SIMON FRASER UNIVERSITY
School of Engineering Science

ENSC 428 Data Communications

Assignment 6 **Due: Never**

1. Nearest Neighbour Decoding

A block code of length n and 2^k equiprobable codewords is used on an AWGN channel. The receiver makes hard decisions on the coded bits to produce the vector $\mathbf{r}$. It then decides the transmitted codeword by a process that is equivalent to

$$\hat{\mathbf{c}} = \underset{\mathbf{c}\in\mathbb{C}}{\operatorname{argmin}}\, d_H(\mathbf{r},\mathbf{c})$$

where $\mathbb{C}$ denotes the set of words in the code and d_H is the Hamming distance. Show that this is a maximum likelihood decision.

2. Performance of a Block Code

For an AWGN channel, you decide to use a BCH code with length $n = 127$ that can correct $t = 4$ errors.

(a) What is the maximum code rate k/n?

(b) The modulation is binary antipodal, the SNR is γ_b and the receiver makes hard decisions on the coded bits. Write an expression for the WER (word error rate). Is there any approximation involved?

(c) Using your expression from (b), write an approximate expression for the WER at large SNR that is based only on the dominant term.

(d) In your expression from (c), substitute the overbound $Q(x) \le \frac{1}{2}\exp\left(-\frac{x^2}{2}\right)$. From this, and the fact that roughly half the information bits are wrong in a typical word error, contrast the resulting BER with that obtainable without coding. Is coding worth the effort in terms of SNR required for a given BER?

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3. Peformance of a Convolutional Code

On another channel, you realize the need for heavy error protection, so you choose the rate 1/3, constraint length 6 convolutional code. Since you are using the Viterbi algorithm, you decide to go for soft decisions.

(a) How many states are there in the Viterbi decoder? How many transitions fanning into and out of every state in the trellis?

(b) If there are n_f error events at distance d_{free}, give an asymptotic (high SNR) expression for the probability of an error event. Do you have enough information to determine the BER?

(c) Assuming that n_f is small enough to be ignored, what is the improvement in required SNR compared with uncoded transmission?

(d) Repeat (b) and (c) for hard decisions.