

ECGR 6090/8090: Information Theory and Applications
(cross-list: ITCS 6165/8165)

Instructor: Prof. Ahmed Arafa, Spring 2022

What is information? Can it be measured? How can we store it and transfer it efficiently with quality guarantees?

This course provides answers to the above questions by introducing the **science of information** along with its current and emerging applications. This branch of science has been first introduced by [Claude E. Shannon](#) in his widely celebrated 1948 paper: **A Mathematical Theory for Communication**, and has since evolved tremendously over the years. Owing to its generic mathematical treatments, it has a wide range of applications in engineering, statistics, mathematics and computer science.

The course will be divided into two main parts:

1. ($\sim 2/3$ of classes) **Elements of information theory:**
Information measures and inequalities;
Source coding & compression;
Channel coding & capacity;
Rate-distortion & quantization;
(time-permitting) Network information theory.
2. (\sim final $1/3$ of classes) **Applications:** (these are some examples)
Information-theoretic Security;
Private Information Retrieval;
Caching Systems;
Information Theory in Machine Learning;
Low Latency Communications.

Part 1 will be covered in a fairly accessible way to most students; it will also include a review of probability and random variables. Students will be divided into groups to conduct a research project on selected topics from Part 2.

- Grading: homework (25%); 1 exam (25%); class participation (10%); research project (40%).
- Prerequisites: probability & random variables + a taste for mathematical reasoning.
- Reference: Thomas M. Cover and Joy A. Thomas, *Elements of Information Theory*, Wiley, 2nd edition, 2006, ISBN: 978-1118324561.
- **Who should take this class?** communication engineers interested in efficient communication system design; computer scientists interested in variant views of privacy & security; data scientists interested in information measures; people interested in mathematical beauty.
- Videos:
[The Bit Player](#) (A movie about Shannon.)
[IEEE Information Theory Society's Great Papers Series](#) (Visual illustrations of some of the impactful results that Information Theory has brought to our world.)