

Error-Correction Coding for Digital Communications

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Preface

Error-correction coding is a new communication technique that increases the energy efficiency of digital communication systems, also providing immunity from errors caused by filtering and fading. Among the problems caused by filtering are certain frequency components of the coding provided by the numerous articles have pointed out deficiencies. First, the algorithm into actual use that is available is sketchy required to evaluate the countermeasures in practice reports.

This book is aimed at the design engineer and for the communication graduate text for an

The book uses classical theorem/procedure ever possible heuristics by drawing analogies mathematical rigor understanding, coding is an impossible task to accomplish at all. The assumption

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differ in two positions, etc. As in the simple example given previously, there will almost always be some patterns that are left over after assigning all those that differ in t or fewer places (thus accounting for the inequality).

At this point we are in a position to relate the amount of redundancy in a code to the number of errors that are correctable. First observe that there are 2^n possible sequences. Each column of the decoding table contains N_c of these sequences so that the number of code words, N_c , must obey the inequality

$$N_c \leq 2^n / \left[1 + n + \binom{n}{2} + \dots + \binom{n}{t} \right] \quad (1-3)$$

This is called a *Hamming bound* or "sphere-packing" bound. The equality in this bound can be achieved only for so-called *perfect codes*. These are codes which can correct all patterns of t or fewer errors and no others. There are only a small number of perfect codes which have been found and consequently the equality in (1-3) is almost never achieved.

At the encoder we envision a process by which a k -symbol information sequence is mapped into an n -symbol code sequence. Although the terminology is usually restricted to the so-called linear codes (to be discussed), we shall refer to any such mapping as an (n, k) code. Since the k -symbol sequence can take on 2^k distinct values, inequality (1-3) can be written

$$2^k \leq 2^n / \left[1 + n + \binom{n}{2} + \dots + \binom{n}{t} \right] \quad (1-4)$$

A measure of the efficiency implied by a particular code choice is given by the ratio

$$R = k/n \quad (1-5)$$

where R is defined as the *code rate*. The fraction of transmitted symbols that are redundant is $1 - R$.

The mapping implied by the encoder can be described by a look-up table. For example, the four-word code discussed previously is described in Table 1-2. The portion of the code sequence contained between the dashed lines is identical to the input sequence. Thus, each code sequence is easily and uniquely related to the input. Not all block codes exhibit this property. Those which do are referred to as *systematic codes*. For systematic codes, the concept of redundant digits becomes very clear and in Table 1-2 consists of the digits in positions 1, 4, and 5. Conversely, codes which do not exhibit this property are called *nonsystematic codes*.

Many good permit the corre remarkable imp to generate and relatively straight of length 40 that ing up to four reveals that this than 10^{-4} . If this of increasing the going to a some averaging. In eit Both options, ho tives.

Before proce practical importa for many years. T scheme for correc (in this case t/n i made arbitrarily. Unfortunately, th procedures encou ratio t/n at the ex (or equivalently, t the relative numb vanishingly small was given by Just construct a class scribed above) an the authors' know real communicat

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