Comments on “Low-Complexity SIC Detection Algorithms for Multiple-Input Multiple-Output Systems”

Hufei Zhu and Yanpeng Wu

Abstract—In the above paper, the optimal-ordered successive interference cancellation (SIC) detector proposed for multiple input multiple output (MIMO) systems was claimed to require a lower computational complexity than the optimal-ordered SIC detector proposed in the paper “An Improved Square-Root Algorithm for V-BLAST Based on Efficient Inverse Cholesky Factorization” (IEEE Trans. Wireless Commun., vol. 10, no. 1, Jan. 2011), since several incorrect complexities were quoted or claimed. In this comment, we revise the incorrect complexities, to draw the conclusion that the above-mentioned two detectors actually require the same dominant complexity.

Index Terms—Multiple input multiple output (MIMO) system, signal detection, successive interference cancellation (SIC), optimal-ordered.

I. INTRODUCTION

In [1], an optimal-ordered successive interference cancellation (SIC) detector was proposed for multiple input multiple output (MIMO) systems, and its computational complexity was compared with the complexity of the optimal-ordered SIC detector proposed in [2]. Unfortunately, incorrect complexities have been quoted in [1] for the detector in [2] and a Givens rotation [3], respectively, and an incorrect complexity has been claimed for the detector in [1], which utilizes a sequence of Givens rotations. In this comment, the above-mentioned incorrect complexities will be revised, and the corresponding conclusion on complexity comparison will be modified.

II. MAIN REMARKS

As in [1], N and M denote the numbers of transmit and receive antennas, respectively. Moreover, as in [2], let \((k, l)\) denotes the computational complexity of \(k\) complex multiplications and \(l\) complex additions.

In row 5 of Table V in [1], only [2] was cited to claim that the dominant worst-case complexity of the optimal-ordered SIC detector in [2] is \(\left(\frac{1}{2}MN^2 + \frac{5}{6}N^3, \frac{1}{2}MN^2 + \frac{1}{2}N^3\right)\), which should actually be

\[
\left(\frac{1}{2}MN^2 + \frac{5}{6}N^3, \frac{1}{2}MN^2 + \frac{1}{2}N^3\right),
\]

since [1] has been given in lines 28 and 29 of the right column on [2] p. 46. On the other hand, [3] was cited in lines 3-5 of the right column on [1] p. 4630, to claim that a complex Givens rotation on a \((j+1)\times2\) matrix requires a complexity of

\[
(2j + 2, 2j + 2).
\]

However, as described in lines 11 and 12 of the right column on [2] p. 46, [2] should be revised into

\[
(3j + 3, j + 1).
\]

Since the complexity of a Givens rotation has been modified from [2] to [3], step 13 in Table II of [1] (which consists of a sequence of Givens rotations) should actually require the worst-case complexity of \((\frac{1}{2}N^3, \frac{1}{6}N^3)\), instead of \((\frac{1}{2}N^3, \frac{1}{3}N^3)\) claimed in lines 8 and 9 of the right column on [1] p. 4630. Accordingly, the worst-case complexity of the optimal-ordered SIC detector proposed in [1], which includes the complexity of the above-mentioned step 13, should be [1] instead of \((\frac{1}{2}MN^2 + \frac{5}{6}N^3, \frac{1}{2}MN^2 + \frac{1}{2}N^3)\) claimed in lines 10-12 of the right column on [1] p. 4630. Thus it can be concluded that both optimal-ordered SIC detectors proposed in [1] and [2] require the same dominant complexity, which is \(O(MN^2 + N^3)\).

III. NUMERICAL EXPERIMENTS

Assume \(N = M\). For different number of transmit/receive antennas, we carried out numerical experiments to count the worst-case and average floating-point operations (flops) of the optimal-ordered SIC detectors proposed in [1] and [2], and the corresponding Matlab source code with an explanatory document has been shared in [4]. The results are shown in Fig. 1. As in [1] and [2], the maximum number of Givens rotations are assumed to count the worst-case flops. To count the average flops, we simulate 10000 random channel matrices \(H\), and neither detectors in [1] and [2] permute the columns in \(H\) for fair comparison\(^1\). From Fig. 1, it can be seen that the complexity of the detector in [1] is close to that of the detector in [2], which is consistent with the complexity comparison in the last section.

\(^1\)In equation (5.1.12) on [3] p. 244, the complex Givens rotation is written as \(\begin{bmatrix} c & -s \\ s & c \end{bmatrix}\) with a real \(c\) and a complex \(s\), which is the same as the complex Givens rotation in lines 8-10 of the right column on [2] p. 46.

\(^2\)In [2], the columns in the channel matrix \(H\) are permuted according to the optimal detection order of the adjacent subcarrier if MIMO OFDM systems are utilized, while in [1], the columns in \(H\) are permuted in increasing order of their norms, or permuted equivalently by the sorted Cholesky factorization. We do not need to compare the different methods to permute \(H\), since the method to permute \(H\) in [1] can be applied in [2], and vice versa. Accordingly, we do not permute \(H\) for fair comparison.

H. Zhu is with the College of Computer Science and Software, Shenzhen University, Shenzhen 518060, China (e-mail: zhuhufei@szu.edu.cn).

Y. Wu is with the Department of Information Science and Engineering, Hunan First Normal University, Changsha 410205, China (e-mail: xjzwxyp@hnfnu.edu.cn).
In this comment, we revise the incorrect worst-case complexity quoted in [1] for the optimal-ordered SIC detector proposed in [2]. On the other hand, we also correct the wrong complexity quoted in [1] for a Givens rotation, to revise the worst-case complexity claimed for the optimal-ordered SIC detector proposed in [1]. By comparing the two revised worst-case complexities for the detectors in [1] and [2], we draw the conclusion that both optimal-ordered SIC detectors proposed in [1] and [2] require the same $O(MN^2 + N^3)$ complexity, which is then confirmed by the results of numerical experiments.

REFERENCES

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