

# Low Complexity Two Stage Decoding of The Nordstrom Robinson Code Based on the Twisted Squaring Construction.

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*Abstract - This paper describes a technique for reducing the decoding complexity of the non-linear Nordstrom Robinson code by dividing the decoding procedure into two stages in order to reduce the total number of trellis paths which must be searched.*

## I. INTRODUCTION.

Decoders, particularly decoders with soft maximum likelihood performance, can be complex devices. There are often a large number of calculations required in order to extract a small amount of information. As codes become more powerful and bit rates increase the demand placed on decoders becomes very high resulting in expensive hardware and complex software. One method of alleviating the implementation problem is to use a powerful code but perform a sub-optimum decoding. By trading correcting ability for a decoder complexity reduction it is possible to significantly reduce decoding complexity whilst maintaining near optimum performance.

Non-linear codes have the potential to be more powerful than an equivalent linear code. As they are free from the strict structure governing linear codes it is possible to design a non-linear code which has more codewords or a greater distance than an equivalent linear code [1]. For example the Nordstrom Robinson [1] [2] code has length 16 and 256 codewords with minimum distance 6. The closest BCH code has 128 codewords, length 15 but only has a minimum distance of 5. Although The Nordstrom Robinson code is non-linear it contains enough structure to allow us to construct a regular trellis and to perform Viterbi decoding as we can for any other block code. The regular trellis of the Nordstrom Robinson code is of a form suitable for a type of low-complexity decoding known as two stage decoding.

## II. TWO STAGE DECODING.

Two stage decoding [3] is a technique used to reduce the complexity of Viterbi decoding. It is essentially a reduced search technique which reduces complexity by considering a smaller number of paths. In order to perform two stage decoding it is necessary to

construct a regular trellis. The aim of the first stage is to determine which sub-trellis or sub-trellises are most likely to contain the correct codeword. The second stage is to decode the selected sub-trellises using a standard Viterbi algorithm. This paper concentrates on a technique for selecting sub-trellises of the Nordstrom Robinson code.

## III. CODE CONSTRUCTION.

The code is constructed by forming co-sets using a twisted squaring construction as described in [4]. The decoding procedure is then as follows:

1. Determine the coset containing the codeword by decoding the Reed Muller code formed by summing the first half of the codeword to the second half.
2. Find the maximum likelihood codeword of the form given in (1) within the coset found in stage 1.

## IV. PERFORMANCE.

The technique described has been simulated and a comparison of results with full decoding are presented. The results show a reduction in complexity of 50-75% for only a small reduction in coding gain.

## V. REFERENCES.

- [1] MacWilliams, F.J., Sloane, N.J.A., "The Theory Of Error Correcting Codes", *North Holland*, 1977.
- [2] A.W. Nordstrom, J.P. Robinson, "An Optimum Nonlinear Code", *Inform. Contr.*, **11**, pp. 613-616, 1967.
- [3] Wu, J., Lin, S., Kasami, T., Fujiwara, T., Takata, T., "An Upper Bound On the Effective Error Coefficient of Two-Stage Decoding, and Good Two-Level Decompositions of Some Reed-Muller Codes", *IEEE Trans Comms*, **42**, pp. 813-818, 1994.
- [5] Forney, G. D., Jr, "Coset codes – Part II: Binary Lattices and Related Codes", *IEEE Trans. Inform. Theory*, **34**, pp. 1152-1187, 1988.