Module (Course Syllabus) Catalogue

2022-2023

College/ Institute	Technology college	
Department	Information and Communication Technology Engineering (ICTE)	
Module Name	Information Theory and coding	
Module Code	INT601	
Degree	Technical Diploma ☐ Bachelor ☑ High Diploma ☐ Master ☐ PhD ☐	
Semester	6TH semester	
Qualification		
Scientific Title		
ECTS (Credits)	5	
Module type	Prerequisite ☐ Core ☑ Assist. ☐	
Weekly hours	4	
Weekly hours (Theory)	(3)hr Class	(125)Total hrs Workload
Weekly hours (Practical)	(0)hr Class	(0) Total hrs Workload
Number of Weeks	12	
Lecturer (Theory)	Soran Abdulrahman Hamad	
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Lecturer (Practical)		
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Course Book

Course Description	Introduction to Information Theory: Modeling of information sources – source coding theorem–source coding algorithms–modeling of communication channels – channel capacity – bounds on communication. Linear block codes: structure – matrix description – Hamming codes. Standard array arithmetic of Galois fields: Integer ring – finite fields based on integer ring – polynomial rings – finite fields based on polynomial rings – primitive elements. structure of finite fields cyclic codes: Structure of cyclic codes – encoding and decoding of cyclic codes. BCH codes: Generator polynomials in terms of minimal polynomial – Decoding of BCH codes – Reed-Solomon codes – Peterson-Gorenstein – Zierler decoder. Convolutional Codes: Introduction to Convolutional Codes – Basics of Convolutional Code encoding and decoding – Sequential decoding – Viterbi decoding.
Course objectives	1. This course will enable students to understand the concept of Entropy, Rate of information and order of source with reference to dependent and independent and source. 2. Study various source encoding algorithms. 3. Model discrete and continuous communication channels. 4. study various error control coding algorithms.
Student's obligation	The student should be attended to the class every week three hours and prepare himself for weekly quizzes and do assignments and home works in the theory weekly
Required Learning Materials	1- Power point presentation 2-white board 3- sheets 3- seminars zoom meeting and Moodle program.

	Task		Weight (Marks)	Due Week	Relevant Learning Outcome
	Paper Review				
	Assignments	Homework	5	3-6-9-12	Explain concept of dependent and independent source, measure of information, Entropy, Rate of information and order of a source
		Class Activity	2	Over all weeks	Represent the information using Shannon Encoding, Shannon Fano, Prefix and Huffman Encoding Algorithms
		Report	5	4	Model the continuous and discrete communication

					channels using input, output and joint probabilities
		Seminar	5	6	Seminar on coding channels source
		Essay			
		Project		6-11	
	Quiz		8	Every week	Weekly outcomes
	Every week reports		10	Over all weeks	
	Midterm Exam		25	12	
	Final Exam		40	15	All the outcomes
	Total		100		
Specific learning outcome:	• After studying this course, students will be able to: 1. Explain concept of dependent and independent source, measure of information, Entropy, Rate of information and order of a source 2. Represent the information using Shannon Encoding, Shannon Fano, Prefix and Huffman Encoding Algorithms 3. Model the continuous and discrete communication channels using input, output and joint probabilities 4. Determine a codeword comprising of the check bits computed using Linear block codes, cyclic codes and convolutional codes 5. Design the encoding and decoding circuits for linear block codes, cyclic codes, convolutional codes, convolutional codes, BCH and Golay codes				
Course References:	**Text book:** 1. Digital and Analog Communication systems.K.Sam SAhanmugam, John Wiley India Pvt. Ltd, 1996 2. Digital Communication, Simon Haykin, John Wiley India Pvt. Ltd, 2008 **Reference Books:** 1. ITC and Cryptography, Ranjan Bose, TMH, II edition, 2007 2.Principles of Digital Commuincation, J.Das, S.K. Mullick, P.KChatterjee, Wiley, 1986-Technology and Engineering 3. Digital Communication- Fundementals and Applications, Bernard Sklar, second edition, Person Education, 2016, ISBN:9780134724058. 4. Information theory and coding, HariBhat, Ganesh Rao, Cengage, 2017. 5. Error Correction Coding, Todd KMoon, Wiley Std. Edition				

Course topics (Theory)	Week	Learning Outcome
Information Theory: Introduction, Measure of information, Information content of message, Average Information content of symbols in Long Independent sequences, Average Information content of symbols in Long dependent sequences, Markov Statistical Model for Information Sources, Entropy and Information rate of Markoff Sources	1,2	Introduction to information theory, measurement, information content of messages and statistical model for information source
Source Coding: Encoding of the Source Output, Shannon's Encoding Algorithm, Shannon Fano Encoding Algorithm Source coding theorem, Prefix Codes, Kraft McMillan Inequality property — KMI, Huffman codes	3,4	Understanding encoding of source output, Shannon's encoding and source coding theorem
Information Channels: Communication Channels, Discrete Communication channels Channel Matrix, Joint probability Matrix, Binary Symmetric Channel, System Entropies. Mutual Information, Channel Capacity, Channel Capacity of Binary Symmetric Channel and Binary Erasure Channel, Muroga's Theorem	5,6	Understanding communication channels, discrete communication channel matrix and binary symmetric channel
Error Control Coding: Introduction, Examples of Error control coding, methods of Controlling Errors, Types of Errors, types of Codes, Linear Block Codes: matrix description of Linear Block Codes, Error detection & Correction capabilities of Linear Block Codes, Single error correction Hamming code, Table lookup Decoding using Standard Array	7,8	Introduction and examples of error control coding, methods of controlling errors, types of error and codes, linear block codes and error detection and correction.
Binary Cyclic Codes: Algebraic Structure of Cyclic Codes, Encoding using an (n-k) Bit Shift register, Syndrome Calculation, Error Detection and Correction	9,10	Understanding principles of binary cyclic codes and calculation of error detection and correction
Convolution Codes: Convolution Encoder, Time domain approach, Transform domain approach, Code Tree, Trellis and State Diagram, The Viterbi Algorithm	11,12	Understanding the convolution encoding, Time domain approach and transform of domain approach Code tree, trellis
Practical Topics	**Week**	**Learning Outcome**

Extra notes:

Find the amount of information gained by observing the source emitting each of these symbols and also the entropy of source.

∴ The self-information "I_k" is given by

$$I_k = \log_2 \frac{1}{P_k} \text{ bits} \quad \text{——— (1)}$$

Since we have four symbols, so K = 0, 1, 2, 3

∴ when K=0, $I_0 = \log_2 \frac{1}{P_0} = \log_2 \frac{1}{0.4} = 1.322$ bits

K=1, $I_1 = \log_2 1/P_1 = \log_2 1/0.3 = 1.737$ bits

K=2, $I_2 = \log_2 1/P_2 = \log_2 1/0.2 = 2.322$ bits

K=3, $I_3 = \log_2 1/P_3 = \log_2 1/0.1 = 3.322$ bits

The entropy of the source is given by,

$$H(X) = \sum_{K=0}^{3} P_K \log \frac{1}{P_K} \text{ bits/msg symbol}$$

$$= \sum_{K=0}^{3} P_K I_K \qquad \because I_K = \log \frac{1}{P_K}$$

$$= P_0 I_0 + P_1 I_1 + P_2 I_2 + P_3 I_3$$

$$= 0.4(1.322) + 0.3(1.737) + 0.2(2.322) + 0.1(3.322$$

∴ $\boxed{H(X) = 1.8465 \text{ bits/msg symbol}}$

Consider a source $S = \{S_1, S_2, S_3\}$ with $P = \{1/2, 1/4, 1/4\}$

Find (a) Self Information of each message

(b) Entropy of source 'S'.

a) Self Information of $S_1 = I_1 = \log_2 \frac{1}{P_1} = \log_2 2 = 1$ bits

self Information of $S_2 = I_2 = \log_2 \frac{1}{P_2} = \log_2 4 = 2$ bits

self Information of $S_3 = I_3 = \log_2 \frac{1}{P_3} = \log_2 4 = 2$ bits

b). Average Information content or Entropy is given by,

$$H(S) = \sum_{i=1}^{3} P_i I_i = P_1 I_1 + P_2 I_2 + P_3 I_3$$

$$= \left(\frac{1}{2}\right)(1) + \frac{1}{4}(2) + \frac{1}{4}(2)$$

$$\therefore \boxed{H(S) = 1.5 \text{ bits/msg symbol}}$$

External Evaluator

1-The course book of communication system is completely related to the syllabus of information theory and coding system, the course catalogue satisfies the goal of information theory and coding subject.

Lecturer: Jabbar Majeed Sadeq