Part-A :

1). **Entropy :-** It is the mean or measure of self information.

It is expressed as :-

$$H = - \sum_{K=0}^{K-1} P_K \log_2 P_K$$

2). **Self Information :-**

Information about the individual event is called self information.

It can be given as :-

$$I_K = \frac{1}{\log_2 P_K} \text{ bits} = -\log_2 P_K$$

where P_K = probability of events

3). **Properties of entropy :-**

i) a) $H(Y) \geq 0$

b) $H(Y) = 0$ if and only if $P_K = 1$ & remaining prob in the set are zero (0).

ii) a) $H(Y) \leq \log_2 K$

b) $H(Y) = \log_2 K$ if and only if $P_K = \frac{1}{K}$ for all K. All the probabilities are equal.

4). **Condition for entropy to be maximum :-**

→ when probability is equally distributed then the entropy $H(X)$ is maximum.

$$H_{max} = \log_2 M$$

5) Joint Entropy :-

The joint entropy $H(X,Y)$ is defined as:-

$$H(X,Y) = -\sum_{i=1}^{M}\sum_{j=1}^{N} P(x_i, y_j) \log P(x_i, y_j)$$

6). Conditional entropy :-

Measure of information about the receiving port Y when X- transmitter is known is conditional entropy. It gives an indication of noise of either in channel. It is given as:-

$$H(Y/X) = -\sum_{i=1}^{M}\sum_{j=1}^{N} P(x_i, y_j) \log P(y_j/x_i)$$

7). Equivocation :-

Measure of information about source where Y - receiver is known is called equivocation. It gives how well one can recover the i/p content from output.

$$H(X/Y) = -\sum_{i=1}^{M}\sum_{j=1}^{N} P(x_i; y_j) \log P(x_i/y_j)$$

8). Significance of $H(Y/X)$ and $H(X/Y)$.

→ . $H(Y/X)$ → It is the conditional entropy, a measure of information about the receiving port, where it is known that X is transmitted.

$H(X/Y)$ — ...

a measure of information about ~~the~~ the source where it is known that y is received.

9) Entropy in the continuous case function.

For 1-D

$$H(X) = E[-\log f(x)]$$

$$H(x) = \int_{-\infty}^{\infty} f(x) \log f(x) \, dx$$

For 2D

$$H(X, Y) = E[\log f(x, y)]$$

$$H(X, Y) = -\int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x, y) \log f(x, y) \cdot dx \, dy$$

10).

11) Mutual information.

It is defined as the amount of information transfered when x_i is transmitted & y_j is received.

It can expressed as :-

$$I(x_i, y_j) = \log_2 \frac{P(x_i/y_j)}{P(x_i)} \text{ bits}$$

or

$$= \log_2 \frac{P(x_i, y_j)}{P(x_i)\, P(y_j)}$$

12) Kraft inequality :- The necessary and sufficient condition for existance of an irreducible noisless encoding procedure with specified word length $(n_1, n_2 -- n_N)$ is that a set of +ve integers $(n_1, n_2 -- n_N)$ can be found such that

$$\sum_{i=1}^{N} D^{-n_i} \leq 1$$

The equation is called kraft inequality.

13) Efficiency of coding :-

The ratio of the average information per symbol to the ~~maximum possible~~ ~~average~~ average length is called efficiency of coding.

$H(X)$

14) Purpose of Coding :- The main purpose of coding is to improve the efficiency of the communication link. The links or information are coded before being transmitted. ~~for~~ This is done to reduce the loss of information and for security purpose. Thus the efficiency of received signal is improved.

15) Encoding :- A process of putting a sequence of characters (letters, numbers, symbols etc) into a specialized format i.e code for efficient transmission is called encoding.

Decoding :- It is the reverse process of encoding. i.e conversion of encoded format back into the original signal is called decoding.

16) Uniquely decipherable encoding :-

The operation in which the correspondence of all possible sequences of words between the two languages without space marks between the words is one-to-one.

17) Redundancy of coding :-

It is the measure of redundance bit of an encoded message bit and is given as:-

$$\text{Redundancy} = 1 - \text{code efficiency}$$
$$= 1 - \eta$$

It should be low as possible.

18). Instantaneous Codes :-

The codes in which no code is the prefix of any other codeword.

eg :-

S_0	0	← codeword
S_1	10 (prefix)	← codeword
S_2	110 (11 prefix)	← codeword
S_3	111	

we can say that no codeword is the prefix of other codewords. Hence they are instantaneous codes.

19) Average length of a code :-

It is given by -

$$\bar{L} = \sum_{i=1}^{M} n_i \cdot P(x_i)$$

where, $\bar{L}$ = average length of code

n_i = length of code word for source symbol x_i.

$P(x_i)$ = Probability of occurance of

20) properties of mutual information :-

i) Mutual information of the channel is symmetric i.e

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

ii) The mutual information is always positive. i.e

$$I(X,Y) \geq 0$$

iii) The mutual information is related to the joint entropy $H(X,Y)$ by following relation -

$$I(X,Y) = H(X) + H(Y) - H(X,Y)$$

21). property of mutual information -

$$I(X,Y) = H(X) + H(Y) - H(X,Y)$$

proof :- $H(X,Y) = H(X/Y) + H(Y)$

$\therefore$ $H(X/Y) = H(X,Y) - H(Y)$

M.I is given by -

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

sub. value of $H(X/Y)$ in $I(X,Y)$

we have

$$\boxed{I(X,Y) = H(X) + H(Y) - H(X,Y)}$$

proved.

22). property of entropy :-

when $P_K = \frac{1}{M}$,

$$H = \log_2 M.$$

proof :- W.K.T $p = \frac{1}{M}$

i.e $P_1 = P_2 = P_3 \ldots P_M = \frac{1}{M}$

$$H = \sum_{K=1}^{M} P_K \log_2 \left(\frac{1}{P_K}\right)$$

$$= P_1 \log_2 \left(\frac{1}{P_1}\right) + P_2 \log_2 \left(\frac{1}{P_2}\right) + \ldots P_M \log_2 \left(\frac{1}{P_M}\right)$$

$$= \frac{1}{M} \log_2 (M) + \frac{1}{M} \log_2 (M) + \ldots$$

$$\boxed{H = \log_2 (M)}$$ proved.

23) properties of information rate :-

24)

25) $P = \{0.5, 0.2, 0.15, 0.1, 0.05\}$

$$H(x) = 0.5 \log \frac{1}{0.5} + 0.2 \log \frac{1}{0.2} + 0.15 \log \frac{1}{0.15} + 0.1 \log \frac{1}{0.1} + 0.05 \log \frac{1}{0.05}$$

$$= 0.15 + 0.13 + 0.12 + 0.1 + 0.06$$

$$= 0.56 \text{ bits / symbol}$$

information Rate

$$R = rH \qquad \text{given } r = 3000$$

$$= 3000 \times 0.56$$

$$= 1695.15 \text{ bits / sec.}$$

UNIT - 2

Part - A

1) **Memoryless channel :-**

The channel in which current output depends only on current input and not on previous is called memoryless channel.

2) **Discrete channel :-**

The discrete communication channel has input x and output y. Both x and y are random variable. When both x i.e input and y i.e output are discrete the channel is called discrete channel.

3) **Discrete memoryless channel :-**

For the discrete channel, both the input and output are discrete random variable. If the current output depends only upon the current input the discrete channel is called memoryless.

4) ~~the~~ **channel matrix**

The discrete memoryless channel is characterized by a matrix ~~whose elements~~ ~~are~~ known as channel matrix and is given as:-

$$D = \begin{bmatrix} P(y_1/x_1) & P(y_2/x_1) & \cdots & P(y_m/x_1) \\ P(y_1/x_2) & P(y_2/x_2) & \cdots & P(y_m/x_2) \\ \vdots & & & \\ P(y_1/x_m) & P(y_2/x_m) & \cdots & P(y_m/x_m) \end{bmatrix}$$

each row of matrix represents fixed i/p.
and each column of matrix represents fixed o/p.

5)

6) Different types of channels :-

i) lossless channel
ii) Deterministic channel
iii) Noiseless channel
iv) Useless channel
v) Symmetric channel.

7) **lossless channel:-**

A channel is lossless if $H(X/Y) = 0$ for all input distributions. A lossless channel is the one in which the input is determined by the output hence more transmission error occurs.

8). **Deterministic channel**

The channel is deterministic if $P(y_j/x_i) = 1$ or 0 for all j. i.e if y is determined by x or equivalently $H(Y/X) = 0$ $\forall$ input distributions.

9). **Noiseless channel:-**

The channel is noiseless if it is both lossless and deterministic.

$$I(X,Y) = H(X) = H(Y)$$

$$C = \max I(X,Y)$$

$$= \max H(X,Y) = \max H(Y)$$

$$C = \log M = \log N$$

$$\boxed{M = N}$$

10). **Useless channel:-**

A channel is useless or zero capacity if $I(X,Y) = 0$ for all input distribution.

A channel $\therefore \boxed{C = 0}$

channel matrix has identical rows.

11) Symmetric channel :-

A channel is symmetric if each row of the channel matrix and each column of the channel matrix contain the same set of numbers. For a symmetric channel $H(Y/X)$ is independent of $P(x_i)$ and depends only on the channel probabilities $P(y_j/x_i)$

12) channel capacity :-

The channel having maximum average mutual information is known as channel capacity. The maximization is taken with respect to input ~~prob~~ probabilities $P(x_i)$

i.e

$$C = \max_{P(x_i)} I(X;Y)$$

13). BSC (Binary symmetry code) :-

It is ~~the~~ discrete memoryless channel with $J = K = 2$ is. It has two input (0,1) and two o/p (0,1). Since o/p is symmetrical to i/p it is called

BSC.

BEC :- Binary Erasure channel has two input (0,1) and three o/p symbols (0,y,1) The letter y indicates the fact that the o/p is erased and no deterministic decision can be made as to whether the transmitted letter was 0 or 1.

14) <u>channel capacity of lossless channel</u>:-

The ~~cap~~ channel capacity for lossless channel is obtained when source entropy is maximum and is given as:-

$$C = \max H(X) = \log M.$$

15) <u>channel capacity of deterministic channel</u>:-

The channel capacity of deterministic channel is obtained when destination entropy is maximum.

i.e $$C = \max H(Y) = \log N.$$

16) <u>channel capacity of noiseless channel</u>

The channel capacity of noiseless channel is obtained when source entropy is equal to destination entropy.

i.e $I(X,Y) = H(X) = H(Y)$

$\therefore \quad C = \log M = \log N$

17) <u>channel capacity of symmetric channel</u>:-

$$C = \log m - h$$

The ~~shan~~ shannon's fundamental theorem states that the capacity of a channel is a fundamental property of an information channel in the sense that it is possible to transmit information through the channel at any rate less than the channel capacity with arbitrarily small probability of error.

i.e $0 < H < C$

and $e > 0$

19). Decoding scheme :-

To achive ~~realbil~~ reliability accuracy should be more. Decoding scheme is the best way to find the correct input. A decoder or decoded scheme is an assignment to every output symbol y_j of an input symbol x_j^* from the alphabet $x_1, x_2, \ldots x_M$.

20). Useless channel :-

when the mutual information i.e $I(X, Y)$ of a channel is zero for all input distribution. The channel ~~capf~~ capacity is also zero. This type of channel is called useless channel.

i.e if $I(X,Y) = 0$

$$\boxed{C = 0}$$

21) channel capacity of unsymmetric channel –

$$C = \log [2^{Q_1} + 2^{Q_2}] \text{ nats/symbol}$$

22). <u>Ideal observer</u> :- For a given input distribution $P(x_i)$ the decision scheme that minimizes over all probability of error should be constructed, such a decision scheme is called as ideal observer.

23). <u>Fano's inequality</u> :-

By this theorem we relate the probability of error to the uncertainity measure.

<u>Theorem</u> :- Given an arbitrary code (s, n) consisting of word $x^1, \ldots x^s$ let $X = (X_1, \ldots X_n)$ be a random vector that equals $x^{(i)}$ with probability $P(x^{(i)})$ where $i = 1, 2 \ldots s$ and $\sum_{i=1}^{s} P(x^{(i)}) = 1$

Let $Y = (Y_1 \ldots Y_n)$ be the corresponding o/p sequence then for the probability error

$H(X/Y) \leq H[P(e), 1-P(e)] + P(e) \log(S-1)$

24). Maximum likely-hood decision scheme :-

For a fixed y, maximizing $P(x_i/y)$ is equivalent to maximizing $P(y/x_i)$. Thus when all the inputs are equally likely, the ideal observer selects the input x_i for which $P(y/x_i)$ is a maximum. The resulting decoder is called maximum likelyhood decision scheme.

25). given $B = 3000\ Hz$

$S/N = 10^3$

$$C = B \log_2 \left(1 + \frac{S}{N}\right)$$

$$= 3000 \log_2 (1 + 10^3)$$

$$= 3000 \times 9.96$$

$$= 2.9 \times 10^4 \text{ bits / symbol.}$$

UNIT - III

Part - A

1). **Information capacity theorem :-**

Information capacity theorem can be stated by considering a zero mean stationary process $x(t)$ that is bandlimited to 'B' Hz. let $X(K)$. $K = 1, 2 - - K$ denote continious random variable obtained by uniform sampling of the process $x(t)$ of Nyquist rate of $2B$ sample/sec

The no. of samples K per second is given as :- $[K = 2BT]$

2). **Differential Entropy :-**

The differential entropy is defined for continious variables. Let us consider the continious r.v X having probability density function $f_X(x)$ then,

$$h(X) = \int_{-\infty}^{\infty} f_X(x) \log_2 \left[\frac{1}{f_X(x)}\right] dx .$$

~~The~~ Here $h(X)$ is called the differential entropy of X.

The ~~ca~~ channel capacity is the maximum information rate which is defined within a certain limits known as shannon limit.

The limit states that for a channel capacity C and information rate R. The rate of information R is always less than the channel capacity C.

i.e $\boxed{R \leq C.}$

4). <u>channel coding theorem</u>

~~&~~ The theorem states that if $R \leq C$, there exist a coding technique such that the output of the source may be transmitted over the channel with a probability of error in the received message which may be made arbitrarily small.

or, the theorem says that if $R \leq C$ it is possible to transmit information without any error even if noise is present.

5). <u>Rate distortion function</u>:- The rate distortion $R(D)$ is defined as smallest coding rate possible for which average distortion is guaranteed not to exceed D.

$$R(D) = \min_{P(y_j/x_i) \in P_D} I(X, Y)$$

6) <u>need for data compression:-</u>

Data compressor is a device that supplies a code with the least no of symbols for the representation of the source o/p, subject ~~to~~ to a permissible or acceptable distortion. Thus it compresses the data in a small size with unavoidable reduction in the information content.

7). Drawbacks of data compression -

i). It is a lossy operation i.e the source entropy is reduced or information is lost.

ii) By encoding the source o/p at a rate smaller than source entropy, exact reproduction of the original signal is no ~~loo~~ longer possible.

'or'

~~Drawbacks~~

6). [illegible]

i) Huge amount of data is generated in text, images, audio, speech & video.

ii) Because of compression, transmission data rate is reduced.

iii) Storage becomes less due to compression.

iv) Transportation of data is easier due to compression.

7). Drawbacks of data compression:-

1) Due to compression, some of data is lost.

2) Compression and decompression increases complexity of the transmitter and receiver.

3) Coding time is increased due to compression and decompression.

8).

Lossless Compression	Lossy compression
i) No information is lost	i) Some information is lost
ii) Completely reversible	ii) It is not reversible.
iii) Used for text and data	iii) Used for speech & video.
iv) Compression ratio is less	iv) High compression ratio.
v) Huffman coding, runlength coding are examples	v) Transform coding, quantization are examples.

9). Entropy coding

It is based on entropy of the source. It assigns codes to the source alphabets according to probability of their occurence. It is lossless compression technique. eg — Runlength encoding, Prefic coding and huffman coding. They are used for compression of the text files.

10). Runlength coding :-

Runlength coding is normally used for the data generated by scanning the documents. fax machine, typewriters etc. The strings of 1's and 0's can be compressed better by Runlength encoding.

eg :- 111111000 00 1111 00000 . .

This string can be encoded as :-

1, 6 ; 0, 5 ; 1, 4 ; 0, 5 - - -

11) statistical encoding :-

~~It explains the statist~~ is

It encodes the statiscal properties of the information. for eg :- a, e, i have higher probability of accurance compared to q, t, z etc. Huffman coding is an example of statistical encoding in which shortlength codewords are assigned to frequently accuring alphabets and larger length codeword are assigned for rarely accuring alphabets.

12). Differential encoding :-

The process in which difference between two successive samples is encoded is called differential encoding. The values of samples are large but the difference between them is very small. Hence less number of bits are required to ~~enc~~ encode the difference. eg:. If two values 230 and 232 are given then the difference to between them to be encoded is very small i.e only 2 bits.

13). Transform encoding :-

It is much powerfull coding technique. which is used for ~~impa~~ coding of image ~~as~~ NXN pixel size, video and audio compression is also done. It uses discrete cosine transform using which an image is transformed into frequency domain without any loss of information.

14).

15) Prefix coding :- Prefix of the codeword means any sequence which is initial part of the codeword. In prefix code, no codeword is the prefix of other codeword. It is a variable length coding algorithm.

16) Need for audio compression

1). Since huge amount of data is generated in audio, hence it needs to be compressed.

2). To reduce the transmission data rate.

3). Storage of audio signal becomes less due to ~~stereo~~ compression.

17). Principle of audio coding :-

Audio coding is described on the basis of of perceptual coding. In perceptual coding. the limitations of human ear are used. we known that human ear can listen very small sound when there is complete silence. But if rather big sounds are present then human ear can not listen small sounds. These characteristics of human ear are used in perceptual coding.

19) . Video compression :- It is used for compression of moving pictures frames and audio. The bandwidth of video depends upon type of applications. Video telephony and video conferencing ~~may~~ uses lowest video bandwidth and digital television or digital movies require very high bandwidth. As the b.w of s/l increases, the ~~bit~~ bit rate of encoded signal also increases.

20) Rate Distortion theory :-

In many practical situation, there are constrain that force the coding to be imperfect. There by resulting in unavoidable distortion This problem is refer to as source coding with a fedility criterion. The branch of the information theory that deals with it is called rate distortion theory.

21) . Lossless compression :-

In lossless compression, no part of the original information is lost during compression. Decompression produces original information exactly. This is independent of human response.

eg:- Huffman coding, runlength coding . etc .

~~22).~~ ~~B.W~~

24) <u>MPEG</u> :- (Motion Picture Expert Group).

It was formed by ISO ; MPEG has developed the standards for compression of video with audio. MPEG audio coders are used for compression of audio. This compression mainly uses perceptual coding.

25) <u>Capacity of colored noise channel</u> :-

$$C = \frac{1}{2}\int_{-\infty}^{\infty} \log_2 K \left(\frac{|H(f)|^2}{S_N(f)} \right) df.$$

where

$|H(f)|$ = Magnitude response of channel.

$S_N(f)$ = Power spectral density of noise.

ad —

Part-A

1) Linear codes :-

If the two code words of the linear code are added by modulo-2 arithmetic, and if produces another codeword is result, Then they are called linear codes.

2) Error correcting codes :-

Codes which are additionaly added to the original code to correct the error present in the original codes. are called error correcting codes. eg:- Hamming codes, BCH codes. Golay etc.

3) properties of syndrome :-

i) Syndrome is obtained by $S = YH^T$.

ii) If $Y = X$ then $S = 0$ i.e no error in o/p.

iii) If $Y \neq X$ then $S \neq 0$ i.e there is an error in o/p.

iv) Syndrome depends on error pattern i.e $S = EH^T$.

4). Hamming distance :-

The hamming distance between the two code vectors is equal to the no of digits in which they differ.

eg. $X = (101)$ $Y = (110)$

Hamming distance = 2.

5) — same as ②.

6). Repetition Codes :-

In this code a single message bit is transmitted and $q = 2t$ bit are parity bits. This code is called repetition code since many redundant check bits are transmitted along with a ~~sign~~ single message bit. This code can correct 't' errors per black.

7). cyclic codes :-

A linear code is called cyclic code if every cyclic shift of the codevector produces some other codevector. This can be ~~sym~~ systematic or nonsystematic.

8). Golay Codes :-

Golay code is the (23, 12) cyclic code whose generating polynomial is given as:-

$$G(P) = P^{11} + P^9 + P^7 + P^6 + P^5 + P + 1$$

This code has minimum distance of $d_{min} = 7$. This code can correct upto 3 errors but can not be generalized to other combinations of n and k.

i) The error correcting and decoding methods of cyclic codes are simpler and easy to implement

ii) The encoders and decoders for ~~for~~ cyclic codes are simpler compared to noncyclic codes.

iii) cyclic codes also detect error burst that span many successive bits.

Disadvantange of cyclic code :-

i) The error detection in cyclic codes is simpler but error correction is little complicated since the combinational logic circuits in error detector are complex.

10). $(n, K) = (15, 9)$

$G(P) = P^6 + P^5 + P^4 + P^3 + 1$

given $q = 3$, $n = 15$, $K = 9$.

burst error correcting efficiency is -

$$Z = \frac{2q}{n-K}$$

$$= \frac{2 \times 3}{15 - 9} = \frac{6}{6}$$

$$\boxed{Z = 1 \text{ or } 100\%}$$

11). Convolutional coding :- The convolutional coding is done by combining the fixed no. of input bits. The i/p bits are stored in the fixed length shift register and they are combined with the help of mod-2 adders. This operation is equivalent to binary ~~+~~ convolution and hence called convolution

12). <u>Code rate of convolutional encoder</u>:- is -

$$r = \frac{k}{n}$$

It is defined as the ratio of message bits and encoder output bits (n)

13). constraint length of a convolution code is the number of shift over which the single message bit can influence the encoder output. It is expressed in terms of message bits.

14).

<u>code tree</u>	<u>Trellis diagram</u>
i) It indicates flow of the coded s/l along the nodes of tree.	i) It indicates transitions from current to next states.
ii) lengthy way ~~to~~ of representing coding process.	ii) Shorter or compact way of representing coding process.
iii) decoding is simple	iii) Decoding is little complex

15) <u>Turbo codes</u>:- Turbo codes are better than linear block codes or convolutional codes. It can be used if theoritical limits of shannon's channel capacity is increased. Turbo codes use a pseduo-random interleaver, which provides better and robust performance than the

16). <u>BCH Codes :-</u> They are the most extensive and powerful error correcting cyclic codes. For any positive integer m and t (where $t < 2^{m-1}$) there exists a BCH code with following parameters –

Block length $n = 2^{m} - 1$

No. of parity check bits $n - k \leq mt$

minimum distance $d_{min} \geq 2t + 1$.

17). <u>RS Codes :-</u> These are nonbinary BCH codes. The encoder of RS codes operate on multiple bits simultaneously. The RS codes have n symbols in the codeword. Each symbol contains m number of bits. Normally, $m = 8$. The t error correcting RS codes has following parameter –

Block length $n = 2^{m} - 1$

Message size = k symbols.

Parity check size $n - k = 2t$.

18). <u>Systematic :-</u> In this message will appear first then check bit will appear.

The ~~block~~ code vector is given as –

$X = MG$

↑ message vector ↑ Generator matrix.

*

Non-Systematic :- Both message and check bit will appear simultaneously. The non-~~sym~~ systematic cyclic code is given as -

$$X(P) = M(P) \cdot G(P) .$$

↑ Generator polynomial of degree q.

19) Code efficiency :- The ratio of message bits in a block to the transmitted bits for that block by the encoder is called code efficiency.

code efficiency = $\frac{\text{message bits in a block}}{\text{transmitted bits for the block.}}$

i.e

$$\boxed{\eta = \frac{K}{n}}$$

20).

In this errors are corrected and detected at receiver by using check bits or redundant bits. The capability of error correcting and detection of receiver depends on the no. of redudant bits in the ~~message~~ transmitted message. The forward acting error correction is faster but overall probability of errors is higher.

22) <u>channel data rate</u> :- It is the bit rate at the output of encoder. If the bit rate at the input of encoder is R_s, then channel data rate will be,

$$R_o = \frac{n}{k} R_s .$$

23) Methods of error correcting :-

i). Forward acting error correction.

ii). Error detection with retransmission.

24). <u>Example of error control coding</u> :-

Let us consider the error control coding scheme which transmits 000 to transmit symbol 0 and 111 to transmit 1. Here, in every message two redundant bits are there. The receiver checks the received triplets and takes the decision in favour of majority of the bits - if ~~the is~~ triplet is 110 the decision is in favour of 1 and if it is 001 or 100 the decision is in favor of 0.

25) Properties of cyclic codes :-

i) Linearity property.

ii) cyclic property.

~~Every clic cyclic shift of the valid~~

ii). <u>convolutional codes</u> :-

The coding operation is discrete time convolution of input sequence with the impulse response of the encoder. The convolutional encoder accepts the message bits continuously and generates the encoded sequence continiously.

Part - A.

1). Methods for decoding of convolutional codes :-

a) viterbi algorithm ~~fo~~ (maximum likelyhood decoding).

b). sequential decoding

c) Free distance and coding gain.

2). Metric :- It is a discrepancy between received signal y and decoded signal at particular node. This metric can be added over few nodes for a particular path.

3). Surviving path :- This is the path of the decoded signal with minimum metric. In viterbi decoding a metric is assigned to each surviving path.

4). free distance :- It is defined as the minimum distance between code vectors i.e equal to minimum weigth of code vector.

$$d_f = [w(x)]_{min}$$

5) coding gain :- It is used as basis of comparision for different coding methods to achieve same bit error rate.

It is given as :-

$$A = \frac{(E_b/N_o)\ \text{Encoded}}{(E_b/N_o)\ \text{coded}}$$

6). probability of error with soft decision decoding :-

$$P_e \leq \sum_{d=d_{free}}^{\infty} a_d \, Q(\sqrt{2\gamma_b R_c d})$$

Here a_d is the no. of paths of distance 'd' from the all zero path which merge with all zero path for the first time.

7) Probability of error with hard decision decoding :-

$$P_e < \sum_{k=\frac{d+1}{2}}^{d} \binom{d}{k} p^k (1-p)^{d-k}$$

8). Noise channel Model :-

9. Maximum likelyhood receiver :-

It is a method used for decoding of convolution codes. The decoding method uses two main points -

i) Metric - It is the discrepancy between the received s/l y and decoded signal at a particular node.

ii) ~~~~ Surviving path :- It is the path of

Charateristics :-

1) It is a dynamic programming algorithm for finding (the most likely sequence of hidden states called) Veterbi path.

2) It is a decoding algorithm for convolutional codes.

11) practical application of veterbi algorithm

→ ~~For used~~ Application in decoding the convolutional codes.

→ Used in CDMA, GSM digital cellular, dial - up modem, satellite, deep-space communications, wireless LANs.

→ Also used in speech recognition, keyword spotting, computational linguistics and bioinformatics.

12). Viterbi decoding :-

It is a technique of decoding a bitstream that has encoded using forward error correction based on a convolutional code. It uses Veterbi algorithm for decoding.

13). Advantange of veterbi decoding

i) It is most resource - consuming.

ii) It can decoder convolutional codes with contraint length K <= 10

iii) There are both software and hardware implementation of a viterbi decoder.

14). Viterbi algorithm is needed for finding the most likely sequence of hidden states called the viterbi path. Viterbi algorithm is used as a decoding algorithm for convolutional codes over noisy digital communication links.

15) <u>forward error correction</u> (FEC)

It is a technique used for contoolling errors in data transmission over ~~a~~ noisy ~~the~~ communication channels.

The FEC is done by adding redundancy to the transmitted information using a predetermined algorithm.

16) <u>Traceback.</u>

It is a process of to accumulate path metrics for up to five times the constraint length $5(K-1)$. It restores ~~an~~ a maximum likelihood path in a inverse direction. Find the node with the largest accumulated cost, and begin traceback from this node.

i) Consistency
ii) Asymptotic normality
iii) Functional invariance.
iv) Higher order properties.

19) Applications of Maxm. Li. MLE

i). Used for a wide range of statistical models like, linear models, exploratory, structural equation modelling, discrete choise models etc;

ii) App- in widespread set of fields.
eg:- Communication system, psychometric, econometric;

iii) data modelling in nuclear and particle physic.
iv) Magnetic resonance imaging.

20). Expression for Maxm Likelihood Receiver:-

$$\left[P(x\text{received}/y\text{ sent}) = \frac{P(x\text{received}, y\text{ sent})}{P(y\text{ sent})} \right]$$

or $P(y\text{ sent}/x\text{ received}) \cdot \frac{P(x\text{received})}{P(y\text{ sent})}$.

21) Normal distribution:-

Normal distribution is a continuous probability distribution that is often used as a first approximation to describe real

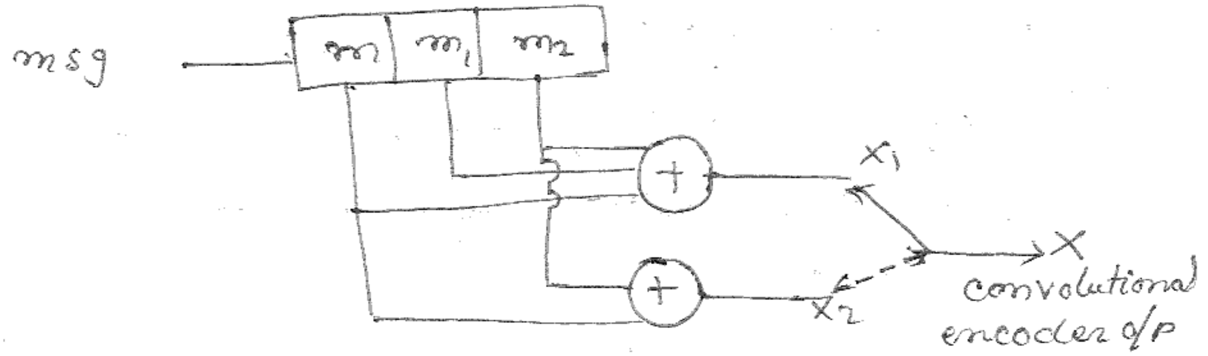
real valued random variables that tend to cluster around a single mean value.

22) Convolutional codes are used in order to achieve reliable data fee transfer.

Including —

digital video, radio, mobile communication, and satellite communication.

24).



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