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Design of Adaptive Filter for Biosignal Noise Cancellation Using Brent Kung Adder

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ABSTRACT

Adaptive filter can update itself with variation in time. Thus it finds its application in variety of signal processing tasks such as System identification, prediction, Inverse Modeling and noise cancellation. When the priori of the signal is unknown, adaptive filters play an important role as they are self-regulating system that uses the recursive algorithm for processing. This paper demonstrates the design of Kalman adaptive filter using parallel prefix adder, the Brent Kung Adder for noise cancellation in ECG signal. Experiments are carried out with traditional adder and the Brent Kung Adder in Kalman Adaptive Filter. The Performance of the filter is analysed in terms of Signal to Noise Ratio and is compared for 4,8,16,32 tap filters and the proposed adder implementation improves the performance of the filter.

Key words : Adaptive Filter, ECG Signal, Brent Kung Adder Adder, Signal to Noise Ratio

1.INTRODUCTION

According to an optimization algorithm, Adaptive filter is a system with linear filter that has a transfer function controlled by variable parameters and means to adjust those parameters. Almost all adaptive filters are digital filters due to the complexity of the optimization algorithms. In practical situations, the system is operating in an uncertain environment where the input condition is not clear and/or the unexpected noise exists. A highly successful solution to this more difficult is found in the "adaptive filter", which is a powerful system with a wide of engineering applications.[9-13].Adaptive filters consist of three basic components: the adaptive filter h(n), the error E(n) and the adaptation function :Y(n)=X(n)*H(n) and as shown in Figure 1.

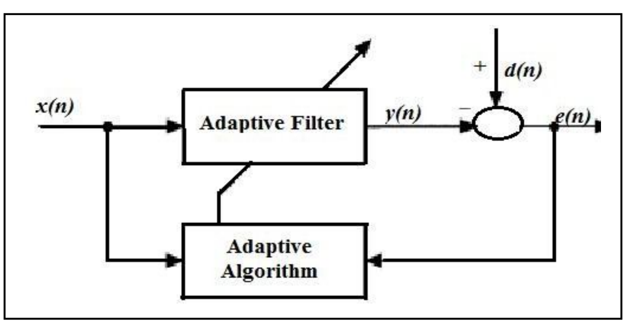

Figure 1: Adaptive Filter-Block Diagram

The goal of the system is to adapt the filter in such a way that the input signal X(n), is filtered an output signal Y(n), that will minimize the error signal E(n), when subtracted from the specified signal D(n). The arrow through the adaptive filter is standard notation to point that the filter is adaptive. This means that all of the filter coefficients can be adjusted in such a way that the mean square error is to be minimized.[16][17] To ensure the steadiness of the adaptive algorithm, most adaptive filters use an FIR type. The adaptive filters are widely utilized in areas like control systems, communications, signal processing, acoustics, to affect random signals with stationary or quasi stationary statistics.

A variety of research papers are available based on adaptive filter and parallel prefix adder. Implementation of PPA-Brent Kung Adder For Computing Application[1][2][5]. They implemented parallel prefix adder and it provided high speed and reduced delay arithmetic operations. There are few literatures related to design of efficient Han Carlson Adder[3]. In this method has wider word length and the parallel prefix adder is replaced as speculative Han-Carlson adder[6] is introduced as variety stages of Brent-Kung and Kogge-Stone adders reduces the complexity of adder design. Parallel prefix adders are used to speed up the binary additions as they are very flexible.[4][5].High level transformation for adaptive filter design has been discussed for area optimisation[9][12][14-15][16,19].High Speed adders and Multipliers has been implemented for various applications.[18]

2.KALMAN ADAPTIVE ALGORITHM

KALMAN algorithm is an algorithm that uses a series of measurements observed over time, containing statistical noise and other inaccuracies, and produces estimates of unknown variables that tend to be more accurate than those based on a single measurement alone, by estimating a joint probability distribution over the variables for each timeframe. The KALMAN filter finds applications in various technologies such as navigation and control of vehicles, motor system etc.,. These filters are mostly used in the field of robotic motion planning and control and also included in trajectory optimization. Evaluation of the current state variables along with their uncertainties is done by KALMAN filter. It does not need any additional past information. When the outcome of the next measurement is observed the estimates are updated.

Step 1: Compute KALMAN gain

$$g(t+1) = k(t)u(t+1)/(uH(t+1)k(t)u(t+1)+QM) \quad (1)$$

Step 2: Filtered output

$$y(t+1) = uH(t+1)w(t+1) \quad (2)$$

Step 3: Error estimation

$$e(t+1) = d(t+1) - y(t+1) \quad (3)$$

Step 4: Update the coefficient

$$w(t+1) = w(t) + e(t+1)g(t+1) \quad (4)$$

Step 5: Compute correlation matrix

$$k(t+1) = k(t) - g(t+1)uH(t+1)k(t) + QP \quad (5)$$

where QM = δ-1IM and QP = δ-1λ

Complexity of KALMAN algorithm is low compared to RLS and AFFINE since matrix operations are not required.

3.BRENT KUNG ADDER

Adders are an integral part of any system that find applications in Arithmetic and Logic Units (ALUs), microprocessors and memory addressing units. The need for a Parallel Prefix Adder (PPA) is that the computation time is faster than the other adders. Let A= an-1 ...a1 a0 and B = bn-1 ... b1 b0 be the n-bit augend and n-bit addend respectively, then binary addition is defined by the equations (6) and (7)

$$Si = ai \oplus bi \oplus ci \quad (6)$$

$$ci = ai\,bi + ai\,ci + bi\,ci \quad (7)$$

Following are the three steps used design of the structure of Brent Kung adder.

3.1Pre-processing

Pre-processing, involves creation of generate and propagate signals. Pre-processing, involves creation of generate and propagate signals. Generate (g_i) and propagate (p_i) signals are defined by the equations (8) and (9) respectively based on prefix computation.

$$gi = ai\,.\,bi \quad (8)$$

$$pi = ai \oplus bi \quad (9)$$

3.2Prefix Computation

PPA construction depends on the notion of group carry propagate and group generate signals. Group generate and group propagate signals are defined by the equations (10) and (11) respectively.

$$G[i{:}j] = G[i{:}j] + P[i{:}j]\,.\,G[j-1{:}k] \quad (10)$$

$$P[i{:}j] = P[i{:}j]\,.\,P[j-1{:}k] \quad (11)$$

Group generate and group propagate signals are generated to as defined by the equation (12) as

$$(G,P)[i{:}k] = (G,P)[i{:}j] * (G,P)[j-1{:}k] \quad (12)$$

3.3 Post-processing

Formation of carry and sum bits for each individual operand bit is involved in Post-processing step. The equations for carry and sum are defined as per equations (13) and (14) respectively.

$$Ci = G[i{:}0] \quad (13)$$

$$Si = pi \oplus ci-1 \quad (14)$$

3. 4 Structure of Brent Kung adder

Figure 2 shows the working of Four bit Brent Kung adder. The inputs are A and B and carry C_{in}.The outputs are calculated using the three stages. Let the input be A = 0011, B = 0101 and C_{in} = 1and the result obtained in simulation is shown in Figure 3

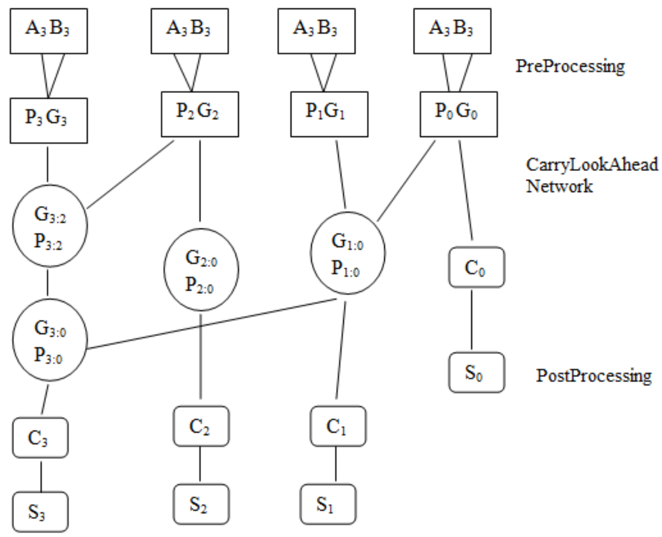

Figure 2: Brent Kung Adder

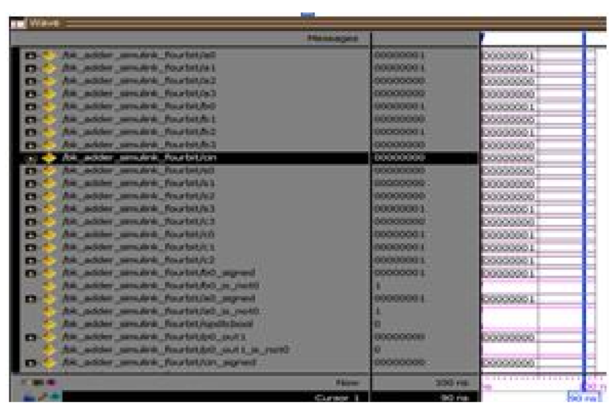

Figure 3: Output ofBrent Kung Adder

4.FILTER DESIGN USING BRENT KUNG ADDER

Figure 4 shows the Eight Tap Conventional KALMAN Adaptive Filter structure is designed and simulated in Simulink.

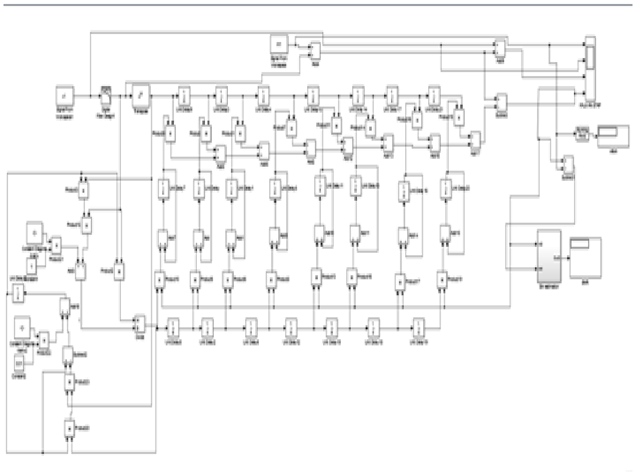

Figure 4: Conventional Kalman Filter of order 8

Figure 5 shows the eight tap KALMAN adaptive filter designed using Four bit Brent kung adder in FIR and Weight updation part is designed and simulated in Simulink.

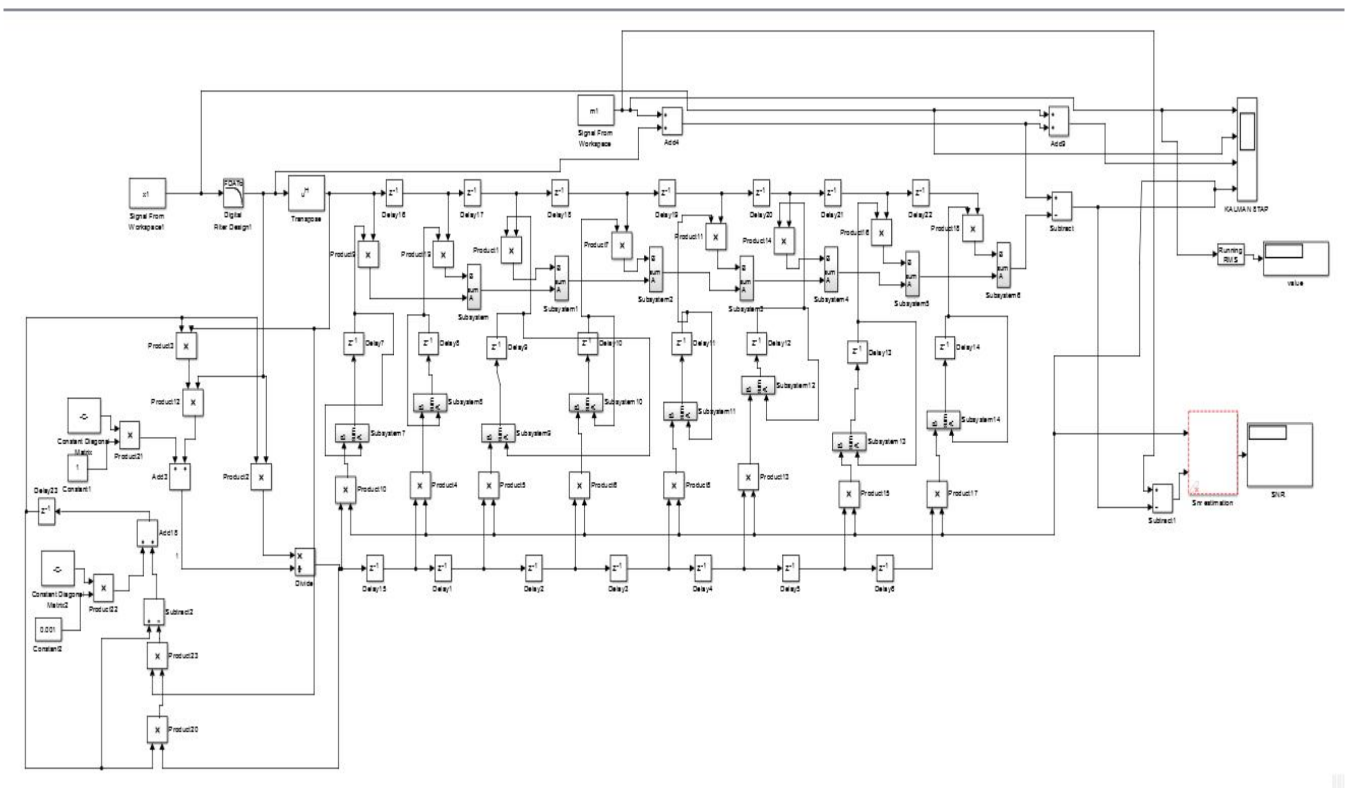

Figure 5:8-Tap KALMAN Adaptive Filter Designed using Four bit Brent Kung Adder in FIR and Weight UpdationPart

5. SIMULATION RESULTS

The Kalman adaptive filter is designed using conventional type, Brent Kung adder in FIR part and Brent kung adder both in FIR and Weight Update part. The ECG signal obtained from MIT BIH database is taken as the input for the performance evaluation of Kalman filter. Kalman filters with filter order 4,8,16 are designed and simulated. The ECG signal used for the analysis is contaminated with Power Line Interference (PLI) noise. ECG Signal contaminated with PLI noise of 50-60 Hz is applied as input signal to the designed filters. The simulations result for 8 tap Conventional Kalman Adaptive Filter is shown in Figure 6.

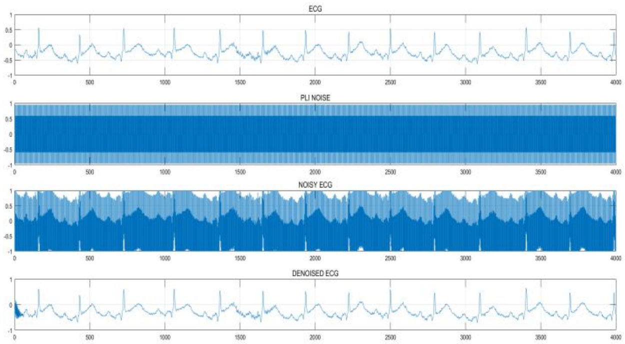

Figure 6: Simulation Output ofConventionalKalman Filter of order 8 using

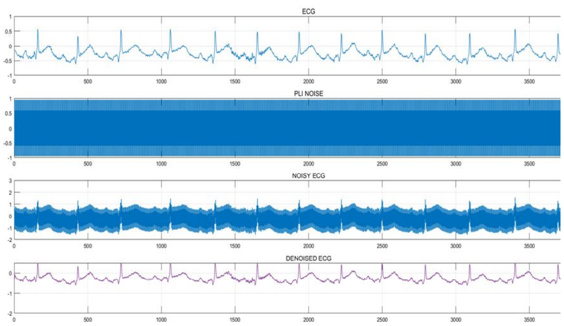

Figure 7: Simulation Output ofKalman Filter of order 8 using Four-bit Brent Kung adder in FIR part and Weight Updation part

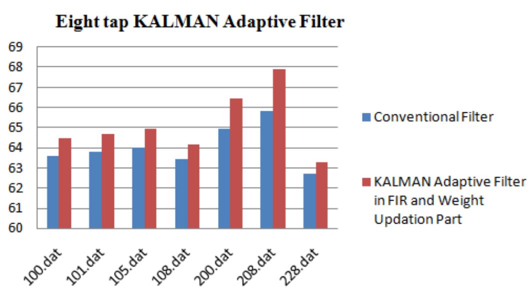

Figure 8: SNR comparison of Conventional and Proposed Filters

Figure 7 shows the simulation output of Eight Tap Kalman Adaptive Filter with modified adder in FIR part and weight updation part in Simulink. Figure 8 reveals the Signal to Noise Ratio for the conventional and proposed filters. It is observed that performance of the filter is improved.

6.CONCLUSION

The Brent Kung adder logic is applied to improve the performance of the adaptive filtering algorithms. This method is used to reduce the number of functional units in the FIR part and weight updation part. The Kalman structure is designed and simulated in Simulink with both conventional and proposed designs. KALMAN Adaptive filter using Brent Kung adder both in FIR part and weight updation part shows an SNR improvement of 26.7% and 32% than Conventional filter design for various ECG signals. It was also inferred that when the length of the filter was increased, there was a significant improvement in signal to noise ratio and minimal reduction in the mean square error. Hence usage of parallel prefix adder like Brent Kung adder in KALMAN Adaptive filter has a performance improvement than Conventional filter design.

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