California State University Stanislaus
Department of Computer Science
Syllabus

Instructor: Dr. Xuejun Liang

My Office: DBH 282
Office Hours: M 2:00 pm-3:00 pm & WF 10:00 am-11:00 am (ZOOM Meeting ID: 4438930033)
Phone: (209) 667-3169, Email: xliang@csustan.edu

Class Information:

Classroom: Bizzini 117
Class Date & Time: MWF 11:00 a.m.-11:50 a.m.
Class Website: https://www.cs.csustan.edu/~xliang/Courses2/CS4450-24S

Hybrid Online - Synchronous. In-person class meetings will be on campus at the room, day, and time listed. Online class meetings will be at the day and time listed. Students must be available at the class times listed in the Class Schedule and must attend in person on days indicated as such by the instructor. Students do not have the option to choose in-person or virtual, nor opt for asynchronous participation.

Catalog Description:

CS4450 Coding and Information Theory. (3 Hours) Pre-requisites: CS 3100 and MATH 2300. Topics to be selected from error detecting and correcting codes, encryption and decryption techniques, RSA and knapsack codes, algebraic coding theory, Hamming distance, sphere packing and its relation to optimal codes, Hamming, Huffman and Gray codes, entropy, channel capacity and Shannon's theorem, bandwidth and the sampling theorem.

Textbook:

Information and Coding Theory, by Gareth A. Jones and J. Mary Jones, Springer, 2000, ISBN 978-1-85233-622-6

Reference Books:

Information Theory, Coding and Cryptography, by Arijit Saha, Nilotpal Manna, Mandal, Pearson India, 2013, Print ISBN-13: 978-81-317-9749-5, Web ISBN-13: 978-93-325-1785-1

Course Goals/Objectives

To give students a rigorous mathematical study of the fundamentals of coding methods (including encryption and decryption, error detection and correction, optimal codes) and information theory (including the idea of information, channels, channel capacity, information entropy, and sampling theory), and to prepare students to make sense of current research papers in coding and information theory and cryptography.

Course Outcomes

Students who successfully complete the course should be able to

1. Determine whether a given code can be decoded uniquely or is instantaneous, construct instantaneous codes, including Huffman code for a source or an extension of a source, and compute the average word length.
2. Describe the concept of Entropy and the meaning of Shannon's First Theorem, compute Entropy for a source, extension, and products, and compute word lengths for Shannon-Fane codes.
3. Describe the concepts and definitions of information channel, system entropies (input entropy, output entropy, equivocation, and join entropy), mutual information, and channel capacity, and apply them to BSC and BEC.
4. Describe Shannon's fundamental theorem, apply the ideal observer rule, the maximum likelihood rule, and the nearest neighbor decoding to BSC and BEC, and compute Pr_E and Pr_C
5. Compute the (extended) Hamming code, Hamming's sphere-packing bound, and the Gilbert-Varshamov Bound, and construct a Hadamard matrix and its corresponding codes.
6. Compute the generator matrix and parity-check matrix (in systematic form) of a linear code and the minimum distance of a linear code. Calculate with the Hamming Codes, the Golay Codes and the Standard Array.

Course Outline* (Major Topics and Weekly Schedule)

Date	Topics Covered
Week 1: 01/26	Introduce the class, Important notification to the class, get familiar with the course syllabus, course materials, and learning environments.
Week 2: 01/29, 01/31, 02/02	Overview of Probability: Fundamentals of Probability including Total Probability and Bayes Theorem. Random Variables and its Characteristics, and Statistical Averages.
Week 3: 02/05, 02/07, 02/09	Mathematical Fundamentals: Modular Arithmetic, Groups, Field, Extension Field, Linear (vector) space, Subspace and Linearly independent, Basis and Dimension, Orthogonality and Dual Space.
Week 4: 02/12, 02/14, 02/16	Mathematical Fundamentals: Matrix, Rank of a matrix, Elementary row operations of a matrix, Matrix operations and group of linear equations Test #1 (Overview of Probability and Mathematical Fundamentals)
Week 5: 02/19, 02/21, 2/23	Overview of coding and information theory. Definitions and examples of codes. Uniquely Decodable Codes, Instantaneous Codes, Constructing Instantaneous Codes, Kraft's Inequality, McMillan's Inequality, Comments on Kraft's and McMillan's Inequalities
Week 6: 02/26, 02/28, 03/01	Code Optimality. Binary Huffman Codes. Average Word-length of Huffman Codes. Optimality of Binary Huffman Codes. r-ary Huffman Codes. Extensions of Sources
Week 7: 03/04, 03/06, 03/08	Test #2 (Chapter 1 and 2) Information and Entropy, Properties of the Entropy Function
Week 8:	Entropy and Average Word-length, Shannon-Fane Coding. Shannon-

03/11, 03/13, 03/15	Fane Coding examples, Entropy of Extensions and Products, Shannon's First Theorem and its Example
Week 9: 03/18, 03/20, 03/22	Information Channel Notation and Definitions: Channel Matrix, Channel Relationship, and Bayes' Formula The Binary Symmetric Channel. System Entropies. System Entropies for the Binary Symmetric Channel
Week 10: 03/25, 03/27, 03/29	Extension of Shannon's First Theorem to Information Channels. Mutual Information. Mutual Information for the Binary Symmetric Channel. Channel Capacity Test #3 (Chapter 3 and 4)
	String Break
Week 11: 04/08, 04/10, 04/12	Using an Unreliable Channel: Decision Rules. An Example of Improved Reliability. Hamming Distance. Statement and Outline Proof of Shannon's Theorem. The Converse of Shannon's Theorem
Week 12: 04/15, 04/17, 04/19	Error-correcting Codes: Introductory Concepts (Galois field, Linear Code, Rate of a code). Examples of Codes. Minimum Distance.
Week 13: 04/22, 04/24, 04/26	Error-correcting Codes: Hamming's Sphere-packing Bound. The Gilbert-Varshamov Bound. Test #4 (Chapter 5 and 6)
Week 14: 04/29, 05/01, 05/03	Matrix Description of Linear Code: Dual Code and Orthogonal Code, Equivalence of Linear Codes: Generator matrix and Parity-check matrix, The Singleton Bound.
Week 15: 05/06, 05/08, 05/10	Minimum Distance of Linear Codes. A sufficient and necessary condition for a t-error-correcting linear code. Perfect Hamming code, Standard array of a linear code. Syndrome Decoding, Syndrome Table. Test #5 (Chapter 7)
Week 16: 05/13, 05/15	Review for the final examination
Week 17:	Final Examination Schedule https://www.csustan.edu/class-schedule/finals-schedule

*It is subject to change.

Grading Scale

Grading Scale will be assigned on a standard scale as below. Clustering of grades may cause the grading scale to be lowered (to your benefit), but it will not be raised.

A	B	C	D	F
90-100	75-89	60-74	45-59	<45

Evaluation:

The overall course grade will be the weighted sum of the points earned in the following categories:

Homework	Tests	Final Exam
20%	50%	30%

Other Polices:

1. I will accept the homework assignments late for maximum three days (including holidays) with the point deduction 20% per day.
2. There will be no makeup tests except in a verified emergency with immediate notification.

Academic Honesty:

The work you do for this course will be your own, unless otherwise specified. You are not to submit other people's or machine's work and represent it as your own. I consider academic honesty to be at the core of the University's activities in education and research. Academic honesty is always expected in this course.

Accommodations for Students with Disabilities

Students with disabilities seeking academic accommodations must first register with the Disability Resource Services (DRS) program, located in MSR 210, ph. (209) 667-3159. Students are encouraged to talk with the instructor regarding their accommodation needs after registering with DRS.