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Comparative Analysis and Simulation of Beam Steering Algorithm for S-band Reception in Moving Vehicle

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ABSTRACT

Antenna with beam forming network has an ability to increase coverage and capacity of communication system. Using beam forming smart antenna is able to form main beam towards the direction of signal arrival thus tracking the signal while moving in vehicle. This is achieved by various beam steering algorithm. In this paper various beam forming algorithms like least mean square(LMS), Normalized least mean square (NLMS), Recursive least mean square(RLS) are simulated and analyzed. Comparison based on mean square error (MSE), no of iteration to converge, required no of multiplication is carried out. Antenna adapts its radiation pattern in such a way that it steers its main beam in the direction of arrival.

Keywords: ***DOA(Direction of arrival),LMS(Least Mean Square),*****NLMS(Normalized Least Mean Square),RLS(Recursive Least Mean square), Beam forming, Beam steering.**

1. INTRODUCTION

Satellite communication system is increasing rapidly with new features. Antenna is an essential component of satellite communication .gain and coverage of antenna decides range and data rate of communication system, with higher gain one can transmit or receive signal for longer distance but coverage area will be reduced. To cover larger area with higher gain can be achieved by beam steering. It makes the antenna intelligent. The need of beam steering arises when we want to receive multimedia data while moving in vehicle in the terrain where terrestrial network is not available specifically for army vehicle.

Beam steering enables us to track the satellite signal in moving vehicle without physical movement of antenna by using adaptive beam forming algorithms. Adaptive beam forming technique has been widely applied in radar, sonar wireless communication and other fields [6].

Adaptive beam forming is a technique in which an array of antennas is used to achieve maximum reception in the desired direction of arrival. This is achieved by varying the weights of the each of antenna used in the array [7][8].

1.1 Problem Statement

This paper presents comparative study and analysis of various beam steering algorithms like least mean square(LMS),Normalized least mean square(NLMS), Recursive least mean square (RLS) will be carried out. Finally the best algorithm in performance based on no of iteration, mean square error, convergence rate will be carried out further for beam steering in moving vehicle.

1.2 Proposed System

Block diagram of proposed system is shown in Fig 1. Modulated signal received by each patch has corresponding phase shift, phase change is applied to received signal, during initial processing each patch phase is estimated by correlating it with reference patch ,in the proposed system reference patch is taken as one of the four patches of system. Correlating the phase and beam steering is carried out by beam forming algorithm where iterative procedure is used making successive correction to weight vector which eventually lead to steering beam that tracks the direction of signal arriving in move. Output from

algorithm block is normalized and all four normalized output are added combined patch output is given to demodulator.

The paper is organized as follows: in Section 2 adaptive algorithms are described. Section 3 presents Matlab and simulation results Section 4 described comparative study and the conclusion is drawn in Section 5

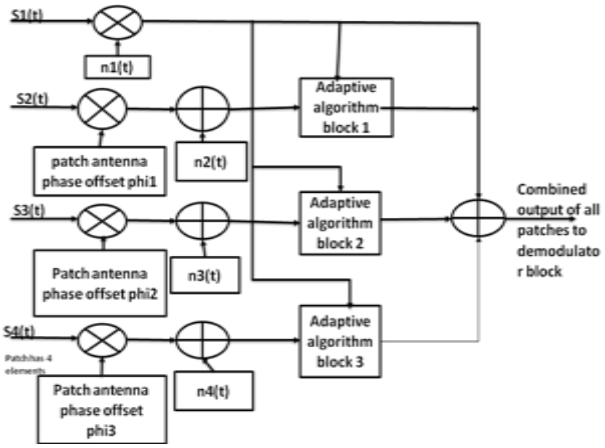


Fig 1.Proposed system block diagram

2. ADAPTIVE ALGORITHMS

The adaptive beam forming algorithms [9] can be classified into various categories: non blind and blind adaptive algorithms [4].non blind adaptive algorithms make use of a reference signal to modify array weight iteratively, so that at the end of every iteration, the output of the weight is compared to the reference signal and generated error signal is used in the algorithm to modify the weights [10]. Least mean square (LMS), Normalized least mean square (NLMS), recursive least mean square (RLS) are non blind algorithms.

Blind adaptive algorithm do not make the use of reference signal and hence no array weight calibration is required [10].constant modulus and decision directed are blind adaptive algorithms. Fig 2 shows the classification of algorithms.

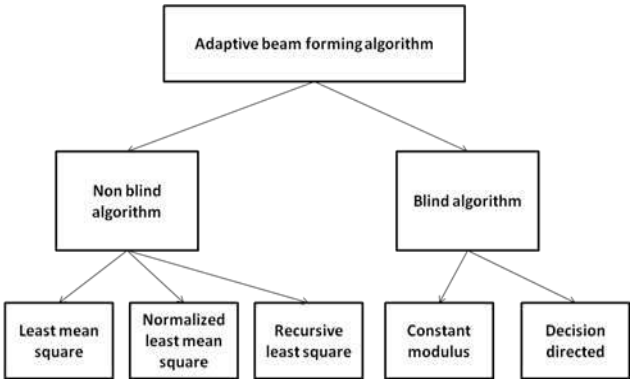


Fig 2 Classification of algorithms

2.1 Least mean square (LMS) algorithm

Least means square algorithm is a linear adaptive filtering algorithm that consists of two basic processes. 1) A filtering process, which involves computing the output of filter produced by tap inputs, and generating estimation error by comparing this output to a desired response.2) An adaptive process, which involves the automatic adjustment of the tap weights of the filter in accordance with the estimation error [11].(chap-9,pp-365).

1. Filter output
   $y(n) = w^H u(n)$
   (1)
2. Estimation error
   $e(n) = d(n) - y(n)$
   (2)
3. Tap-weight adaption
   $w(n+1) = w(n) + \mu u(n) e^*(n)$
   (3)

2.2 Normalized least mean square (NLMS) algorithm

LMS algorithm experiences a gradient noise amplification problem. To overcome this difficulty, we may use normalized LMS algorithm, which is companion to LMS algorithm correction is applied to tap weight vector [11](chap-9, pp-432).

1. Filter output
   $y(n) = w^H u(n)$
   (4)
2. Estimation error
   $e(n) = d(n) - y(n)$
   (5)
3. Tap-weight adaption
   $w(n+1) = w(n) + \frac{\mu e(n)(u(n))}{\|u(n)\|^2}$
   (6)

2.3 Recursive least mean square (RLS) Algorithm

In recursive implementation of the method of least squares, the computation starts with known initial condition and use the information contained in new data samples to update the old estimates.[11](chap 13 ,pp-563).in RLS algorithm weighting factor is chosen as $\rho(k) = \lambda^{n-k}$,where λ is a positive constant close to, but smaller than, one. The choice of λ<1 results in

a scheme that puts more emphasis on the recent samples of the observed data and tends to forgets the past. this is desirable for tracking capability.[12](chap 12 pp-419).

1. Computation of gain vector

$$u(n) = \psi^{-1}(n-1)x(n) \quad (7)$$

$$k(n) = \frac{1}{\lambda + x(n)u(n)}u(n) \quad (8)$$

2. Filtering

$$y_{n-1}(n) = w(n-1)x(n) \quad (9)$$

3. Error estimation

$$e_{n-1}(n) = d(n) - y_{n-1}(n) \quad (10)$$

4. Weight adaption

$$w(n) = w(n-1) + k(n)\,e_{n-1}(n) \quad (11)$$

5. $\psi^{-1}(n)\,update$

$$\psi^{-1}(n) = \lambda^{-1}(\psi^{-1}(n-1) - k(n)[x(n)\psi^{-1}(n-1)]) \quad (12)$$

3. SIMULATION RESULTS

This section provides the simulation results that are carried out in matlab for various beam forming algorithms.

3.1 LMS algorithm

Simulation of LMS for different values of step size is carried out in MATLAB as shown in Fig 3. The results of the response are discussed in comparative study Table 1.

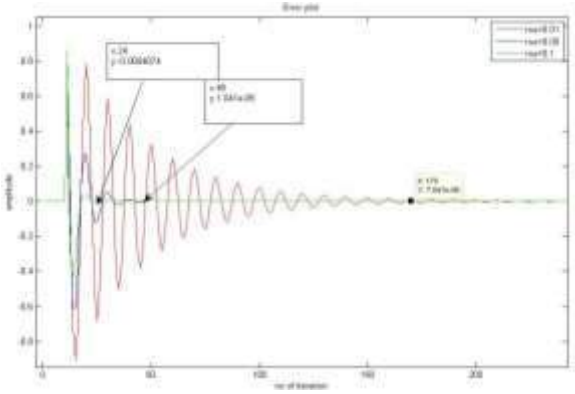


Fig 3 Error plot of LMS for different step size SNR 100db

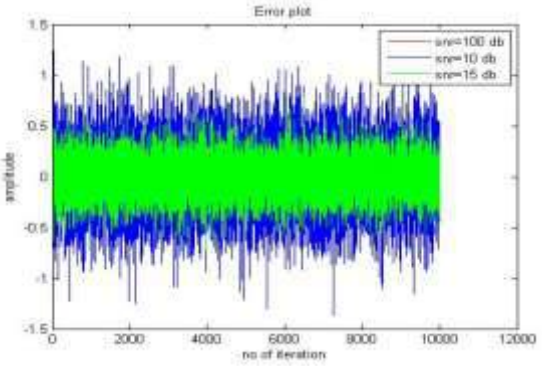


Fig4 Error plot of LMS For different SNR and step size 0.1

3.2 NlMS algorithm

Simulation of NLMS for different value of step size and different value of SNR is carried out which is shown in Fig 5 and fig 6

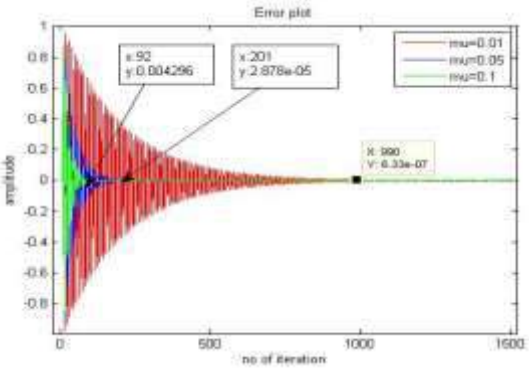


Fig 5 Error plot of NLMS For different step size SNR 100db

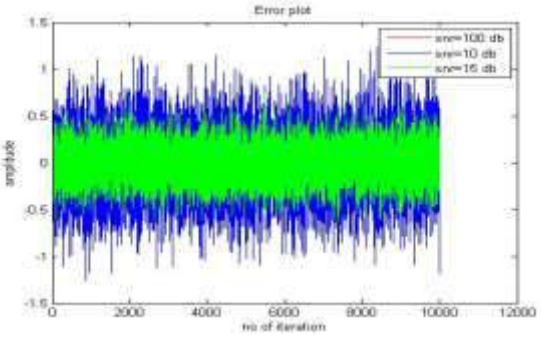


Fig 6 Error plot of NLMS for different SNR step size 0.1

3.3 RLS algorithm

Simulation of RLS algorithm for different value of forgetting factor (FF) is carried out in MATLAB is shown in Fig 7 and Fig 8

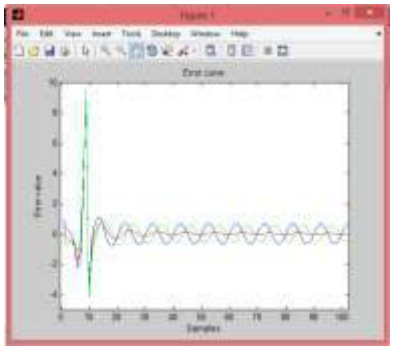


Fig 7 Error plot of RLS For different FF & SNR 100db

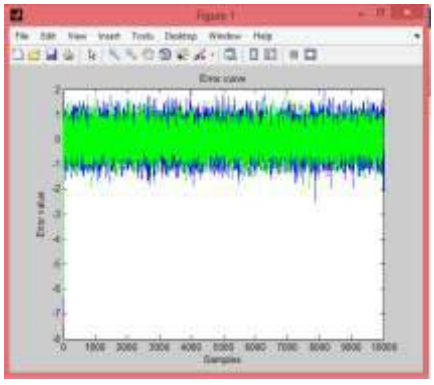
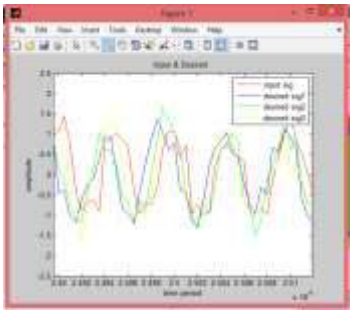


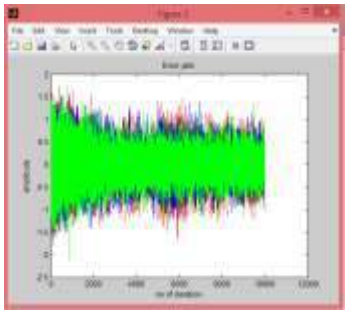
Fig 8 Error plot RLS F.F=0.999 SNR 10dB

3.4 NLMS algorithm for dynamic condition

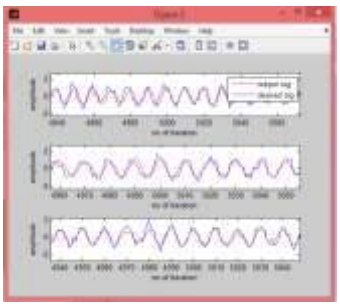
When vehicle is moving on straight path the phase shift between the incoming signal capture by antennas is continuously varying so here simulation carried out for continuously varying phase shift between four signals where one is taken as reference. Here known phase shift of 60 degree,20 degree,90 degree are taken. Simulation is shown in below figures.



(a) Input signal curve



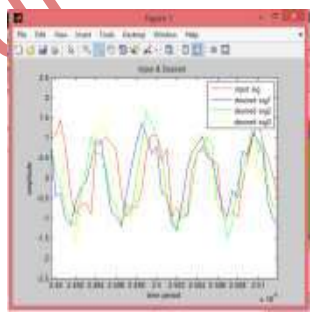
(b) Error



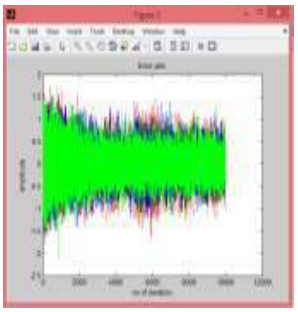
(C) Tracking

Fig 9 Input, error curve and Tracking of signal with continuous varying phase shift NLMS step size=0.01with SNR=10dB

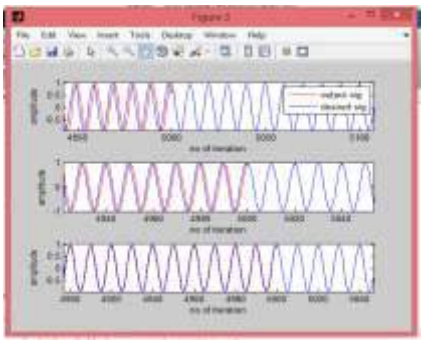
When vehicle is moving on straight path having speed breaker the phase shift between the incoming signals captured by antenna suddenly increases when speed breaker arrives, so simulation is carried out assuming the phase shift of 60 degree in first half of time period and sudden phase shift of 45 degree in second half of time period. Results are shown in Fig 10.



(a) Input signal



(b) Error curve



(C)Tracking

Fig 10 Input, error curve and Tracking of signal with sudden phase shift NLMS step size=0.01with SNR=10dB

4. COMPARATIVE ANALYSIS

Table 1. Comparative Analysis

Algorithm	Step Size	SNR	No of iteration	Remark
LMS	0.01	100 db	170	As the step size is reduced ,the rate of convergence of LMS algorithm is correspondingly decreases
	0.05		48	
	0.1		24	
	0.1	100 db	24	
		15db	Value does not converges exactly to zero it converges around zero	
		10 db		
NLMS	0.01	100db	990	Normalization results in stable adaption algorithm
	0.05		201	
	0.1		92	
	0.1	100db	92	
		15db	Value does not converges exactly to zero it converges around zero	
		10db		
Algorithm	**Forgetting factor**	**SNR**	**No of iteration**	**Remark**
RLS	0.999	100db	23	Higher complexity
	0.09		25	
	0.999	100db	23	
		10db	Value does not converges exactly to zero it converges around zero	
		15db		

5. CONCLUSION

Performance of adaptive beam forming algorithm based on mean square error, no of iteration & complexity are different for LMS, NLMS, RLS. Different algorithm converges for different value of step size parameter, it is found that NLMS algorithm provide better result above step size value of 0.0001 and LMS algorithm provide better result for step size value below 0.1.

It is found that NLMS algorithm performance is best compared to LMS & RLS for tracking signal(S-Band) in moving vehicle.

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