SDF-SGR Based Complex Matrix Inversion with Low Complexity for MIMO Receivers

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***Abstract*****－In multiple-input multiple-output (MIMO) communication systems, complex matrix inversion is a very computationally demanding operation. Especially when the antennas number increases, the complexity of matrix inversion becomes very high. This paper presents a Square root and Division Free Squared Givens Rotations (SDF-SGR) based algorithm to be applied to complex matrix inversion. Square root is avoided in the whole algorithm, and by storing numerators and denominators, division is free during the Squared Givens Rotations part. This algorithm based on Squared Givens Rotations, could effectively reduce the complexity compared to the traditional matrix inversion algorithms.** **In addition, a scale controlling procedure is proposed to avoid the risk of additional over-/underflow problem, which could guarantee the stability of the whole algorithm.**

***Index Terms*－matrix inversion, low complexity, multiple-input multiple-output (MIMO), Givens rotation.**

1. INTRODUCTION

Multiple-input multiple-output (MIMO) systems [1]-[4] employing multiple antennas at both the transmitting and receiving side of the radio link, has been used in many communication systems, such as IEEE 802.11ac, IEEE 802.11ad, IEEE 802.11n, and 3GPP-LTE [5], [6], [7], to greatly enhance the performance of wireless communications. However, the design of MIMO receivers is usually very complicated. Among the most intensive tasks, complex matrix inversion is one of the most complex demanding parts. For example, the Zero-forcing (ZF) and minimum mean-squared error (MMSE) decoding algorithms both require complex matrix inversion [8]. When the antennas number increases, the matrix inversion is hardly implemented in hardware because of its high complexity. So it is necessary to figure out an efficient matrix inversion algorithm with low complexity.

Matrix inversion is a common operation in many signal processing problems, and it is well elaborated in previous publications, for example, the book by Golub and Van Loan [9]. For large matrices, QR decomposition is traditionally applied to the original matrix to generate a unitary matrix Q and an upper triangular matrix R, then back substitution could be used to compute the inverse matrix of R. Since the inverse matrix of Q is simply its Hermitian transpose, QR decomposition is an algorithm that is widely studied for matrix inversion, such as Gram-Schmidt transform, Householder matrices, and Givens rotations [9]. But the disadvantage of these algorithms is that they require high-complexity square root operations. Recently, Squared Givens Rotations (SGR) [10] has attracted researchers’ attentions for hardware implementation for QR decomposition. The SGR algorithm could avoid the square root operation and reduces the number of multiplications by half [11], [12]. However, the SGR algorithm could hardly process the problem when zeros occur on the diagonal elements of the matrix either initially or during processing. In [13], a modified SGR (MSGR) algorithm was proposed. The MSGR algorithm could solve the drawback of SGR algorithm. But many division operations are still involved in the MSGR algorithm, which could consume lots of silicon areas and cause latency in hardware implementation. These disadvantages could be effectively overcome in square root and division Free squared Givens rotations (SDF-SGR) algorithm. In addition a scale controlling procedure is proposed to avoid the risk of additional over-/underflow problem, which could guarantee the stability of the whole algorithm.

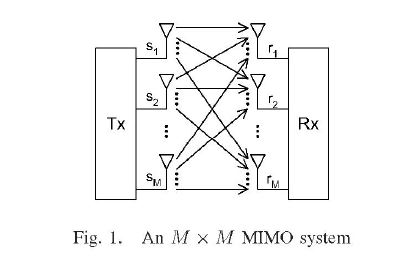
In this paper, an algorithm with low complexity for complex matrix inversion based on SDF-SGR is presented. The remainder of this paper is organized as follows. In section II, we briefly introduce the MIMO system. In section III, the SDF-SGR based algorithm is described, including the scale controlling procedure. In section IV, we analyze the complexity of the whole algorithm. Section V is the simulation results. And we finally conclude this paper in Section VI.

1. MIMO COMMUNICATION SYSTEM MODEL

In this section we will briefly introduce the MIMO system. Figure 1 shows a typical M X M Multi-Input Multi-Output (MIMO) system. In a MIMO system, for the transmission function

r=Hs+n

Where r is the receiving signal, s is the transmitting signal, H is the channel matrix, and n represents noise. Channel estimator estimates the channel matrix H, and the decoding methods performs matrix inversion involving H and the noise n before detecting s from r.



ZF (zero-forcing) and MMSE (minimum mean-square error) are the algorithms that are commonly used in decoding methods.

1. SDF-SGR BASED ALGORITHM FOR COMPLEX MATRIX INVERSION
2. COMPLEXITY ANALYSIS
3. SIMULATION RESULTS
4. CONCLUSIONS

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