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ITC Tutorial-2

(Q.1) Encode the message "CAFFEINE" using Shannon-Fanno coding.
Calculate efficiency of the code.

(Q.2) Compress the message "HEART BEAT" using ~~Huffman coding~~

a) Huffman Coding
b) Shannon - Fanno Coding
c) Calculate and compare the code efficiency in both the cases.

(Q.3) Define Kraft's inequality theorem. Check whether it is satisfied in question 1 & 2.

(Ans 1) CAFFEINE

$P(C) = \frac{1}{8} = 0.125$

$P(A) = \frac{1}{8} = 0.125$

$P(F) = \frac{1}{4} = 0.25$

$P(E) = \frac{1}{4} = 0.25$

$P(I) = \frac{1}{8} = 0.125$

$P(N) = \frac{1}{8} = 0.125$

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x_i	P_{x_i}	Col 1	Col 2	Col 3	Code	len
E	0.25	0	0		00	2
F	0.25	0	1		01	2
A	0.125	1	0	0	100	3
C	0.125	1	0	1	101	3
N	0.125	1	1	0	110	3
I	0.125	1	1	1	111	3

$\bar{L} = P \times H$

$= 0.25 \times 2 + 0.25 \times 2 + 0.125 \times 3 + 0.125 \times 3 + 0.125 \times 3 + 0.125 \times 3$

$= 1 + 0.375 + 0.375 + 0.375 + 0.375$

$= \cancel{1}\,2.5$

$H(x) = 0.25 \log_2(4) + 0.25 \log_2(4) + 4(0.125 \times \log_2(8))$

$= 0.5 \log_2(4) + 0.5 \log_2(8)$

$= \cancel{2\log_2(4)}\ 2.5$

$\eta = \frac{H}{L} \times 100 = \frac{2.5}{2.5} \times 100 = 100\%$

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(Ans 2) "HEARTBEAT"

$P(H) = \frac{1}{9}$ $P(R) = \frac{1}{9}$

$P(E) = \frac{2}{9}$ $P(T) = \frac{2}{9}$

$P(A) = \frac{2}{9}$ $P(B) = \frac{1}{9}$

(B) Shannon-Fanno Coding

x_i	P_{x_i}	Col 1	Col 2	Col 3	Code	len
A	0.22	0	0	0	00	2
E	0.22	0	1	1	01	2
T	0.22	1	0	0	100	3
B	0.11	1	0	1	101	3
H	0.11	1	1	0	110	3
R	0.11	1	1	1	111	3

$L = 2 \times 0.22 + 2 \times 0.22 + 3 \times 0.22 + 0.11 \times 3 + 0.11 \times 3 + 3 \times 0.11$

$= 2.53$

$H(x) = \sum_{i=0}^{n} P_{x_i} \log_2 \left(\frac{1}{P_{x_i}}\right)$

$H(x) = 0.22 \log_2 \left(\frac{1}{0.22}\right) + 0.22 \log_2 \left(\frac{1}{0.22}\right)$

$+ 0.22 \log_2 \left(\frac{1}{0.22}\right) + 0.11 \log_2 \left(\frac{1}{0.11}\right)$

$+ 0.11 \log_2 \left(\frac{1}{0.11}\right) + 0.11 \log_2 \left(\frac{1}{0.11}\right)$

$= 1.441 + 1.0508$

$= 2.491$

$$\eta = \frac{H}{\bar{L}} \times 100 = \frac{2.491}{2.53} \times 100 = 98.418\ \%$$

efficiency.

(a) Huffmann Coding

x_i	P_{x_i}					
A	0.22	00	0.22	0.33	0.44	0.55
E	0.22	01	0.22	0.22	0.33	0.43
I	0.23	1001	0.22	0.22	0.22	
B	0.11	001	0.22	0.22		
H	0.11	0000				
R	0.11	0001	0.11			

x_i	P_{x_i}	Code	Code length
A	0.22	01	2
E	0.22	10	2
I	0.22	11	2
R	0.11	001	3
H	0.11	0000	4
B	0.11	0001	4

$$H(X) = 3\left(0.22 \times \log_2\left(\frac{1}{0.22}\right)\right) + 2\left(0.11 \times \log_2\left(\frac{1}{0.11}\right)\right)$$

$= 2.49$ bits/symbol.

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~~Q 3~~
(Ans 3) Krafts inequality theorem

- This theorem states that it is a necessary and efficient to improve the existence of prefix code to be uniquely decodable ~~system~~ ~~to be given~~ code to be given symbols and are bits used to represent and symbol for i=1 to n.

in Q1 all the symbols are uniquely identified.

For Q2

x_i	P_{x_i}	code ~~ki~~ length
A	0.22	2
E	0.22	2
T	0.22	2
R	0.11	3
Y	0.11	4
B	0.11	4

$\frac{1}{2} + \frac{1}{2} + \frac{1}{2} + \frac{1}{3} + \frac{1}{4} + \frac{1}{4} \Rightarrow 1$

$\therefore$ Condition satisfied for Q_2