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EEE/ECE F311

Communication Systems

Tutorial-14

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Tutorial-14

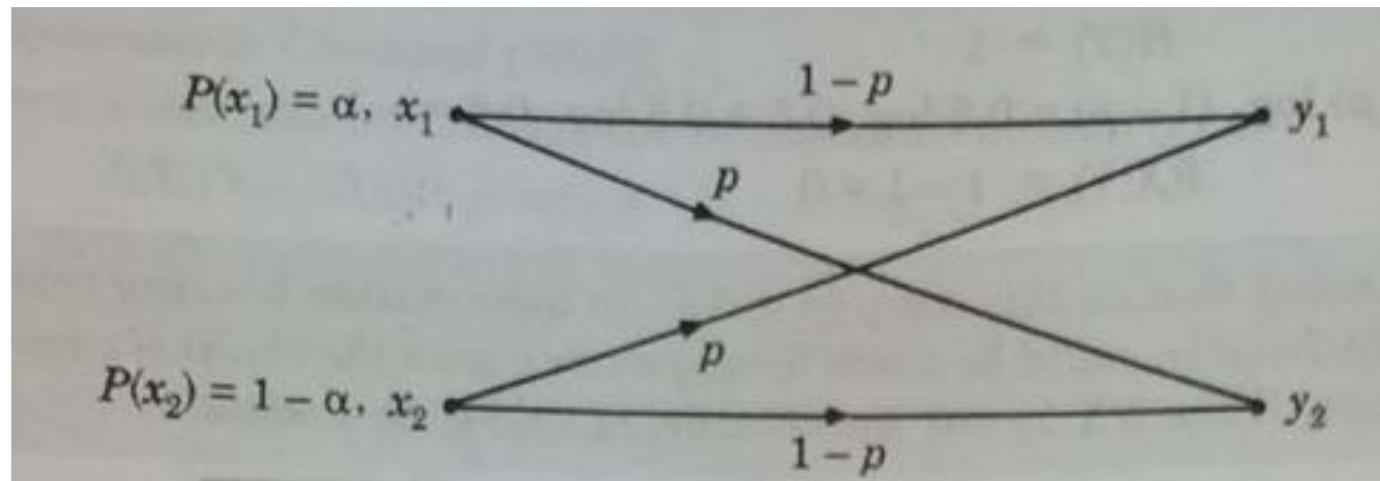
1. A Binary symmetric channel (BSC) with $P(x_1) = \alpha$.

(i) Show that the mutual information $I(X;Y)$ is given by

$$I(X;Y) = H(Y) + p \log_2 \frac{1}{p} + (1-p) \log_2 \frac{1}{1-p}$$

(ii) Calculate $I(X;Y)$ for $\alpha=0.5$ and $p=0.1$

(iii) Repeat part (ii) for $\alpha=0.5$ and $p=0.5$, and comment on the result.





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Solution 1

$$I(X;Y) = H(Y) - H(Y|X) = H(Y) + p \log_2 p + (1-p) \log_2 (1-p)$$



Tutorial-14

Solution 1 (ii)

$$I(X;Y) = 0.531 \text{ bits/message}$$

Solution 1 (iii)

$$I(X;Y) = 0$$



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2. A DMS X has four symbols x_1, x_2, x_3, x_4 with probability $\frac{1}{2}, \frac{1}{4}, \frac{1}{8}$, and $\frac{1}{8}$. Construct a Shannon Fano code for X; show that this code has the optimum property $n_i = I(x_i)$ and the code efficiency is 100 percent.



Tutorial-14

Solution 2

$H(X)=1.75$ bits/Message



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3. A DMS X has five equally likely symbols.

- (i) Construct a Shannon–Fano code for X, and calculate the efficiency of the code.
- (ii) Construct another Shannon–Fano code and compare the results.
- (iii) Repeat for the Huffman code and compare the results.



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Solution 3

$H(X) = 2.32 \text{ bits/Message}$

$L = 2.4 \text{ bits/Message}$

$\eta = 96.7\%$



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4. A DMS X has five symbols x_1, x_2, x_3, x_4, x_5 with probabilities 0.4, 0.19, 0.16, 0.15 and 0.1.
- (i) Construct a Shannon–Fano code for X, and calculate the efficiency of the code.
 - (ii) Repeat for the Huffman code and compare the results.



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Solution 4

Shannon Fano Code:

$H(X) = 2.15 \text{ bits/Message}$

$L = 2.25 \text{ bits/Message}$

$\eta = 95.6\%$

Huffman Code:

$H(X) = 2.15 \text{ bits/Message}$

$L = 2.2 \text{ bits/Message}$

$\eta = 97.7\%$



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5. Given an AWGN channel with 4 kHz bandwidth and the noise power spectral density $\eta/2=10^{-12}$ W/Hz. The signal power required at the receiver is 0.1 mW. Calculate the capacity of this channel.



Tutorial-14

Solution 5

C = 54.44 Kbps



6.

An Analog signal having 4 kHz bandwidth is sampled at 1.25 times the Nyquist rate, and each sample is quantized into one of equally likely levels. Assume that the successive samples are statistically independent.

- (i) What is the information rate of this source?
- (ii) Can the output of this source be transmitted without error over an AWGN channel with a bandwidth of 10 kHz and an S/N ratio of 20 dB?
- (iii) Find the S/N ratio required for error-free transmission for part (i).
- (iv) Find the bandwidth required for an AWGN channel for error-free transmission of the output of this source if the S/N ratio is 20 dB?

Number of source symbols =256



Solution 6

- (i) $R = 80 \text{ Kbps}$
- (ii) $R > C$ error-free transmission not possible
- (iii) $S/N \geq 24.1 \text{ dB}$
- (iv) $B \geq 12 \text{ KHz}$



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Thank You !