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Conventional and Subspace Algorithms for Mobile Source Detection and Radiation Formation

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ABSTRACT

Background/objectives: The objective of the study is to increase the resolution and radiate sharper beam towards the user in mobile communication using Smart Antenna. *Methodology:* The Conventional and Subspace Algorithms from the literature are studied and simulated in MATLAB so that the foundation is laid for better detection of algorithms and radiation formation. The results are explained for varying number of antenna elements and mobiles sources placed close to far. *Findings:* The classical direction of arrival algorithms namely CAPCON, Maximum Entropy Method, Maximum Likelihood Method are used to find the direction of mobile users based on the computation of the power spectrum. Several methods namely Least Mean Square, Griffiths Method, Variable Step Size Griffiths and Recursive Least Square are used to form the main beam for the user detected by the direction of arrival algorithms. *Novelty/improvements:* In order to take further the research on enhancing the resolution and having a higher convergence rate with reasonable step size, this paper presents the well-known conventional and modern algorithms from the literature. The results are simulated are well described for performing parameters.

1. INTRODUCTION

Smart Antenna increases the capacity of the Mobile Communication System by making use of either Maximal Ratio Combining or Diversity combining techniques. Smart Antenna has to perform a duplex operation. It has to receive signals as well as transmits signals. The reception part mainly requires the detection of user directions called Mobile Source Detection (MSD) or Direction of Arrival. The transmission part involves transmitting radiation into the look directions, also known as Radiation Formation or Beamforming.

There are many Mobile Source Detection algorithms in the literature each of the approaches has its own way of determining the power spectrum in the network. In a similar way, there are many Radiation Formation algorithms that are responsible for the transmission part.

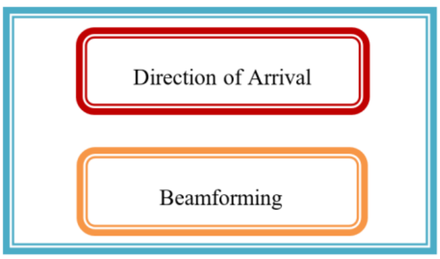

Figure 1. Smart antenna block

Figure 1 shows Smart Antenna Block. The direction of Arrival is responsible for sensing the electromagnetic wave and then detects the direction of mobile users. Radiation Formation is responsible for radiation formation to direct the wave towards the users. The authors strive to present the classical and modern algorithms for smart antenna as part of the literature work and to utilize these results for the near future work to be carried out.

2. LITERATURE REVIEW

There are many multi-access techniques that are proposed in the literature namely Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), Code Division Multiple Access (CDMA) and Space Division Multiple Access (SDMA).

In FDMA [1] technique the entire channel bandwidth is divided into multiple sub-channels with a guard band between the channels. Each channel is assigned to the Mobile Station whenever it enters the coverage area of the Base Station. As the number of Mobile users increases the FDMA will not be able to handle by maintaining equal Quality of Service for all the users in the network due to the presence of Limited Capacity.

The Third generation partnership project- long term evolution (3GPP-LTE) standard makes use of single carrier frequency division multiple accessing (SC-FDMA) technique used for uplink transmission. SC-FDMA makes use of orthogonal frequency division multiplexing (OFDM) to deliver high throughput, high spectral efficiency, and bit error rate.

In Time Division Multiple Access (TDMA) [2, 3] technique the entire channel is divided into multiple time slots and each of the Mobile users is given a specified time slot. This will increase the capacity a few percentages more than FDMA but TDMA suffers from Latency. There is a possibility of co-channel interference in narrowband TDMA cellular networks. The gain in TDMA is achieved based on higher system capacity and lower network outage.

Code-division multiple access (CDMA) [4] is a channel access method in which unique code is used for creating a communication channel. The bandwidth is divided into several bands of frequencies that are allowed for several users. The radio environment is used for narrowband and wideband propagation.

In the SDMA [5] technique, the entire channel is divided into spatial slots. It increases the capacity of the system by a huge amount as it can provide the channel to multiple users at the same time with the same frequency but in different angular orientation. The SDMA technique can be described as below.

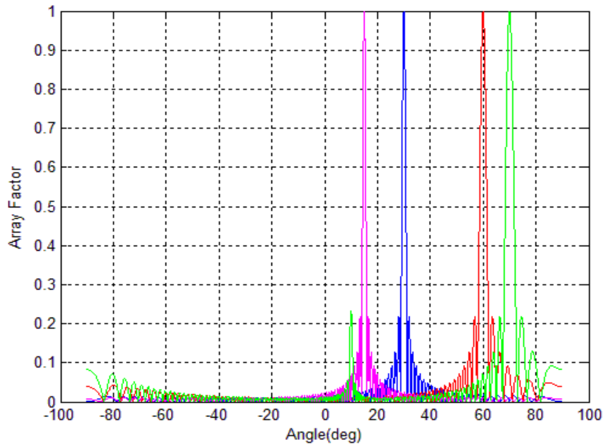

Figure 2. SDMA user channels

The optical cell is an alternative for angle diversity transmitter and the SDMA configuration can increase the bandwidth exponentially and it can also reduce inter-cell interference. Figure 2 shows there are 4 channels provided at 15 degrees, 30 degrees, 60 degrees and finally one at 70 degrees. The smart antenna block can be described as the combination of two things one is Mobile Source Detection at the reception unit and Radiation Formation as the transmission unit.

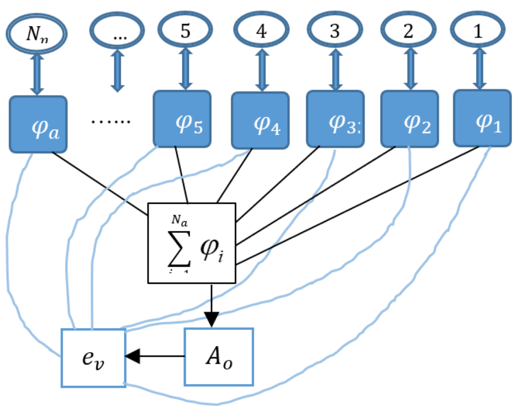

Figure 3. Typical smart antenna diagram

Figure 3 shows the smart antenna block as show in the fig there are N_n antennas arranged in a linear fashion. Each antenna considered here is of type diploe. These antennas receive electromagnetic waves. The antennas are connected to phase shifters and each antenna is assigned a unique phase shift ϕ_i in general i.e. ϕ_1 for first phase shifter and in the same fashion ϕ_a represents the phase shift applied to last antenna element N_a. The phase shifters values are then added up by using the summer $\sum_{i=1}^{N_a} \phi_i$ and after that they are multiplied with the received signal in order to obtain Array output *Ao* and finally the difference is derived in between the training signal transmitted from mobile station and Array factor to obtain the error signal e_v. The phase shifters values are updated in such a way that e_v is minimized.

The next two consecutive sections of the paper talk about the Angle of Hit algorithms and radiating the beam techniques present in the literature. The later sections have these algorithms simulated in MATLAB.

3. BACKGROUND FOR MOBILE SOURCE DETECTION

The direction of an electromagnetic wave hit determination makes use of multiple array sensors [6]. Information theory is used for finding the number of unmanned aerial vehicles. The approximation function is used to compute the direction by taking the help of combined support vector regression. Multiple kernel learning and super-resolution provides a low signal to noise ratio. L-shaped array [7] is used to find the Mobile Source Detection even in the environment which has gain phase uncertainties. Estimation of uncertainties in the channel gain is done and then the elimination of phase uncertainties is done with the help of Schurz-product obtained from auto correlation of received data is responsible for removing the errors across eliminate adjacent sources

The processing of the signal at the antenna sensor arrays to detect the direction of the EM wave is done using multiple signal classification (MUSIC) [8]. The resolution is a measure of differentiating two energy EM waves which have equal amplitude. When the numbers of energy sources are little then the resolution of MUSIC is less and can be improved with the help of Min norm algorithms. SDMA systems make use of MSD algorithms. The combination of MUSIC and neural networks [9] is used for DAO estimation. Multi-Layer Perceptron (MLP) based network with training data helps in improving the DAO estimation. The training can be done on MLP with the help of a Genetic Algorithm (GA).

The comparison between various algorithms namely Bartlett, Minimum Variance Distortion less Response (MVDR) and MUSIC is performed [10]. The sensitivity values by changing the space between antenna elements and changing the number of sensor arrays are done. Each algorithm makes use of its own pseudo spectrum to generate the estimation spectrum. When coherent signals with narrowband property hit the antenna array then QR based method [11] of DAO can be used along with recursive least squares (RLS) by providing feedback in terms of null space and model and once this can be monitored with the help of Luenberger state observer then estimates can be done in an automated fashion.

DAO estimation with the help of Normalized Least Mean

Square NLMS [12] is done with the help of the covariance matrix. With the help of a sequential estimation approach much better accuracy is achieved. The smart antenna is good if the estimation of directions is efficient. When the matrix pencil method [13] is applied on the uniform linear array (ULA) then root means the square error is improved along with resolution probability.

The signal with sparse nature can be reconstructed at the base station using compressive sensing [14]. Compressive sensing makes use of precise measures to estimate DAO. The cost of hardware can be reduced using a quantization device which is having a low rate. MSD values with a one-bit measure id done using improved fixed-point continuation (FPC) algorithm. In the acoustic environment, the signal from a sound generator hits the microphone at a certain angle [15]. The microphone arrays re subjected to noise and reverberation value in a practical case. Time differences of arrival (TDAO) for signals arriving at microphone array elements are responsible for finding the direction of the signal. The accuracy of TDAO estimation will become lesser due to noise and multipath. Multi-channel cross-correlation coefficient (MCCC) algorithm is used to estimate the DAO and is very robust for practical applications when a number of microphones are taken into consideration.

Multi-stage Wiener filter (MSWF) [16] makes use of forwarding recursions in order to find the noise subspace whether the signals are coherent or non-coherent in nature. This avoids the determination of covariance matrix and Eigenvalues computation the algorithm is faster compared to the MUSIC algorithm and accuracy is improved. The adaptation to signal which has varying time-frequency characteristics [17] has a lot of computations involved in classic MUSIC. For each of the signals, a variable core function is applied independently by making use of time window length and frequency. The algorithm improves the accuracy and stability of spatial time frequency-based estimation and also one more advantage of the Novel method is side lobe power leakage control.

The MSD algorithms can be used in radar, astronomy, communications and military applications. Bartlett and Capon method [18] estimate the directions of the source but fail if two sources are located at closer angles. To overcome this disadvantage the covariance matrix has to undergo Eigen based process which can generate subspaces and improve DAO estimation using MUSIC. In radar applications, high resolution is a demand for MSD [19] algorithms but the DAO algorithms suffer from performance when the number of snapshots is less. Variant min-norm method can be used to obtain the MSD estimates when the Snapshot is single. The accuracy and resolution are increased using a multi-target environment.

The sparsely-based reconstruction [20] methods accuracy can be improved by making use of Co-prime sensors with L1+L2 sensors which will increase the freedom to choose from O(L1+L2) to O(L1*L2). The assumption made in the sparse based direction method required the target to be present within a predefined grid. The grid method and the convex relaxation method make resolve the issue of mismatch between grid and sparse signals. The blocking matrix is computed by making use of signals from sound-source and voice activity values [21]. The steering vector is made robust. When the EM wave hits the sensor it undergoes interference and also is exposed to ambient noise. The proposed method performs noise suppression to improve SNR.

The positions where sensor nodes are placed along with frequency response, spatial response [22] are unknown in nature leading to blind Radiation Formation. The blind beamformer will perform the decoupling of the frequency and spatial domain values. The directivity in the space domain can be predesigned to solve the MSD estimate technique. The beamformer achieves higher SNR as compared to the classical Radiation Formation method. MSD estimated accuracy suffers from the error of location. Expectation maximization (EM) algorithm [23] fixes the location error by applying optimization function on each frequency window after that information is extracted from the frequency window, the information is combined.

Many spectral based methods and Eigen structure algorithms [24] perform the estimation of DAO. The statistical performance of the Maximum Likelihood (ML) method is better by making use of the Genetic Search Algorithm (GSA) to find a solution that performs optimization in the environments of low SNR. GSA will have better performance with respect to RMSE and resolution probability.

Dual parallel uniform linear array (ULA) [25] generates rotationally invariant covariance matrices by making use of Single snapshot to find the DAO. The algorithm will not perform snapshot accumulation as well as correlation computation. To improve the accuracy even at a lower SNR environment then data fold technique is used on in-phase data. The sonar system [26] will have underwater objects to be detected and they operated at a standard frequency of 12 kHz. MUSIC and Estimation of Signal Parameters by Rotational Invariance Techniques (ESPRIT) can be used to determine the position of the table in the submarine tank.

The MSD estimation [27] can be done with the help of a genetic algorithm. The algorithm is divided into two parts. The first part formulation of terms of genetic and the second part is changing antenna array structure and find the impact on genetic algorithm with respect to accuracy and reliability.

The combination of Mobile Source Detection and Method of Moments (MoM) [28] will help in improving signal-to-interference and noise ratio (SINR). MSD will find the user location and interference location. The data of MSD is taken, a shaped pattern is generated, and then the shape is provided as input to MoM.

The weights are computed to have deeper nulls towards interference signals and then send the main beam towards the desired signal. Unlike normal Radiation Formation which computes the weights iteratively becomes slow this method will update weight vectors when there is a change in the estimated value of MSD.

For an environment which is rich of pedestrian, enhanced MUSIC MSD [29] algorithm constructs an obstruction map. Orthogonal Projection Matrix (OPM) is constructed after that QR decomposition method is applied to efficiently determining correct directions of the node.

4. BACKGROUND FOR RADIATION FORMATION

Sensing Points Network (SPN) will make use of intelligent reflecting surface (IRS) which can work in a better fashion even during the time of fading due to additional reflections obtained through phase shifts. The beam forming using multiple antenna elements increases the data rate capacity as well as minimize the power utilization and hence is also used for 5G networks [30].

The WIFI networks can make use of smart antenna to improve the bandwidth requirements. A beam switch algorithm which can be compatible with traditional WIFI can be used. The beam switching technique allows direct establishment to the access links and then completes the entire process with switcher mechanism [31].

The vortex waves can be generated with the help of uniform circular patch array. Two kinds of phase shifts are applied to the array elements with first stage as Orbital Angular Moment and second phase is beam steering using circular array. Different antenna shapes with different array sizes are used for performing the phase control [32].

Sparse Linear Array (SLA) contains array elements with reduced peak level on the side lobes and then it makes use of interpolation technique to find the phase shift angle. The estimation of the phase shifts is done and then angular values will be supplied to the uniform linear array to form the beam towards the target special signal [33].

Uniform Linear Array is placement of antenna at regular intervals in the line. The amount of scattered interference can be reduced by making use of constraints which are sparse in nature by applying weights on the antennas and this technique is called as LASSO. By making use of directivity factor (DF), white noise gain (WNG) and the obtain amount of signal to interference ratio (SIR) [34].

The entire array of sensors is divided into multiple independent subsets of arrays with each element will have phase co-efficient. The vector of phase shifts combined together provides a signal which can have power towards desired user and then reduces the amount of interference using interference plus noise covariance matrix (INCM). Two kinds of sand witches namely vector formation and then perform the execution of smoothing. The SOI and INCM combined together will help in detection of desired user and then form the beam towards the user [35].

For the cellular networks the downlink speed and quality become very less as the number of users increase. There can be even multi armed bandit (MAB) issue in which signals get mixed when the number of users are higher than half of sensor array. Beamforming with the constraint of Thompson sampling (TS) is responsible for achieving the maximum gain by increasing the convergence rate [36].

For the high speed railways (HSRs) the constraints of time varying and fading values effect the performance of the network. The interference between the carriers due to high speed is increased. Hence normal frequency channels cannot produce better data and performance value. The alignment of the beam and gathering of special data is responsible for better tracking and maintenance of spatial data. The channel state information of higher dimension can be reduced by making use of Kalman filter along with compression of data [37].

The use of Capon's minimum variance distortion less algorithm is used in the computation of co-efficient for sample matrix inverse (SMI) can be applied to array data. The maximum value of co-efficient is divided with respect to all the values in the matrix until Toeplitz rectification is done. The approach improves the signal to interference ratio by suppressing the value of interference data [38].

Modified Farrow Structure FIR Filtering method makes use of subpart of the delay vector in order to obtain better efficiency as compared to traditional FIR filtering methods. The FIR filter when used with 'N' frequency can provide help in wideband Radiation Formation for sonar timeline [39].

The co-prime array will make use of high order cumulate in order to get the co-efficient values. Two domains namely domain1 is the actual sensor array and the second array is the virtual array. The utilization of virtual array will reduce the cost of the elements of array. The width of the main lobe will have magnificent reduction in width and then there is computation of Gaussian noise [40].

The coverage range will be narrow in nature and then there are signals coming from different units present in the building. Secant squared beamforming can be used to feed the current to each of the antenna element in order to achieve better optimization using a genetic process [41].

The spatially separate signals can sometimes have overlapping of data which can be of same frequency and then there are multiple different angles from which data appears. The angle of orientation of the mobile signals with respect to base station (BS) can help in forming the beam towards the desired direction and reduced signal or nulls in other directions [42].

The elements are placed in a linear fashion, then weight is applied to the elements in order to generate beamforming data. The performance of beamforming can get degraded by making if subset of elements fail. The weights can be recalculated and then applied to array elements in order to mitigate loss in beam formation [43].

The estimation techniques make use of linear co-efficient by making use of singular value decomposition and the processing is performed on each of the individual co-efficient are applied to elements [44].

Fibonacci branch search (FBS) is applied on the equal spaced lined array and then different search rules are applied to each of the elements. Different elements interact with each other and then search engine rules are applied to the array elements in order to achieve higher convergence and optimization [45].

High resolution can be achieved by making use of coprime data. A subset of sensors can be used to achieve the same results as obtained by large array. Different elements can be divided into sub elements. Each sub elements can be used to achieve better beamforming with high side lobes and better gain [46].

The entire set of array elements is divided into two separate arrays. The configuration can be sparse in nature which can be used for detection of sources and then send the beam towards the array elements. The reduction of grating lobes can be achieved by making use of virtual and real patterns of data [47].

5. IMPLEMENTATION OF ALGORITHMS

This section describes the analysis of Mobile Source Detection and Radiation Formation.

5.1 CAPCON method

Consider we have a time series data to be analyzed. Once time series data is used then uniform weighting is applied to rectangular window. In order to find the estimated value each element must be assigned a similar weight. The estimation of the directions [48] can be obtained by solving the following equation:

$$P_{bartlett} = \frac{S^{H}{}_{v}(\theta)\, TC\, S(\theta)}{N_{antenna}{}^{2}} \tag{1}$$

where, $S_v(\theta)$=steering vector for an angle θ; $S^H{}_v(\theta)$=Hermitian transpose of steering vector; *TC*=total correlation matrix; $N_{antenna}$=Number of Antenna Elements.

5.2 Maximum entropy method

The Fourier transform must be computed and followed by correlation so that the entropy reaches its maximum value. The power spectrum estimation of MEM method can be done in a finite dimension using Lang and McClellan algorithm. The DAO [48] can be estimated using the following equation:

$$P_{MEM} = \frac{1}{S(\theta)_v^H\, M_{EC} M_{EC}^H S_v(\theta)} \tag{2}$$

where, $S_v(\theta)$=steering vector for an angle θ; $S^H{}_v(\theta)$=hermitian transpose of steering vector; M_{EC}=column in total correlation matrix which corresponds to maximum entropy; M_{EC}^H=Hermitian transpose of M_{EC}.

5.3 Maximum likelihood method

The method [49] considers that the power is arriving from one direction and all other directions have the signal as interference resource. The Signal to Interference (SIR) will be maximum with a signal which does not contain any distortions with respect to phase and amplitude. The power spectrum of Maximum Likelihood Method (MEM) is computed using the following:

$$P_{MLM} = \frac{1}{S_v^H(\theta)\, TC_{inv}\, S(\theta)} \tag{3}$$

where, $S_v(\theta)$=steering vector for an angle θ; $S^H{}_v(\theta)$ =hermitian transpose of steering vector; TC_{inv}=inverse of total correlation matrix.

5.4 MUSIC

MUSIC [50] methods provide the estimation of the mobile user directions with lesser bias as compared to traditional methods. MUSIC assumes that the noise vectors across the antenna elements are not correlated. MUSIC requires the knowledge of number of users to be detected before estimation.

$$P_{MUSIC} = \frac{1}{S(\theta)_v^H\, NS\, NS^H\, S_v(\theta)} \tag{4}$$

where, $S_v(\theta)$=steering vector for an angle θ; $S^H{}_v(\theta)$=hermitian transpose of steering vector; *NS*=Noise Subspace; NS^H=Hermitian transpose of Noise Subspace.

5.5 Least mean square

The signal can be enhanced by reducing the interference signal. The radiation will be send towards the desired direction and then side lobes are reduced. The achievement of better Radiation Formation can be achieved by making use of mean square error will be reduced. Beam width will be reduced and then error will also be reduced. The weights can be computed using the following equation:

$$w(n+1) = w(n) + \delta\, conj(e) x(n) \tag{5}$$

where, $w(n+1)$=next element for weight; $w(n)$=previous weight; δ=mean; $conj(e)$=conjugate value of error signal; $x(n)$=actual input signal.

5.6 Griffiths method

The estimation accuracy can be increased by making of signal which is known at the array elements. The Griffiths algorithm can be composed using a phase shift equation as below:

$$\begin{aligned} &Pw_{Griffths}(n+1) \\ &= P\, w(n) + 2\ \ SS\ \ C_{ts,rs} - 2\ \ SS\ ArO(n)\, rsig \end{aligned} \tag{6}$$

where, $Pw(n)$=phase weight values; *SS*=Step Size; $C_{ts,rs}$=multiple signal between trained and signal at *BS;* $ArO(n)$=array values output for specific signal sample; $rsig(n)$=signal obtained at base station for n^{th} sample.

5.7 Variable step size Griffiths

The variable step size Griffiths (VSSG) makes use of multiple factors to compute high convergent phase values. Convergence and Smoothness are used to compute the phase shifts. VSSG can be computed as below:

$$P_{MLM} = \frac{1}{S_v^H(\theta)\, TC_{inv}\, S(\theta)} \tag{7}$$

where, $Aw(n)$=phase shift supplied to antenna elements; *SS*=Step Size; *CR*=relation between trained and base vector; $|rsc|$=add elements to all co-efficient.

5.8 Recursive least square

RLS chuck is developed on top of Least Mean Square. The phase factors can be build using three kind of constraints namely correlation factor, alpha factor and gain. The phase factor can be computed by using the following equation:

$$\begin{aligned} &PF_{RLS}(n) = PF(n-1) + Ga^{-1}(n-1)\, r(n) \\ &[t(n) - tsc^H(n)\, PF_{RLS}(n-1)] \end{aligned} \tag{8}$$

where, $PF_{RLS}(n)$=phase factor for n^{th} sample; $Ga(n)$=gain of the system; $r(n)$=received signal at *BS*; $t(n)$=training signal at *BS;* $c(n)$=correlation $t(n)$ and $r(s)$.

6. RESULTS

This section describes the results related to algorithms present in the literature. The performance of the DAO algorithms is done based on Bias and Resolution. The next section will make use of Radiation Formation algorithm to compute the phase factor to form main beam towards desired user and then send side lobes towards interference are suppressed.

6.1 Mobile source detection algorithms

The capability of algorithms to perform the right estimation for mobile sources which have same energy is called as Resolution. The bias is the difference between the estimation direction and the actual direction.

Table 1. Antenna elements and wide direction sources

Parameter Name	Parameter Value
Number of Antennas	8
Number of Mobile Users	4
Amplitude	[1 2 3 4]
Actual Directions	[10 30 45 60]

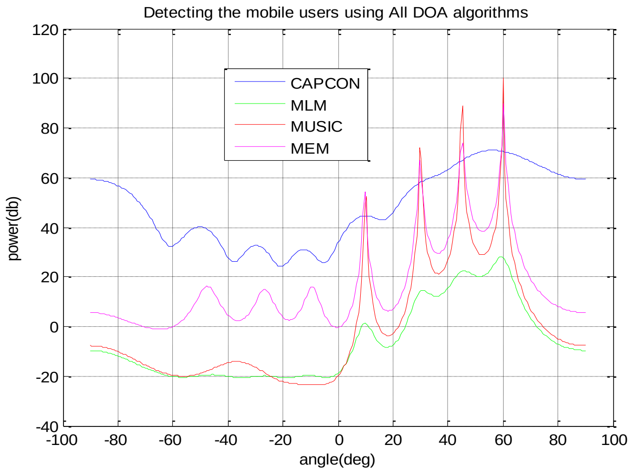

Figure 4. Antenna elements wide separation of mobile sources

Table 1 describes input values for 8 Antenna elements and wide direction sources. Figure 4 shows the algorithm comparison. As shown, MUSIC algorithm and MEM algorithm are able to detect the location of mobile sources at 10, 30, 45 and 60 degrees. MLM method also able to detect the mobile sources and the CAPCON method is unable to detect the mobile sources. Table 2 shows the input for the case of 8 antenna elements and close separation of mobile sources.

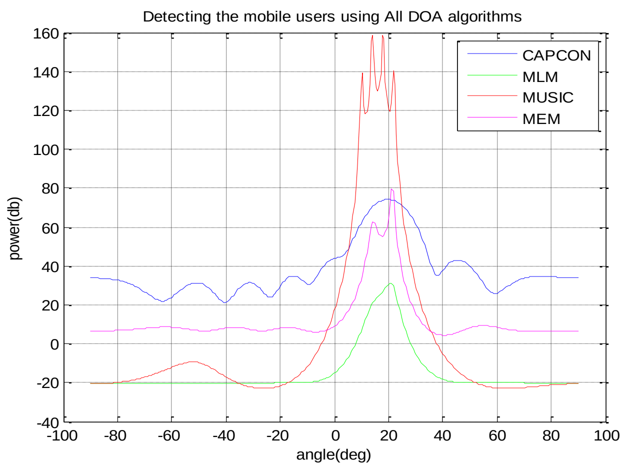

Figure 5. 8 Antenna elements with close separation of mobile sources

Figure 5 shows the 8 antenna elements. As shown in the Figure 5 MUSIC method is capable of detecting the mobile sources with directions as 10, 14, 18 and 22 degrees, MEM is able to detect only 10 and 22 degrees. MLM and CAPCON are able to detect only one direction of 14 degrees. Table 3 shows the input for the 3rd experiment with 100 antenna elements.

Table 2. Antenna elements and close direction sources

Parameter Name	Parameter Value
Number of Antennas	8
Number of Mobile Users	4
Amplitude	[1 2 3 4]
Actual Directions	[10 14 18 22]

Table 3. 100 antenna elements and close direction sources

Parameter Name	Parameter Value
Number of Antennas	100
Number of Mobile Users	4
Amplitude	[1 2 3 4]
Actual Directions	[10 30 45 60]

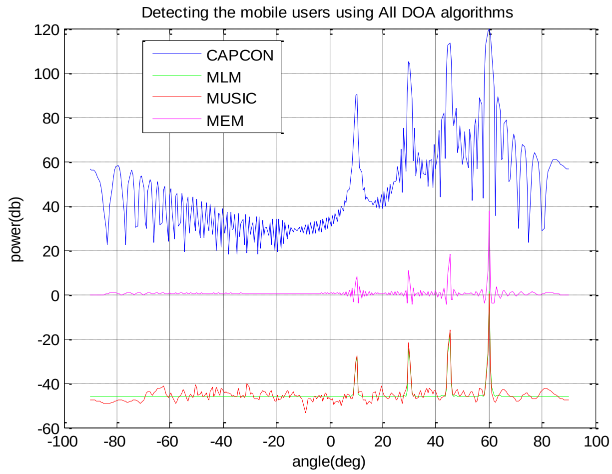

Figure 6. 100 Antenna elements with wide separation of sources

Figure 6 shows the 100 antenna elements spectra for the four algorithms. As shown in the fig the resolution capability of all the four algorithms is increased as all the four algorithms are capable of detecting the directions of mobile sources. Table 4 shows the number of antenna elements used and close direction sources.

Figure 7 shows the direction detected by all the algorithms for close direction sources for large antenna elements. CAPCON, MUSIC, MEM, and MLM are able to detect all the four direction sources accurately.

Table 4. 100 antenna elements with close direction sources

Parameter Name	Parameter Value
Number of Antennas	100
Number of Mobile Users	4
Amplitude	[1 2 3 4]
Actual Directions	[10 14 18 22]

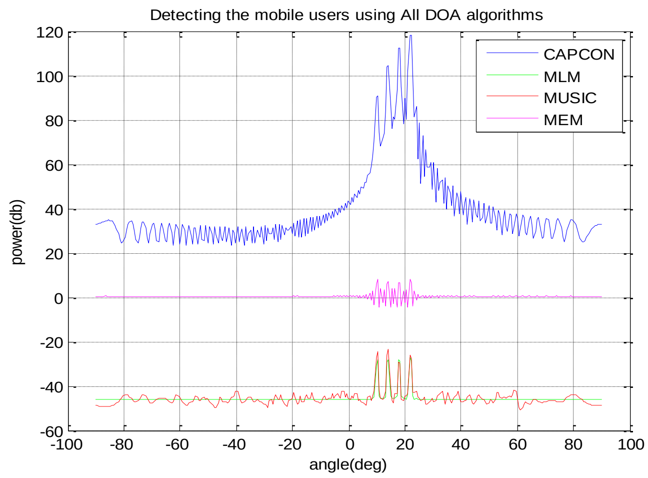

Figure 7. 100 elements with close direction sources

The Root Mean Square comparison of the algorithms is defined as below (Table 5):

Table 5. RMSE comparison for algorithms

Algorithm Name	RMSE
CAPCON	0.95
MEM	0.93
MLM	0.85
MUSIC	0.843

6.2 Radiation formation algorithms

This section describes the comparison of the algorithms with the presence of single or multiple elements acting as interference. Results are simulated for variable antenna elements.

Table 6. Comparison of algorithms for less antenna and single interferer

Parameter Name	Value
Number of Antennas	8
Desired Direction	30
Number of Interferers	1
Interference Direction	60

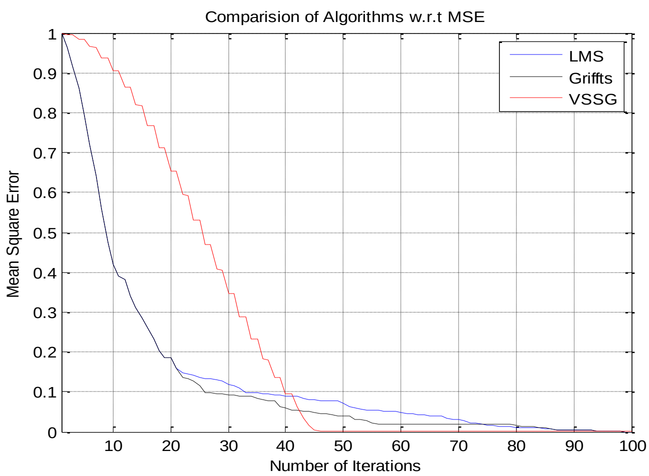

Figure 8. MSE comparison case 1

Figure 8 shows the MSE Comparison Case1 for the input parameters shown in Table 6. Three algorithms are compared namely LMS, Griffiths and VSSG. VSSG has high convergence with a least value at around 48 iterations, followed by Griffiths which is around 88 iterations and then for LMS it is 90 iterations.

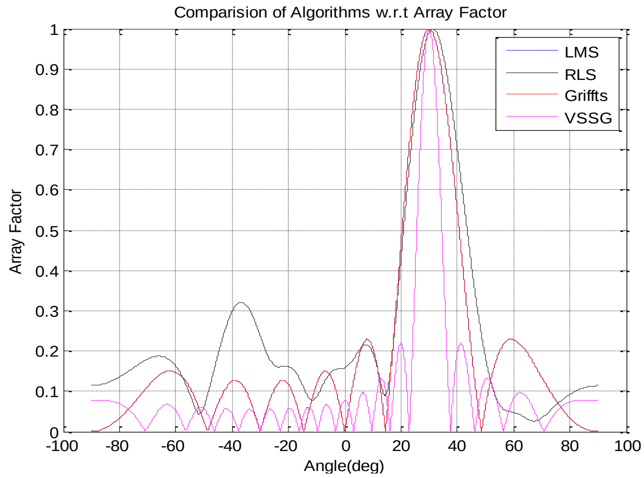

Figure 9. Radiation formation for case 1

Figure 9 shows the radiation formation for Case1. As shown in the Figure 9 all the algorithms will form the main beam towards the desired user at an angle of 30 degrees.

Table 7. Comparison of algorithms for less antenna and multiple interferer

Parameter Name	Value
Number of Antennas	8
Desired Direction	45
Number of Interferers	3
Interference Direction	[30 60 90]

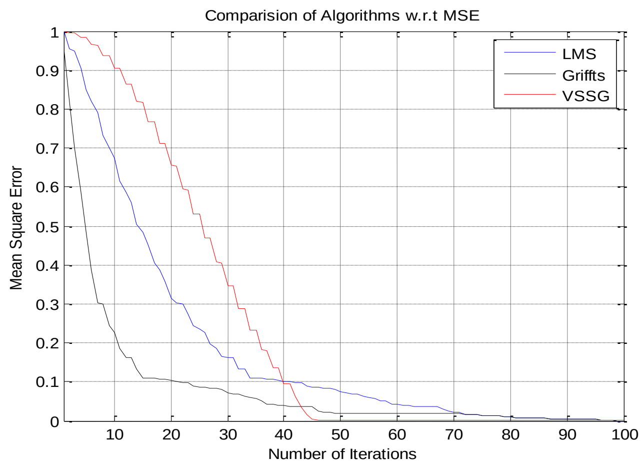

Figure 10. MSE comparison case 2

Figure 10 shows the MSE Comparison Case2 for multiple interferers for Table 7. Three algorithms can be compared using LMS, Griffiths and VSSG. VSSG has high convergence with a least value at around 45 iterations, followed by Griffiths and LMS which is around 96 iterations.

Figure 11 shows the various algorithms form the desired signal at around 45 degrees. But RLS has higher dimension side lobes as well which is not desirable.

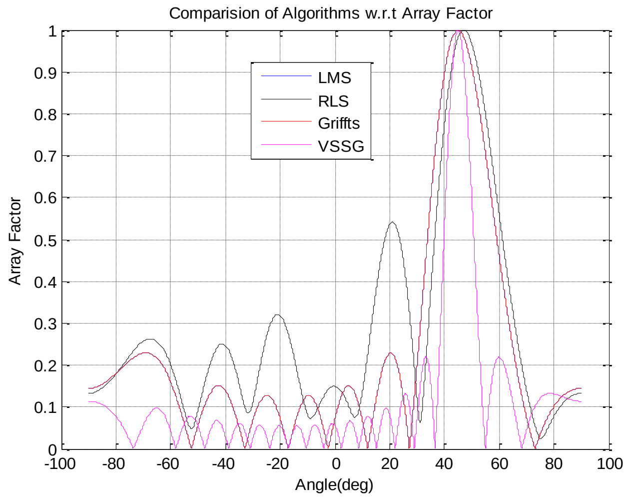

Figure 11. Radiation formation for case 2

Table 8. Comparison of algorithms for high antenna and single interferer

Parameter Name	Value
Number of Antennas	100
Desired Direction	45
Number of Interferers	1
Interference Direction	30

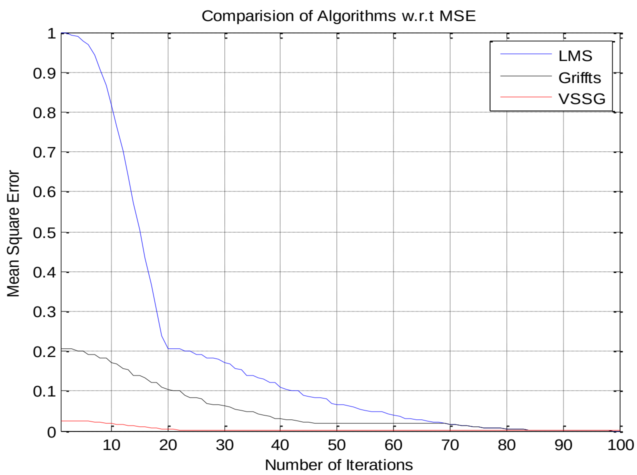

Figure 12. MSE comparison case 3

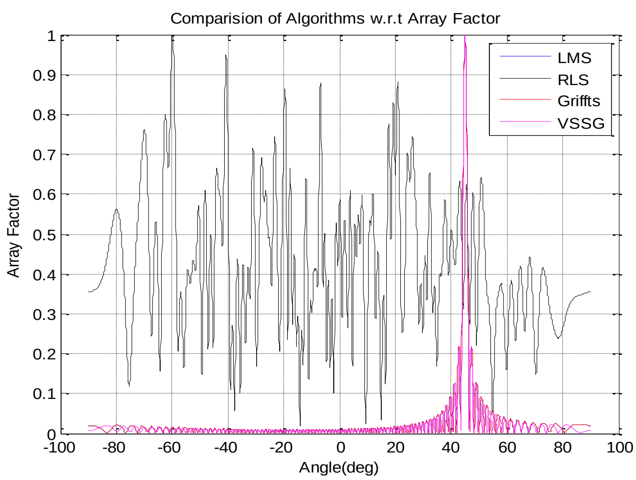

Figure 13. Radiation formation for case 3

Figure 12 shows the curve of MSE decreasing with respect to the number of iterations for higher number of Antennas as shown in Table 8. The MSE for the two algorithms namely LMS and Griffiths can have a value of 80 iterations and then for the VSSG it will be around 22 iterations.

Figure 13 shows all the three algorithms form the main beam towards the desired user with an angle of 45 degrees but RLS forms the main beams in multiple directions in a distorted manner.

Table 9. Comparison of algorithms for high antenna and multiple interferer

Parameter Name	Value
Number of Antennas	100
Desired Direction	30
Number of Interferers	3
Interference Direction	[45 60 90]

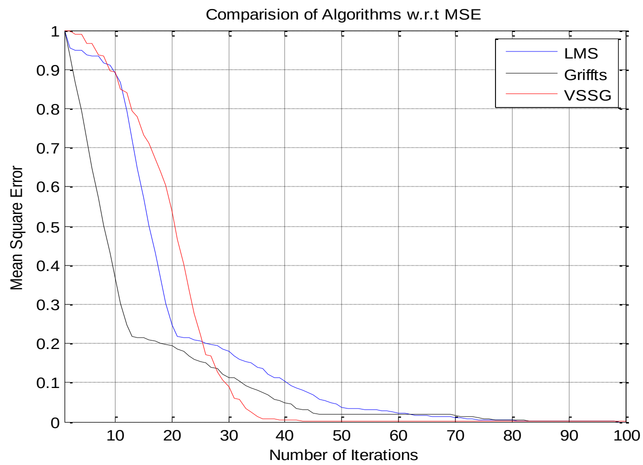

Figure 14. MSE comparison case 4

The mean square error comparison shown in the Figure 14. As shown in the Figure 14 VSSG has the high convergence of 40 iterations followed by Griffiths and LMS with a value of 75 iterations for input values of Table 9.

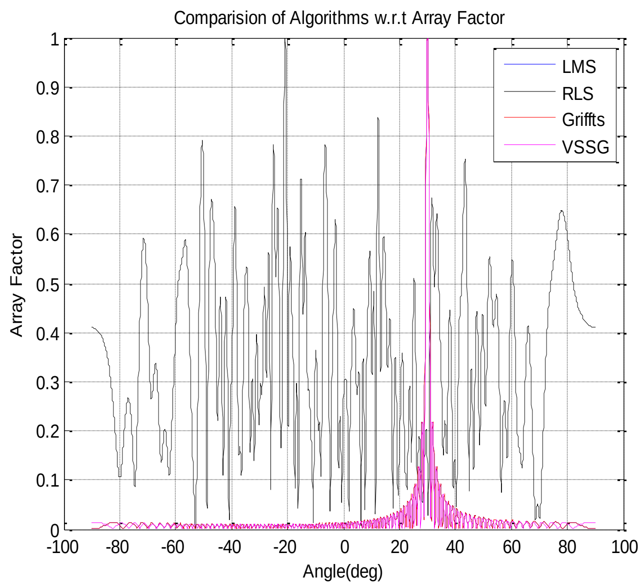

Figure 15. Radiation formation for case 4

Figure 15 shows the radiation formed by making use of all algorithms namely LMS, RLS, Griffiths and VSSG. LMS, Griffiths and VSSG will form main beam towards 30 degrees and then RLS forms beams at various multiple different directions.

7. CONCLUSION

From the literature, the detection of mobile sources involves the computation of steering vectors, covariance matrix, Eigen computation, and power spectra measure. From the various cases of Simulation, the following conclusions can be achieved

(1) For the Case of many antenna elements and wide direction sources High-Resolution MUSIC method detects all the mobile sources and even conventional methods namely MLM, MEM and CAPCON method perform better.

(2) For the Case of many antenna elements and close separation of sources, both the conventional method and High-Resolution methods perform in a better fashion.

(3) For the Case of less antenna elements and wide separation of sources high resolution methods perform better i.e. MUSIC method as compared to Conventional method namely MLM, MEM and CAPCON method.

(4) For the case of close direction sources and fewer antenna elements, High-Resolution Method i.e. MUSIC is only capable of detecting the mobile sources but MLM, MEM and CAPCON methods fail miserably

(5) The Resolution for the conventional method is improved for high sensor elements and hence requires a large amount of Cost for maintenance of the base station

(6) The power spectrum amplitude for large RF elements is lower in High-Resolution methods and hence needs to be enhanced.

(7) The side-lobe suppression needs to be improved and hence the factorization of Eigen subspace needs to be considered to improve the sensitivity.

For the Case of Radiation Formation described in the literature various algorithms have been found which can improve the capacity of the network by providing good channels for the users to communicate and then suppress the interference sources.

(1) For the Case of Low Number of Array Elements and single or multiple interferers algorithms can form main beam towards the desired user and MSE will be less for VSSG followed by Griffiths and LMS algorithm.

(2) For the Case of High Number of Array Elements and single or multiple sources can form main beam towards desired except RLS which forms main beam towards multiple directions. The MSE of VSSG is less as compared to LMS and Griffiths.

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