Ministry of Higher Education and Scientific Research
University of Technology
Department of Computer Sciences
Final Exam 2014-2015
1st Term Exam

Branches: Networks Management & Multimedia
Class: 2nd
Subject: Information Theory and Coding

Date: 14 / 6 / 2015
Time: Three Hours
Assist. Lecturer: Osama Younus

Notes: Answer only ***six*** questions. Ten marks for each one.

Q1: Construct an instantaneous code using Shannon-Fano code and an optimal code using Huffman code for the following source, and compare between the average length of code L and the coding efficiency η for these codes.

$$\begin{pmatrix} X \\ P \end{pmatrix} = \begin{pmatrix} x_1 & x_2 & x_3 & x_4 & x_5 \\ 0.41 & 0.17 & 0.17 & 0.17 & 0.08 \end{pmatrix}$$

Q2: Answer about the following:

A. Draw the curve of the average amount of information $H(P)$ for a binary source of information sends 0, 1 with probabilities $P, 1-P$.

B. The messages x_1, x_2, x_3 are sent independently with equal probabilities through an information channel. Find the average amount of mutual information $I(X,Y)$ through the channel. The transition matrix for this channel is

$$P(Y \mid X) = \begin{pmatrix} 0.5 & 0.5 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0.5 & 0.5 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0.5 & 0.5 \end{pmatrix}$$

Q3: Answer about the following:

A. Prove that $I(X,Y) = H(X) + H(Y) - H(X,Y)$.

B. What are the two fundamental questions of communications theory to which informati theory provides answers? What are these answers?

Q4: Consider an alphabet of 8 symbols whose probabilities are as follows: (answer about only 5)

A	B	C	D	E	F	G	H
$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{16}$	$\frac{1}{32}$	$\frac{1}{64}$	$\frac{1}{128}$	$\frac{1}{128}$

a) If someone has selected one of these symbols and you need to discover which symbol it is by asking 'yes/no' questions that will be truthfully answered, what would be the most efficient sequence of such questions that you could ask in order to discover the selected symbol?

b) By what principle can you claim that each of your proposed questions is maximally informative?

c) On average, how many such questions will need to be asked before the selected symbol is discovered?
d) What is the entropy of the above symbol set?
e) Construct a uniquely decodable prefix code for the symbol set.
f) Relate the bits in your prefix code to the 'yes/no' questions that you proposed in a).

Q5: Put 'T' next to the sentence number if the sentence is true and 'F' if the sentence is false and correct the error (choose only 5):

1. The movements and transformations of information, just like those of a fluid, are constrained by mathematical and physical laws.
2. Joint entropy $H(X,Y) = H(X) \cup H(Y)$.
3. Mutual information $I(X,Y) = H(X) \cap H(Y)$.
4. The maximum possible entropy H of an alphabet consisting of N different letters is $H = \log_2 N$.
5. If U=1010100 and V=0110110, then the distance between U and V, d (U, V) is 7.
6. Information cannot be measured.

Q6: a BSC has been connected with a binary source of information whose symbol probabilities are $p(x_1) = \frac{3}{4}$ and $p(x_2) = \frac{1}{4}$, the channel matrix is

$$P(Y \mid X) = \begin{pmatrix} \frac{2}{3} & \frac{1}{3} \\ \frac{1}{3} & \frac{2}{3} \end{pmatrix}$$

Compare the channel capacity C with the mutual information I.

Q7: Suppose we want to send the following messages: 1101, 0110, 1000, 1110, by using Hamming's method find the check digits which are sent with these messages to detect and correct one single errors. Assume this message 1010100 is received. Does it contain any single error? If there is any single error then what is the original sent message.

<<<Good Luck>>>