EE 646
Advanced Information Theory

Instructor:
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Textbook:
Thomas M. Cover and Joy A. Thomas: "Elements of Information Theory," 2nd edition, Wiley-Interscience, 2006.

Additional reading:
Robert G. Gallager: "Information Theory and Reliable Communication," John Wiley, 1968.
Raymond W. Yeung: "A First Course in Information Theory," Kluwer, 2002.
Abbas El Gamal and Young-Han Kim: "Network Information Theory," Cambridge University Press, 2012.

Prerequisites
Probability Theory.

Course contents:
Information theory was founded by Claude Shannon in his groundbreaking 1948 paper "The mathematical theory of communications." In that paper he proved, surprisingly, that it is theoretically possible to communicate over a noisy communication link without *any* error and at a finite rate (bits/s), and he found the maximum rate at which zero-error communication is possible, called the channel capacity. This result has been driving the revolution in digital communications we have seen since – it took around 50 years to find practical implementations of Shannon's theoretical result. He also considered the question of how many bits it takes to represent information and thereby founded the whole field of data compression that is behind modern inventions like Zip-files, MP3, and MPEG.

The first part of the class considers these classical results based on Cover and Thomas' book.

While Shannon already solved the direct link communications problem in 1948, i.e., found the channel capacity, results for channels with multiple terminals are scarce, both when it comes to channel capacity and compression. This area, under the broad topic network information theory, is where currently much research is going on.

The second part of the class considers network information theory based on both Cover and Thomas' book and current research papers.

Lectures
MWF 8:30-9:20.

Office hours:
MWF 12:30-1:30

Grading:
Presentations	10%
Homework (once per week):	20%.
Midterm:	30%.
Final:	40%

Course Schedule

The schedule is only a guideline – count on some changes during the semester

Week	Date	Lesson	Topic	Textbook
1	1.13	1	Introduction	Ch. 1
	1.15	2	Entropy	2.1-2.3
	1.17	3	Mutual Information	2.4-2.5
2	1.20	Martin Luther King day, no class		
	1.22	4	Jensen's inequality	2.6
	1.24	5	The log-sum inequality	2.7-2.9
3	1.27	6	Fano's inequality	2.10
	1.29	7	The AEP	Ch. 3
	1.31	8	Entropy rate	4.1-4.2
4	2.3	9	Entropy rate	4.3-4.5
	2.5	10	Data compression	5.1-5.2
	2.7	11	Optimal codes	5.3-5.5
5	2.10	12	Huffman codes	5.6-5.8
	2.12	13	Shannon coding	5.9-5.10
	2.14	14	Shannon coding	5.11
6	2.17	President's day; no class		
	2.19	15	Channel capacity	7.1-7.3
	2.21	16	Joint typicality	7.4-7.6
7	2.24	17	Achievability of channel capacity	7.7-7.8
	2.26	18	Converse	7.9-7.10
	2.28	19	Feedback capacity	7.11-7.12
8	3.3	20	Source-channel coding	7.13
	3.5	21	Differential entropy	8.1-8.3
	3.7	22	Differential entropy	8.4-8.6
9	3.10	23	Achievability of Gaussian channel capacity	9.1
	3.12	Midterm		
	3.14	24	Converse	9.2-9.3
10	3.17	25	Parallel Gaussian channels	9.4-9.5
	3.19	26	MIMO channels; Feedback capacity	9.6
	3.21	27	Rate distortion theory	10.1-10.2
11	3.24			
	3.26	Spring break.		
	3.28			
12	3.31	28	Calculation of rate distortion	10.3
	4.2	29	Proof of rate-distortion	10.4-10.5
	4.4	30	Proof of rate-distortion	10.6-10.7
13	4.7	31	Universal source coding	13.1-13.2
	4.9	32	Arithmetic coding	13.3
	4.11	33	Lempel-Ziv	13.4
14	4.14	34	Optimality of LZ	13.5
	4.16	35	Optimality of LZ	13.5
	4.18	Good Friday; no class		
15	4.21	36	Network information theory; Student presentations	Papers
	4.23	37	Network information theory; Student presentations	Papers
	4.25	38	Network information theory; Student presentations	Papers
16	4.28	39	Network information theory; Student presentations	Papers
	4.30	40	Network information theory; Student presentations	Papers
	5.2	41	Network information theory; Student presentations	Papers
17	5.5	42	Network information theory; Student presentations	Papers
	5.7	43	Network information theory; Student presentations	Papers
	5.9	Study days; no class		