ECE 642
Information Theory and Source Coding

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Course Information

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Office Hours: T: 2:00–3:00pm, Th: 11:30am–12:30pm, 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:

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

- (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/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.

A Typical Communication System

1. **Source**: Origin of information to be communicated
   (e.g., voice, images, computer data, DNA sequences, physical measurements, etc.)
③ **Channel**: Physical Medium across which information must be transferred.

(e.g., microwave link, optical fiber, free-space (MW or optical), magnetic storage medium (disk or tape), optical storage medium (CD or DVD), phonograph record, telephone line, thin-cane telephone string, etc.)

⑤ **Destination (Sink, user)**: This is where the information is used.
(Could be CRT/display, human visual system, human ear, computer system, etc.)
(2) **Encoder**: Provides necessary processing (coding) of source output before transmission through channel.

"Matches source to channel"

**Example**: Suppose you have a source that produces a message using a 4-letter alphabet and you want to send it over binary channel.

\[
\text{Source} \rightarrow \text{Encoder} \rightarrow \begin{align*}
a_1 & \rightarrow 0 \\
a_2 & \rightarrow 10 \\
a_3 & \rightarrow 110 \\
a_4 & \rightarrow 111
\end{align*}
\]

(4) **Decoder**: Processes the channel output with the goal of producing an "acceptable" replica of the source output.
Sometimes the encoder and decoder are broken into two parts (each)

We will see that we can always do this decomposition and still achieve optimal performance if we encode in large blocks (asymptotically).