Chapter 2

LITERATURE SURVEY

A systematic comparison [7] of the performance of different DOA algorithm like Bartlett, MUSIC has been extensively studied by analyzing the simulation result with MATLAB. MUSIC provides high resolution.

Multiple Signal Classification [8] (MUSIC) algorithm with Uniform Linear Arrays (ULA) is used with theoretical analysis which provides the better estimation of the signals. In this paper, the three types of Eigen structure algorithms have been discussed and their performance have been compared. The three algorithms are multiple signal classification (MUSIC), the Estimation of Signal Parameter via Rotational Invariance Techniques (ESPRIT) and non-subspace method Maximum-Likelihood Estimation (MLE) for Direction of Arrival (DOA). It is observed that the DOA estimation algorithm performance is based on uniform linear array (ULA).

MATLAB is used for simulation and comparison of the results show that the MUSIC algorithm has high stability and accuracy compared to ESPRIT and MLE algorithms.

In [9], a study on finding DOA using MUSIC algorithm has been carried out. Eigen value decomposition is realized using rotation mode. This is done to decrease the number of computations to achieve real time array direction finding. The performance estimation of MUSIC algorithm is done by varying number of antenna elements in an array and its simulation is done in MATLAB.

In [10], it is observed that MUSIC algorithm has better performance in terms of angular resolution, antenna array elements and root mean square error (RMSE).

In [11], the authors have made a comparative study between several DOA algorithms having narrow band signals and are corrupted by AWGN. The study is limited to one dimensional stationary case and the performance of each algorithms is evaluated. It is observed that, in high level noise, the performance of minimum norm algorithm is better whereas in low level noise the partial covariance method and the MUSIC method have almost similar performance.
In [12], it is presented that with the use of smart antenna with DSP, the channel capacity can be increased along with the communication coverage range. This further helps in obtaining electronically beam steering along the direction of interest in addition to forming nulls towards interferences. Traditional smart antennas could not find applications in military and defense systems since they are expensive, complicated, bulky and consume more power. The smart antennas for commercial applications have to be small in size, consume less power and should have low cost of fabrication. The authors have introduced few low-cost smart antennas for satellite communication and terrestrial mobile applications. The ku and ka-band type smart antenna can be used for satellite applications and s-band small size low power smart antennas can be used for mobile terminals in terrestrial wireless communication.

In [13], the authors have discussed the importance of MIMO in increasing the network capacity. The estimation of direction of algorithms is vital in order to obtain the source-location. A study has been made on 2-D unitary estimation of signal parameters by using rotational invariance techniques (U-ESPRIT) for azimuth and elevation angles. This is also compared with signal parameter estimation via rotational invariance techniques. The results show that U-ESPRIT is better. The network capacity [13] can be increased with the usage of Multiple-Input Multiple-Output (MIMO). Direction of Arrival algorithms estimation is vital for obtaining the location of sources. 2-D unitary estimation of signal parameters via rotational invariance techniques (U-ESPRIT) is used for both elevation and azimuth angles-ESPRIT is also compared with estimation of signal parameters via rotational invariance techniques and proved that U-ESPRIT is better. In full duplex cellular networks [14] array of antennas is used at the base station along with relay nodes. The Full Duplex (FD) system relaying increases the capability of cellular network. The impact factor is analyzed by introducing interference as one of the constraint.

Establishing the communication link between the fishing vessels [15] and the sea shore can be achieved by placing the base station at the sea shore. The high gain antenna ensures long distance connectivity but coverage will be very less. Smart antenna with adaptive beam forming can be used to improve coverage. DOA algorithms along with beam steering can be used in order to improve connectivity. Direction of Arrival estimation can be done using linear programming [16] by finding the sparse coefficients. The solution avoids the computation of second order programming problem.

Independent component analysis (ICA) [17] method determines the number if sources by grouping the number of array elements for signal estimation. Tensor array [18] processing allows the estimation of DOA with assumption of unknown gain pattern even though space diversity is missing. To have better Smart Cities it is necessary that the third gen-
eration systems increase the system capacity along with the reduction is the co-channel interference.

From [19], it is observed that the signal to noise ratio can be optimized for multiple antenna arrays in a specific direction by incorporating smart antennas. Applebee array algorithm is used for interference rejection. The direction of arrival estimation is performed in noisy environments by the combination of fractional lower order statistics and sparse signal [20] representation technique with linear transformation. The Robust Multiple Signal Classification [21] algorithm is applied for under water application using a model for noise correlation the spurious peaks are suppressed by this method which are caused by mismatched noise.

Paper [22] discusses about the angle of arrival estimation algorithm MUSIC which makes use of a beam forming network, and a multiband antenna consisting of four antenna elements which are circularly polarized. It makes use of switch which produces radiation across different lobe directions. The antenna array chamber [23] has extra signals in the quite zone. If the reflection point can be determined then the extra signals can be removed or by the combination of mode rotation of and minimized combining mode rotation with CLEAN (CMRCLEAN), in the presence of signal in quite zone, it has the ability to detect the closely spaced sources. There are 2 kinds of DOA algorithms namely subspace based method and sparsely based method. The problem of basic mismatch can be overcome by the Covariance matrix reconstruction approach (CMRA) for sparse linear array (SLA) and uniform linear array (ULA). Co prime [24] array is used for estimating the source based on the sparse matrix by forming a virtual linear sub array with a sliding window to remove spurious peaks. DOA algorithm [25] used for estimating the location based on noise subspace by suppressing the interference signals. The range and Doppler shift [26] of target can be determined by using the DOA algorithms with two kinds of antennas namely linear and planar arrays. Wideband sparse Bayesian learning (WSBL) [27] method first converts the signal into time frequency domain by applying discrete Fourier transform after that power distribution is computed across various frequency which increases the estimation accuracy. In case of urban environments [28] the GPS antenna does not provide position accuracy. A vehicle to vehicle communication using packets from Road side Unit with estimate of angle of arrival using least square method localizes the vehicle and improves the signal to noise ratio.

The DOA algorithms provide estimation [29] for all electromagnetic waves impinging on the array but are not able to differentiate between desired user and interference user. Affine projection algorithm with the help of reference signal and correlation provides the capability of identifying the desired user. Maximum-likelihood [30] direction-of-arrival (DOA) estimation involves estimation of toeplitz covariance matrix and then estimation
of location from the covariance matrix. In a MIMO based system it is difficult to form perfectly orthogonal waveform [31] signals (POWS). The Non Perfect OWS (NonPows) converts the covariance matrix into steering matrix and then performs pre whitening process for noise produced by Non Pows.

The relationship between wavelet transforms [32] and fast Fourier transform methods are used to find the direction of arrivals. The method is a combination of wavelet and spatial method. DOA can be estimated using conventional ESPRIT [33] (estimation of signal parameter via rotational invariance technique) which takes into account electromagnetic coupling among antennas.

Direction of arrival (DoA) [34] estimation can be performed by computing the correlation between the received signal strength and expected antenna beams. Direction-of-arrival estimation [35] relies on a multibeam antenna which predefines set of radiation patterns with distinct main directions.

Estimation of DOA in the frequency hopping [36] networks can be improved by using subspace projection on Short Time Fourier Transform. Generation-ESPRIT [37] is used to perform DOA of non-circular signal for non-uniform linear array which is an improvement to ESPRIT. There are 2 types of DAO approaches namely Subspace Method and Sparsely Methods. Uniform linear array and sparse linear array incorporates the covariance matrix reconstruction approach. The DOA estimation has been discussed in [39] for multiple incident RF sources. The R matrix of the QR factorized received data matrix provides necessary information about the signal and noise subspaces estimation of the signal arrival angle from signal subspace is similar to the approach incorporated by conventional MUSIC algorithms. From [40], it is seen that if all the minors of an n x n real matrix A are strictly positive, then that matrix is an STP (Strictly totally positive). If all the nontrivial minors of a n x n real triangular matrix A are strictly positive, then A is called a $\Delta$STP matrix. It has also been proved that matrix $A + \Delta$ is an STP matrix, if and only if $A = LU$ where U is upper triangular matrix and L is lower triangular matrix and L and $U$ are $\Delta$STP nature.

Smart antenna [41][42] concepts are described which increases the capacity by directing the beam in different directions on the same frequency using Least Mean Square (LMS), Recursive Least Mean Square Algorithm (RLS), Normalized Least Mean Square (NLMS) and Sample Matrix Inverse (SMI). The smart antenna algorithms will increase the capacity and at the same time reduces the co channel interference using LMS, RLS and SMI.

Paper [43] introduces a new adaptation algorithm which is designed to process real time data in large antenna arrays. A set of filter co-efficients is determined by the algorithm in order to minimize the mean square error in a multidimensional linear filter.
The step size and cross correlation between input and desired signal based gradient are used in variable step-size Griffiths LMS algorithm [44] it has been observed that for stationary as well as for non-stationary noise, the performance of the algorithm is better and acceptable.

Griffiths cross correlation [45] is adopted to derive gradient and step size which are robust to observation noise for obtaining efficient robust variable step size.

The robust minimum variance [46] algorithm is a distortion less response (MVDR) beam former. The algorithm makes use of kalman filter which reduces the computational cost. In an application using ducts [47] if there is an error in microphone then it is placed at a far place from the control source to avoid effects of near fields. Due to which there will be delays which affects the convergence of the algorithm. By applying the x and u factor the convergence can be improved even in such environments.

Lot of studies has been performed on how to control the active noise and apply the practical implementation on a Texas instrument processor [48], Modeling can be done either using an offline or online mode which control the active noise. It is also evident that such modeling will be equal to impulse response of secondary path. Once modeling is done faster accuracy and reduced prediction error can be achieved. There is a non linear relationship between step size [49] and error signal based on the input signal. The step size can be modified based on error value of a set of 2 iterations current and previous which can bring a certain immunity to noise signal and improve MSE. In order to reduce the complexity and energy consumption and also maintain the performance a quaternion factor [50] is computed by modifying the LMS algorithm.

Many variations of beam forming have been presented which makes use of fixed beam formers. Vector-sensor arrays [51] contain crossed dipole pairs that can account for a signal's polarization along with DOA. A quaternion signal model is used in designing the weight coefficients for a fixed set of vector-sensor locations which can be achieved by minimizing the side lobe levels along with maintaining unitary response for the main lobe. $\ell_1$ relaxation is applied to LMS [52] to improve its performance by deriving 2 kinds of variations zero-attracting LMS (ZA-LMS) and the reweighted zero-attracting LMS (RZA-LMS) $\ell_1$ norm is applied in the LMS Cost function which accelerates convergence and achieves lower Mean Square Error. Sparse linear-phase finite-impulse-response multiple-notch filters [53] makes use a range of frequencies $[0, \pi]$. Iteratively reweighted orthogonal matching pursuit (IROMP), is based on the orthogonal matching pursuit performed under the weighted $l_2$-norm whose weights are iteratively computed through the hybrid $l_1/l_2$-norm minimization. Vector signal modeling [54] can be used for quaternion algebra. Single value decomposition is used for approximation of linear algebra value. Coprime arrays [55] are used to increase the area of freedom by offering larger apertures. The two properties
namely robustness and efficiency are managed in a balance format. Covariance matrix is used to estimate desired signal steering. In order to maintain quality service [56] there should be more radio heads. The balanced transmission power and circuit power via RRH selection and beam forming. The fast baseband transmit [57] for distributed antennas are used to achieve better beam formation by applying the weight updates cyclically. The channel estimation [58] is based on received power measurements for multi antenna using energy transfer system. The key for beam forming is to maintain the low energy. There must be an estimation of transmit and received beam forming weights for better channel estimation. Multi-group multicast beam forming [59] in wireless systems with large antenna arrays is a well-known non-convex quadratically constrained quadratic programming (QCQP) problem. As the number of users in a group increases the performance of such a method decreases. The low-cost technique [60] for digital beamforming on receiver can be implemented which can be used to synthesize multiple beam patterns in different directions. Recursive least squares algorithm can be employed for adaptive filters to linear, complex valued signal as well as modelling of system. A structured covariance matrix maintains data of non-circularity nature of input data to solve the widely linear least square task for each snapshot. This property is exploited by widely linear complex modeling and conventional modeling is done easily by the WL-RLS algorithm. In paper [62] the idea of Aitken method is developed to accelerate the rate of convergence of an error sequence which is received by training a NN with sigmoidal activation function through the back propagation algorithm.