Masa Loai Melhem

Final Assignment 1

Q1 (a) state and explain the following

• source coding Theorem

=> Source coding theorem : This is also known as Noiseless coding theorem or shannon's first theorem.

=> establishes the limits to possible data compression, and the operational meaning of shannon entropy.

• channel coding Theorem

=> channel coding theorem : systematic redundancy can be introduced into the transmitted signal so that channels can be used with improved reliability This is called channel coding or Error control coding,

=> answers the question of how much band width is left for data communication while using the most efficient code.

(b) compute the $\boxed{\text{source entropy}}$ of the following text.

" Sometimes the inspiration you need to achieve your dreams can be found in a few simple words of wisdom "

* 102

⇒ Source entropy ⇒ H(S)

$$H(S) = \sum P_K \log_2 \frac{1}{P_K}$$

⇐ أول شئ كتابة كل عنصر واحتماله

s	7 / 104	b	1 / 104
o	9/104	f	3/104
m	5 / 104	w	3/104
e	11/104	l	1/104
t	4/104	فراغ	18/104
i	8/104	"	2/104
h	2/104		
n	6/104		
p	2/104		
r	4/104		
a	5/104		
y	2/104		
u	3/104		
d	5/104		
c	2/104		
v	1/104		

Scanned with CamScanner

* Probability :

$\frac{1}{1024}$	3
$\frac{2}{1024}$	5
$\frac{3}{1024}$	3
$\frac{4}{1024}$	2
$\frac{5}{1024}$	3
$\frac{6}{1024}$	1
$\frac{7}{1024}$	1
$\frac{8}{1024}$	1
$\frac{9}{1024}$	1
$\frac{11}{1024}$	1
$\frac{18}{1024}$	1

$$* \quad H(S) = \Sigma P_K \log_2 \frac{1}{P_K}$$

$$= 3\left[\frac{1}{104}\log_2 104\right] + 5\left[\frac{2}{104}\log_2 \frac{104}{2}\right]$$

$$+ 3\left[\frac{3}{104}\log_2 \frac{104}{3}\right] + 2\left[\frac{4}{104}\log_2 \frac{104}{4}\right]$$

$$+ 3\left[\frac{5}{104}\log_2 \frac{104}{5}\right] + 1\left[\frac{6}{104}\log_2 \frac{104}{6}\right]$$

$$+ 1\left[\frac{7}{104}\log_2 \frac{104}{7}\right] + 1\left[\frac{8}{104}\log_2 \frac{104}{8}\right]$$

$$+ 1\left[\frac{9}{104}\log_2 \frac{104}{9}\right] + 1\left[\frac{11}{104}\log_2 \frac{104}{11}\right]$$

$$+ 1\left[\frac{18}{104}\log_2 \frac{104}{18}\right]$$

$$= 0.19328 + 0.548119 + 0.44268 + 0.361572$$
$$+ 0.6315 + 0.237 + 0.262 + 0.2846$$
$$+ 0.3055 + 0.3427 + 0.4379$$

$= 4.0469$ bits/symbol

(c) Describe the relative merit s and demerits of the following source coding schemes.

(i) Huffman coding
(ii) Lempe - Ziv coding.

⇐ وصف المزايا والعيوب النسبية لمخططات تشفير المصدر التالية :

* advantages of Huffman coding :

1. Huffman coding would adapt automatically to choose the best code for each specific input, and the code might be quite different from one text to the next.

2. they are prefix codes.

3. Anothe advantages of Huffman coding is that you can use it for any alphabet starting from [0, 1] finished chinese hieroglyphs, while Morse is defined only for English letters.

* dis advantages of Huffman coding :

1. The requiement of Knowledge of statistics of the source can not be always known priori (in advance)

بقدرش اعرف أي احتمالية بشكل مسبق بالنسبة لـ 1 0

2. does not fully repersent relationship bet words and phrases.

! تخربش الكلمات في الجمل وهيك

3. Huffman coding process is not unique.

ليست دائماً غالباً فلازم أفحص

4. Requires great amount of memory

* advantages of Lempel - Ziv coding :

1. Simpler to inplement than Huff man coding .

2. Lempel - Ziv coding is efficient because it does not need to pass the string table to the decompression .

3. There is no need to analyze the incoming text

⇐ إضافي : من مساوئ هذه الطريقة أطوال البتات مش متناسقين لما بدي افحص uniquelly decodable بدي أوقف وجيب أشكال .

* dis advantages of Lempel Ziv coding :

1. The method is good at textfiles but not good at other types of files ,

2. The amount of storage needed is indeterminate as it depend on the total length of all the strings .

(d)

0001011100101001 01

1	2	3	4	5	6	7	8	9
0	1	00	01	011	10	010	100	101

0010 0011 1001 0100 1000 1100 1101

1 1 4 2 4 6 6

$\Leftarrow$ الأطوال متساوية وآخر اثنين بختلفو بآخر بت

(e)

prefix codes :

تعريفين

① a code in which no code word is the prefix of any code word is called "a prefix-free code.

② set of binary sequence, probability such that no sequence in probability is a prefix of any other sequence in probability.

Kraft inequality :

* the Kraft inequality gives a necessary and sufficient condition for the existence of a prefix code or a uniquelly decodable code.

Q2:-

$\boxed{a}$ (i) mutual information

for two varibles x, y the mutual inform $I(x,y)$ is the amount of certunty Regarding x that we learned after obsergy

$$I(x,y) = H(x) - H(x|y)$$
$$= H(x,y) - H(y|x) - H(y|y)$$
$$= H(x) - H(y|x)$$
$$= I(y/x)$$

(2) Chanel capacity

is the max rate of which information could Be Transmitted without loss of information and it's know as Shannon's chanel capacity

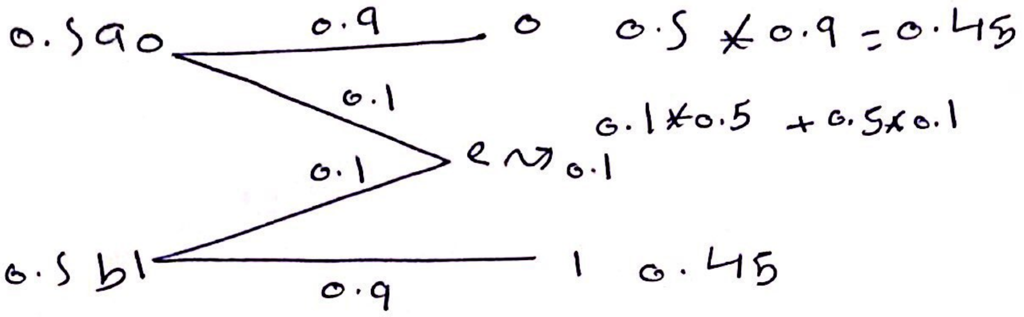
$$C = w \log(1 + S/N)$$

Q2

$\boxed{b}$

let $P(\alpha) = 0.5$

$\alpha = 0.1$



$C = I(Y, X) = H(y) - H(Y/X)$

$H(y) = \sum py \log \frac{1}{py}$

$= 2\left[0.45 \log_2 \frac{1}{0.45}\right] + \left(0.1 \log \frac{1}{0.1}\right)$

$= 1.03667 + 0.3322$

$H(y) = 1.36887$ bit/symbol

$H(y/x) = \sum P_x \cdot H(y/x)$

$= 2\left(0.5\left(0.9 \log \frac{1}{0.9} + 0.1 \log \frac{1}{0.1}\right)\right)$

$= 2(0.5 \times 0.13667) + 0.1 \times 3.349)$

$2(0.0683) + (.3349$

Q2 $\boxed{b}$

$\boxed{H(y/x) = 0.8064}$

$C = I(Y/x) = H(y) - H(Y/y)$

$= 1.36887 - 0.8064$ (8)

$\boxed{I(y/x) = 0.5432 \text{ bit/Symbol}}$

Q2

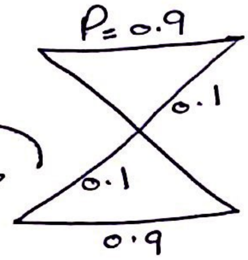
$\boxed{C}$

*البلوك الي عنا ~~معطى~~ مكافئ لـ BSC

*الاحتمالية هي $0.1 = \text{Cross}$

input → [BSC] → [BSC] → output

مصفوفتها

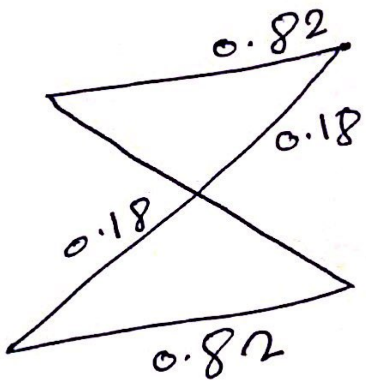


$$P = \begin{bmatrix} p & q \\ q & p \end{bmatrix}$$

$$P = \begin{bmatrix} 0.9 & 0.1 \\ 0.1 & 0.9 \end{bmatrix} * \begin{bmatrix} 0.9 & 0.1 \\ 0.1 & 0.9 \end{bmatrix}$$

first BSC   second

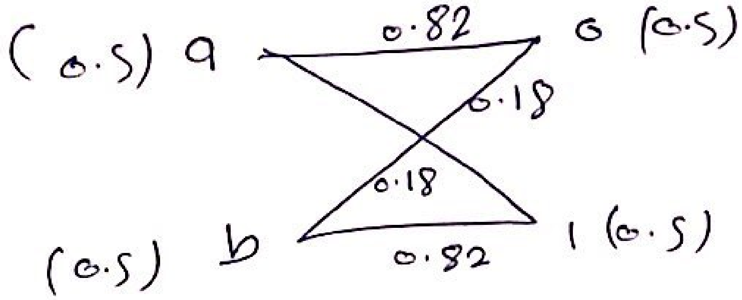
$$P = \begin{bmatrix} 0.82 & 0.18 \\ 0.18 & 0.82 \end{bmatrix}$$



Q2 Capacity

$\boxed{D}$

$\boxed{\text{let } P = 0.5}$



$P(0) = 0.5 * 0.82 + 0.5 * 0.18$

$\boxed{P(0) = 0.5}$

$P(1) = 0.5 * 0.18 + 0.5 * 0.82$

$\boxed{P(1) = 0.5}$

$C = I(Y, X) = H(y) - H(y/x)$

$H(y) = \sum py \log \frac{1}{py}$

$= (0.5 * \log \frac{1}{0.5}) + (0.5 * \log \frac{1}{0.5})$

$= 0.5 + 0.5 = 1$ Bit/sym

$H(y/x) = \sum P_x H(y/x)$

$= 2 * 0.5 (0.82 \log \frac{1}{0.82} + 0.18 \log \frac{1}{0.18})$

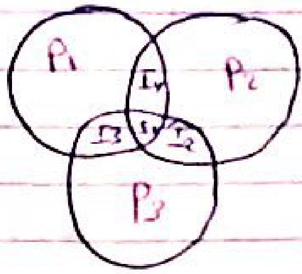
$= 2 (0.5 (0.23475 + 0.44528)$

$\boxed{H(y/x) = 0.68003 \text{ bit/sym}}$

$C = H(y) - H(y/x) = 1 - 0.68003$ (10)

$\boxed{C = 0.31997 \text{ Bit/Sym}}$

Q4]



* block code form: $I_1, I_2, I_3, I_4, P_1, P_2, P_3$

$P_1 = I_4 + I_1 + I_3$
$P_2 = I_4 + I_1 + I_2$
$P_3 = I_1 + I_2 + I_3$

1. given the information digits

$$\begin{array}{cccc} I_1 & I_2 & I_3 & I_4 \\ 1 & 0 & 1 & 1 \end{array}$$

$P_1 = 1 + 1 + 1 = 1$
$P_2 = 1 + 1 + 0 = 0$
$P_3 = 1 + 0 + 1 = 0$

transmitted code word

$$\begin{array}{ccccccc} 1 & 0 & 1 & 1 & 1 & 0 & 0 \\ I_1 & I_2 & I_3 & I_4 & P_1 & P_2 & P_3 \end{array}$$

2. code rate: $\frac{k}{n} = \boxed{\frac{4}{7}}$

3. recieved $\rightarrow$

$$\begin{array}{ccccccc} I_1 & I_2 & I_3 & I_4 & P_1 & P_2 & P_3 \\ 1 & 1 & 1 & 1 & 1 & 0 & 0 \\ 7 & 6 & 5 & 4 & 3 & 2 & 1 \end{array}$$

find the transmitted:

$$\overset{4}{1}\overset{2}{1}\overset{1}{0} \Longrightarrow 6$$

∴ the error occured in bit $\underline{\underline{6}}$

$\boxed{10}$

$$C_1 = P_1 + I_4 + I_1 + I_3 = 1 + 1 + 1 + 1 = 0$$

$$C_2 = P_2 + I_4 + I_1 + I_2 = 0 + 1 + 1 + 1 = 1$$

$$C_3 = P_3 + I_1 + I_2 + I_3 = 0 + 1 + 1 + 1 = 1$$

$$\begin{bmatrix} 0 \\ 1 \\ 1 \end{bmatrix}$$

$\therefore$ transmitted code word = 1011100

$\boxed{B}$ repetition code (5.1)
↓
(n,1)

0 → 00000
1 → 11111

the recived code 11001

1's = 3
0's = 2

number of 1's > number of 0's

$\boxed{\therefore \text{ transmitted bit} = 1}$

code rate $= \frac{1}{n} = \boxed{\frac{1}{5}}$

$\boxed{11}$

Q3] 6,3 systematic victor block code

$b_0 = m_0 + m_1 + m_2$
$b_1 = m_0 + m_2$
$b_2 = m_0 + m_1$

(a) $G = [I/P] = \begin{bmatrix} 1 & 0 & 0 & 1 & 1 & 1 \\ 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 1 & 1 & 0 \end{bmatrix}$

(b) $C = i * G$

$$\begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 0 & 0 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \\ 1 & 1 & 1 \end{bmatrix}_{8*3} \quad \begin{bmatrix} 1 & 0 & 0 & 1 & 1 & 1 \\ 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 1 & 1 & 1 & 0 \end{bmatrix}_{3*6}$$

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$$C = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 1 & 1 & 0 & 1 & 1 \\ 1 & 0 & 0 & 1 & 1 & 1 \\ 1 & 0 & 1 & 0 & 0 & 1 \\ 1 & 1 & 0 & 0 & 1 & 0 \\ 1 & 1 & 1 & 1 & 0 & 0 \end{bmatrix}_{8\times 6}$$

$\boxed{Q_3 \quad b}$

$$G = \begin{array}{c} \\ x_0 \\ x_1 \\ x_2 \\ x_3 \end{array} \begin{array}{c} \begin{array}{ccccccc} c_1 & c_2 & c_3 & c_4 & c_5 & c_6 & c_7 \end{array} \\ \begin{bmatrix} 1 & 0 & 1 & 1 & 0 & 0 & 0 \\ 1 & 1 & 1 & 0 & 1 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 & 1 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 & 1 \end{bmatrix} \end{array}$$

[a] all code vector:-

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201710212

$C_0 = 0\,0\,0\,0\,0\,0\,0 \qquad d=0$

$c_1 = x_0 + x_1 + x_2$

$c_2 = x_1 + x_2 + x_3$

$c_3 = x_0 + x_1 + x_3$

$c_4 = x_0$

$c_5 = x_1$

$c_6 = x_2$

$c_7 = x_3$

[b] $\boxed{d_{min} = 3}$