

# Genetic Algorithm optimized Neural Network based Adaptive ECG Interference Canceller for Premature Infants in Incubators

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## ABSTRACT

This paper proposed a hybrid neural network Back propagation (BP) algorithm optimized by Genetic Algorithm (GA) for the diminution of the fundamental electromagnetic interferences in Incubators. Gradient based techniques have been proposed in the past for the elimination of incubator noise but they are susceptible to local minima problem. Genetic algorithms are a class of optimization procedure which is good at examining an intelligent way for selecting the number of hidden layer neurons, learning rate and momentum constant of the Artificial Neural Network (ANN) to find values close to the global minimum. The result analysis shows that the proposed approach shows good performance in cancelling the ECG interference over other conventional approaches.

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## 1. INTRODUCTION

Incubators work mainly by providing the air around premature babies warm, but their motors create Electro Magnetic Fields in the area where they lie. In May 2008, a new scientific study recommended that Electro Magnetic Fields (EMF) produced by incubators have the ability to modify the heart rates of newborn babies. Electro Magnetic Fields (EMFs) produced by incubators influence newborns HRV (Heart Rate Variability), showing an influence on their autonomous nervous system [1]-[2]. According to the American Academy of Pediatrics [3] high noise levels are common in NICU and in incubators, causing considerable hearing damage to preterm infants and disturb the normal development of the infant. Intense noise can cause serious physiological responses in infants such as changes in heart rate, blood pressure, oxygenation and respiration [4].

Electro Magnetic Interference is one of the major problems encountered in recording infant ECG is the presence of unwanted 50/60-Hz interference in the output [5]. Methods of adaptive noise cancellation were suggested by Widrow and Glover in 1975. The purpose of Active Noise Cancellation (ANC) is to filter out an interference component by identifying a model between measurable noise source and the corresponding non measurable interferences [6]. A linear model does not perform well for situations where nonlinear phenomena take place. Hence there is a need of adaptive nonlinear filtering approach. The ANC system is used to depreciate the noise inside the incubators. ANC works based on the principal of

superposition i.e. an anti – noise with equal amplitude and opposite phase is produced by the system and combined with the primary noise to cancel the undesired noise.

In [7], Thakor et al. proposed an LMS adaptive recurrent filter structure for acquiring the impulse response of the normal QRS complex and this method is also applied to several arrhythmia detection problems. Patrick.S.Hamilton [8] investigated the relative performance of an adaptive and nonadaptive 50/60-Hz notch filter applied to an ECG signal. Elimination of Electro Magnetic Interference on ECG signals is a demanding problem by virtue of the fact that the frequency of such EMI may change with time. A nonlinear adaptive EMI filter is proposed by Alizera K. Ziarani [9] to tackle this problem.

Notch filters and adaptive cancellers have been suggested to annihilate electromagnetic interferences. In [10], Suzanna et al. proposed an improved adaptive canceller for the diminution of the fundamental power line interference component and harmonics in electrocardiogram recordings. In [11], Yue-Der Lin and Yu Hen Hu proposed a Power Line Interference (PLI) detector that exerts an optimal Linear Discriminant Analysis (LDA) algorithm to make a decision for the PLI presence.

In this paper we adopted a hybrid algorithm (GAANN) that integrates GA and BP algorithm aims to combine the capacity of GA in global minimum and the optimized fast execution of the BP algorithm. Moreover BP algorithms get trapped into a local minimum, which makes the algorithm entirely dependent on the initial parameter settings. GAs is characterized by performing global search by selecting the optimized number of neurons in the hidden layer, learning rate and momentum factor of the neural network.

In section Active Noise Control Incubators, the desire of active noise control in incubator is explained. In Section HYBRID GA-BP ALGORITHM for ECG Interference Cancellation the removal of EMI artifacts from ECG in infant incubators using hybrid GA-BP algorithm are detailed. Section Simulation Results shows the simulated results of premature ECG interference elimination in incubators. Section Conclusion summarizes the findings and performance of the proposed GAANN algorithm.

## 2. PROPOSED HYBRID GA ALGORITHM FOR INTERFERENCE CANCELLATION

Genetic algorithm (GA) is a global searching and optimization procedure emulates biological evolution to solve optimization problems. GA is less vulnerable to local minima problem. Genetic adaptive algorithm has been developed to optimise the artificial neural network for active noise control applications. This genetic algorithm operates with three steps. First, the current evaluation is estimated using the fitness function. Second, the GAs selects “parents” from the current population. Third the GA produces “children” from selected “parents” using crossover and mutation operations.

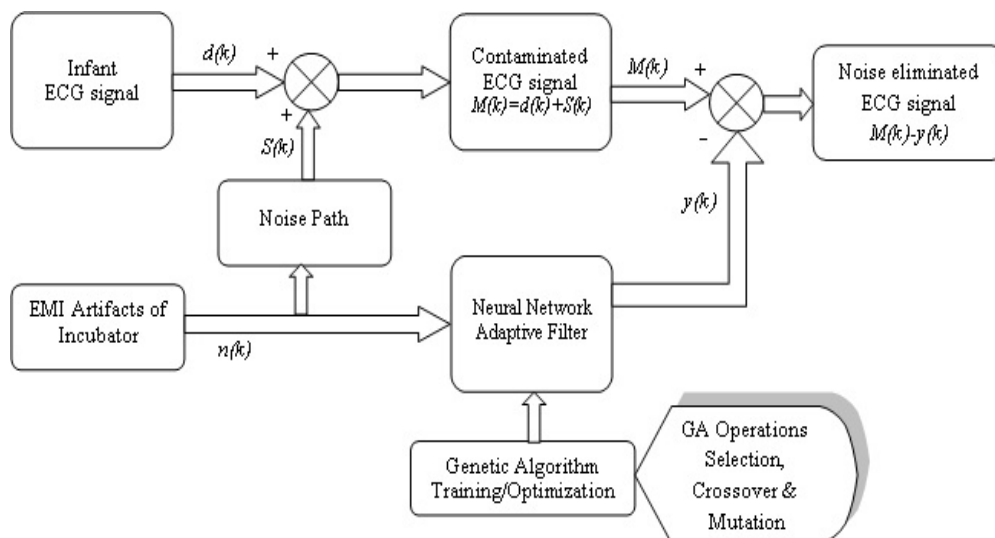


Figure 1. ANC for infant incubator using Hybrid GAANN algorithm

The Hybrid GA-NN algorithm uses a combination of neural network, adaptive filtering techniques and genetic algorithm. Figure 1 shows the block diagram of active noise control for infant incubators using hybrid GAANN algorithm. The contaminated signal  $M(k)$  consists of desired ECG signal  $d(k)$  which is

corrupted by uncorrelated additive incubator noise  $S(k)$ . The input to the adaptive filter is an incubator noise  $n(k)$  modified by the environment. The contaminated signal  $M(k)$  output is compared with the output of the adaptive filter  $y(k)$ .

The Contaminated signal output is given by

$$M(k) = d(k) + S(k) \quad (1)$$

The residual error is

$$e(k) = M(k) - y(k) \quad (2)$$

The optimization of GAANN interference canceller is performed with the learning rate and the momentum constant varied from 0 to 1 and the hidden neurons varied from 31 to 150. The crossover probability of the GA is chosen as 0.9 and the mutation probability is chosen as 0.12. For this training a maximum of 500 generations are performed with a population size of 50 and with 500 training epochs. During each GA generation, the best fitness score (minimum MSE) achieved by the population at the optimum dimension is stored. Using the proposed algorithm an optimized ANN is achieved with  $Nh = 172$ ,  $Lr = 0.6761$  and  $Mc = 0.3043$ . Thus, the proposed algorithm yields a compact network configuration in the architecture space rather than the complex ones as long as optimality prevails. The

### 3. SIMULATION RESULTS

The synthetic premature infant ECG signal generated is shown in Figure 2a and is corrupted by the noise source in the incubator Figure 2b. The electromagnetic interference signal produced from the noise source is shown in Figure 2c. The contaminated ECG signal (Figure 2d) consists of premature infant ECG signal and the electromagnetic interference signal. The neural network is trained using noisy interference as its input, with clear ECG signal is the desired target. The interference caused by the incubator is estimated using the proposed GA based ANN algorithm. Figure 3 shows the error between the generated premature infant ECG signal and the output of the interference eliminated network and is concluded from the output that the proposed hybrid ABC algorithm effectively cancels the interference minimum mean square error value is obtained.

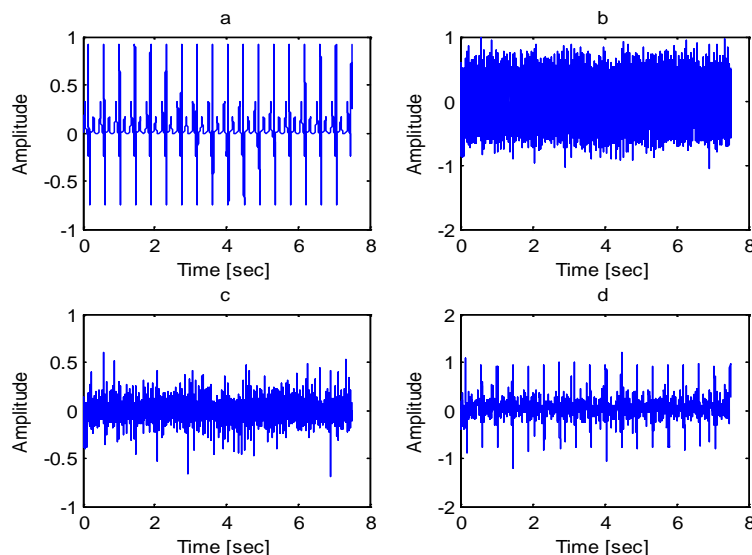


Figure 2. Measured ECG Signal from Incubator (a) Synthetic Infant ECG (b) Noise Source (c) Interference Signal (d) Contaminated ECG

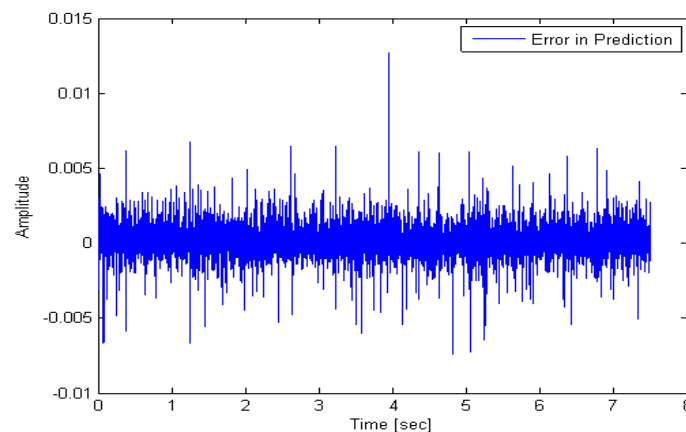


Figure 3. Residual error signal (hybrid GA algorithm)

The Performance Analysis of the proposed GAANN based noise cancellation algorithm is compared with that of conventional ANN algorithm in terms of Root Mean Square Error (RMSE) and the GAANN shows better performance as shown in Table I.

Table I. Performance Analysis

Algorithm	ANN	GAANN
RMSE	0.12	0.013

#### 4. CONCLUSION

In this paper the problem of interference cancellation from incubator using Hybrid GAANN algorithm is proposed. The BP is more successful in local searching and the GA is good at global searching and its performance of robust is excellent. For this, the input, hidden neurons and the desired response signals are properly chosen in such a way that the filter output is the best least squared estimate of the desired signal. The system proposes in this paper plays an important role in reducing the incubator ECG interference signals. The results showed the incubator noise can be significantly reduced using the developed hybrid GAANN algorithm.

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