared to normal least mean square algorithm. This property makes the adaptive filter has an important application in noise cancellation.

Index Terms— sign function; modified sign function; least Mean Square algorithmt ; QX-Least Mean Square Algorithm.

1 INTRODUCTION

The adaptive filters are popular owing to its simplicity but even simpler approaches are required for many real-time applications. Reduction of the complexity of the Adaptive filter had received attention in the area of adaptive filter. [1]

A signal corrupted from noise is to be extracted find its application in various application fields, such as digital communications, radar, sonar and biomedical engineering, so that uncorrupted signal can be used for signal processing. And less power is utilized by system. Suppressing information bearing signal from signal corrupted by a sinusoidal interference utilize a fixed notch filter tuned to the frequency of the interference in traditional method. But in this case a precise frequency of the interference is to be known, but when notch is required to be very sharp, then adaptive noise cancellation provide solution for extracting information bearing signal from corrupted signal.
the method for filtering a information bearing signal from noise corrupted signal uses a filter that filters the noise from corrupted signal and information bearing signal remain unchanged. a fixed or adaptive filter can be utilized for filtering process.
Adaptive filters have the capability to adjust their own parameters automatically using an adaption algorithm. On the other hand, fixed filters design is based on prior knowledge of both the information bearing signal and the noise.

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In design of adaptive filter a priori knowledge of signal or noise characteristics is not required. In this paper we have used adaptive filter for noise cancellation using quantized least mean square algorithm. An application of noise cancellation for adaptive filter have highly advantageous in various fileld.It makes use of primary input supplies an information – bearing signal and a that are uncorrelated with each other. Noise is the correlated version of the sinusoidal interference supplied as the reference input. Primary input contains both the signal and noise. Reference input is filtered and subtracted from a primary input so noise is attenuated or eliminated by subtracting the reference input from primary input.

2 ADAPTIVE NOISE CANCELLATION

In order to improve signal-to noise ratio (SNR) for a system, adaptive filters find an application of adaptive noise cancellation where noise from the corrupted information bearing signal is extracted. This process is known as adaptive noise cancellation. An Adaptive Noise Cancellation is typically a dual-input, closed-loop adaptive feedback system where two inputs are: the primary input signal and reference input.

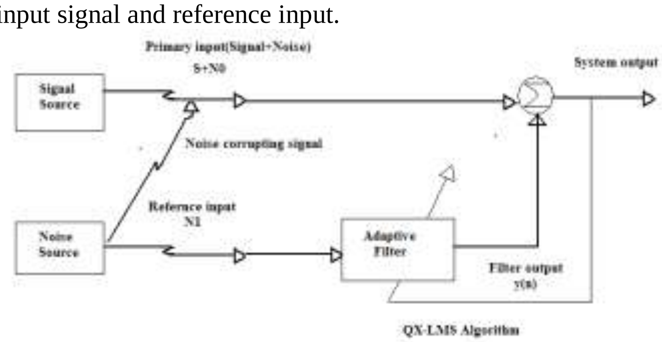

Fig. 1 Block diagram for Quantized Adaptive Noise cancellation scheme

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Block diagram for quantized adaptive noise cancellation scheme is shown in fig. 1. A signal source used to transmit signal that signal is corrupted by a noise. The combined signal and noise form the primary input to the quantized adaptive noise canceller. Input to the filter receives a noise, uncorrelated with the signal but correlated in some unknown way with the noise. Adaptive filter processes this noise input signal using QX-LMS adaption algorithm and filtered to produce an output y(n) that is approximated version of noise. Then the output of adaptive filter is subtracted from the primary input which is combination of signal and noise to produce the system output. The overall system output is the output for Quantized adaptive noise canceller.
In the system shown in Fig. 1, FIR filter is used as a adaptive filter where the reference input (noise) is processed. This filter differs from a fixed filter in sense that this filter automatically adjusts its coefficients weight (impulse response) using an adaption algorithm. In this paper filter uses QX-LMS adaption algorithm so that the error can be minimize by adjusting the filter coefficients.

3 LMS ALGORITHM

The LMS algorithm is a widely used algorithm for adaptive filtering. The algorithm is described by the
Following equations:

$$y(n) = \sum_{i=0}^{M-1} w_k(n) * x(n-i) \text{ .... } (1)$$

$$e(n) = d(n) - y(n) \text{ .... } (2)$$

$$w_k(n+1) = w_k(n) + 2\mu * e(n) * x(n-i) \text{ .... } (3)$$

In these equations, the tap inputs $x(n), x(n-1), x(n-2), ..., x(n-M+1)$ form the elements of the reference signal $x(n)$, where $M-1$ is the number of delay elements. $d(n)$ denotes the primary input signal, $e(n)$ denotes the error signal and constitutes the overall system output. $w_k(n)$ denotes the tap weight at the nth iteration. In equation (3), the tap weights update in accordance with the estimation error. And the scaling factor μ is the step-size parameter. μ controls the stability and convergence speed of the LMS algorithm..[2]
The LMS algorithm is convergent in the mean square if and only if μ satisfies the condition: $0<\mu<2/\text{tap-input power}$

$$\text{Where tap-input power} = \sum_{k=0}^{M-1} E[|u(n-k)|^2]$$

4 QUANTIZED LMS ALGORITM

The Modified Sign Function is three level quantization scheme whose value is dependent on the value of δ and is given as,[3]
Where msgn{.} is the modified sign function defined as:[1]

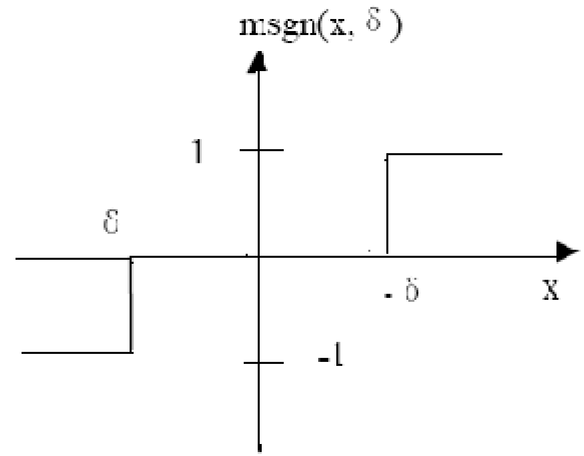

Fig. 2 : Modified Sign Function

$$mgsn = .\begin{cases} +1, \delta \le x_n(i) \\ 0, -\delta < x_n(i) < \delta \\ -1, x_n(i) \le -\delta \end{cases}$$

It should be noted that the implementation of such an adaptive filter has potentially greater throughput because for those times when the tap input signal, $x_n(i)$, is less than the specified threshold, δ, then $\hat{x}_n(i)$ will be equal to zero and no coefficient adaptation for the corresponding weight needs to be performed. This means that some of the time-consuming operations in the weight update formula can be omitted, thereby leading to a reduction of the computational load on the processor. Whether this potential can be realized depends on the architecture used in the processor and also in applications
For this three level Quantization Scheme, Adaptive LMS algorithm can be written as, [4]

$$w(n+1) = w(n) + \mu e(n)\hat{x}(n)$$

Where $\hat{x}(n)$ is the three levels Quantized input signal,

5 SIMULATION AND RESULT

MATLAB results for the normal LMS and Quantized LMS are shown below, in normal LMS, primary input is the combination of information bearing signal and sinusoidal interference, input to the adaptive filter is the correlated version of the sinusoidal interference

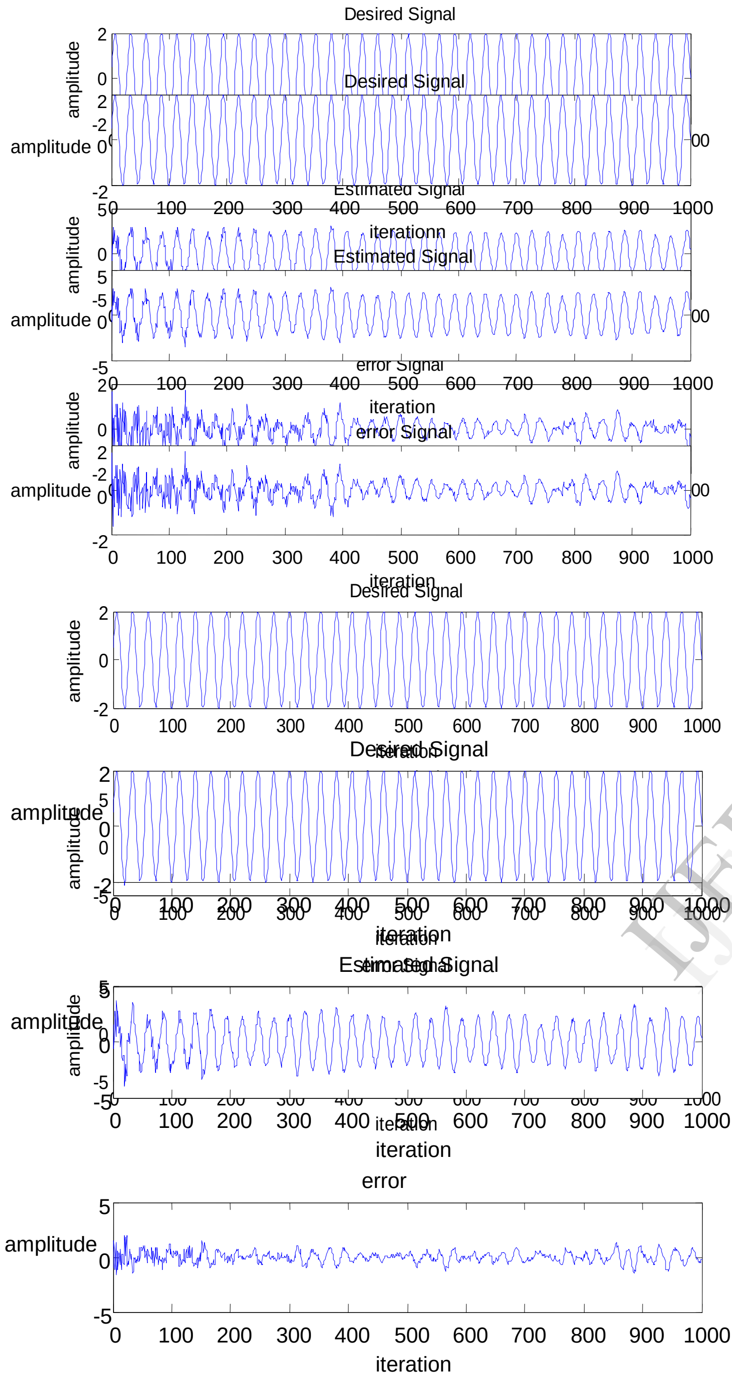

Fig.4 Noise cancellation using modified clipped QX-LMS

4 Conclusion

Adaptive noise cancelling is a method of adaptive filtering that can be applied whenever a suitable reference input is available. The principal advantages of the method are its adaptive capability, its low output noise, and its low signal distortion. The adaptive capability allows the processing of inputs whose properties are unknown. Output noise and signal distortion are generally lower than can be achieved with conventional optimal filter configure

tions. In this paper, Quantized LMS is used for noise cancellation which is better as compared as normal LMS algorithm and results are compared on MATLAB.

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