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An Inclusive Survey on Various Adaptive Beam Forming Algorithm for 5G Communications Systems

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Abstract. There are several existing wireless system in 5G technology, originating interference in same frequency band and degenerate the concert of received signal. Antenna System comprise of different Beamforming methods in which direction of required signal is generated by the beam and nulls and the voids are set in the direction of unwanted signal(Interference). The survey of different blind and non-blind beamforming algorithms are discussed using smart antenna and phased array. It involves Least Mean Square (LMS), Normalized Least Mean Square (NLMS),Recursive Least Square(RLS),Sample MatrixInversion(SMI),Linear Constrained Minimum Variance(LCMV),Constant Modulus (CMA), Decision feedback equalization based LMS(DFE-LMS) areconsidered. These algorithms are outlined to be claimed in 5G network to provide good quality, capacity and dealing with coincidence of signals and interference.

Keywords: SmartAntenna System, Beamforming, Adaptive algorithms, LMS, DFE-LMS, NLMS, LCMV,RLS,CMA,SMI, MVDR

1. Introduction

1.1 5G Technology

5G is the fifth generation technology.It needs multiple input and multiple output antennas.The network plays larger role than previous generations.5G is awaited to hand over high data rates upto 20Gbps.Its core network consists of user plane and control plane. Qualcomm Snapdragon X50 hardware is constructed . The power for this new technology is very less consumed and the objects will operate without help of human help.It requires high latency and it is based on OFDM technology. MIMO technology will be using in 5G applications. Its network need diversified demands.

Smart antennas are group of antennas which works based on smart signal processing algorithms and recognize spatial signal signatures. It performs several functions namely estimation of Direction of arrival(DOA), beamforming, intrusion nullify and place the ray in the desired direction. There are two types, they are Omnidirectional and directional.

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It is used to enhance security system, coverage, quality of signal, capacity, more compatible and reduce interference. It is completely software designed, and structure is complex and costly. It is a signal processing technique used for directing the signal towards the required direction and can also be reached to very long distance. In this technique, many antenna elements are combined to ensure that signals at certain angles are subjected to constructive interference and some undergo destructive interference. The beam power and direction is varied by changing the phase and amplitude of the wave, which is controlled by the beamformer. There are three different types of beamforming namely Analog, Digital and Hybrid Beamforming. It increases coverage volume and used with MIMO technology.

A beam of waves directed in the desired direction without changing the antenna's position. Phase shifter is used to transmit the antenna power. It is used in military system to detect planes and missiles. There are several types of phased array. They are active phased array which has analog transmitter which is used to direct the beam. The passive phased array is attached to one transmitter or receiver. Passive phased array is commonly used. It is used in different AM broadcast stations to improve signal power and capacity. It is also used in FM broadcasting to proliferate the gain of an antenna.Adaptive beamforming is a procedure to identify Signal of Interest (SOI) using temporal filtering and interference cancellation. The aim is to acquire the optimal array weights and modify the direction of main lobe to that of desired beam along with interference signal suppressionThe process of adaptive beamforming algorithms is represented in Figure 1. The comparison between different types of blind and non blindbeamforming algorithms will be discussed in section 2.

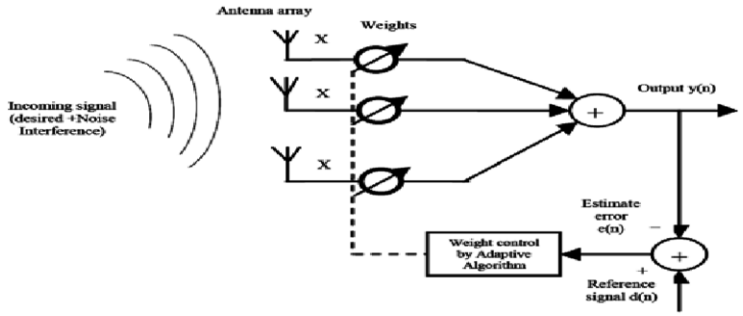

Figure 1. Adaptive Beamforming

2. Related Works

2.1Adaptive Beamforming Algorithm For 5g Interference -Coexistence Communication

There are diverse wireless structures in 5G technology that coexist and results in interference in identical frequency band which deteriorates the acquired signal. Chao Li et.al [1] has proposed to handle interference coexistence communication. Linearly Constrained Minimum variance filter(LCMV) is adopted.In LCMV, output power is taken as cost function and operates well with anti-interference. We compare LC-LMS and Log sum LC-LMS. Log sum penalty is forced on cost function. Uniform Linear Array rectifies the optimization problem. Many parameters are considered in order to

reduce the convergence rate ie step size, constraint z, number of antenna M. LC-LMS merge at n=3500 and Log sum LC-LMS converges at n=2500.When number of antenna increase, steady state will be normal. The null point of log sum LC-LMS is more intense than LC-LMS with gain lower by 30dB. Thus Log sum LC-LMS has an upper hand to that of LC-LMS.

2.2 Analysis Of Different Beamforming Algorithms

RF systems transmit the radio frequency energy towards receiving antenna. B. RajendraNaik et.al [2] designed different beamforming techniques where the beam is formed and steered to desired directions. Digital beamforming performs both transmit and receive functions. Two such algorithms are analyzed - Least Mean Square(LMS) and Normalized Least Mean Square Algorithm(NLMS) is analyzed. Adaptive antenna originates weights for array components. In LMS, Mean Square Error is minimized and step size parameter is kept constant. The issue is smaller the step size, smaller the convergence rate. This issue is rectified in Normalized Least Mean Square(NLMS).In NLMS, the step size parameter is updated in order to increase the convergence rate. LMS takes 55 iterations to solve the error whereas NLMS takes less iterations to solve the error. Therefore NLMS is better than LMS.

2.3 Beamforming Using Constant Modulus Algorithm(CMA)

Smart antenna radiates ray in the right direction. It helps in reducing interference. Dr. A. S Bhalchandra et.al [3] has proposed beamforming technique using Constant Modulus Algorithm(CMA). This method is known as blind beamformingalgorithm, that does not require skill about the signal. Here the weights are controlled to boost the Signal to Noise ratio. The capacity of CMA is upgraded by increasing the number of transmission bits. Algorithm is trailed for different values of wavelength, step size parameter. This concluded the perfect results by merging the distance (ie $d= \lambda/2$) and the step size parameter $\mu=0.01$.Thus, convergence is faster as the step size increases. Even so CMA is blind algorithm, it avoids interference and intensify capacity and quality.

2.4 Rescended Direction Of Adaptive Beamforming Using Linear Constrained Minimum Variance Algorithm

Linear Constrained Minimum Variance, an adaptive beamforming algorithm, which is used to nullify interference and drive the beam in the desired direction by determining the weight angles. The weight factor calculated does not direct the beam towards target. So in order to enhance this algorithm, Artificial intelligence is used.Particle swarm optimization (PSO), dynamic mutated artificial immune system(DM-AIS), and Gravitational search algorithm(GSA) are integrated to the prevailing LCMV technique. The step size parameter ($0<\mu<1$)is used to elevate the convergence rate. The SINR parameter was investigated for the following algorithms [4]. The SINR values for LCMV, PSO, DM-AIS, GSA algorithms are 4.40dB, 56.18dB, 72.89dB, 80.65dB respectively. It is inferred that GSA's performance is commendable compared to the rest of the algorithms and it provides highly directive beams.

2.5 Enactment Of Recursive Least Square Algorithm(RLS)

The convergence rate of Least Mean square (LMS) is slower due to step size parameter. To overcome this drawback, Recursive least squares (RLS) algorithm is adopted. Figure 2 depicts the block diagram of RLS beamforming network. The RLS filter aims at minimizing the cost function by choosing the filter coefficients and reconditioning the filter with new arrival of data.The following specification were taken into account in[5]. For N=8 antenna elements with spacing of 0.5λ, convergence rate is analyzed. In this algorithm, step size is replaced by gain matrix and as the number of antenna elements is increased, better performance is attained.

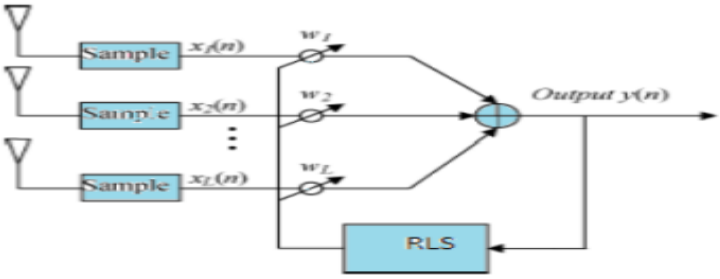

Figure 2. RLS beamforming network

2.6 Sample Matrix Inversion (SMI) Algorithm

SMI algorithm is initiated for adaptive beamforming , offers greatest SINR and convergence. Here noise and signal share parallely. The array result is accumulated with time differing weights are added to generate the output. The conventional beamformer does not rectify jamming problem, so SMI algorithm is used to void the jammer direction. The use of SMI algorithm is described in Figure 3. For array size of 15x15 operating at a frequency of 3GHz [6], convergence rate is analyzed. This algorithm places a null in the direction of interference, thereby suppress noise. It finds its application in the field of radar for calculating weight factors at a higher rate of convergence. It exhibits superior performance to that of LMS and RLS.

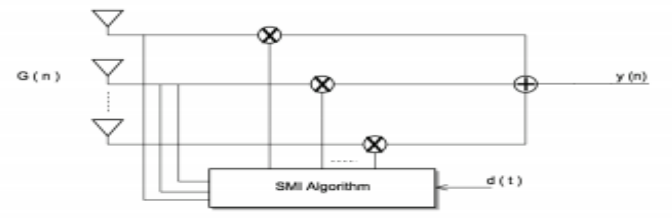

Figure 3. Sample Matrix Inversion algorithm [6]

2.7 Enhanced Nulling Using Minimum Variance Distortionless Response Beamformer (MVDR)

MVDR is used to drop in interfering signals and steer the beam in the preferred direction. It has the potential of regulating the weight factors. The void level on the intrusion sources remains unacceptable. MVDR cause optimization problem. To mitigate this problem, dynamic mutated artificial immune system (DM-AIS) [7] is introduced to strengthen MVDR beamformer for increasing the signal to noise ratio (SINR).DM-AIS isexploited to elevate the nullified level of adaptive beamforming ability. The originated weight factors are based on population size and sensors. Here three types are discussed. In DM-AIS, weight factor is determined by mutation and cloning method, mp-AP MVDR is hinge on multiparametric approach. It is observed that DM-AIS gave better result of 122.49% in 20^{th} iteration. The SINR value for MVDR, DM-AIS, mp-QP MVDR is 25dB, 76.98dB and 86.98dB respectively.

3. Conclusion

Here many adaptive beamforming algorithms are analyzed and their performance is given based on their convergence rate, step size parameterμ, steady state, and wavelength, weight factor etc. Based on the convergence rate, convergence parameter is decided. This will be little complex and costly as the number of antenna increases. If the nulls are placed in the preferred direction, the capacity and service quality will be enhanced. Thus CMA and NLMS has higher convergence rate compared to other algorithm.

References

[1] Chao Li, and SiyeWang, An improved Adaptive BeamForming Algorithm for 5G Interference-coexistence communication .2019 IEEE/CIC International Conference.

[2] PraneetRaj Jeripotula, B. RajendraNaik. Performance Analysis of Adaptive Beamforming Algorithm .2018 IEEE.

[3] PrachitaP.Tribhuwan[1] Dr.A.S.Bhalchandra,"AdaptiveBeamforming using CMA .International Journal of Engineering and Management Research,2015..

[4] Soodabeh Darzi,1TiongSiehKiong .Null Steering of Adaptive Beamforming Using Linear Constraint Minimum Variance Assisted by Particle Swarm Optimization, Dynamic Mutated Artificial Immune System, and Gravitational Search Algorithm.Scientific World Journal 2014.

[5] MissNayan B. Shambharkar[1], Prof. Prakash M. Mainkar[2],Dr. G. N. Mulay.Implementation of RLS Beamforming Algorithm for Smart Antenna System.International Journal of Engineering ,Volume-4, Issue-2, April-2014

[6] D. N. Patel, B. J. Makwana and P. B. Parmar, Comparative analysis of adaptive beamforming algorithm LMS, SMI and RLS for ULA smart antenna.2016 International Conference.

[7] TiongSieh Kiong,1 S. Balasem Salem,2 Johnny KohSiaw Paw,2 K. Prajindra Sankar,2 and Soodabeh Darzi3 “Minimum Variance Distortionless Response Beamformer with Enhanced Nulling Level Control via Dynamic Mutated Artificial Immune System .Minimum Variance Distortionless Response Beamformer with Enhanced Nulling Level Control via Dynamic Mutated Artificial Immune System.Scientific World Journal,2014.