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LOW COMPLEXITY SIGNAL DETECTION ALGORITHM BASED ON THE NOVEL ITERATIVE NEWTON ALGORITHM

Shekar. Y and Dr. Rahul Mishra
Department of Electronics & Communication Engineering, Dr. A. P. J. Abdul Kalam University, Indore (M. P.) India -452010
Corresponding author Email: shekar4b3@gmail.com

Abstract:
In order to solve the problem of massive MIMO detection and calculation of communication system with terahertz, the algorithm signal detection with high-complexity based on iterative Newton algorithm is proposed. By improving the initial matrix in Newton iterative algorithm, the addition of step factor, reduce the computing complexity, and improve the speed of convergence; by adding the adjustment factor, the stability, reliability and scene applications of the algorithm are guaranteed. The simulation results show that compared with the traditional algorithm, the algorithm has lower calculation complexity and faster convergence speed. Thenumber of iterations is 3 times, the MMSE algorithm performance can be approached.
Keywords: Massive MIMO, MMSE, Netwon approximation.

1. INTRODUCTION

The large-scale multiple input multi-output (MIMO) technique is an important part of the 6G Terahertz communication system [1]. It not only makes the communication system more reliable, but also expands the capacity of the communication system. However, in the 6G system [2], tens of thousands of antenna units will be placed in the antenna array [3], so that the calculation complexity of the MIMO system receiving end is unbearable. The group and control technology of the super large antenna array can be split into multiple groups [4] to reduce the number of antenna units in the array and apply the traditional MIMO signal detection algorithm.

Large -scale MIMO technology can make use of spatial resources to greatly improve spectrum utilization rate and system energy efficiency, and large increase in number of antenna also increases capacity of the system [5]. The research results have been studied in field of large-scale MIMO signal detection. These results have contributed greatly in computing complexity, detection performance, and algorithm convergence speed. Jiang et al. [6] proposed a Jacobi-based iteration algorithm; GAO et al. [7] detection algorithm based on the Richardson algorithm is proposed. Compared to the minimum square error (MMSE, MinimumMean Square Error) algorithm, these two algorithms have low calculation complexity, but there are disadvantages of slow convergence speed. BAKULIN et al. [8] changed the line to change, avoiding the high -dimensional matrix to seek inverse operations, the algorithm complexity decreases, but it requires 12 iterations to achieve good performance. ZHU et al. [9] detection algorithm based on the Neumann-level expansion is proposed. Through the level of the number of matrix, the algorithm was widely used because of low complexity. But the calculation complexity is higher than the matrix to seek reverse during the expansion number is greater than or equal to 3. BJ 10RCK [10] proposed a method of accelerating the iteration of relaxation factor.GAO et al. [11] proposed a super loose iterative algorithm for the optimal relaxation factor. ZHANG et al. [12] proposed improved symmetry super loose iterative algorithms. After several iterations, better detection performance can be obtained. However, because number of antennas of system's receiver has a great impact on performance of algorithm, applicable scenarios are greatly limited. Jin et al. [13] signal detection algorithm based on Newton iterative iteration is proposed, which obtained a faster convergence speed, and the detection accuracy was also high, but the excessive matrix multiplication operation brought higher calculation complexity. ChatAut et al. [14] Based on the approximate message transmission (AMP, APPROXIMATE MessagePassing) algorithm, it proposed a low -complexity MIMO detection calculation method, which improved MIMO detection accuracy, but it usually needs 6-8 iterations to approach the MMSE algorithm performance Convergence speed is limited.

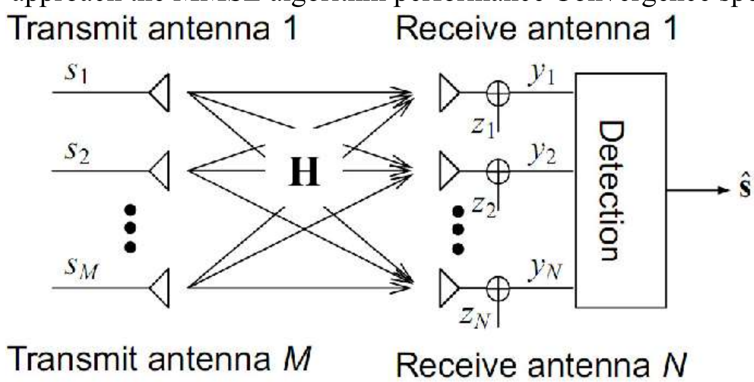

Figure 1: MIMO system model

In this article a signal detection based on Newton iterative algorithm is proposed. By improving initial value of the iterative, the addition of the steps factor, and the addition of the adjustment factor, the calculation complexity of the algorithm is reduced, the convergence speed of algorithm is accelerated, and stability of algorithm is guaranteed. The algorithm can work in the two modes of θ and θ = 0. When θ, you can achieve the MMSE algorithm performance after 3 iterations; when θ = 0, it is necessary to iterate to achieve the MMSE algorithm performance, but the complexity is greatly reduced, especially for large processing data and real -time requirements. Not high.

2. SYSTEM MODEL

Suppose the MIMO system contains n receiving antennas, K to launch antennas, $N \times K$, and the system model is shown in Figure 1.

MIMO system receiving signal can be represented

$$y = Hx + n$$

where, $x = (x_1, x_2, \dots, x_K)^T \in C^{K\times 1}$ indicates the transmitted signalx_k,$y = (y_1, y_2, \dots, y_N)^T \in C^{N\times 1}$the received signal, $y_k$receives an antenna signal for k root; $H = (h_1, h_2, \dots, h_K) \in C^{N\times K}$ indicates that the channel matrix,$h_i = \left(h_{1,i}, h_{2,i}, \dots, h_{N,i}\right)^T \in C^{N\times 1}, h_{m,n}$ is the normalized channel gain between the m -receiving antenna, and obey$h_{m,n} \sim CN(0,1); n = (n_1, n_2, \dots, n_N)^T \in C^{N\times 1}$additive white Gaussian noise, the average value of n_i is 0, and variance σ_n^2. Here, assume that the signal experiences a flat and declining channel.

MMSE detection on the received signal is obtained as

$$\hat{x} = (H^H H + \sigma^2 I_k)^{-1} H^H y$$

where, $\hat{x}$ indicates the emission signal vector estimation value.
If $b = H^H y$ indicates the matching filter, $A = (H^H H + \sigma^2 I_k)^{-1}$ indicates MMSE filter matrix, then the formula (2) is rewritten as it

$$\hat{x} = A^{-1} b$$

where, the calculation complexity of A^{-1} is $O(K^3)$ [15].

3. PROPOSED ALGORITHM

The basic idea of iterative algorithm is to decompose A into a form of $A = P + Q$ [16], where P is not strange, the iterative formula is

$$x^{(k)} = Bx^{(k-1)} + f = P^{-1}\left(-Qx^{(k-1)} + b\right)$$

where, $B = -P^{-1}Q = I_k - P^{-1}A, f = p^{-1}b, k$ are the number of iterations. When satisfying $lim_{k\to\infty} B^k = 0$, iterates convergence. Assuming the startingis estimated to be $x^{(0)} = P^{-1}b$, then the result of second iteration can be expressed as

$$x^{(k)} = P^{-1}\left((P-A)x^{(k-1)} + b\right) = \sum_{i=0}^{k}(I - P^{-1}A)^i P^{-1} b$$

Table. 1: Comparison of computational complexity between proposed algorithm and Newton iterative algorithm

Algorithm,	**Computational complexity**
Algorithm1	NK+K
Algorithm2	NK+3K
Newtons iterative algorithm	NK^2+NK+K

3.1 Newton Iterative Algorithm

Ordering X_0 is the initial estimate of A^{-1}, then k times NEWTON iteration can be written as [17]

$$X_k = X_{k-1}(2I - AX_{k-1})$$

When satisfying $\|I - AX_0\| < 1$, achieve convergence. Because the Newton iteration algorithm is a second convergence, its calculation complexity depends only on the number of iterations. Literature [16] pointed out that the results of the NEWTON iteration algorithm K is the same as the result of 2K −1 times in algorithms based on Neumann -level. Therefore, under the same system configuration, the Newton iteration algorithm has a faster convergence speed than other iteration algorithms.

3.2 Low Complexity MIMO Detection Algorithm

This article conducts MIMO detection based on the Newton iteration algorithm. By improving the initial matrix to reduce the complexity and increase convergence of algorithm; by adding steps, the algorithm convergence speed has been greatly improved, and then reliability and stability of algorithm are guaranteed by adding adjustment factor. Algorithm 1 Signal detection based on Low complexity iterative newton algorithm (adjustment factor θ ≠ 0)
Inputs: H, y, σ^2, K
Output: x

1. Initialization
2. $A = H^H H + \sigma^2 I, b = H^H y$
3. $X_0 = \alpha I // X_0$for the initial matrix, α is optimal relaxation factor, and I is $K \times K$ dimension matrix.
4. Iteration starts
5. For $k = 1, \dots, n$ do
6. $e_k = AX_k - I$ $//e_k$ for error matrix
7. $\eta = \frac{1}{1+\frac{\theta trace(e_k)}{K}}$$//\theta$ is adjustment factor, η step factor
8. $X_k = X_{k-1} - \eta X_{k-1}(AX_{k-1} - I)$
9. End for

$$x = X_k b$$

In particular, when the adjustment factor θ = 0, it can be further simplified to the iterative formula, and the algorithm complexity is further reduced by avoiding the MMSE matrix calculation. Signal detection based on Low complexity iterative NEWTON algorithm (adjustment factor θ = 0) is shown in algorithm 2.

Algorithm 2:Signal Detection based on Low complexity iterative newton iteration algorithm (adjustment factor θ = 0)

Input: H, y, σ^2, K, N

Output: x

1. Initialization
2. $b = H^H y, \alpha = \frac{1}{N+K}$
3. $X_0 = \alpha I, V = \sigma^2 X_0, x^{(0)} = X_0 b // X_0$ for the initial matrix
4. Iteration starts
5. For $k = 1, \dots, n$ do
6. $x^{(k)} = x^{(k-1)} + (I - X_0 H^H H - V)^{2^{k-1}} x^{(k-1)}$
7. $end\ for$

$$x = x^{(n)}$$

The iterative formula in Step 6) is derived below. Since the initial iteration matrix $X_0 = \alpha I$, based on the formula (6), the initial iteration can be written as

$$X_1 = X_0(2I_K - AX_0) = 2X_0 - X_0(X_0^{-1} + Q)X_0 = X_0 + (-X_0 Q)X_0$$

where, $Q = A - X_0^{-1}$ the corresponding estimation signal is

$$x^{(1)} = X_0 b = x^{(0)} - (X_0 Q)x^{(0)} = x^{(0)} - (X_0 A - I)x^{(0)} = x^{(0)} + (I - X_0 H^H H - V)x^{(0)}$$

where, $x^{(0)} = X_0 b$ and $V = \sigma^2 X_0$ are diagonal matrix. Use the classic Newton iterative formula (i.e., (6)) to perform the next iteration.

$$X_2 = X_1(2I - AX_1) = (X_0 - X_0 Q X_0)\big(2I - (X_0^{-1} + Q)(X_0 - X_0 Q X_0)\big) = X_1 + (-X_0 Q)^2 X_1$$

where

$$x^{(2)} = X_2 b = x^{(1)} + (X_0 A - I)^2 x^{(1)} = x^{(1)} + ((X_0 H^H H + V)^2 - 2(X_0 H^H H + V) + I)x^{(1)}$$

Similarly, the results of N iteration (i.e., step 6) can be launched as a native.

$$x^{(n)} = X_n b = \big(X_{n-1} + (-X_0 Q)^{2^n} X_{n-1}\big)b = x^{(n-1)} + (I - X_0 H^H H - V)^{2^{n-1}} x^{(n-1)}$$

3.3 Initial MatrixX_0:

Since $A = H^H H + \sigma^2 I$ is the positive setting matrix of Emit, the upper triangle and lower triangle part of the matrix are the same as symmetrical matrix, so matrix $A$is written as

$$A = D - L - L^H$$

where, D is the matrix composed of the diagonal element of A; $-L$ is the strict upper triangle part of A; and $-L^H$ is obtained after the $-L$converted, which is the strict lower triangle of A.

In the iterative algorithm, there are two main types of matrix. One is main value of the original value, when the number of transmitter and receiving antennas of the MIMO system becomes infinite, according to random matrix theory, the maximum and minimum of the MMSE detection algorithm filtering matrix will remain stable and converge to

$$\lambda_{min}(A) = N\left(1 - \sqrt{\frac{K}{N}}\right)^2$$

$$\lambda_{max}(A) = N\left(1 + \sqrt{\frac{K}{N}}\right)^2$$

In this case, the channel sclerosis will become extremely obvious. At this time, the non - diagonal element of the filter matrix can be ignored, that is, A can approximate the diagonal element. At this time, there is $D \approx D^{-1}(L + L^H)$.

Combined with the iterative matrix of the Jacobi iteration detection algorithm

$$B_J = D^{-1}(L + L^H)$$

we get the following form of the Jacobi algorithm iterative matrix

$$B_J = D^{-1}(L + L^H) = I - D^{-1}A = I - \frac{A}{N}$$

From the formula (13) and the formula (15), the characteristic value of B_J can be obtained

$$\lambda_{min}(B_J) = 1 - \left(1 + \sqrt{\frac{K}{N}}\right)^2$$

$$\lambda_{max}(B_J) = 1 - \left(1 - \sqrt{\frac{K}{N}}\right)^2$$

This is calculated that the radius of B_J spectrum is

$$\rho(B_J) = \max|\lambda(B_J)| = \left(1 + \sqrt{\frac{K}{N}}\right)^2 - 1$$

In Richardson algorithm, the form of the iterative matrix corresponding to it is

$$B_R = I - \alpha A$$

The value of the optimal relaxation parameter is usually set to

$$\alpha_{opt} = \frac{2}{\lambda_{max} + \lambda_{min}}$$

From (18) and (19), and combined with (13), the quasi-optimal relaxation parameter is written into

$$\alpha_{opt} = \frac{2}{\lambda_{min}(A) + \lambda_{max}(A)} = \frac{1}{K + N}$$

This can further obtain the radius of the Richardson algorithm.

$$\rho(B_R) = \max|\lambda(B_R)| = \frac{2N}{K + N}\sqrt{\frac{K}{N}}$$

Comparison analysis of formula (17) and formula (21) can be obtained

$$\rho(B_R) < 2\sqrt{\frac{K}{N}} < 2\sqrt{\frac{K}{N}} + \frac{K}{N} = \rho(B_J)$$

The radius of the iterative matrix in the iterative algorithm is negatively related to convergence speed of the algorithm [10], so the convergence speed of Richardson algorithm is obtained faster.

Since the Newton iteration algorithm is positively related to other iteration algorithms, in the iterative algorithm, when the initial matrix is $X_0 = \alpha I$, the convergence speed is faster than $X_0 = D^{-1}$; $X_0 = \alpha I$ as the initial iteration matrix is also achieve faster to collect the speed of convergence than $X_0 = D^{-1}$ as initial iteration matrix. Therefore, $X_0 = \alpha I$ is selected as the initial value of the improvement algorithm.

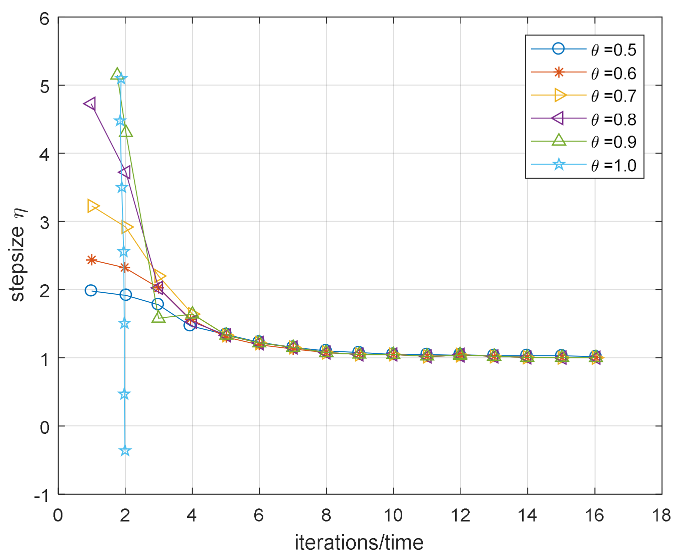

Figure 2: Effect of different θ values on the step size when $X_0 = \alpha I$

Step factor η

In order to improve the convergence of the algorithm, on the basis of the initial value improvement, the step factor η is added to the newton iteration formula to obtain

$$X_k = X_{k-1} - \eta X_{k-1}(AX_{k-1} - I) = X_{k-1} + \eta(I - X_{k-1}A)X_{k-1}$$
$$= (1 + \eta)X_{k-1} - \eta X_{k-1}AX_{k-1}$$

Because the filter matrix $A = H^H H + \sigma^2 I$ is symmetrical, the initial error matrix $e_0 = I - X_0 A$ is also symmetrical. It can further prove that the matrix e_k is symmetrical matrix by reciprocity, and for $k = 0,1,2,..,n$ are established. Therefore, $e_k$is diagnosed through the following transformation

$$\boldsymbol{e_k = U\Lambda_k U^H}$$

where, matrix U is a typical matrix, and $U^T = U^{-1}, \boldsymbol{\Lambda_k} \in \boldsymbol{C^{N\times K}}$ is the diagonal matrix.

Table 2: Comparison of iterative process complexity between the proposed algorithm and newton iterative algorithm

Iterations	Algorithm1	Algorithm2	Newton iterative algorithm
1	$K^2(2N+1)+2K(2N+3)$	$5NK$	$3KN+5KN$
2	$K^2(4N+5)+2K(3N+1)$	KN	$3NK^2+KN$
3	$2K(9N+7)+2K(N+5)$	$15NK$	NK^2+7KN
4	$K^2(15N+8)+K(15N+4)$	$31NK$	$15NK^2+15NK$

Table 3: Computation complexity of proposed algorithm with existing algorithms

Iterations	Algorithm 1	Algorithm 2	Newton's iterative algorithm	Algorithm based on Neumann series expansion	Literature [12] algorithm
1	$(N+2)K^2 + (3N+5)K$	$5KN+9K$	$2NK^2 + 2KN + 5K$	$4NK$	KN
2	$(3N+4)K + (2N+3)K$	$8NK+3K$	$4NK^2 + 2KN + 3K$	NK^2+KN	$2KN$
3	$(9N+5)K^2 + 4(3N+5)K$	$16NK+3K$	$8NK^2 + 8NK + K$	$K^2+NK^2 + NK$	$3NK$
4	$(15N+8)K^2 + (16N+5)K$	$32NK+3K$	$16NK^2 + 16NK + K$	$2K^2+NK^2 + NK$	$4NK$

The diagonal matrix is expressed as

$$\boldsymbol{\Lambda_{k+1} = \Lambda_k - \eta\left(\Lambda_k - \Lambda_k^2\right)}$$

The error matrix is

$$\boldsymbol{e_{k+1} = U\Lambda_{k+1}U^H}$$

For the matrix U and V of the equivalent $U^HU = UU^H = I$and $V^HV = VV^H = I$, given a non-strange matrix $A \in C^{K\times K}$, to obtain

$$\|UA\|_2 = \|AV\|_2 = \|UAV\|_2$$

The error matrix must meet $\|e_{k+1}\|_2 \leq \|e_k\|_2$ to ensure the convergence of the newton iterative algorithm.

$$\|\boldsymbol{U}\boldsymbol{\Lambda}_{k+1}\boldsymbol{U}^{H}\| = \|\boldsymbol{e}_{k+1}\|_2 \leq \|\boldsymbol{e}_k\|_2 = \|\boldsymbol{U}\boldsymbol{\Lambda}_k\boldsymbol{U}^{H}\|$$

Thus have

$$\|\boldsymbol{\Lambda}_{k+1}\|_2 \leq \|\boldsymbol{\Lambda}_k\|_2$$

In this way, the convergence of $e_k$is transformed into research on$\boldsymbol{\Lambda}_k$.

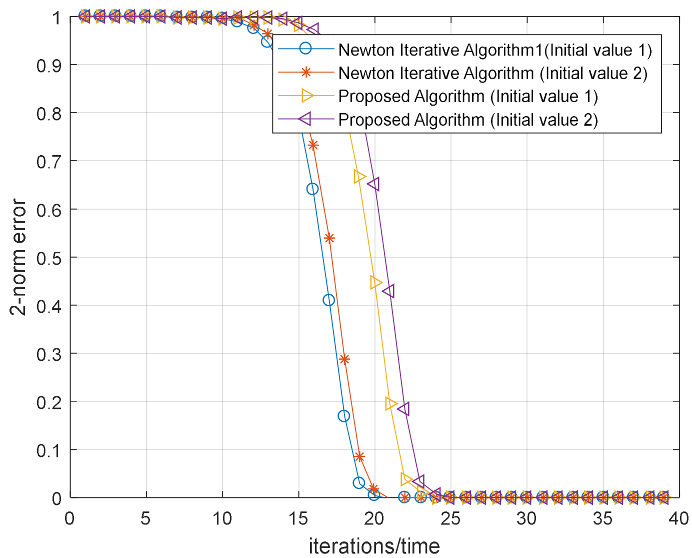

Figure 3: Comparison of the convergence speed of Newton iterative algorithm and algorithm 1 under the condition of 2 initial values

Let the diagonal matrix $\Lambda_k = diag\left(\mathcal{E}_{1,k}, \dots, \mathcal{E}_{i,k}, \dots, \mathcal{E}_{n,N_i}\right), k = 0, 1, \dots, K$,according to (25) , it is obtained as

$$\mathcal{E}_{i,k+1} = \mathcal{E}_{i,k} - \eta\left(\mathcal{E}_{i,k} - \mathcal{E}_{i,k}^2\right)$$

To converge the algorithm, $\|I - X_0A\|_2 < 1$, that is, the requirements, $-1 < \mathcal{E}_{i,0} < 1, i = 1,2, \dots, K$. At the same time, $\lim_{k\to\infty} e_k = 0$, $\lim_{k\to\infty} \Lambda_k = 0$, that is

$$\left|\mathcal{E}_{i,k+1}\right| = \left|\mathcal{E}_{i,k} - \eta\left(\mathcal{E}_{i,k} - \mathcal{E}_{i,k}^2\right)\right| < \left|\mathcal{E}_{i,k}\right|$$

According to the convergence of the iterative algorithm, the combination formula (31) $-1 < \mathcal{E}_{i,0} < 1, \eta > 0$, so that the step-long factor η should be satisfied

$$0 < \eta < \frac{2}{1 - \mathcal{E}_{i,k}}, -1 < \mathcal{E}_{i,0} < 1, \forall i = 1, 2, \dots, K$$

From the formula (30), when the matrix element $\mathcal{E}_{i,k+1}$is 0, the step -long factor reaches the best value, that is,

$$\eta = \frac{1}{1 - \mathcal{E}_{i,k}}$$

The average value of the diagonal matrix elements is expressed as $\bar{\mathcal{E}}$, that is, $\bar{\mathcal{E}} = \frac{1}{K}\sum_{i=1}^{N} \mathcal{E}_{i,k}$, the best value of the improved algorithm step factor is

$$\eta_{opt} = \frac{1}{1 - \frac{1}{K}\sum_{i=1}^{N} \mathcal{E}_{i,k}} = \frac{1}{1 - \bar{\mathcal{E}}}$$

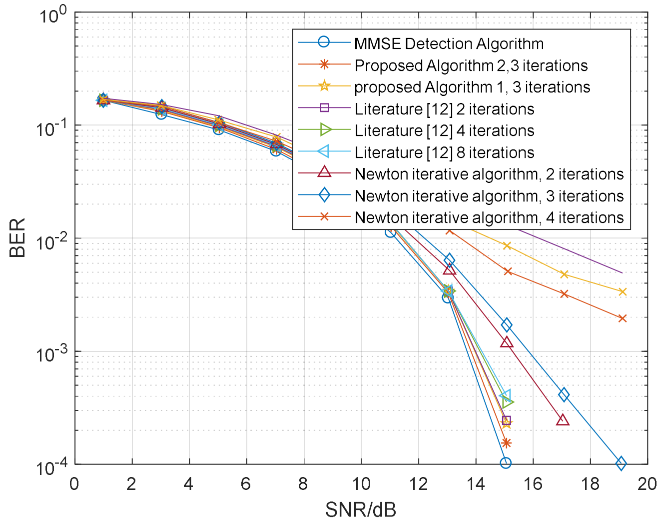

Figure 4: Algorithm (algorithm 1 and algorithm 2), literature [12] algorithm, Newton iterative algorithm, MMSE detection algorithm's BER performance

Adjustment factor θ :

According to the theory of convex optimization, if the step is too large, the extreme point may be missed, resulting in the formula (29) not established. In order to make the algorithm more stable, add the adjustment factor θ in the formula (34), that is,

$$\eta_{opt} = \frac{1}{1 - \theta\,\bar{\mathcal{E}}}$$

where, the distribution of θ is closely related to the distribution of $\mathcal{E}_{i,k}$.

Figure 2 has the effect of different θ values on the step length when $X_0 = \alpha I$ is given. It can be seen from Figure 2 that at the initial stage of iteration, the larger the θ, the larger the steps, especially when θ is close to 1.0, it is easy to converge. In summary, setting θ = 0.8 here, which not only guarantees the stability of the algorithm, but also accelerates the convergence of the algorithm.

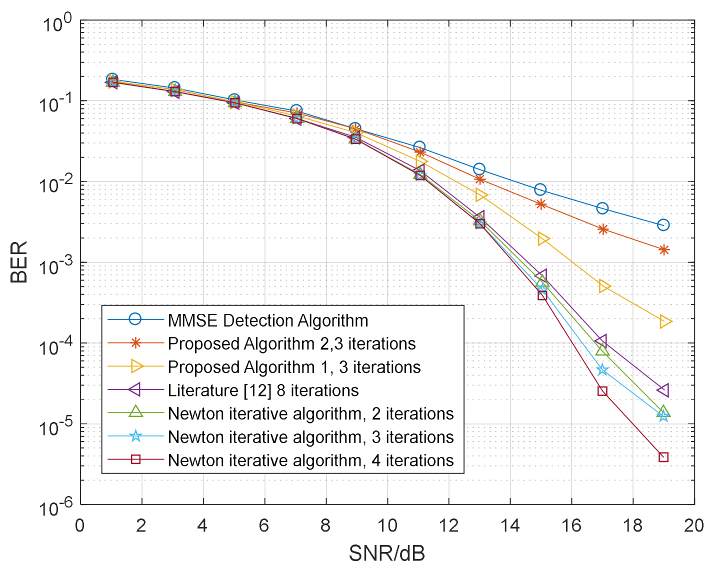

Figure 5: Algorithm (algorithm 1 and algorithm 2), literature [12] algorithm, Newton iteration algorithm,MMSE detection algorithm at the antenna scale of 64 × 1024

I. Algorithm complexity analysis

1.1.Initialize some calculation complexity

Table 1 is comparison of the calculation complexity of the initialization part of this article algorithm with the Newton iterative algorithm. Thealgorithm (algorithm 1 and algorithm 2) in Table 1 greatly reduces the calculation complexity of the initialization part.

1) Algorithm 1 initialization part of the complexity

In algorithm 1, the calculation complexity of $b = H^H y$ can easily calculated, and the calculation complexity of $X_0$is K, so total calculation complexity of algorithm 1 is $NK + K$.

2) The complexity of algorithm 2 initialization part

In algorithm 2, the calculation complexity of $b = H^H y$, and the calculation complexity of NK, X_0, V and $x^{(0)}$ is K, so the total calculation complexity of algorithm 2 is $NK + 3K$.

3) Newton iterative algorithm initialization part of the complexity

For the initialization of the Newton iterative algorithm, it involves the calculation of obtaining $D^{-1}$and $b = H^H y$. The calculation complexity of $D^{-1}$is $NK^2 + K$, plus the calculation complexity of the $H^H y$ part, the total calculation complexity is $NK^2 + NK + K$.

1.2.Computational complexity of iterative process

Table 2 is compared with the complexity of the iterative process of the iteration of the Newton.It can be seen from Table 2 that in algorithm 1, the step -long factor has accelerated the convergence speed, but the calculation of the filter matrix A cannot be avoided, so compared to algorithm 2, algorithm 1 has a higher complexity. However, compared to the Newton algorithm, the complexityis still reduced.

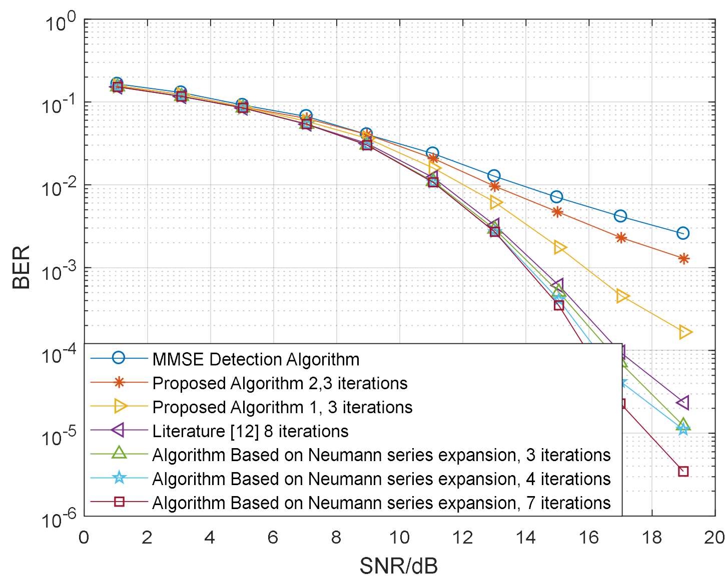

Figure 6: Algorithm (Algorithm 1 and Algorithm 2), Literature [12] algorithm, algorithm based on Neumann level, MMSE detection algorithm at an antenna size at 32 × 256, bit ratio performance curve

Compared with the NEWTON iteration algorithm, algorithm 1 is introduced by the stepped factor η, so the diagonal matrix and the matrix multiplication$X_k A$, the complexity isK^2; $X_k = X_{k-1} - \eta X_{k-1}(AX_{k-1} - I)$ introduced η, increased the multiplication operation of the constant and matrix$\eta\left(X_{k-1}(AX_{k-1} - I)\right)$, the complexity is$K^2$, so algorithm 1 increases the calculation of $2K^2 + K$ compared with the Newton iteration algorithm each time.

In the process of iteration, algorithm 2 first needs to calculate the calculation of $X_0 H^H H x^{(0)}$and $Vx^{(0)}$, which is divided into $2NK + K$ and K. Because $(I - X_0 H^H H - V)x^{(0)}$ is a vector, the calculation complexity of the NEWTON iteration required $(2^{n+1} - 1)$ $(NK + K)$ is therefore.

1.3.Complexity of overall process of algorithm

The comparison of the total complexity of algorithm (algorithm 1 and algorithm 2), Newton iterative algorithm, algorithm and literature [14] algorithm based on the Neumann -level number are shown in Table 3.

This article takes the 32 × 256 MIMO system as an example. The calculation complexity of the initialization part required by the algorithm (algorithm 1 and algorithm 2) and the Newton iterative algorithm are 257K, 259K, and $256K^2 + 257K$, respectively. In order to approach the performance of the MMSE algorithm, the number of iterations of the three is set to 3, 4, and 4 times in turn, and the calculation complexity during iteration is $1798K^2 + 1795K$, 7936NK, $3840K^2 + 3840K$. The complexity is $1795K^2 + 2052K$, 8195K, $4096K^2 + 4097K$. The algorithm based on the Neumann number needs at least 7 iterations to approach the performance of the MMSE algorithm, but at this time the calculation complexity has reached $5K^3+256K^2+256K$, and the complexity reaches the level of $O(K^3)$. Literature [14] algorithm requires 8 iterations to approach the performance of the MMSE algorithm, and the required calculation complexity is 2048K.It can be seen that compared to algorithm 1 and Newton iterative algorithm compared to the complexity, there is a magnitude of magnitude, only O (K) level, and the algorithm as the literature [14] algorithm is the same level. Algorithm 1 Due to the improvement of the initial value and the increase in convergence speed, compared with the Newton iteration algorithm, the complexity is much reduced, but because the step -long factor is added, there is no method like algorithm 2 to decompose The result of the iteration of the iteration of the number of iterations solve the result of the second iteration. Compared with the algorithm 2, it still has a high complexity, but it has a faster convergence speed. Therefore, the algorithm of this article can be used for different needs.

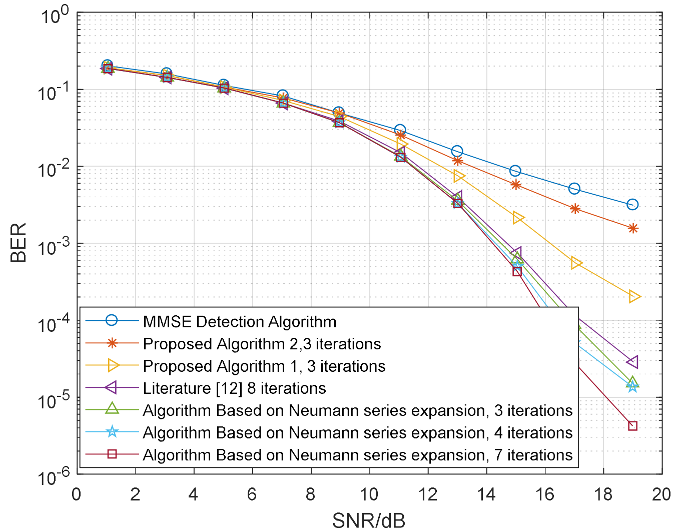

Figure 7: The algorithm (algorithm 1 and algorithm 2), the literature [12] algorithm, the algorithm based on the Neumann class, the MMSE detection algorithm at the antenna size is 64 × 1024

In addition, when the number of sending and receiving antennas is 64×1024, similarly, the calculation complexity required for algorithm 1. Algorithm 2, and Newton iterative algorithm is $7174k^2+8196k$, 32771K, $16384K^2+16\,385K$. In this case, the complexity of the NEUMANN-level number development method is $5K^3+1024K^2+1024K$, and the complexity of the literature [14] algorithm is 8192K. The conclusion is consistent with the previous.

II. Simulation analysis

The simulation parameter settings are as follows: The modulation method is 64QAM, the channel is the fast decline of the Relay channel, occupying the Terahz frequency band. The system uses large antenna array grouping and control technology to split the large -scale antenna array into several groups. The scale of each group antenna is 32 × 256.

Figure 3 First compares the detection error, initial initials are $X_0 = \alpha I$, and the initial value is $X_0 = D^{-1}$. It can be seen from Figure 3 that improving the initial value can not only reduce the complexity of the calculation, but also accelerate the convergence of the algorithm to a certain extent. In addition, Figure 3 also compares the convergence speed of the NEWTON iteration algorithm and algorithm 1 under the case of two initial values. From Figure 3, it can be clearly seen that no matter how the initial value is selected, the additional factor can speed up the convergence.

Figure 4 gives an error -bit rate performance of algorithm (algorithm 1 and algorithm 2), literature [14] algorithm, Newton iterative algorithm, and MMSE detection algorithm. It can be seen from Figure 4 that the literature [14] algorithm requires 8 iterations to approach the detection performance of the MMSE algorithm, and algorithm 1 and algorithm 2 require 3 and 4 iterations to approach the MMSE algorithm. The Newton iteration algorithm requires 4 iteration to approach the MMSE algorithm, but its computing complexity is high. In short, the calculation complexity of the algorithm (algorithm 1 and algorithm 2) is less than the newton iteration algorithm, especially the calculation complexity of algorithm 2 is one order of magnitude smaller than the Newton iteration algorithm.

Figure 5 gives an error -bit rate performance curve of this article algorithm (algorithm 1 and algorithm 2), literature [14] algorithm, Newton iterative algorithm, and MMSE detection algorithm at 64 × 1 024. It can be clearly seen from Figure 5 that the algorithm of this article still maintains superiority. Figure 6 gives the algorithm (algorithm 1 and algorithm 2), literature [14] algorithm, algorithm -based algorithm, MMSE detection algorithm at an antenna scale of 32 × 256. It can be seen from Figure 6 that the convergence speed of the algorithm of this article is better than the algorithm and literature [14] algorithm based on the Neumann number expansion; Under the same number of iterations, the algorithm error rate curve of this article is far better than the Neumann -level number expansion. The algorithm and literature [14] algorithm; in terms of algorithm complexity, the algorithm of this article is far lower than the algorithm based on Neumann -level.

Figure 7 gives an error ratio performance curve of algorithm (algorithm 1 and algorithm 2), literature [14] algorithm, algorithm -based algorithm -based algorithm, MMSE detection algorithm at the antenna scale of 64 × 1 024. It can be seen from Figure 7 that the algorithm of this article still maintains a better detection performance.

4. CONCLUSION

In order to solve massive MIMO system signal detection complexity and slow convergence speed in the high -scale MIMO system signal in the 6G band, this article proposes a signal detection algorithm based on the Newton iteration algorithm. By improving iteration matrix, the algorithm adds the iterative long factor to speed up the convergence speed of the algorithm; by adding the adjustment factor, it improves the reliability and stability of the algorithm. For scenarios with large amount of data and low real -time requirements, the adjustment factor $\theta = 0$ can be avoided, and the calculation of the iterative process filtering matrix A is avoided. Furtherreduce the calculation complexity and reach the O (K) level. The simulation results show that compared with the currently widely used Newton iteration algorithm and the Neumann -based algorithm, the algorithm of this article has a faster convergence speed, better detection performance and lower algorithm complexity; compared to literature [14] Algorithms, algorithms in this article have a faster convergence speed.

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