Iterative Soft Decision Decoding of Reed Solomon Codes Based on Adaptive Parity Check Matrices

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Abstract — This paper presents a soft decision decoding algorithm for Reed Solomon (RS) codes using their binary image representations. The novelty of the proposed decoding algorithm is in reducing the submatrix corresponding to the less reliable bits to a sparse nature prior to each decoding iteration. Simulation results show that the new method provides significant gain over hard decision decoding (HDD) and compares favorably with other popular soft decision decoding methods [1].

I. INTRODUCTION

Reed Solomon (RS) codes are widely employed magnetic recording systems due to their good minimum distances. However, in existing standards, RS codes are decoded via algebraic hard decision decoding (HDD), which does not fully exploit the error correction capability of the original code. Consequently, soft decision decoding of RS codes is of research interest.

In this paper, we present an iterative decoding algorithm based on adaptive parity check matrix. The proposed iterative algorithm is applied to the binary image expansion of RS codes over GF($2^m$) (similar to [2]).

The proposed algorithm can be described as a two stage iterative procedure. 1) In the parity check matrix updating stage, all bit-level reliabilities are sorted by their absolute values. Then the sub-matrix corresponding to least reliable and independent positions (LRIP) in the parity check matrix are systemized to be a sparse nature (details can be found in [4]). This will facilitate 2) In the bit reliabilities updating stage, iterative decoding is applied to generate extrinsic information. Extrinsic information is scaled by a damping coefficient and fed to update the bit-level reliabilities and the procedure iterates.

The proposed decoding algorithm is similar to [2]. The proposed iterative decoding algorithm is similar to and can be viewed as a generalization of the iterative decoding algorithm proposed by Lucas et al. [3].

The novelty of the proposed decoding algorithm is in reducing the submatrix corresponding to the less reliable bits to a sparse nature prior to each decoding iteration. Simulation results show that the new method provides significant gain over hard decision decoding (HDD) and compares favorably with other popular soft decision decoding methods [1].

The performance gain of the proposed algorithm over HDD at an FER = $10^{-4}$ is given in Table I. The damping coefficient alpha and the maximum number of iterations are provided. It can be seen from the result that the proposed algorithm outperforms HDD by a large margin and it also compares favorably with known RS codes soft decoding methods (due to page limit, they are not shown here). The computational complexity of this new method increases only polynomially with respect to either codeword length $n$ or the minimum distance $d_{min}$. The proposed algorithm can also offer flexible performance-complexity trade-off for different applications.

Table 1: Gain of proposed algorithm over HDD decoding

<table>
<thead>
<tr>
<th>Code</th>
<th>FER</th>
<th>$\alpha$</th>
<th>Iter.</th>
<th>Gain over HDD</th>
</tr>
</thead>
<tbody>
<tr>
<td>RS(31,25)</td>
<td>$10^{-4}$</td>
<td>0.05</td>
<td>20</td>
<td>2.3dB</td>
</tr>
<tr>
<td>RS(63,55)</td>
<td>$10^{-4}$</td>
<td>0.12</td>
<td>20</td>
<td>1.8dB</td>
</tr>
<tr>
<td>RS(255,239)</td>
<td>$10^{-4}$</td>
<td>0.12</td>
<td>20</td>
<td>0.8dB</td>
</tr>
</tbody>
</table>

REFERENCES


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