Performance Analysis of MIMO System Using Fish Swarm Optimization Algorithm

M. Kasiselvanathan[1], S. Lakshminarayanan[2], J. Prasad[3], K.B. Gurumoorthy[4] and S. Allwin Devaraj[5]

[1,2]Assistant Professor, Department of Electronics and Communication Engineering, Sri Ramakrishna Engineering College, Coimbatore, India, [1]kasiselvanathan@gmail.com, [2]shrinarayanan20@gmail.com

[3]Assistant Professor, Department of Electronics and Communication Engineering, KPR Institute of Engineering and Technology, Coimbatore, India, prdece@gmail.com

[4]Assistant Professor (Ad hoc Faculty), Department of Electronics and Communication Engineering, National Institute of Technology, Calicut, India, gurukb85@gmail.com

[5]Assistant Professor, Department of Electronics and Communication Engineering, Francis Xavier Engineering College, Tamil Nadu, India, babu.allwin@gmail.com

*Corresponding Author: M. Kasiselvanathan ; E-mail: kasiselvanathan@gmail.com

ABSTRACT- During the signal identification process, massive multiple-input multiple-output (MIMO) systems must manage a high quantity of matrix inversion operations. To prevent exact matrix inversion in huge MIMO systems, several strategies have been presented, which can be loosely classified into similarity measures and evolutionary computation. In the existing Neumann series expansion and Newton methods, the initial value will be taken as zero as a result wherein the closure speed will be slowed and the prediction of the channel state information is not done properly. In this paper, fish swarm optimization algorithm is proposed in which initial values are chosen optimally for ensuring the faster and accurate signal detection with reduced complexity. The optimal values are chosen between 0 to 1 value and the initial arbitrary values are chosen based on number of input signals. In the proposed work, Realistic condition based channel state information prediction is done by using machine learning algorithm. Simulation results demonstrate that the suggested receiver's bit error rate performance characteristics employing the Quadrature Amplitude Modulation (QAM) methodology outperform the existing Neumann series expansion and Newton methods.

Keywords: MMSE, BER, MIMO, Complexity, Signal Detection

1. INTRODUCTION

The key objective of the enormous MIMO systems engages deployment of highly large amount of antenna arrays on Base Station (BS) so as to raise network capability, reliability, and decrease overall transmitted power. Large scale MIMO systems can give extremely high data rates, and can fulfil rapidly through rising demand for wireless connectivity [9]. For uplink MIMO system, still the linear detectors perform matrix inversion for detecting the signal. It gives high computational complexity and degrades the performance [2].

In terms of spectrum and energy efficiency, large-scale MIMO can achieve increasing orders of magnitude [10]. In practical, understanding attractive advantages of massive MIMO gets several challenges, due to increased multi - user disruptions, one of them is the signal detecting algorithm [11]. When the size of the network in a large MIMO system grows, the best detector is the Maximum Likelihood (ML) detector, and it seems to have a high level of mathematics problems.

To simulate matrix inversion, the truncated Neumann Series expansion (NSE) is used, whose efficiency and computing difficulty scale sequentially with the set of relevant series terms [7,8]. In [6], the Minimum Mean Square Estimation parallel interference cancellation for huge MIMO systems, the (MMSE-PIC) technique with Neumann series extension approximations is suggested. On the approach which is based, an enhanced Newton iterative approach is given by changing the matrix-matrix item through from collection of variables [3]. An optimum energy distribution system based on the artificial fish swarm algorithm is proposed to assist to the quality of service (QoS) of cognitive radio networks dependent on interference alignment [5]. An enhanced fish swarm algorithm for neighbourhood rough set minimization is proposed by incorporating a configurable parameter to govern the vision and step size of artificial fish, avoiding the problem

of uneven number of iterations that plagued a classic artificial fish swarm algorithm [4]. To handle large-scale linear programming difficulties, an enhanced binary artificial fish swarm algorithm (IBAFSA) is introduced. Levy flying and adjustable mean visual range to explore region greater improve the state the variables of IBAFSA, and a twofold to enhance the efficiency of advancement of the society in optimizing, a threshold selection method is used [1].

2. MIMO SYSTEM MODEL

A large MIMO system has 'N_t' transmit antennas and 'N_r' receive antennas with reception ($N_t \leq N_r$). The relationship is modelled as

$$\overline{Y} = \overline{H}\overline{X} + \overline{N} \qquad (1)$$

Where,

$\overline{X} = (\overline{x}_1, \overline{x}_2, \overline{x}_3, ... \overline{x}_{Nt})^T$ Represents transmitted signal vector.

$\overline{Y} = (\overline{y}_1, \overline{y}_2, \overline{y}_3, ... \overline{y}_{Nr})^T$ Represents received signal vector.

$\overline{\Omega}$ - Collection of M complex symbols for M-QAM constellation.

$\overline{H}$ - ($N_r \times N_t$) channel matrix with each coefficient $\overline{h}_{ij} \sim CN(0, 1)$.

$\overline{N} = (\overline{n}_1, \overline{n}_2, ... \overline{n}_{Nr})^T$ denotes ($N_r \times 1$) i.i.d.

The Equation (1) is rewritten as

$$Y = HX + N \quad (2)$$

Where,

$X = (R\{\overline{X}\}^T I\{\overline{X}\}^T)^T$ denotes real transmitted vector.

$\Omega = \{\pm 1, \pm 3 \cdots \pm(\sqrt{M} - 1)\}$ is a collection of $\sqrt{M}$ real symbols.

$Y = (R\{\overline{Y}\}^T I\{\overline{Y}\}^T)^T$ is ($2N_r \times 1$) real equivalent received vector.

H is the channel matrix provided in Equation (3).

$$H = \begin{bmatrix} R\{\overline{H}\} & -I(\overline{H}) \\ I(\overline{H}) & R(\overline{H}) \end{bmatrix} \quad (3)$$

$N = (R\{\overline{N}\}^T I\{\overline{N}\}^T)^T$ denotes the noise vector.

2.1 Linear MMSE Detection

If H is precisely calculated at Base Station (BS), then the MMSE It is possible to depict detection by,

$$\hat{X} = (H^H H + \sigma^2 I)^{-1} H^H y = A^{-1} b \quad (4)$$

Where b $= H^H y$ is the result of y matching filter, and $A = H^H H + \sigma^2 I$ denotes the MMSE filtering matrix and I denotes the K dimensional unit diagonal matrix.

3. PROPOSED WORK

In the proposed research technique, initial values are chosen optimally by using fish swarm algorithm for ensuring the faster and accurate signal detection with reduced complexity. The optimal values are chosen between 0 to 1 value and the initial arbitrary values are chosen based on number of input signals. The Realistic condition based channel state

information prediction is done by using machine learning algorithm.

3.1 Fish Swarm Optimization Algorithm

Step1- Start the status of the fish by changing various (population size is *N*). Create *N* artificial fish individuals at irregular intervals in the given range, where vision is the artificial fish's highest vision range, Phase is the greatest step, is indeed the packed with people component, n could it be greatest proportion of artificial fish trying to find feed, and c, d are chaos evolution variables.

Step2- The noticeboard is being set up. Evaluate and measure the objective functions of each beginning fish, then place the best artificial fish on its noticeboard.

Step3- Choosing what to do. Every artificial fish simulates swarming and pursuing behavior and chooses the best behavior by evaluating objective functions; the usual behavior is seeking for feed.

Step4- Evolution that is chaotic. Execute mutations to every fish's present position based on Xinext = Xi+cti-d; if the status is beyond the given range, create Xinext at arbitrary in the viable area. Calculate f (Xinext),

If f (Xinext) is superior to f (Xi), then, Xi = Xinext Otherwise, do notupdate; set ti= 4ti(1-ti).

Step5- Make changes to the noticeboard. Update the noticeboard with every fish's present position by evaluating its optimal solution; the best situation is Xbest.

Step6- Apply chaos evolution to the fish's present ideal situation just on noticeboard. Execute chaotic mutations to reach the best state based on dcuXX (feasible region) iinext (superior region)

−+= (do not update)

Need not upgrade if the status is outside of the possible range. If the computed function values f(Xcbest) are better than f(Xbest), then,

Xbest= f (Xcbest) otherwise, do not update; set u=4u(1-u).

Step7- Examine the terminating situation. If the criteria are met, exit the ongoing method and output the best result; otherwise, proceed to step three. The results achieved by this hybrid algorithm are better to those provided by AA when evaluated with the six-hump camel back functionality and applied to PLP. This method can successfully solve both limited and uncontrolled problems.

4. RESULTS AND DISCUSSION

The chapter compares and contrasts the obtained from the suggested methodologies. There are 64 sending antennas and 64 receiving antennae, correspondingly. *Figure 1* shows the BER result of the suggested fish swarm optimization algorithm based MIMO receiver for (64x64) antennas using 32-QAM, 64-QAM, and 128-QAM encoding modes (1-3). From the Figure 1, it is observed that for increasing the value of SNR, when comparing to other current approaches, in perspective of BER, the proposed method outperforms the others. The suggested technique outperforms current
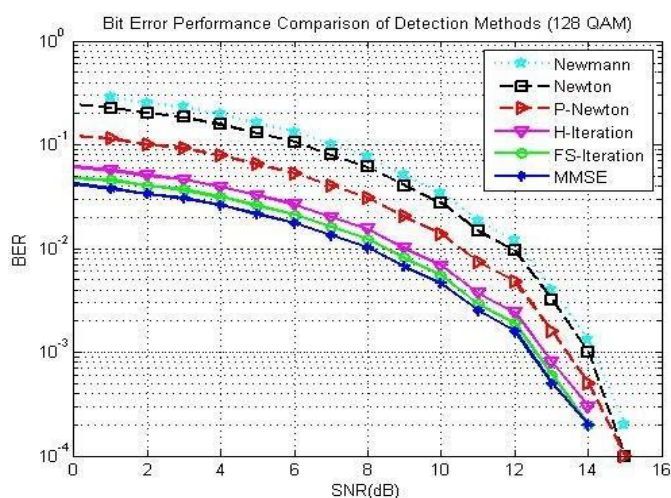
identification techniques like Neumann series recognition and Newton identification.
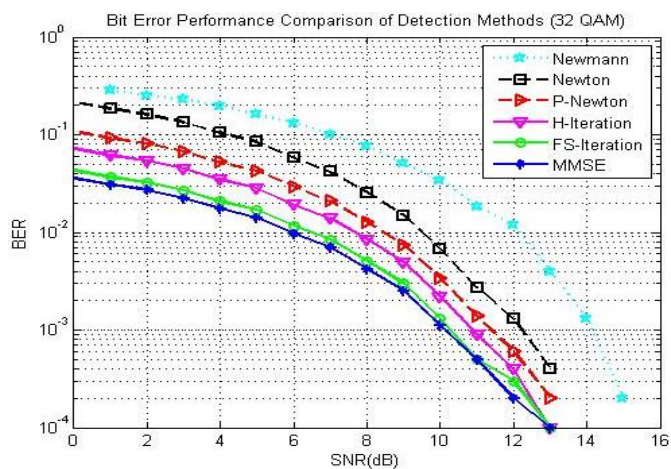
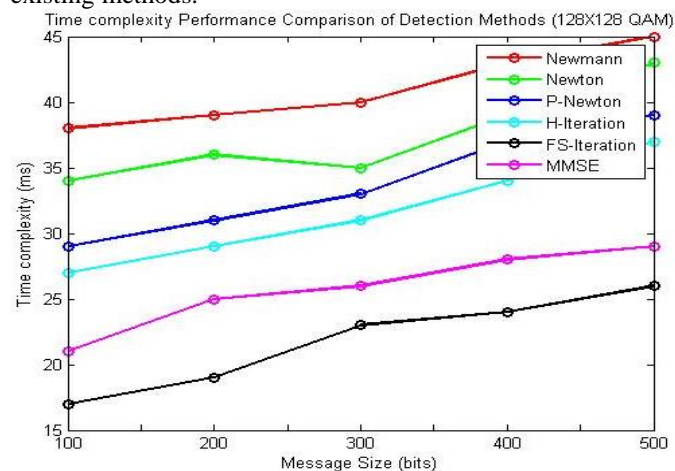**Figure 1**: BER performance of the proposed and existing methods for 32-QAM
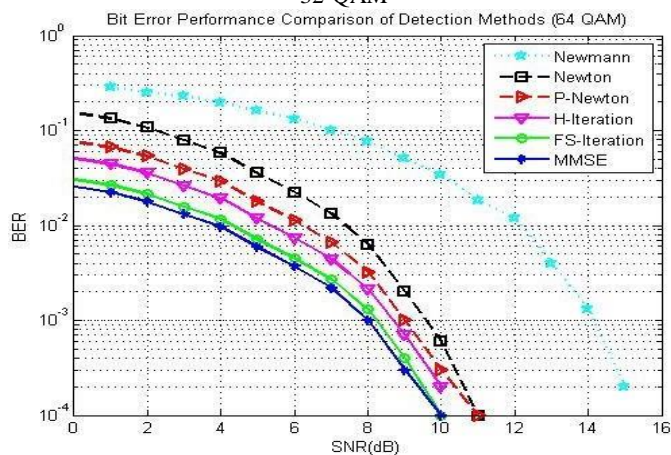
Figure 2: BER performance of the proposed and existing methods for 64-QAM

Figure 3: BER performance of the proposed and existing methods for 128-QAM

The time difficulty of a method is the amount of time it takes to process the input stream. *Figure 2* shows a comparative of computation time among current solutions and the suggested

approach. It is observed that the proposed method fish swarm algorithm gives reduced time complexity than the other existing methods.

Figure 4: Time complexity performance of the proposed and existing methods

5. CONCLUSION

Wireless communication systems performance is greatly enhanced by MIMO configuration for an abundance of antennas. The fish swarm optimization algorithm based large MIMO system is proposed in which initial values are chosen optimally for ensuring the faster and accurate Low-complexity signal identification. For numerous antennas, the efficiency features of the suggested approach and current QAM methods are compared. The simulated outputs indicate whether the proposed solution is effective receiver's bit error rate best performance outperforms the current Neumann series expansion and Newton approaches. The proposed method can be utilized in potential application areas such as WIMAX 802, Wireless local area networks, 5G networks, Radar and other communication applications.

REFERENCES

[1] Y. Zhu and H. Gao, "Improved binary artificial fish swarm algorithm and fast constraint processing for large scale unit commitment", IEEE Access, vol. 8, pp. 152081-152092, 2020.

[2] Swarnima Singh, Vikash Yadav (2021), An Improved Particle Swarm Optimization for Prediction of Accident Severity. IJEER 9(3), 42-47. DOI: 10.37391/IJEER.090304.

[3] C. Zhang, X. Liang, Z. Wu, F. Wang, S. Zhang, Z. Zhang and X. You. "On the low-complexity, hardware-friendly tridiagonal matrix inversion for correlated massive MIMO systems", IEEE Transactions on Vehicular Technology, vol. 68, no. 7, pp. 6272-6285, 2019. http://doi.org/10.1109/TVT.2019.2915171

[4] F. Jin, Q. Liu, H. Liu and P. Wu, "A low complexity signal detection scheme based on improved Newton iteration for massive MIMO systems", IEEE Communications Letters, vol. 23, no. 4, pp. 748-751, 2019.

[5] L. Zou, H. Li, W. Jiang and X. Yang, "An improved fish swarm algorithm for neighborhood rough set reduction and its application". IEEE Access, vol. 7, pp. 90277-90288, 2019.

[6] K. Guo, R. Qiu and C. Cai, "A power allocation algorithm based on artificial fish swarm algorithm for cognitive radio networks

based on interference alignment", In 2017 4th International Conference on Systems and Informatics (ICSAI), pp. 1013-1017, 2017. http://doi.org/10.1109/ICSAI.2017.8248434

[7] Vipin Gupta, Dr. Praveen Dhyani (2016), Analysis of MIMO OFDM in different Bonds rate of QAM, BPSK, QPSK. IJEER 4(3), 62-66. DOI: 10.37391/IJEER.040301. http://ijeer.forexjournal.co.in/archive/volume-4/ijeer-040301.php

[8] L. Fang, L. Xu and D.D. Huang, "Low complexity iterative MMSE-PIC detection for medium-size massive MIMO", IEEE Wireless Communications Letters, vol. 5, no. 1, pp. 108-111, 2015.

[9] D. Zhu, B. Li and P. Liang, "On the matrix inversion approximation based on Neumann series in massive MIMO systems", In 2015 IEEE international conference on communications (ICC), pp. 1763-1769, 2015.

[10] M. Wu, B. Yin, G. Wang, C. Dick, J.R. Cavallaro and C. Studer, "Large-scale MIMO detection for 3GPP LTE: Algorithms and FPGA implementations", IEEE Journal of Selected Topics in Signal Processing, vol. 8, no. 5, pp. 916-929, 2014.

[11] H. Holma, and A. Toskala, "LTE advanced: 3GPP solution for IMT-Advanced", John Wiley & Sons, pp. 1-14, 2012.

[12] H.Q. Ngo, E.G. Larsson, and T.L. Marzetta, "Energy and spectral efficiency of very large multiuser MIMO systems", IEEE Transactions on Communications, vol. 61, no. 4, pp. 1436-1449, 2013.

[13] F. Rusek, D. Persson, B.K. Lau, E.G. Larsson, T.L. Marzetta, O. Edfors and Tufvesson, F, "Scaling up MIMO: Opportunities and challenges with very large arrays", IEEE signal processing magazine, vol. 30, no. 1, pp. 40-60, 2012.