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Efficient Threshold based non-sample spaced sparse channel estimation in OFDM system

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ABSTRACT

This paper addresses the efficient non-sample spaced sparse channel estimation with a proposed effective threshold. The goal of this paper is to realize efficient channel estimation with a few number of pilots and without the prior knowledge of the channel statistics, noise standard deviation (STD) for the non-sample spaced sparse channels. To realize this goal, an effective noise STD estimation method based on the estimation method proposed in [1] and the delay tracking (DT) method proposed in [2] is developed. With the estimated noise STD, an effective threshold is obtained for efficient channel taps detection. Both theoretical analysis and simulation results demonstrate that without the prior knowledge of noise STD, the proposed method can achieve the approaching channel estimation performance as the conventional compressed sensing (CS) based method.

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INTRODUCTION

Channel estimation, which is the major means of acquiring the channel state information (CSI), is essential for the orthogonal frequency division multiplexing (OFDM) system. Over the past years, compressed sensing (CS) theory has been widely used in the sparse channel estimation field including the non-sample spaced sparse channel [2–6]. Under the CS theory, the non-sample spaced sparse channel can be characterized with several coefficients randomly located within the delay space or delay-Doppler space. Because of the random location of those coefficients, channel reconstruction with Nyquist rate cannot achieve sufficient precision. In this case, high resolution sparse channel estimation becomes popular [2, 4-6]. However, for high resolution sparse channel reconstruction, the size of dictionary [4] (measurement matrix in CS) will be dramatically increased with the oversampling factor R ($R > 1$), which significantly increases the complexity of the channel reconstruction algorithm. To solve this problem, [2] proposes a novel adaptive delay tracking (DT) method, which achieves comparatively good channel estimation performance meanwhile significantly reduces the computational complexity by decreasing the number of coherence matching computations between the bases of the measurement matrix and the residual vector.

Stopping criterion is essential for CS based non-sample spaced sparse channel estimation. Similar with the stopping criterion for the traditional LS or DFT based sparse channel estimation and sample spaced sparse channel estimation with CS, the channel statistics (power delay profile of the channel, channel sparsity et al), noise standard deviation (STD) or signal to noise ratio (SNR) can be employed as the basic parameters for obtaining effective stopping criteria [7-8].

In this paper, an effective threshold based non-sample spaced sparse channel estimation method is proposed. The proposed threshold based non-sample spaced channel estimation method can achieve high channel estimation performance with low complexity, meanwhile, it does not require the prior knowledge of the channel statistics and noise STD.

CHANNEL ESTIMATION METHODS

1. Proposed initial DT algorithm

Consider the case of channel sparsity $K=1$, there is no noise and inter-carrier interference (ICI). Conventional orthogonal matching pursuit (OMP) method has the high computational complexity in delay tracking (DT) primary due to its large number of delay grids in Figure 1.(b). In order to significantly reduce the computational complexity, a computationally efficient DT algorithm is proposed in [2] (Figure 1.(a)). The DT algorithm proposed in [2] is an iterative delay tracking process and highly relies on the coherences between the residual vector and the bases vectors in the measurement matrix. Therefore, [2] can achieve good channel estimation performance in the case of uniformly distributed pilot arrangement, however, in the case of non-uniformly pilot arrangement, its performance will be degraded.

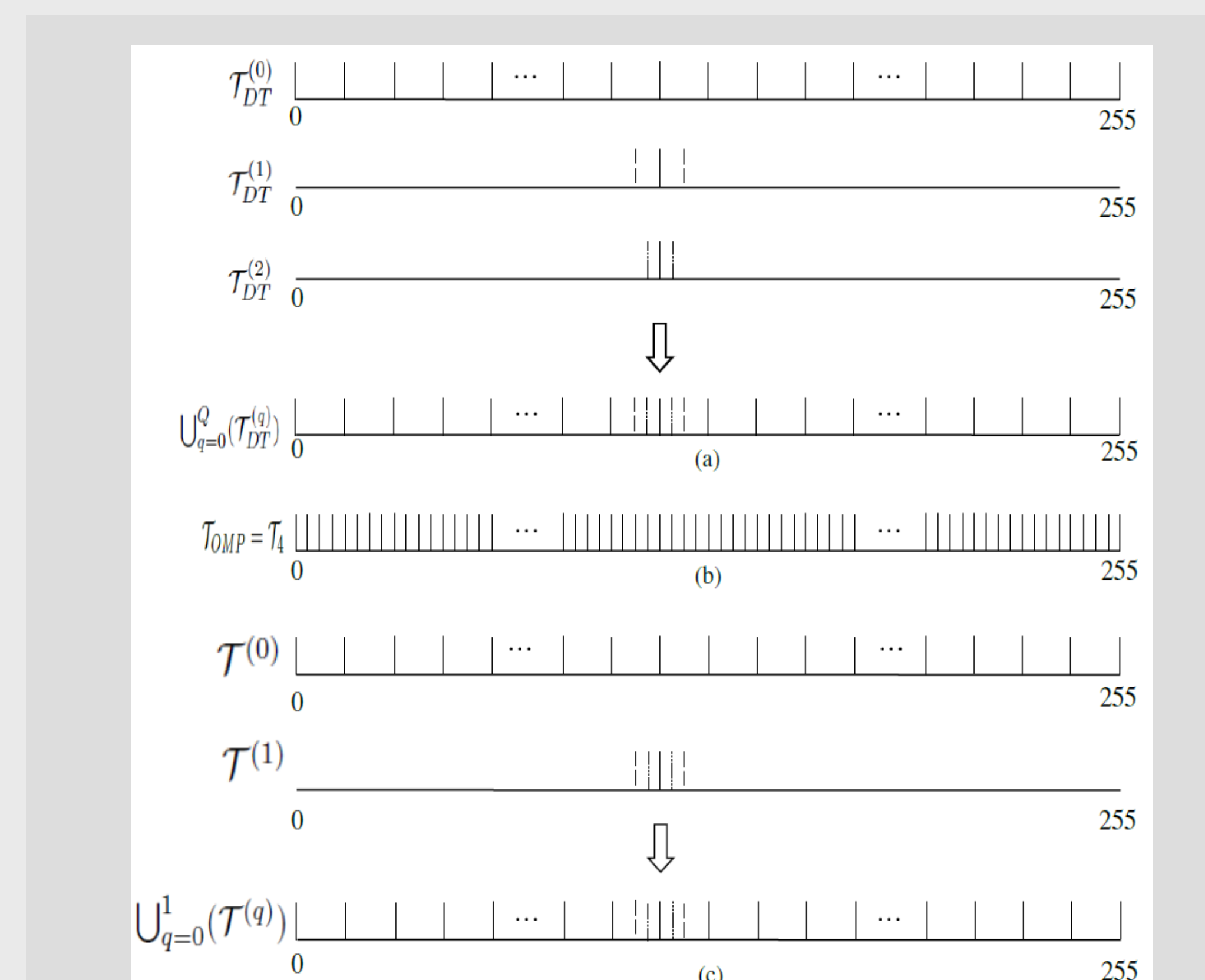


Figure 1. Tap delay grids of the method in [2] (a); tap delay grids of the OMP algorithm (b); Tap delay grids of the proposed method (c)

A one time local delay expansion method, which is more direct and robust, is proposed. (presented in Figure 1. [c])

2. Proposed threshold based non-sample spaced sparse channel estimation

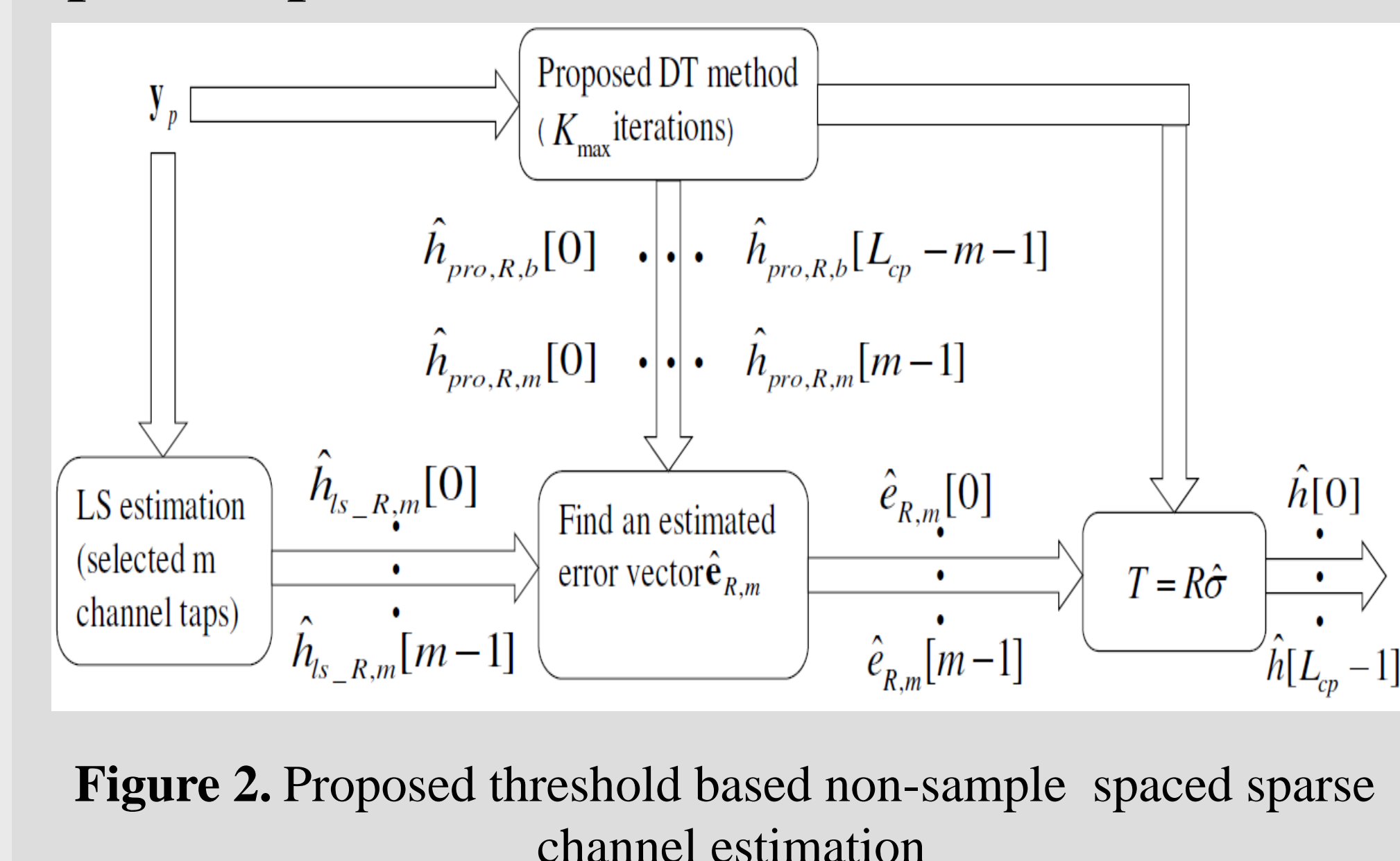


Figure 2. Proposed threshold based non-sample spaced sparse channel estimation

SIMULATION RESULTS

OFDM system with 1024 subcarriers, among which 128 subcarriers are pilots. Suboptimal non-uniform pilot arrangement method in [9] is used for good spectral efficiency. The length of cyclic prefix is 256. A six tap channel with the delay of each channel taps uniformly distributed and the exponentially distributed power delay profile (POD).

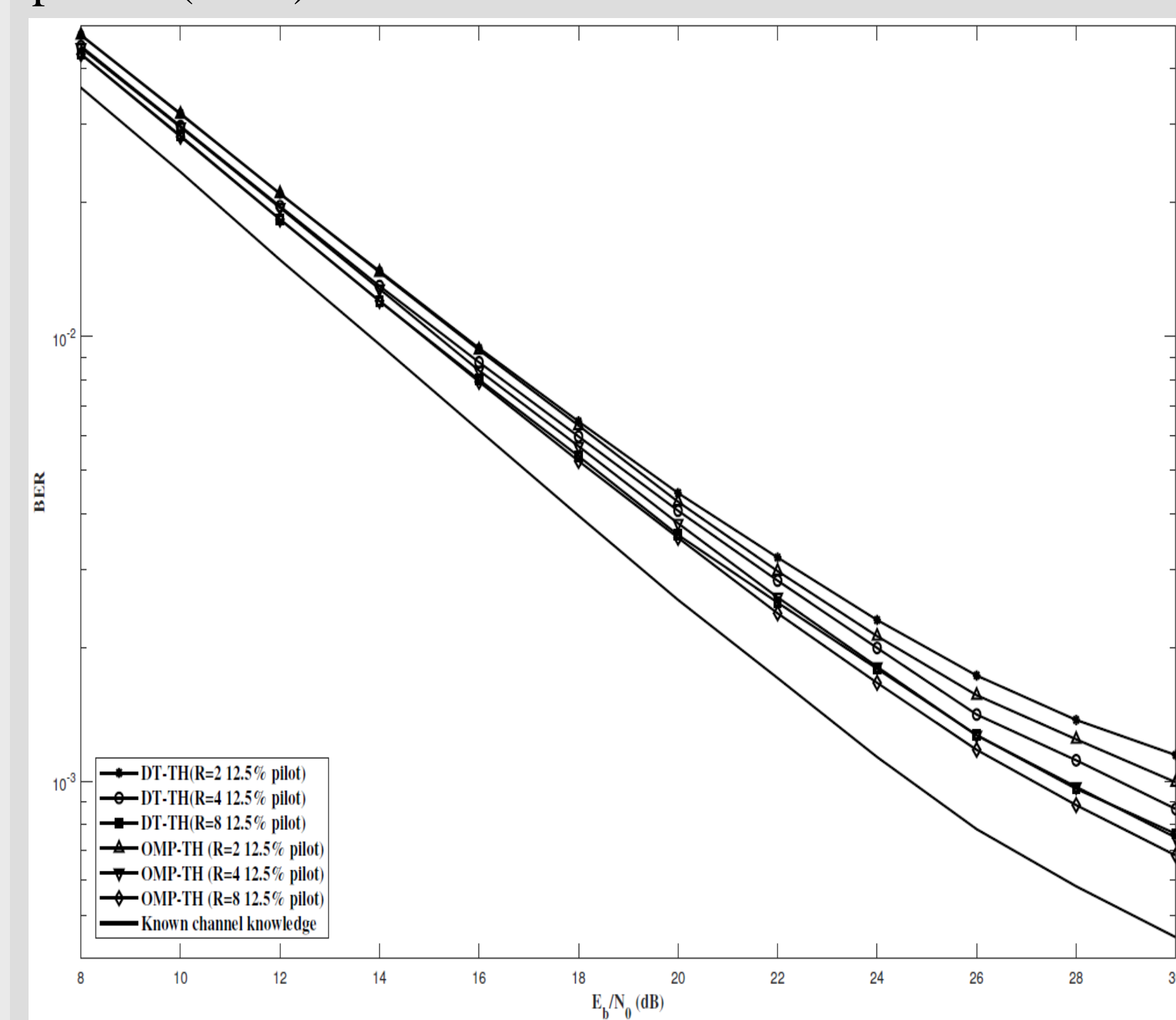


Figure 3. BER performance comparison of the proposed DT-TH method and the conventional OMP-TH method

The proposed DT-TH method has the approaching bit error rate (BER) performance with the conventional OMP-TH method with different R , especially in low E_b/N_0 and with $R = 8$. The proposed DT-TH method has approaching or less computational complexity than the OMP-TH method.

CONCLUSIONS

In this paper, we propose an efficient threshold based non-sample spaced sparse channel estimation method. The proposed threshold estimation method is mainly based on the effective noise STD estimator, which is obtained by a constructed error vector. Theoretical analysis has been made on the error vector to demonstrate the effectiveness of the proposed method. Simulations show that with $R \geq 8$, the proposed method can achieve approaching performance with the OMP method with the prior knowledge of noise STD, and its computational complexity is approaching or less than the conventional OMP method.

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