CS258: Information Theory

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http://www.cs.sjtu.edu.cn/~chengfan/
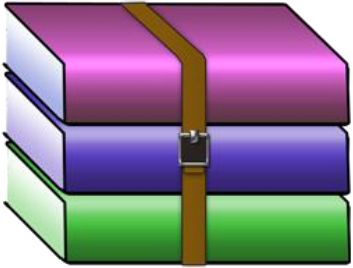chengfan@sjtu.edu.cn
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群名称：2020信息论
群　　号：980176094

Outline

- ☐ Course Motivations
- ☐ Course Syllabus
- ☐ Prerequisites
- ☐ Course Schedule

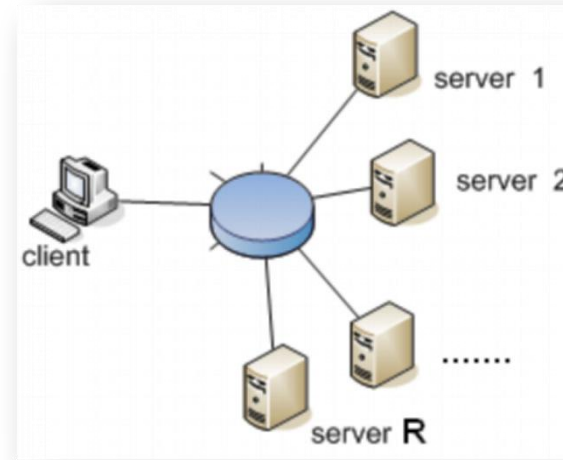# Data Compression

What's the limit of data compression tools?
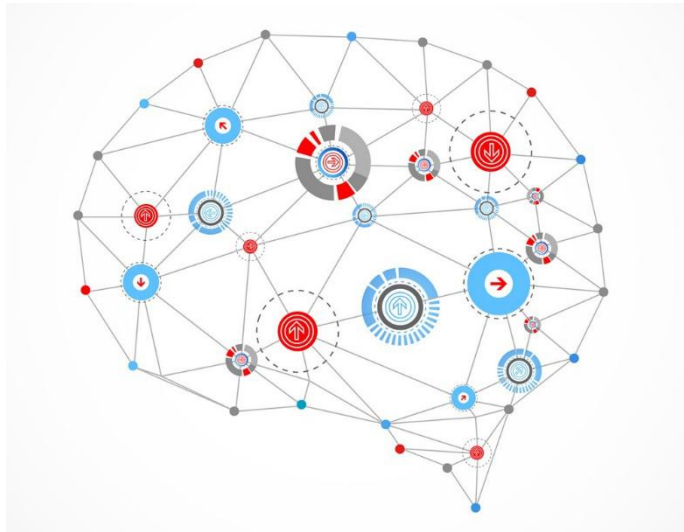
What's the difference of video formats?

Big Data

Data **redundancy** and **efficiency**?


Can we recover it?

Machine Learning

Information Theory concepts in Deep Learning (AI)

- ☐ Popular cross-entropy loss function
- ☐ Building decision trees on basis of maximum information gain
- ☐ Viterbi algorithm widely used in NLP and Speech
- ☐ Concept of encoder-decoder popularly used in Machine Translation RNNs and various other type of models
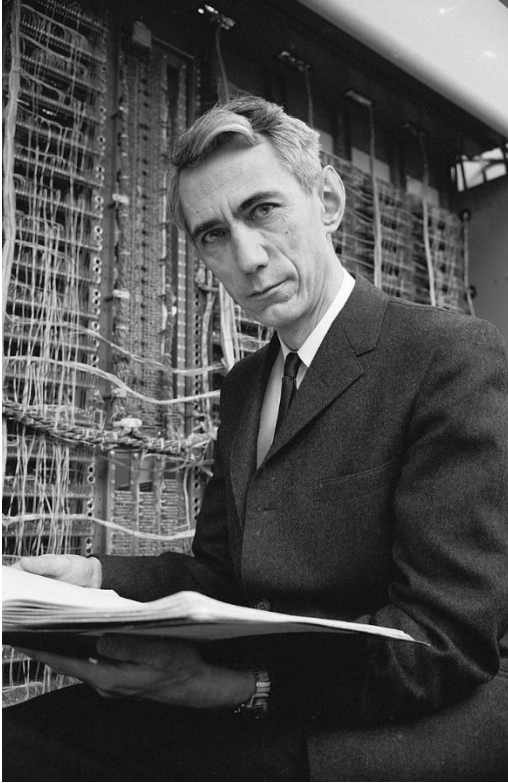
Security
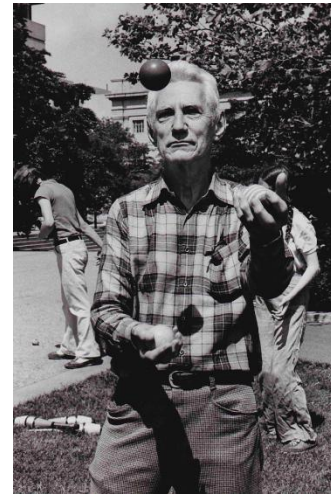
I have a secret to share...
However ...
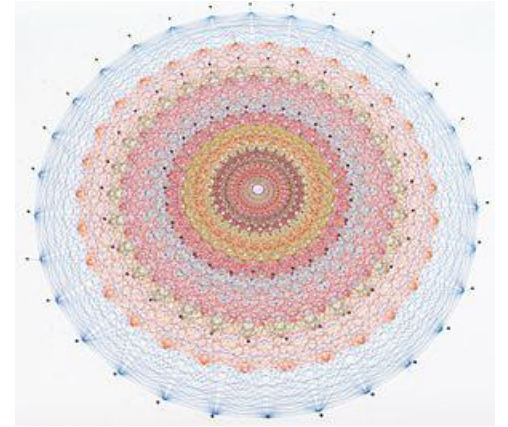
All you need is information theory

C. E. Shannon

Unicycling

Juggling

Magnetic mouse

Claude. E. Shannon (1916-2001)
https://en.wikipedia.org/wiki/Claude_Shannon

C. E. Shannon: father of information

- ✓ Mathematician
  - ✓ Ph.D. in Mathematics from MIT. Worked at AT&T Bell Labs and RLE in MIT
- ✓ Electrical engineer
  - ✓ Mater's Thesis: electrical applications of Boolean algebra could construct
    any logical, numerical relationship
- ✓ Cryptographer
  - ✓ "A Mathematical Theory of Cryptography," 1949.
- ✓ Friend of Turing
   For two months early in 1943, Shannon came into contact with the leading
    British mathematician Alan Turing. Shannon and Turing met at teatime in the
    cafeteria. Turing showed Shannon his 1936 paper that defined what is now
    known as the "Universal Turing machine"

Advent of Information Theory

C. E. Shannon, "A Mathematical Theory of Communication," Bell System Technical Journal, 27 (3): 379–423, July, 1948.
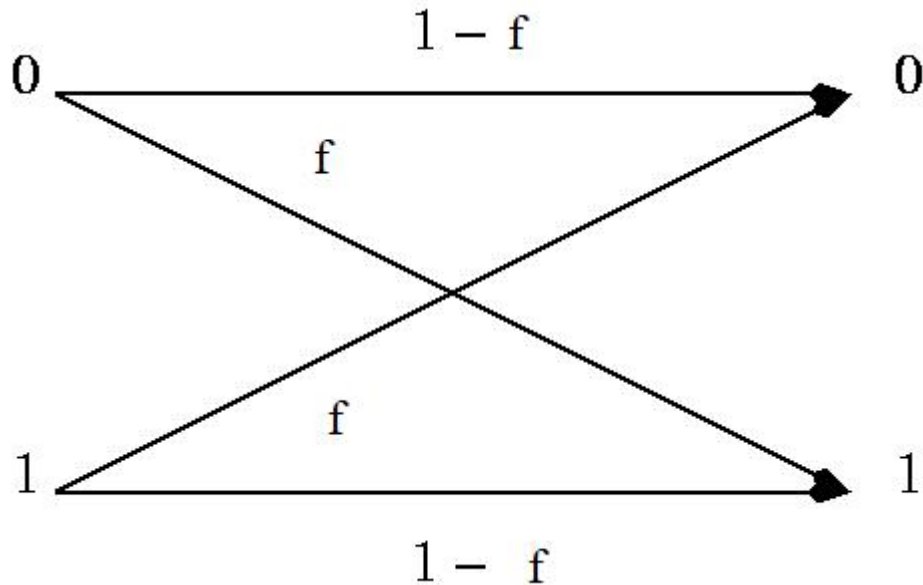
The **fundamental problem** of communication is that of reproducing at one point either exactly or approximately a message selected at another point.

C. E. Shannon, 1948

Topics in IT

Big Data Analytics
Coding for Communication and Storage
Coding Theory
Combinatorics and Information Theory
Communication Theory
Complexity and Computation Theory
Compressed Sensing and Sparsity
Cryptography and Security

Detection and Estimation
Distributed Storage
Emerging Applications of Information Theory
Information Theory and Statistics
Information Theory in Biology
Information Theory in Computer Science
Statistical/Machine Learning
Network Coding and Applications

Network Data Analysis
Network Information Theory
Optical Communication
Quantum Information and Coding Theory
Shannon Theory
Signal Processing
Source Coding and Data Compression
Wireless Communication and Networks

IT with other fields
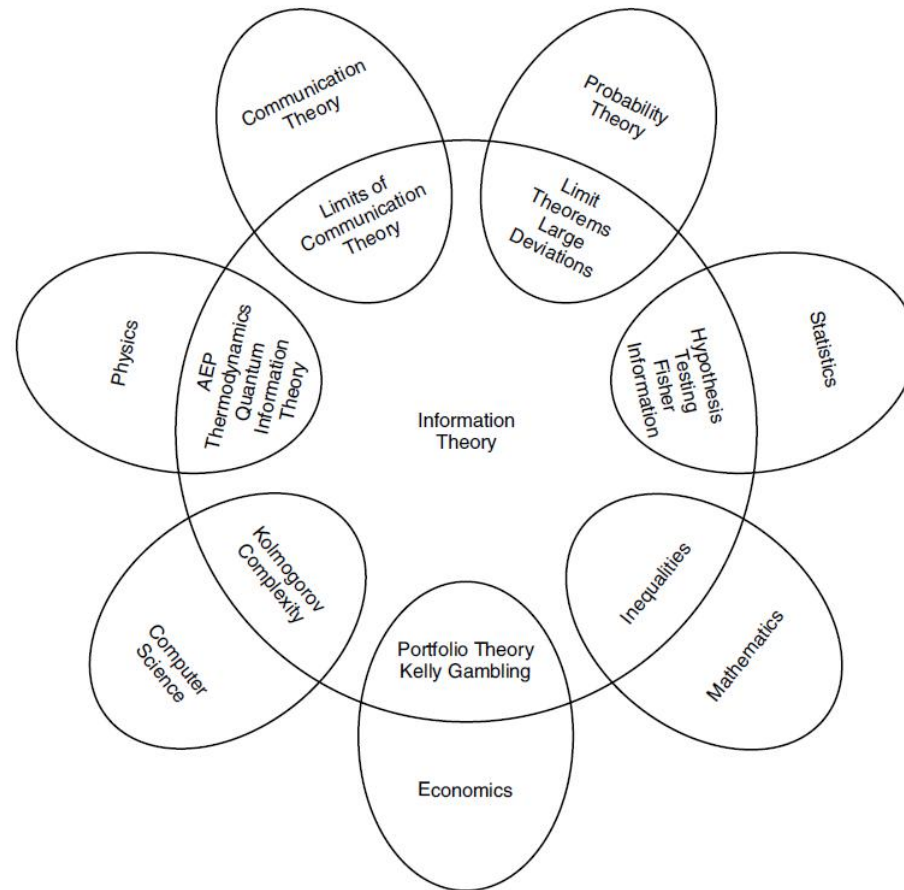
Elements of Information Theory, Thomas M. Cover and Joy A. Thomas

Course Motivation

□ Introduce information theory to at the basic level
- ✓ Entropy, mutual information
- ✓ Classical problems in information theory and their solutions
- ✓ Train students a solid background of information theory
- ✓ Focus on high level reasoning
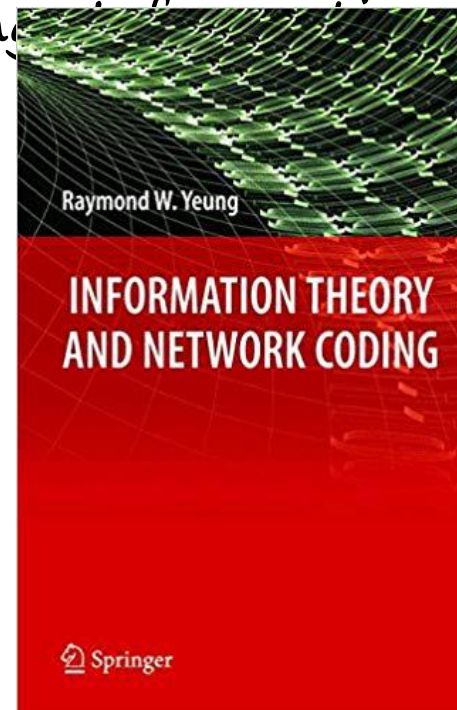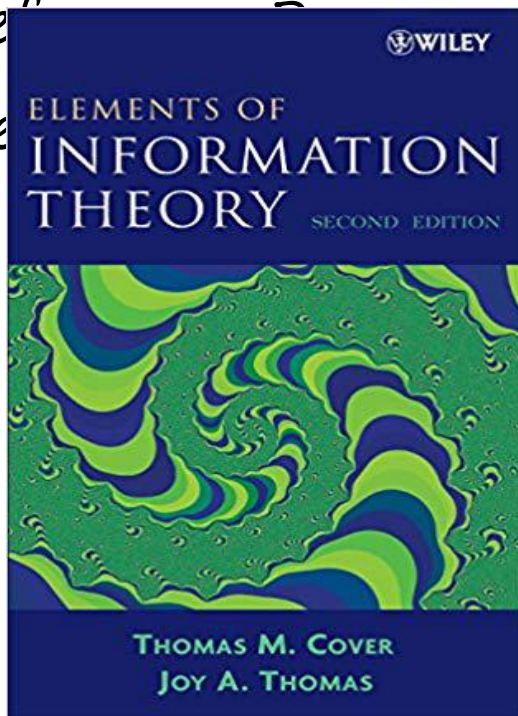- ✓ Potential application in machine learning, security, etc.

Prerequisites

- ☐ Basic probability theory
- ☐ Basic optimization: convex and concave functions
- ☐ Reasoning in analysis

Textbook

☐ Course lecture notes

☐ Textbook: Thomas Cover, Elements of Information theory, 2nd

☐ Reference: Raymond W. Yeung, Information Theory and Network Coding

Course Syllabus

Lectures (15 lecture + 1 Q&A)

1. Introduction and information measures (Ch. 1-2), 3-4 lectures

2. Asymptotic Equipartition Property (Ch. 3), 1-2 lectures

3. Entropy Rates of a Stochastic Process (Ch. 4), 1-2 lectures

4. Data Compression (Ch. 5), 2-3 lectures

5. Channel Capacity (Ch. 7), 2 lectures

6. Differential Entropy (Ch. 8), 2 lectures

Course Schedule

Lecture Time: 1st –8th week

Monday: 08:00–10:00 a.m. (1st –2nd)

Wednesday: 10:00–12:00 a.m. (3rd –4th)

Location:

Room 115, Upper Hall, SJTU

Grade Policy

Grade Distribution: 30% + 30% + 40%

- ☐ Classroom attendance: 10%

- ☐ Homework: 15%

- ☐ Interaction: 5%

- ☐ Course Project: 30%

- ☐ Final exam: 40%

Instructors

Instructors

   Prof. Fan Cheng, chengfan@sjtu.edu.cn

Course Assistants

   Mr. Chuanming Liu

☐ Q&A sessions（答疑）

   ☐ By appoint or in discussion group

☐ Link for course:

      OC and QQ Group.