University of Southern California

Department of Electrical Engineering

Course Number & Title: EE565 Information Theory and Compression
Units: 3
Semester and time: Spring 2016 – 2:00-3:20pm MW
Location: OHE136
Instructor: Prof. Salman Avestimehr
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Office hours: 12-2pm Wednesdays
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Catalogue Description: Entropy and mutual information. Variable and fixed-length, lossless and lossy compression. Universal compression. Text and multimedia compression. Channel capacity. Error-correcting codes. Erasure and Gaussian channels.

Course Description: Information theory answers two fundamental questions in communication and compression theories: What is the ultimate data compression (answer: the entropy H), and what is the ultimate transmission rate of communication (answer: the channel capacity C). This course covers fundamental theories and practical algorithms for both data compression and reliable communication. It includes the following topics: Entropy and other information measures. Variable and fixed-length lossless and lossy source codes. Universal compression. Applications to text and multimedia compression. Channel capacity and channel coding theorem. Error-correcting codes and real channels. Applications to erasure channels and Gaussian channels.

Learning Objectives: EE565 is designed as the entry point for graduate studies in information theory at the Viterbi School of Engineering at USC. At the completion of the subject, students will have mastered basic concepts and tools in information theory, and will be able to analyze a wide range of problems in data compression and data communication over noisy channels. They will also be able to design algorithms for data compression, and design error correction codes for data communication.

Prerequisites: EE 464 or EE 465 or EE 503.

Required Textbook:

1) T. M. Cover and J. A. Thomas, *Elements of Information Theory*, Wiley, 2nd ed, 2006.

Recommended Textbooks:

1) Information Theory, Inference, and Learning Algorithms by David J. C. MacKay. Cambridge, 2003.
2) A First Course in Information Theory by Raymond W. Yeung. Springer, 2002.
3) R. G. Gallager, *Principles of Digital Communication*, Cambridge University Press, 2008.

Grading:

- Homework (25%). Assigned weekly (approximately 10 assignments), due the following week by 5pm. No late papers will be accepted.
- Midterm exam (30%). It will be on Wednesday February 24th from 2-4pm.
- Final exam (35%).
- Project (10%). The project will be assigned by the instructor after the midterm exam, and it will be due on the last lecture. For the project, the students will be asked to design and implement a compression algorithm for a given text file. The deliverables are (1) the MATLAB code and (2) a report describing the implemented compression algorithm. The grade will be based on (1) compression rate achieved by the proposed algorithm (80% of the project grade) and (2) clarity and detail of the project report (20% of the project grade). The students should work on the project individually.

Project Description:

Course project: the purpose of the class project is for you to learn hands-on experience of data compression. For the project, the students will be asked to design and implement a compression algorithm for a given text file. The deliverables are (1) the MATLAB code and (2) a report describing the implemented compression algorithm.

Project timeline: The project will be assigned by the instructor after the midterm exam (on week 8 of the class). The deliverables are (1) the MATLAB code and (2) a report describing the implemented compression algorithm, which will both be due on Week 15 of the class.

Grading breakdown of the course project: The grade will be based on (1) compression rate achieved by the proposed algorithm (80% of the project grade) and (2) clarity and detail of the project report (20% of the project grade).

Tentative Weekly Schedule:

Date	Topic	Reading
Week 1	Basic information measures.	
	HW1 assigned.	2.1–2.3
Week 2	Properties of information measures. Typicality.	
	HW1 due. HW2 assigned.	2.4–2.9. 3.1–3.3.
Week 3	Lossless compression, Huffman coding.	
	HW2 due. HW3 assigned.	5.1–5.8
Week 4	Universal compression and connections with learning, entropy rate,	
	Compression of stationary sources. HW3 due. HW4 assigned.	13.1–13.2
Week 5	Algorithms: Arithmetic coding, Lempel-Ziv, Burrows-Wheeler	
Transform.	HW4 due. HW5 assigned.	13.3 – 13.5
Week 6	Binning, and Slepian-Wolf coding.	
	HW5 due. HW6 assigned.	15.4, 15.8.
Week 7	Point-to-point communication channels. Channel capacity.	
	HW6 due.	7.1–7.7
Week 8	Midterm exam. Channel coding theorem for DMC.	7.8–7.10
	Project assigned.	
Week 9	Examples of error-correcting codes and decoding algorithms.	
	HW7 assigned.	7.11
Week 10	Differential entropy and channel coding theorem for Gaussian	
channels.	HW7 due. HW8 assigned.	8.1–8.6, 9.1–9.2
Week 11	Bandlimited channels and parallel channels.	
	HW8 due. HW9 assigned.	9.3–9.4
Week 12	Feedback. HW9 due. HW10 assigned.	7.12, 7.13, 9.6
Week 13	Multiple-access channels. HW10 due. HW11 assigned	15.3
Week 14	Broadcast channels. HW11 due	15.6
Week 15	Introduction to some of current research topics in information theory.	
	Project Due.	
Final Exam	For the date and time of the final for this class, consult the USC	
	Schedule of Classes at www.usc.edu/soc.	

Statement on Academic Conduct and Support Systems:

Academic Conduct

Plagiarism – presenting someone elses ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Section 11, Behavior Violating University Standards https://scampus.usc.edu/1100-behavior-violating-university-standards-and-appropriate-sanctions/. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct/. Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the Office of Equity and Diversity http://equity.usc.edu/ or to the Department of Public Safety http://capsnet.usc.edu/department/department-public-safety/online-forms/contact-us. This is important for the safety whole USC community. Another member of the university community – such as a friend, classmate, advisor, or faculty member – can help initiate the report, or can initiate the report on behalf of another person. The Center for Women and Men http://www.usc.edu/student-affairs/cwm/ provides 24/7 confidential support, and the sexual assault resource center webpage sarc@usc.edu describes reporting options and other resources.

Support Systems

A number of USCs schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the American Language Institute http://dornsife.usc.edu/ali, which sponsors courses and workshops specifically for international graduate students. The Office of Disability Services and Programs http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html provides certification for students with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, USC Emergency Information http://emergency.usc.edu/ will provide safety and other updates, including ways in which instruction will be continued by means of blackboard, teleconferencing, and other technology.