APMA 1710: Information Theory

Brown University, Fall 2011

The fundamental problem of information theory is *efficient* and *reliable* communication of messages from a source to a destination. Efficient communication requires compression, and reliable communication over a noisy channel requires error-correction. Overcoming these problems is essential to making modern communications possible — phones, computers, televisions, cameras, CDs, DVDs, Blu-ray, satellites, gaming devices, wired and wireless Internet, even barcodes — all of these rely on compression and/or error-correction algorithms. This course explores both the theoretical and practical aspects of information theory and coding. We will answer the theoretical questions: *How much compression is possible for a given source? What is the highest rate of transmission one can obtain for a given channel, and still have arbitrarily small error?* Further, we will look at state-of-the-art algorithms for compression and error-correction coding.

Prerequisites: Comfort with probability, calculus, and computer programming.

Introduction

The goal of this class is to introduce you to the ideas and techniques of information theory and coding. Many of these ideas have their origin in Claude Shannon's stunning 1948 paper, "A Mathematical Theory of Communication," in which he raised and answered most of the theoretical questions of information theory. However, it would take several decades for practical algorithms to start to come close to the limits of what Shannon proved was possible in theory. In only the last 10-20 years, revolutionary breakthroughs in coding theory have occurred, and modern techniques are approaching the limits of optimality.

Administrative Information

Class Time/Location:

The class will meet Monday, Wednesday, and Friday at 11:00 am - 11:50 am, in Wilson 304.

Instructor:

Jeff Miller (jeffrey_miller@brown.edu)

Office Hours: Monday 1:00-2:30pm, 180 George St., Room 102A

Teaching assistant:

Reza Aghajani (mohammadreza_aghajani@brown.edu)

Grading

Overall grades will be determined as follows:
60% homeworks, 15% midterm, 20% final, 5% class participation.

Course website

See the course website at
`http://www.dam.brown.edu/people/jmiller/IC/`
for more information.

Outline of topics for the course:

COMPRESSION

- Symbol codes, Kraft-McMillan inequality
- Source coding theorem
- Huffman codes
- Arithmetic coding

FUNDAMENTALS

- Entropy
- Related quantities (e.g. relative entropy, mutual information), and their properties
- Inequalities

TYPICALITY

- Typicality and the AEP
- Joint typicality

ERROR-CORRECTION (THEORY)

- Repetition codes, Hamming (7,4) code
- Channels and Channel capacity
- Channel coding theorem

ERROR-CORRECTION (METHODS)

- Linear codes, Hamming codes
- Gallager (LDPC) codes
- Fountain codes

RATE-DISTORTION THEORY

- Rate-distortion theorem