EDC310 Digital Communications

Practical Assigment 1

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Introduction

You are to develop a simulation platform[1] for a BPSK, 4QAM, 8PSK and 16QAM communication system transmitting information over an additive white Gaussian noise (AWGN) channel. To ensure information can be transmitted at a larger rate, compression will be used to first compress the data before being transmitted.

Question 1 [25]

Develop a method to take a paragraph of text and compress it using the Lempel-Ziv algorithm. The paragraph of text needs to be converted to a sequence of ASCII values. From this sequence, phrases can then be extracted to be used to set up the dictionary table. The dictionary table will then be used to compress the sequence, as well as decompress the sequence.

Question 2 [25]

Develop a method to take a paragraph and compress it using Huffman coding. In table 1, the letters and their probability are listed. Set up the Huffman tree, and set up a method that can compress and decompress the information using a given Huffman tree. Convert all the uppercase letters to lowercase letters before compression.

Table 1
LETTER PROBABILITIES

Letter	Probability	Letter	Probability
a	0.0968	n	0.0371
b	0.0568	o	0.0130
c	0.0717	p	0.0113
d	0.0583	q	0.0317
e	0.0442	r	0.0311
f	0.0192	s	0.0265
g	0.0005	t	0.0252
h	0.0254	u	0.0296
i	0.0298	v	0.0129
j	0.0406	w	0.0046
k	0.0366	x	0.0178
l	0.0067	y	0.0248
m	0.0170	z	0.0181
space	0.2125	.	0.0002

[1] All software must be developed in *Python* 3.

Question 3 [50]

Design and develop a simulation platform to simulate the performance for BPSK, 4QAM, 8PSK and 16QAM modulation through an AWGN channel. Evaluate the bit-error rate (BER) and symbol-error rate (SER) performance in the range $E_b/N_0 \in [-4{,}12]$ dB.

1. Generate a sequence of bits using a uniform random number generator. If the value is below 0.5, add a zero to the sequence, and if the value is above and equal to 0.5, add a one to the sequence. This is to ensure a significant amount of bits are used to test the system.

2. Map the bits to symbols using the respective modulation constellations.

3. Add noise to the symbols using a Gaussian random number generator as follows:

$$r_k = s_k + \sigma n_k, \tag{1}$$

   where $n_k = (n_k^{(i)} + jn_k^{(q)})/\sqrt{2}$. $n_k^{(i)}$ and $n_k^{(q)}$ are zero mean, unity variance, Gaussian random variables.

   Since

$$SNR = 10\log\left(\frac{|a|}{2\sigma^2}\right) = 10\log\left(\frac{1}{2\sigma^2}\right) = \frac{E_b}{N_0}, \tag{2}$$

$$\sigma = \frac{1}{\sqrt{10^{\frac{E_b}{10N_0}} 2 f_{bit}}} \tag{3}$$

   where $f_{bit} = log_2(M)$ and M is the number of symbols in the modulation constellation. Note, with BPSK the added noise should be real, thus the adjusted formula is $n_k = n_k^{(i)}$.

4. Detect the received symbols by calculating the Euclidean distance between the received symbol and all of the symbols in the constellation (see (4) below). The symbol with the smallest Euclidean distance is the most probable transmitted symbol.

$$\Delta^{(i)} = |r_t - s^{(i)}|^2 \tag{4}$$

5. Compare the detected symbols to the transmitted symbols and count the symbols errors.

6. Determine the SER by dividing the number of symbol errors by the number of transmitted symbols.

7. Convert the detected symbols back to bits and compare the detected bits to the transmitted bits and count the bit errors.

8. Determine the BER by dividing the number of bit errors by the number of transmitted bits.

Instructions

An evaluation script is provided with pre-defined functions. The evaluation script should be completed to perform the before mentioned tasks. The script should then be uploaded to AMS before the deadline, the 25th of August.

- The last submission will be taken as your final submission.
- Ensure all the Python functions are callable, even if it does not return the correct answer. If the file can not be imported, then it can not be marked.
- Do not copy! The copier and the copyee will receive zero and disciplinary action will follow for both parties.
- For any questions, please make an appointment with me Prof Myburgh or Mr Fourie.