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DOA Estimation using Non-eigen Decomposition and Beamforming in Dynamic Condition

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Abstract

This paper presents simulation results for a smart antenna system based on direction of arrival estimation and null steering. Direction of Arrival (DOA) estimation is based on non-eigen decomposition method Dynamic-PM algorithm for identifying the directions of the desired user and nullifies all other interfererence. This system can be used to reduce multipath and co-channel interference. These benefits include the enhancement of coverage and the channel capacity, lower transmitted power, better signal quality, higher data rate and providing value-added services such as user's position location (PL) and at the same time to minimize interference arising from other user by introducing nulls in their direction. Also this paper deals with adaptive beam forming approach for the dynamic case based on smart antennas and adaptive algorithms used to compute the complex weights like Dynamic Least Mean Square (Dynamic-LMS) algorithm.

Keywords – *direction-of-arrival (DOA), Dynamic-Propagator Method (Dynamic-PM), Position Location (PL), Smart Antenna, Array Antenna, Dynamic-Least Mean Square (Dynamic-LMS)*

1. Introduction

There is an ever increasing demand on mobile wireless operators to provide voice and high speed data services. At the same time, these operators want to support more users per base station to reduce overall network cost and make the service cost is affordable to subscribers. As a result, wireless systems that enable higher data rates and higher capabilities are pressing need. Unfortunately because the available broadcast spectrum is limited, attempts to increase traffic within a fixed bandwidth create more interference in the system and degrade the signal quality. When omni-directional antennas are used at the base station, the transmission and reception of each users signal becomes a source of interference to other users located in the same cell, making the overall system interference limited.

The demand for wireless services has risen dramatically from few years. Wireless communication systems are evolving from the second generation systems to the third and fourth generation systems, which will provide high data rate multimedia services as video transmission. New value added services such as the position location (PL) services for emerging calls, the fraud detection, intelligent transportation systems, and so fourth are also coming in to reality.[1]-[2]-[3]

The smart antenna systems can generally be classified as either switched beam or adaptive array systems. In a switched beam systems can generally be classified as either switched beam or adaptive array systems. In a switched beam system multiple fixed beams in predetermined directions are used to serve the users. In this approach the base station switches between several beams that gives the best performance as the mobile user moves through the cell. Adaptive beam forming uses antenna arrays backed by strong signal process capability to automatically change the beam pattern in accordance with the changing signal environment. It not only directs maximum radiation in the direction of the desired mobile user but also introduces nulls at interfering directions while tracking the desired mobile user at the same time. The adaptation achieved by multiplying the incoming signal with complex weights and then summing them together to obtain the desired radiation pattern. These weights are computed adaptively to adapt to the changes in the signal environment. The complex weight computation based on different criteria and incorporated in the signal processor in the form of software algorithms like Least Mean Square. [6]

A smart antenna technology can achieve a number benefits like increase the system capacity, greatly reduce interference, increase power efficiency [4]-[5]. In this paper, focus on the accurate DOA estimation using Dynamic-Propagator algorithm and provide the services to the desired user by steering the beam pattern using Dynamic-Least Mean Square (Dynamic-LMS) algorithm and analyze detailed MATLAB simulation results for these algorithms. [8]-[9]-[10]

2. Basics of Smart Antenna System for DOA Estimation and Beamforming

Since most DOA estimation algorithm have reached a mature state, accurate estimation of the angle of arrival of signals impinging an array of antenna becomes the most important parameters regarding the performance of an adaptive array. Conventional methods, linear prediction methods, eigen structure methods and estimation of signal parameters via rotational invariance techniques etc. are the most powerful tool for DOA estimation. [7] All these methods are based on the digital beamforming antenna array. Incoming signals are received by the antenna elements and down converted to base band signal and fed into a digital signal processor chip where the algorithm can execute and processed on the incoming data, DOA is to be estimated. Till all this theories are analyzed for the static users i.e. users are fixed at their initial position (angle) and radiate the radiation pattern towards the antenna element. In this paper, we focus on the users are moves from one position to another and find out the correct position location (PL) of the desired user. We use here the extended version i.e. Dynamic-PM algorithm for correct DOA estimation in the dynamic environment.

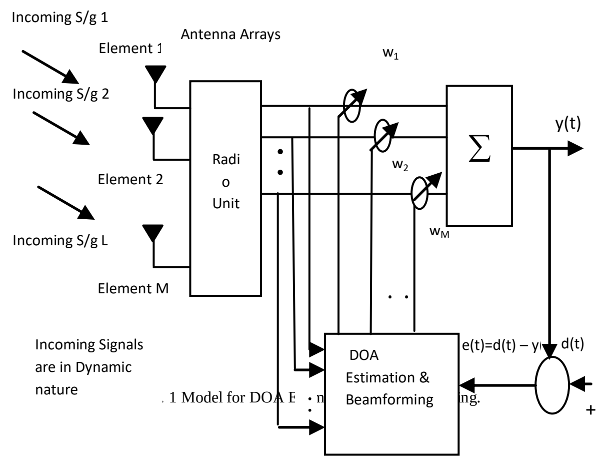

Fig.1 also shows the Dyanamic-LMS adaptive beamforming network, Uniform Linear Array (ULA) with M isotropic elements, which forms the integral part of the adaptive beamforming system. In short, the beam forming is done digitally, the beam forming and signal processing units normally be integrated in the same unit. For the DOA estimation and beamforming the antenna array and signal processing unit etc are the common.

3. DOA Estimation & Beamforming System for Dynamic Condition

In this paper the general configuration for array antenna having M elements and L number of incoming signals are to be consider with antenna element spacing, d=λ/2, where λ is the incoming signal wavelength. Incoming signals are L out of these, one user is in dynamic condition and rest is in static nature, Fig. 2.

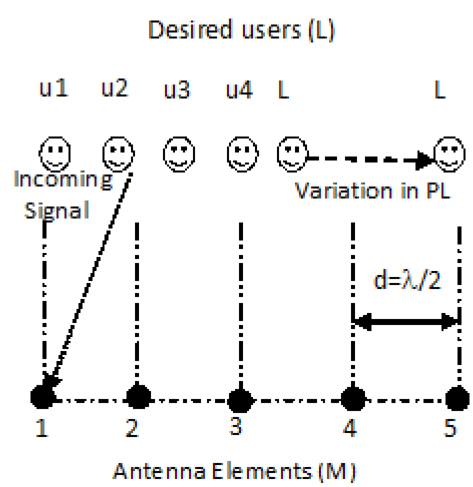

Fig.2 Dynamic user configuration

a. DOA Estimation using Dynamic-PM algorithms.

First set the noise properties SNR antenna array spacing d, M number of elements in antenna array, N-number of times steps, dt and t are the length of time step and time vector. Then set the incoming signal (L) properties, for DOA and beam forming number of incoming signals, f_0 is the incoming signal frequency, set amplitude and phase then round up the data noise. Calculate the matrix that content the antenna outputs

$$X(t) = A(\theta) * s(t) + n_x(t) \qquad (1)$$

$$Y(t) = A(\theta) * \phi_1 * s(t) + n_y(t) \qquad (2)$$

Where A =steering vector, s =signal received at first antenna, $n_x(t)$, $n_y(t)$ are the additive white gaussian noise ϕ_1 is the diagonal matrix containing information about elevation angle for sub array x and y.

b. Beamforming using Dynamic-LMS

Fig. 1, shows the Dynamic-LMS adaptive beamforming network, it consist of antenna arrays, signal processing unit, radio unit and adaptive weights. Consider a Uniform Linear Array (ULA) with *M* isotropic elements, which forms the integral part of the adaptive beamforming system as shown in the figure above.

The output of the antenna array *x(t)* is given by,

$$x(t) = s(t)a(\theta_0) + \sum_{i=0}^{M_u} u_i(t)a(\theta_i) + n(t) \qquad (3)$$

$s(t)$ denotes the desired signal arriving at angle θ_0 and u_i denotes interfering signals arriving at angle of incidences θi respectively. $a(\theta_0)$ & $a(\theta_i)$ represent the steering vectors for the desired signal and interfering signals respectively. Therefore it is required to construct the desired signal from the received signal, the interfering signal and additional noise $n(t)$

Dynamic-LMS algorithm can be summarized in following equations.

output $\quad y(n) = w^h x(n) \qquad (4)$

Errors $\quad e(n) = d^*(n) - y(n) \qquad (5)$

Weight $\quad w(n+1) = w(n) + \mu x(n) e^*(n) \qquad (6)$

4. Simulation Results

a. Simulation Result for DOA Estimation

Computer Simulation has been conducted to evaluate the DOA estimation using Dynamic-PM in dynamic condition. Number of antenna array elements and the incoming signals are 5, the array spacing 'd' is taken half of the wavelength i.e. 0.5. The number of snapshots N=100, and the wave number 'k' is 180. We can evaluate the performance of Dynamic-PM algorithm to estimate the DOA of incoming signals.

The real directions for the incoming signal are 25, 80, 130 and 155 degrees and one user is in dynamic condition, whose movement starts at an angle of 50^0 and end at 89.99^0 with the interval 0.40, and the real directions are estimated up to 100 samples, for 5 users, this is shown in Fig. 3.

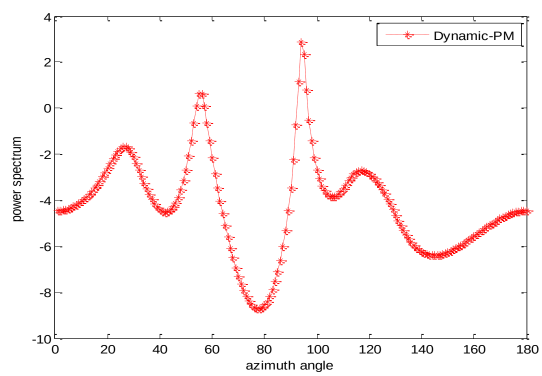

Fig. 3: Power spectrum using Dynamic-PM algorithm (L=5 &M=5)

Fig. 3, show result of power spectrum versus the azimuth angle for the five coherent sources with estimated DOA at five different degrees.

In this result, DOA estimation of incoming signals is not much more accurate. But the user who moves from their initial position and rest at the end, at an angle 94^0 and the magnitude of power spectrum is 2.86.

b. Simulation Result for Beamforming

The performance evaluation carried out through simulation using MATLAB. The five incoming signals are arriving with different angles, out of this four are coming with directions 25, 80 130 and 155 degrees and one is moved from 50^0 to 89.6000 with the intervals of 0.400, i.e. dynamic case. And the beamformer shows the results which is shown in Fig. 4 and 5. Fig. 4 shows the Normalized Array Factor

Plot & Fig.5, Null Steering Beamformer for Dynamic Case., desired user at an angle of 92.600 and all other four interferer users are nullify. Also the Beamformer for the same case is shown in Fig. 5.

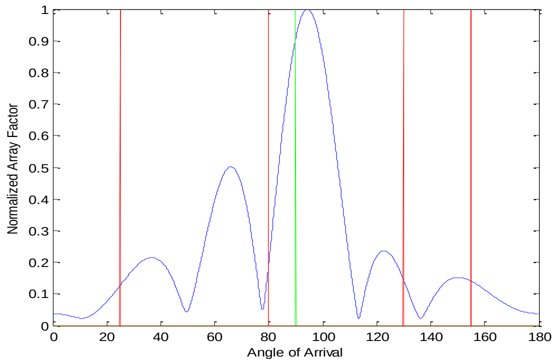

Fig. 4: Normalized Array Factor Plot for Dynamic-LMS

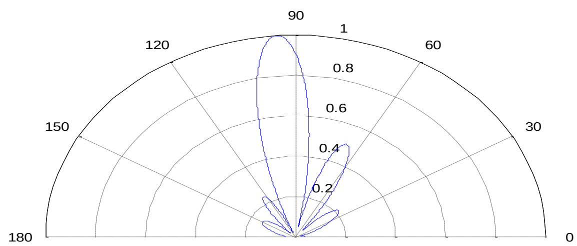

Fig. 5: Null Steering Beamformer for Dynamic-LMS

5. Conclusion

We have evaluated Dynamic-PM method based on the non-eigen decomposition to estimate angle of incoming signals i.e. DOA and steer the beam towards the desired user using Dynamic-LMS, in dynamic condition. By studying this we come to following conclusion:

- Even with equal number of elements (L=M) Dynamic-PM can estimate the DOA with small deviation.
- Magnitude of Power for Dynamic-PM is small in size.
- Apply weights to each element in the array so as to steer the antenna pattern towards a known look direction.
- And the capability to resolve multiple targets with separation angles smaller the main lobe beam width of the array.

Once the DOA is estimated, the beamformer adapts the antenna pattern to steer the main beam towards the desired user and place nulls in the unwanted direction through Dynamic-LMS algorithm.

References

[1] T.S. Rappaport, J.H. Reed and B.D. Woerner, “Position location using wireless communications on highways of the future,” *IEEE Communications Magazine*, vol. 34, no.10, pp. 33-41, 1996.

[2] G.V. Tsoulos, “Smart antennas for mobile communication systems: benefits and challenges,” *IEEE Electronic & Communication Engineering Journal*, Vol 11, no.2 pp. 84-94, 1999.

[3] K.J. Krizman, T.E. Biedka, and T.S. Rappaport, “Wireless position location: fundamentals, implementation strategies, and sources of error,” in Proc. *IEEE Vehicular Technology Conference*, Vol 2 pp. 919-923, Phoenix, Ariz, USA, MAY 1997.

[4] Tsoulos G.V. Meach MA. Swalas S.C. Adaptive Antennas for Third Generation DS-CDMA Cellular Systems, *Proceedings of the 45th Vehicular Technology Conference*, Vol 1, pp. 45-49, July 1995.

[5] Okamoto G.T. Smart Antennas and Wireless LANS. Kluwer Academic Publishers, Norwell Mass., 2002

[6] Ch. Santhi Rani, P.V. Subbaiah, K. Chennakesava and S. Sudha Rani, “LMS and RLS Algorithms for Smart Antennas in a W-CDMA Mobile Communication Environment,” *ARPN Journal of Engineering and Applied Sciences”* Vol. 4, no.6, August 2009.

[7] Godara, L.C., “Application of Antenna Arrays to Mobile Communications, Part II: Beamforming and Direction-of Arrival Considerations,” Proceedings of the IEEE, Vol. 85, No. 8 pp 1195- 1245, August 1997.

[8] Rudra Pratap, “Getting Started with MATLAB 7”, *OXFORD University Press,New Delhi,2006.*

[9] Brian R. Hunt Ronald L. Lipsman, “ A Guide to MATLAB – for Beginners and Experienced Users” *Cambridge University Press,2001*

[10] Timothy A. Davis and Kermit Sigmon,“ MATLAB Primer” , *A CRC Press Company,7th Edition 2005.*