ECE 642
Information Theory and Source Coding

Prof. Mark R. Bell

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ECE642 Information Theory and Source Coding
Fall 2017

Mark R. Bell
MSEE 336

Course Information

Instructor: Prof. Mark R. Bell
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Office Hours: T: 11:00–noon, Th: 2:00–3:00pm, or by appointment.

Text: T. M. Cover and J. A. Thomas, *Elements of Information Theory*, 2nd Edition, Wiley, 2006. In addition, there will be several papers handed out during the course, particularly for the information on source coding.

Grading Policy: There will be two mid-terms worth 25% of the final grade each, a final exam worth 40% of the final grade, and homework worth 10% of the final grade. Homework will be collected and spot checked, but not graded in detail. Solutions will however be available. In cases of borderline grades, homework will be scrutinized to determine the final course grade. For this reason, I recommend you make a copy of your homework before handing it in, as homework will not be returned until after the final exam.

Homework Collaboration Policy: I allow and encourage collaboration on the homework. However, I expect you to write up your own solutions and understand what you hand in.

Course Outline: A brief outline of the course is as follows:

1. Introduction and Mathematical Preliminaries
2. Noiseless Source Coding
3. Channel Coding Theorem for Discrete Memoryless Channels
4. Channel Coding Theorem for the Gaussian Channel
5. Source Coding with a Fidelity Criterion (Rate Distortion Theory).
6. Source-Channel Coding Theorems.
7. Source Coding Techniques.

Additional References: A number of additional books will be put on reserve in the Potter Engineering Library. These include:

1. R. G. Gallager, *Information Theory and Reliable Communication*, Wiley, 1968.
2. R. J. McEliece, *The Theory of Information and Coding*, Addison-Wesley, 1977.
3. R. Ash, *Information Theory*, Wiley, 1965.
4. R. Blahut, *Principles and Practice of Information Theory*, Addison-Wesley, 1987.
5. N. S. Jayant and P. Noll, *Digital Coding of Waveforms*, Prentice-Hall, 1984.
6. A. Gersho and R. M. Gray, *Vector Quantization and Signal Compression*, Kluwer, 1992.
7. D. J. C. MacKay, *Information Theory, Inference, and Learning Algorithms*, Cambridge, 2003. (http://www.inference.phy.cam.ac.uk/mackay/itila/book.html)

Skype Office Hours: This semester, I am on medicine that makes me immunocompromised. Because of this, catching a cold or other illness could be a significant problem. For this reason, I will be holding office hours using Skype and a document camera during office hours. Hopefully this will be every bit as effective as standard office hours. Thank you for your understanding with this issue.

ECE 642: Information Theory and Source Coding

- Prerequisite: ECE 600
- Tools:
  - Probability and Random Variables
  - Basic Analysis (limits, convex functions, etc.)
  - Some mathematical sophistication (proofs)
  - A little combinatorics

ECE 642: Information Theory and Source Coding

- Text: Cover and Thomas, *Elements of Information Theory,* 2nd Ed., Wiley, 2006.
- (The first edition can also be used.)
- We will take material from other books and papers.
- The book gives a very broad and up-to-date coverage of information theory and its application areas.

- Course Title: *Information Theory* and *Source Coding*
  Part 1 of course — Part 2 of Course
- Information theory is the primary tool for the theoretical analysis of source coding.
- What is Information Theory?

  "The fundamental problem of communication is that of reproducing at one point either exactly or approximately a message selected at another point." — *C.E. Shannon*
- *A/The Mathematical Theory of Communication* — Shannon

- Information Theory does many things:
  - It describes how to measure information (as a quantity)
  - It provides bounds on achievable rates of communication in the presence of noise
  - It provides bounds on the minimum amount of information required to represent an *information source*
  - *It is **not** a constructive theory*. It does not tell you how to (practically) construct codes that achieve the capacity of a channel, but it does supply some hints.

1.1

Information theory does not consider the meaning of information

- It deals with the amount of information

$\Rightarrow$ I.T. deals with carriers of information.

1.2

History: I.T. was developed by Claude E. Shannon.

C.E. Shannon:
- Born in Petoskey, MI in 1916.
- Died Feb. 24, 2001

- Undergrad EE & Math U-M, 1936
- Ph.D Math (Genetics) MIT 1940

- In 1948, Shannon published "A Mathematical Theory of Communication" in BSTJ
- In 1949, reprinted in book form as "The Mathematical Theory of Communication"

Shannon went on to publish a few more papers on I.T., each of which introduced something fundamental.

(n.b. MIT M.S. Thesis on relay logic circuits and Boolean Algebra
- "The most important M.S. Thesis in History"

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