Fundamentals of Information Theory

About this course

Yayu Gao

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About Myself

- Yayu Gao 高雅玙(鱼 yú)

香港城市大學 City University of Hong Kong

电机工程系博士

访问学者

电信学院副教授

Dian since 2002

Dian团队导师

- IEEE/CCF Member、IMT-2030（6G）推进组网络智能方向成员、国际电信联盟ITU-T华中科技大学成员
- 研究方向：未来WiFi、6G技术、去中心化网络、网络智能、可信边缘智能
- 研究项目：
  - 国家科技部、湖北省重点研发计划
  - 国家、湖北省自然科学基金
  - 企业横向合作项目（华为/国网/烽火/联通）

个人主页

About Myself

学术交流

访问美国华盛顿大学
Sumit Roy教授团队

担任ICCC-2022组委会共同主席

MICoN 移动智能通信网络论坛

担任MiCoN学术论坛组委会成员

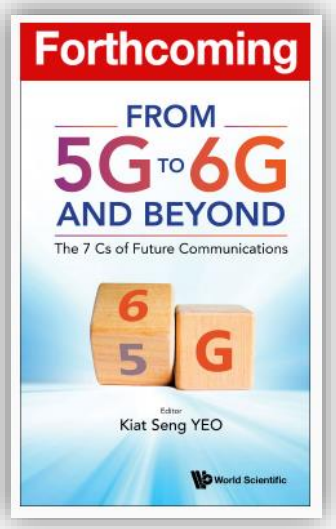
访问香港城市大学

访问英国华威大学

参观智慧社区应用示范

课题组活动

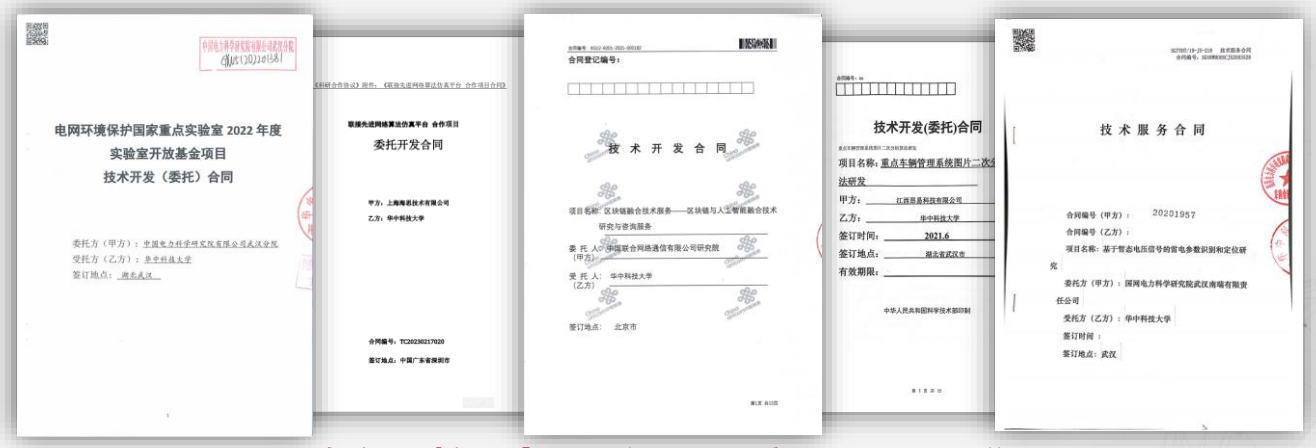
近期部分成果介绍



成果受邀收录于23年
5G/6G相关书籍

国际会议最佳论文

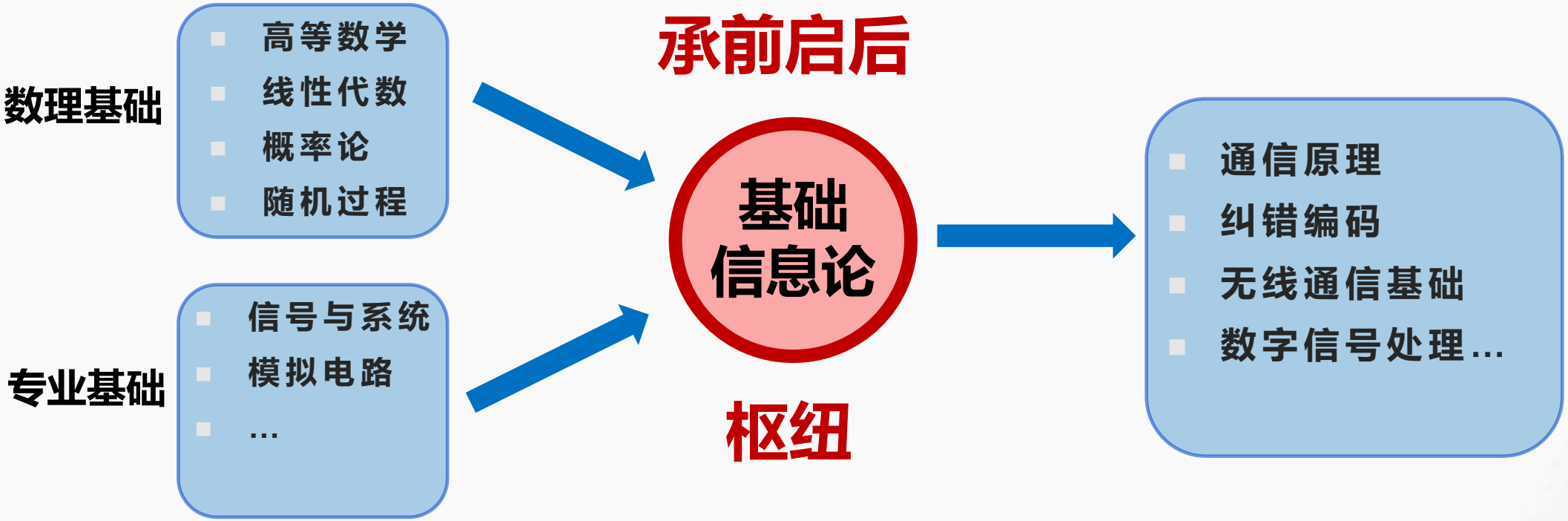
全国青年教师授课竞赛一等奖



常年保持校企合作：华为/国家电网/中国联通等

About this course

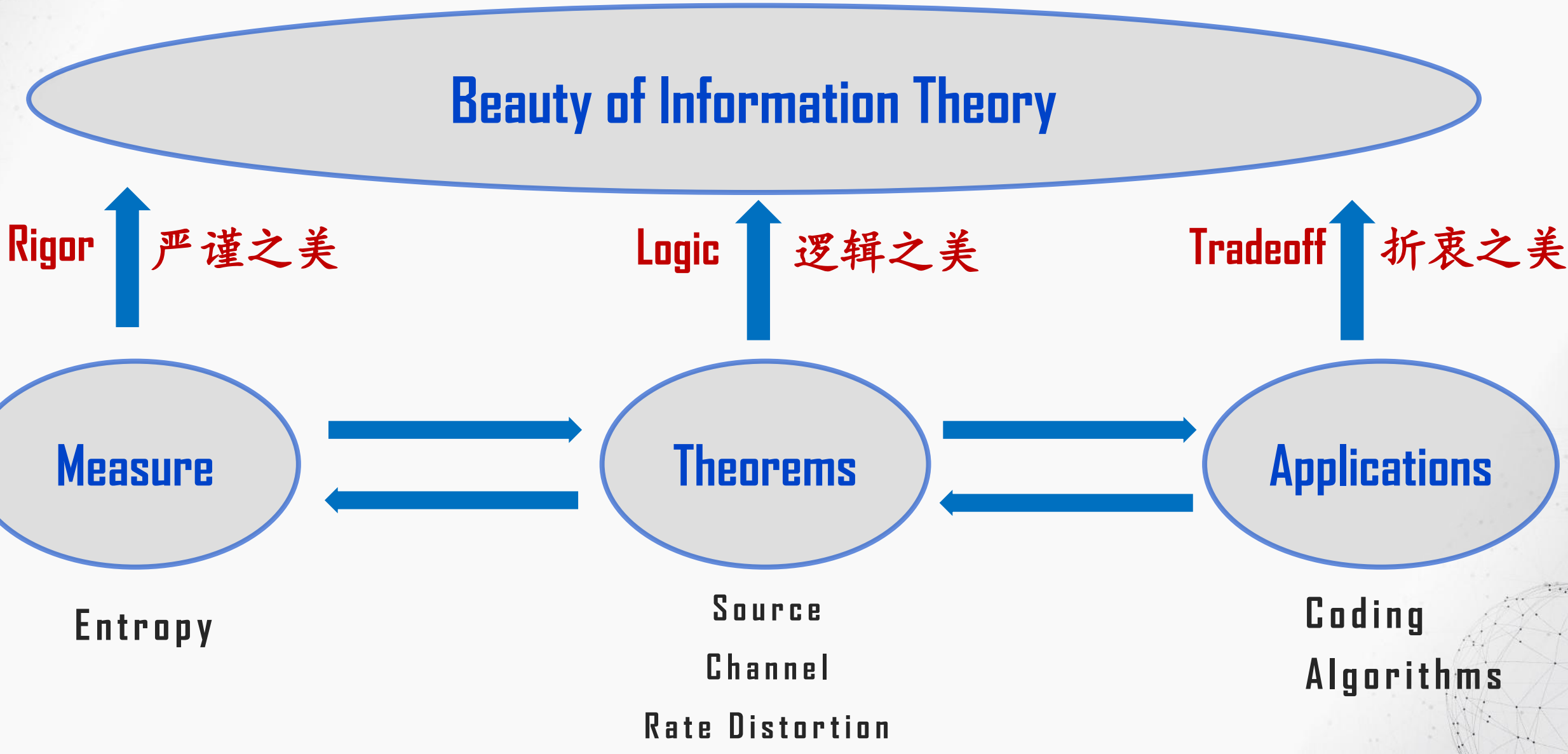
- 《基础信息论》是我院的九门**专业核心**课程之一。



What you will learn in this course?

- **Knowledge**
  - Information theory framework
  - Coding theorems (source, channel, rate-distortion theorems)
  - Applications (source coding, channel coding, …)
- **Skill**
  - Programming
  - Implementation of coding algorithms
  - Survey (Reference Searching/Reading/Summarizing)
- **Insights**
  - Key concepts in IT
  - Theory vs. Applications
  - How IT impacts the communication society and others?

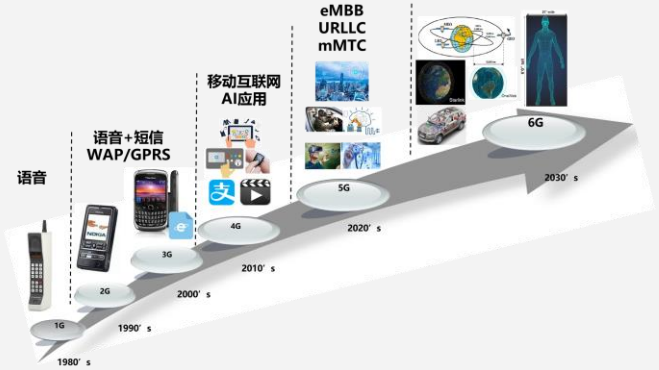
Course Goal


Beauty of Information Theory
Rigor 严谨之美
Logic 逻辑之美
Tradeoff 折衷之美
Measure
Theorems
Applications
Entropy
Source
Channel
Rate Distortion
Coding
Algorithms

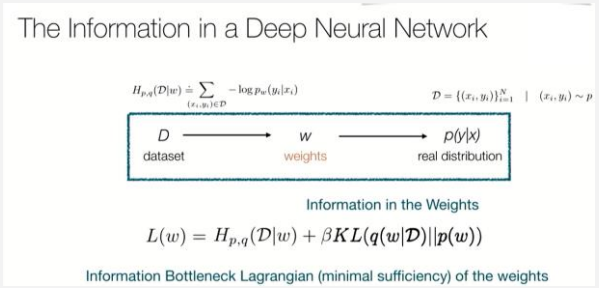
Course Goal: Why should we learn Information Theory?

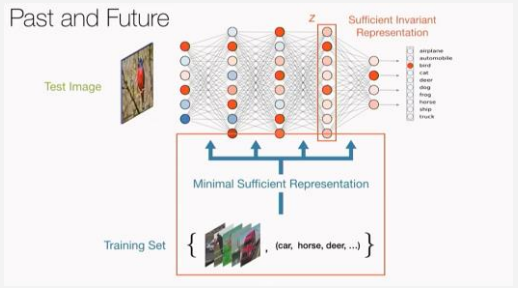
It's USEFUL!

- 是信息时代的两大理论基石之一
- 是通信系统演进的核心驱动力——1G→5G



- 经典与现代结合：用信息论视角打开人工智能的黑箱?

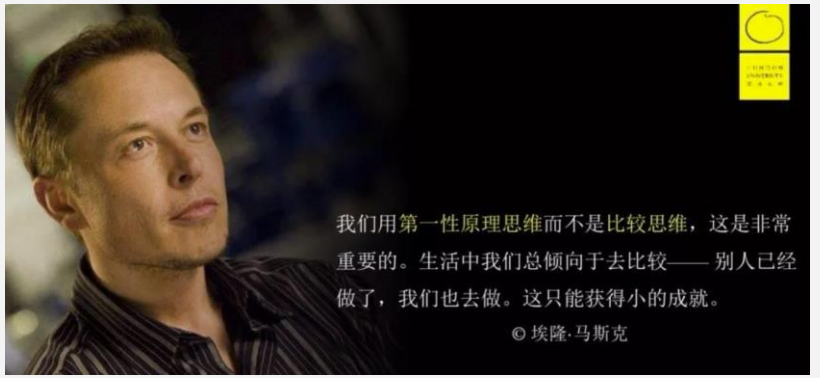




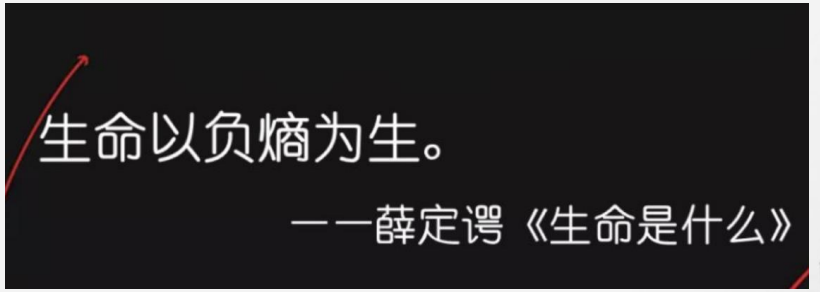
C.R. The Dynamics and Control of Differential Learning, Stefano Soatto

It's INTERESTING!

- 是一种非常有效的思考方式——第一性原理



- 是一种全新思考问题、生活的角度——信息量与熵
  - 理论与应用的结合
  - 严谨与直觉的结合

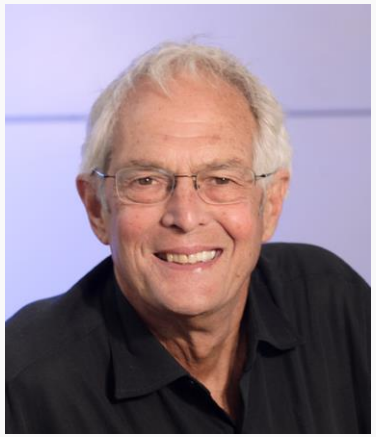


Course Grading

- **Prerequisite courses**
  - Probability Theory
  - Stochastic Process
- **Course materials**
  - Textbook
  - Lecture notes
  - Reference books and papers
- **Grading**
  - In-class assignment (10%)
  - Homework (20%)
  - Course Project (20%)
    - Individual (10%)
    - Group (10%)
  - Final Exam (50%)

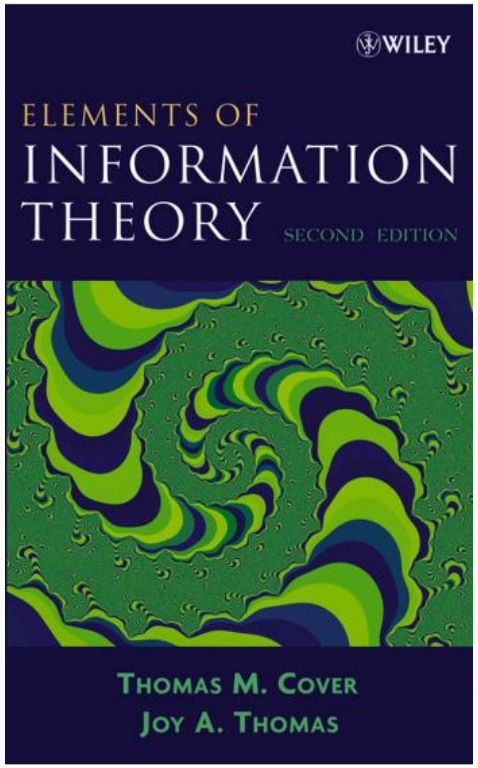
Textbook: Elements of Information Theory

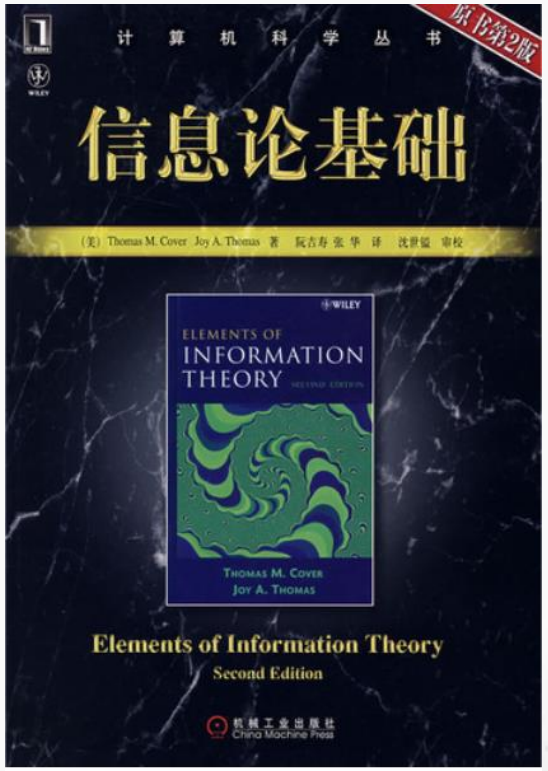
- Thomas M. Cover and Joy A. Thomas, *Elements of Information Theory*, 2nd, John Wiley & Sons, 2006.
- Thomas M. Cover and Joy A. Thomas, 阮吉寿(译者), 张华(译者), 信息论基础(原书第2版), 机械工业出版社.



Thomas M. Cover
Prof. @Stanford U.
(1938-2012)

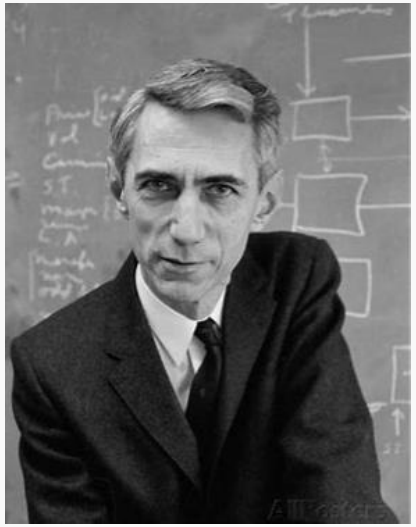
"The jewel in Stanford's crown."





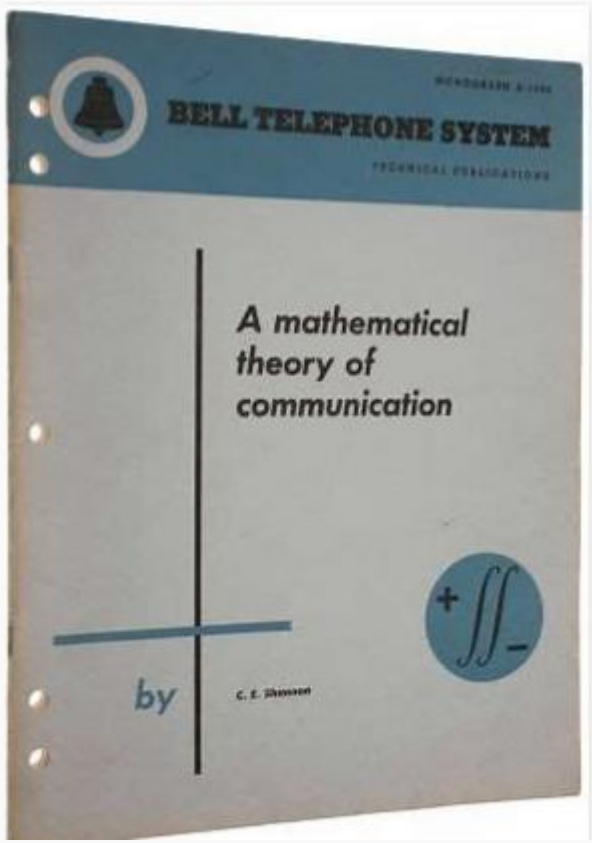
Landmark paper in information theory

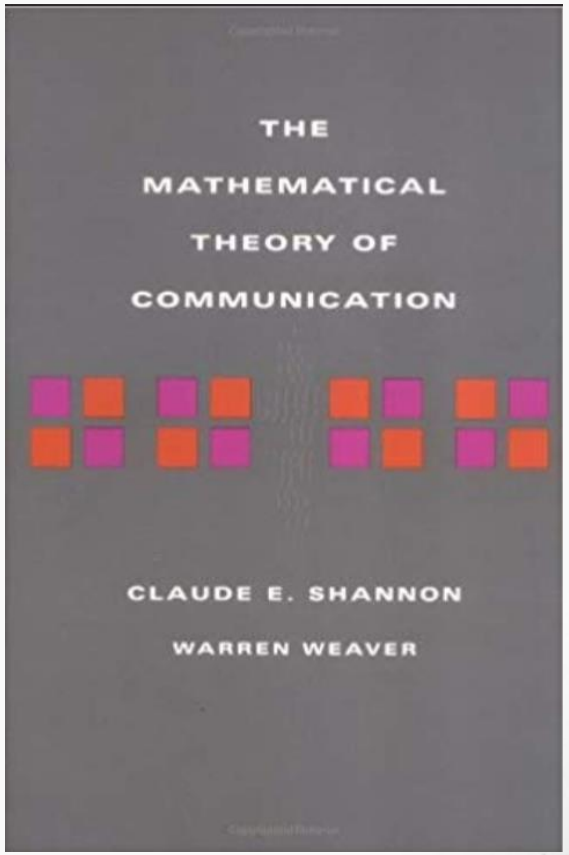
- Claude E. Shannon, "*A Mathematical Theory of Communications*," Bell System Technical Journal, July & October 1948.



Claude E. Shannon
Bell Lab, Prof. @MIT
(1916-2001)

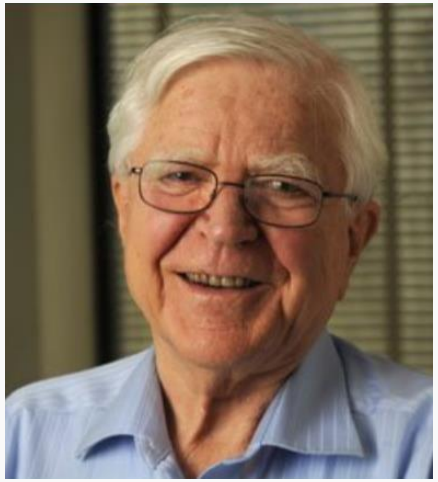
"Father of Information Theory."





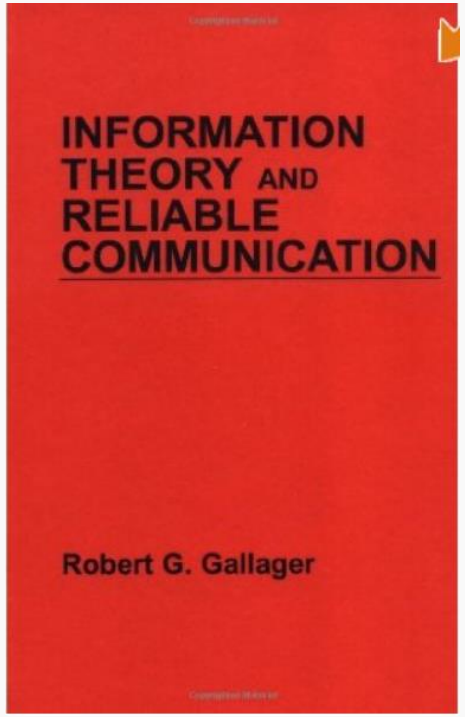
Reference Books in English

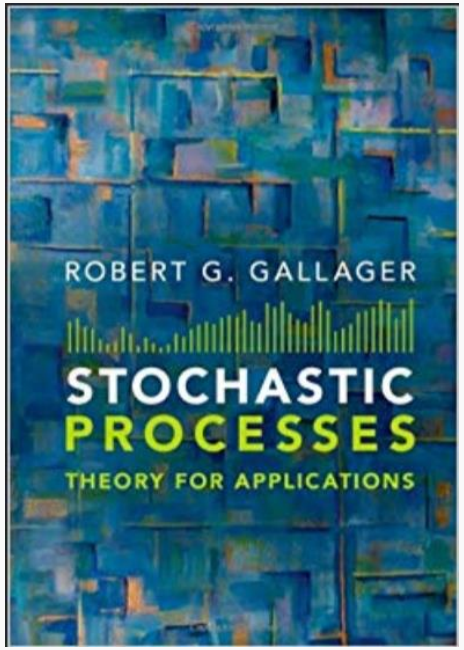
- Robert G. Gallager, *Information Theory and Reliable Communication*, John Wiley & Sons, 1968.

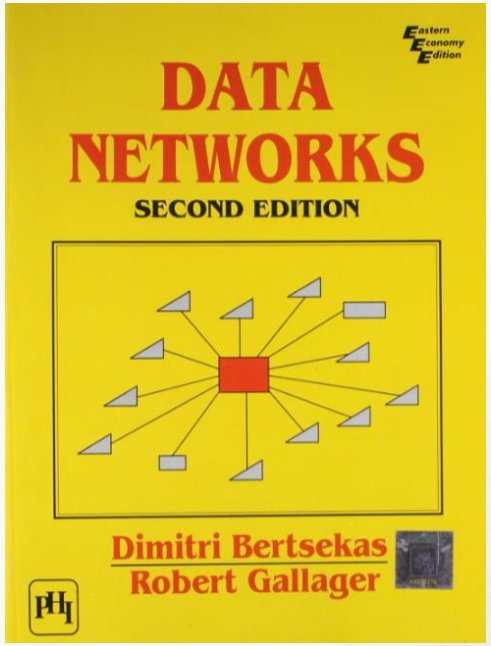


R.G. Gallager
Prof. @MIT
(1931-)

"Fundamental Contributions to Communications Coding Techniques ."



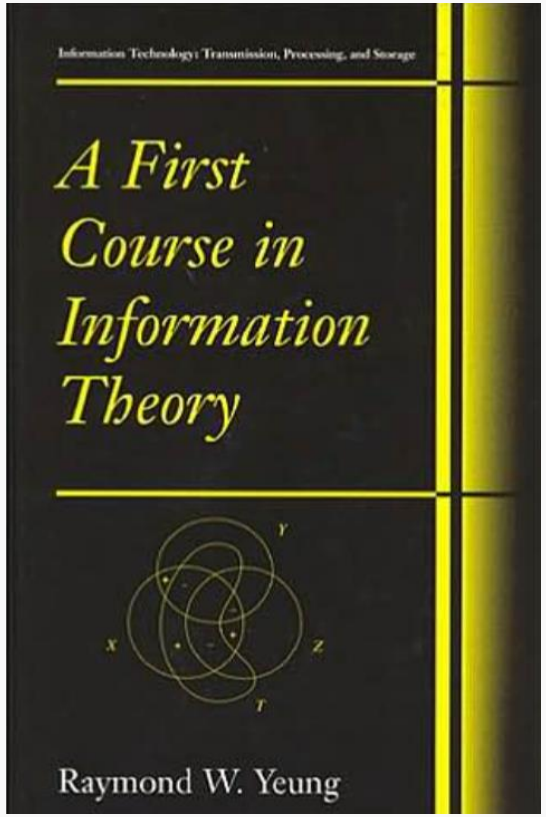


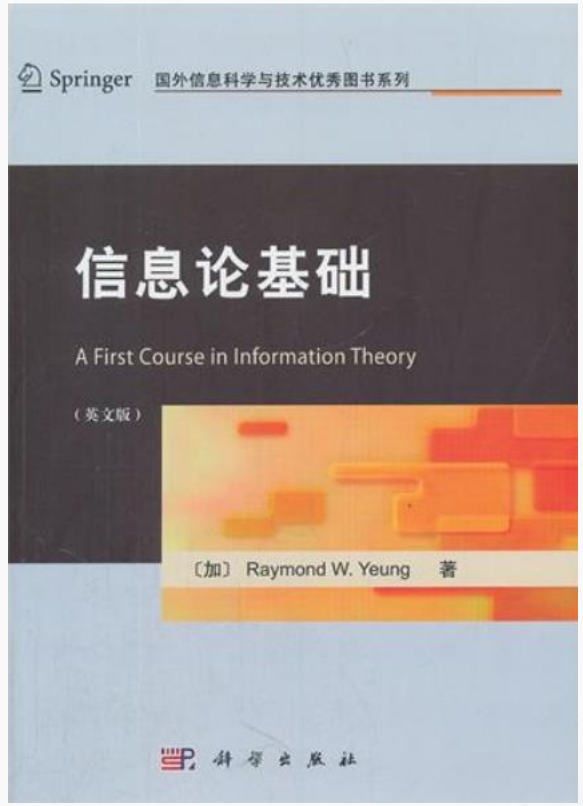


Reference Books in English

- Raymond W. Yeung, *A first course in information theory*, New York : Kluwer Academic/Plenum Publishers, 2002.

R. W. Yeung 杨伟豪
Prof. @CUHK





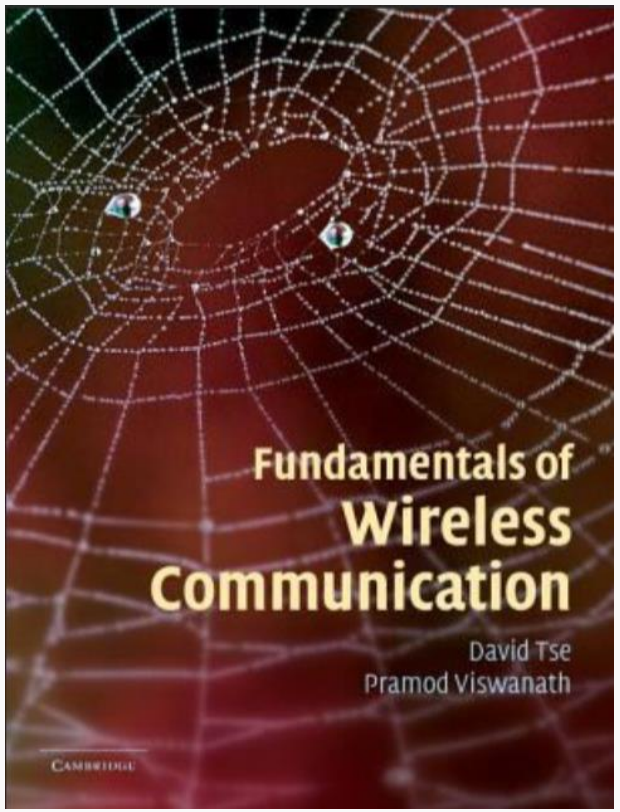
"Contributions to Network Coding Theory."

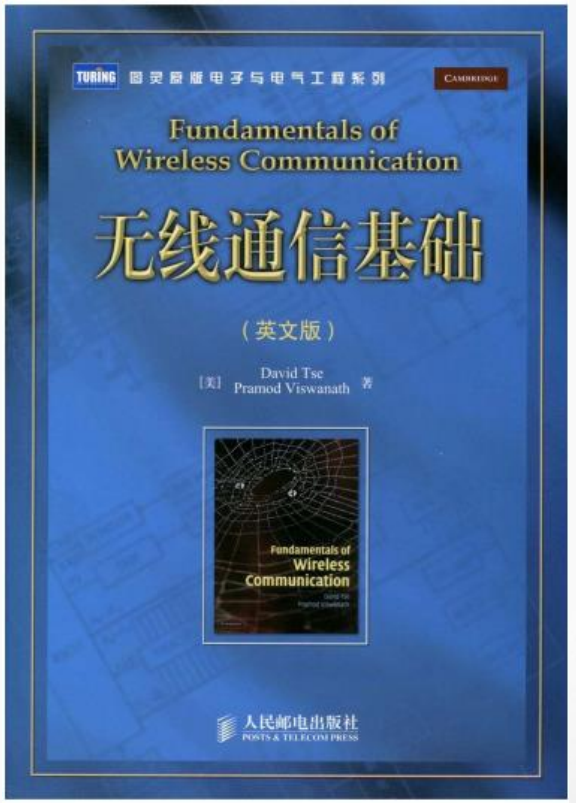
Reference Books in English

- David Tse and Pramod Viswanath, *Fundamentals of wireless communication*, Cambridge: Cambridge University Press, 2005.

D. Tse 谢雅正
Prof. @Stanford U., UCBerkley

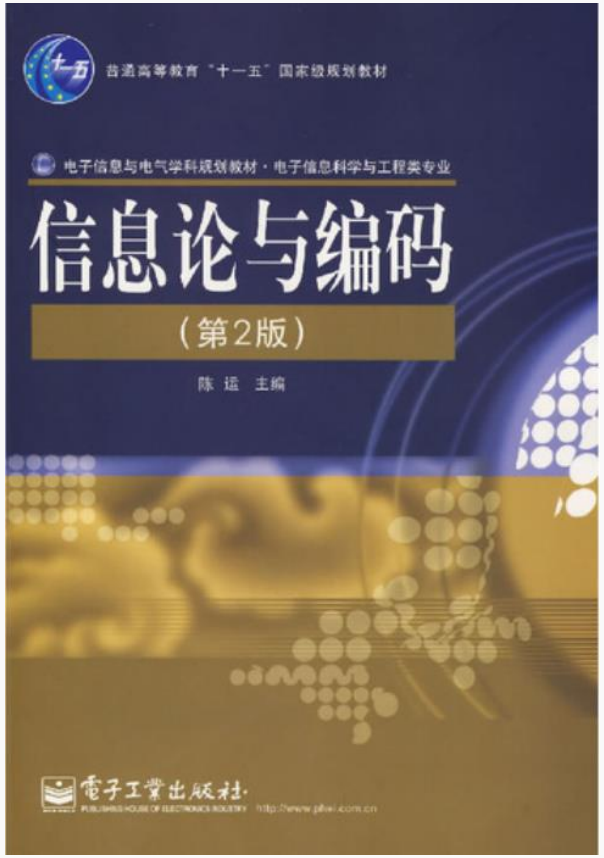
"Contributions to wireless network information theory."

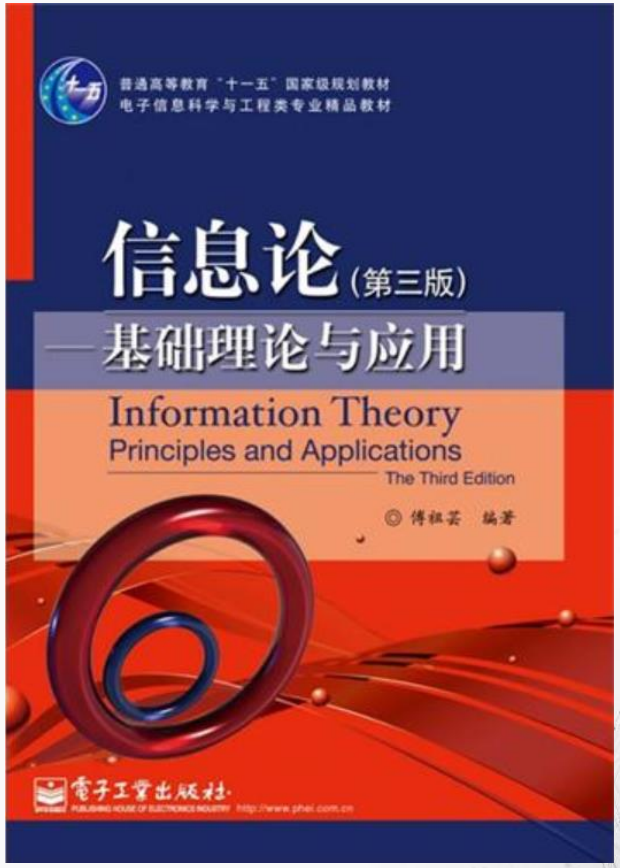




Reference Books in Chinese

- 陈运等，信息论与编码（第2版），电子工业出版社，2007.（面上班教材）
- 黄佳庆，程文青，信息论基础，电子工业出版社，2010. (我院自主编写教材)
- 傅祖芸，信息论-基础理论与应用，电子工业出版社，2001.（细致）





Reference Courses

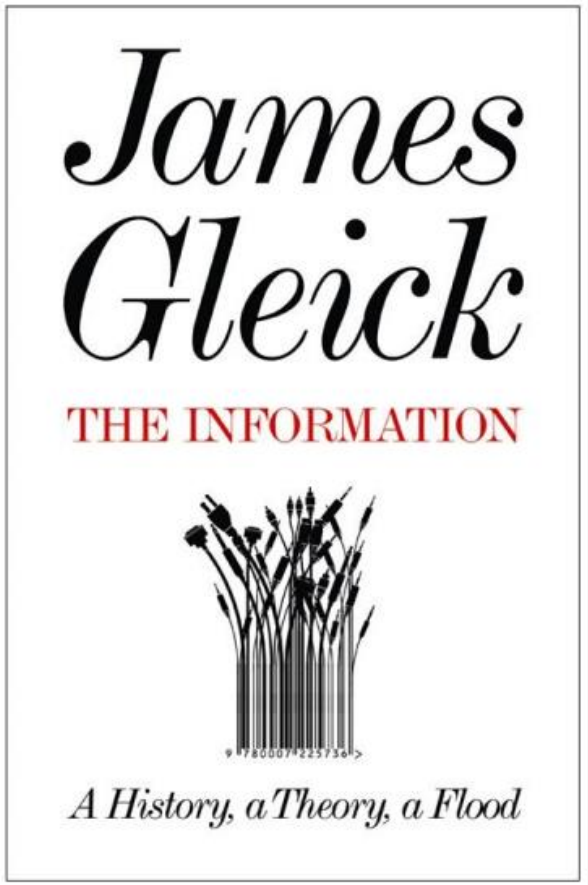
- Prof. Thomas M. Cover in Stanford University
  - http://www.stanford.edu/~cover/
- Information Theory by Prof. Raymond W. Yeung
  - https://www.coursera.org/course/informationtheory
- A Short Course in Information Theory by David J.C. MacKay
  - http://www.inference.phy.cam.ac.uk/mackay/info-theory/course.html
- Information theory course in MIT
  - http://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-441-information-theory-spring-2010/index.htm
- 清华大学 应用信息论基础（国家级精品）
  - http://www.xuetangx.com/courses/course-v1:TsinghuaX+70230063X+sp/about
- 国防科技大学 信息论与编码基础（国家级精品）
  - http://www.icourses.cn/sCourse/course_3257.html

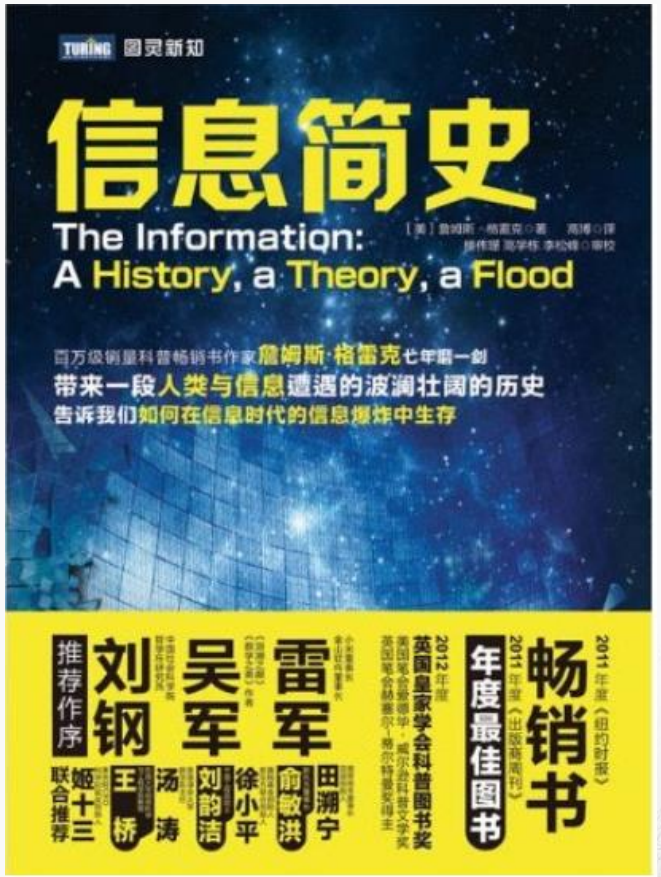
Recommended Popular Science Readings

- James Gleick, *The Information: A History, A Theory, A Flood*, 2012.

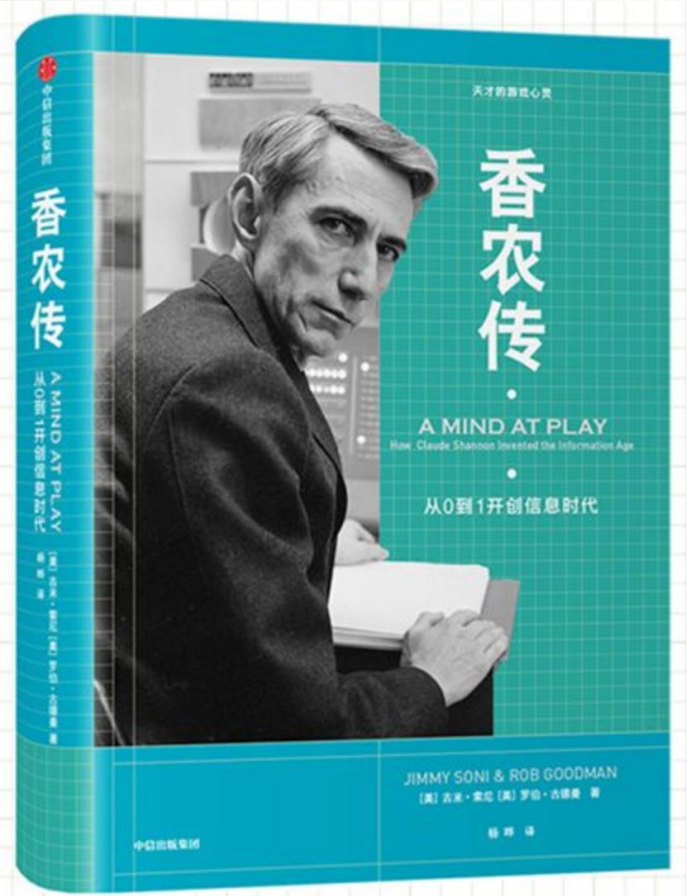
James Gleick
Historian of science
(1954-)

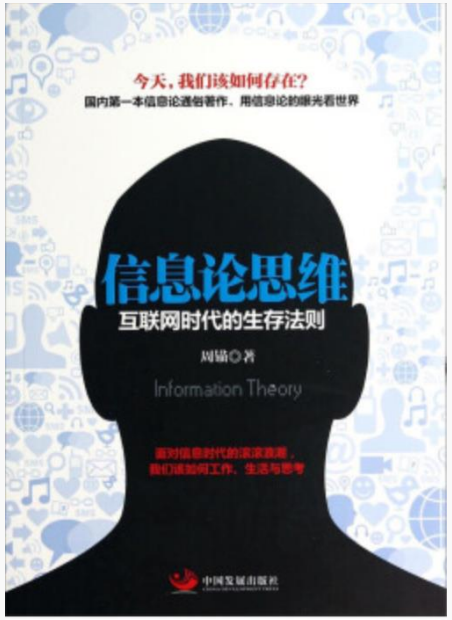
"One of the great science writers of all time."

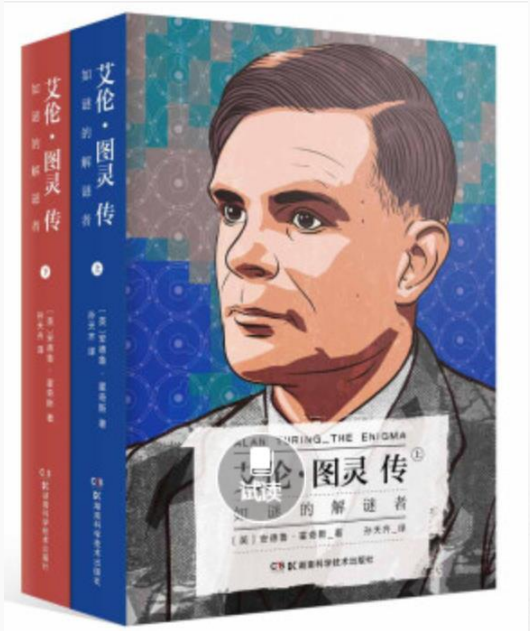




Recommended Popular Science Readings







Course Organization

- **24** hours in class and **??** hours extended learning
- **Introduction (2 hours)**
- **Basic Concepts (8 hours)**
- **Data Compression (6 hours)**
- **Channel Capacity (4 hours)**
- **Rate Distortion Theory (3 hours)**
- **Overview (1 hour)**

Class Organization

- **In each class (90 mins), we will**
  - Guidance (5-10 mins)
    - 本节课重点难点
  - Teaching (70-80 mins)
  - Interaction (5-10 mins)
    - 随堂测验解析 （微助教）
    - 解答问题

Course Resources

QQ Group

群名称：基础信息论2023-高...
群　号：477437355

微助教

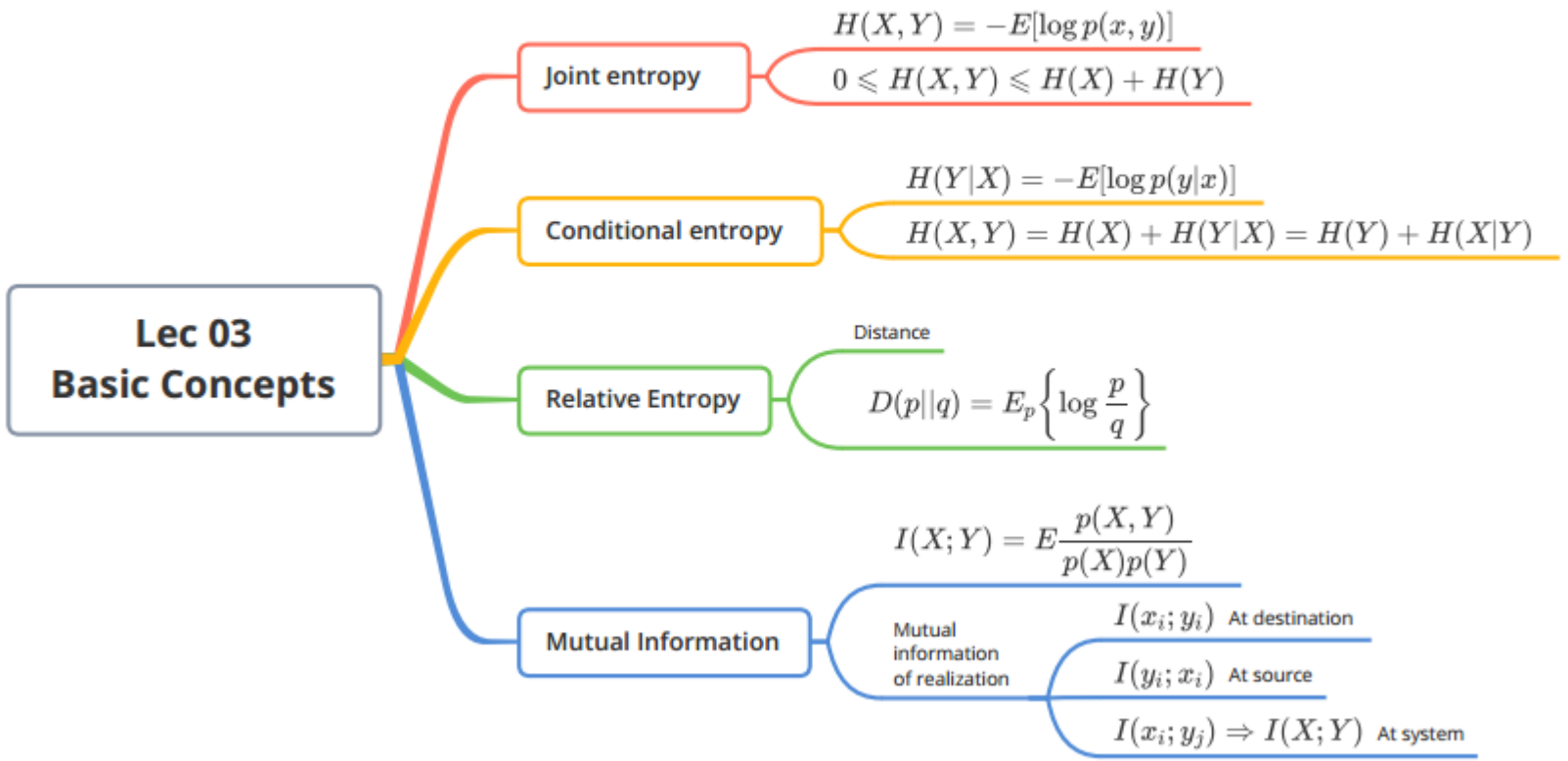
课堂名称：基础信息论
课堂编号：KS751

Suggestions for In-class Notes

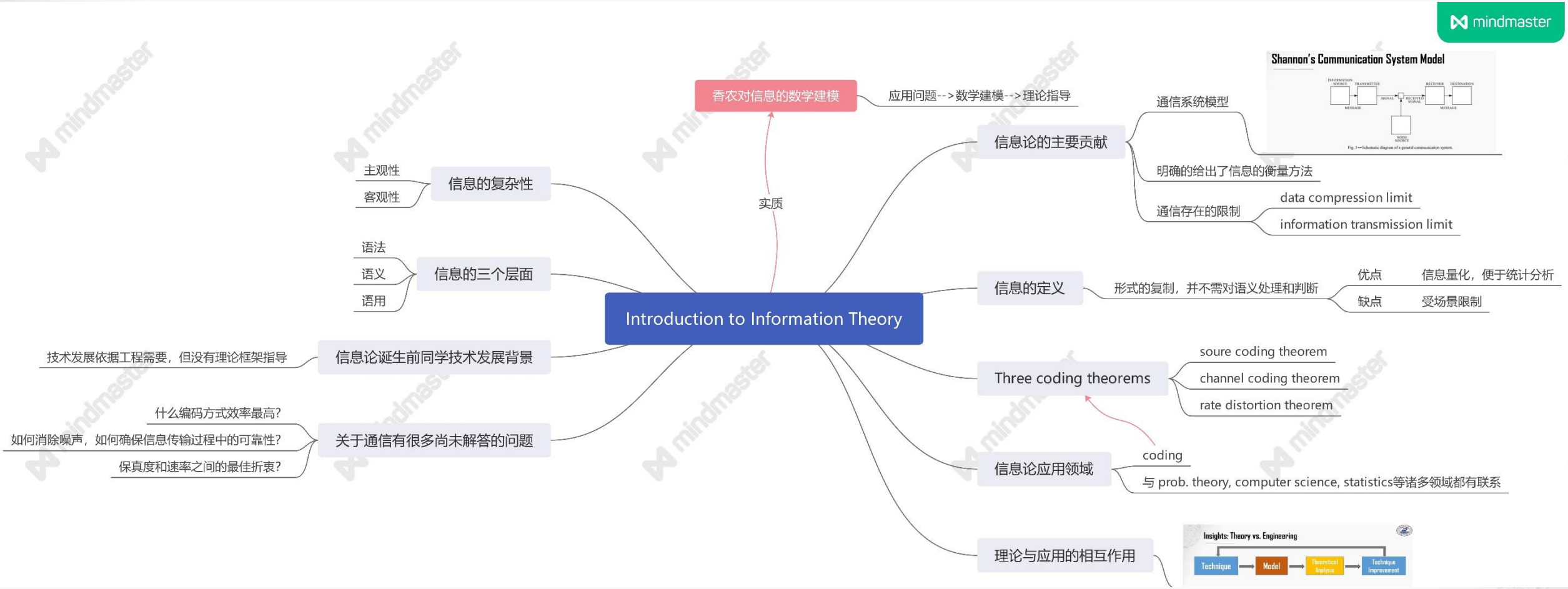
- 本次学习的**知识点**有哪些?
- 通过学习我**清楚了哪些问题**?
  - 描述问题是什么
  - 给出问题的回答
- 我有哪些**待解决的问题**?
- 以本次学习内容为主线，结合本课程已经了解的相关知识，厘清知识点之间的**逻辑**关系，通过**思维导图**表现出来
  - 推荐软件：MindMaster

Exemplary Notes Last Year

MINDMAP



Exemplary Notes Last Year



Exemplary Notes Last Year

- source coding algorithms
  - shannon code
    - 编码理论
      - $\log_2 \frac{1}{p(x_i)} \le l_i < \log_2 \frac{1}{p(x_i)} + 1$
      - 采用所处的分布作为编码
    - 问题　只有当为均匀分布时为最优的
    - 编码效率
      - $\eta = \frac{H(S)}{\bar{L}}$,
      - 子主题
  - hoffman code
    - 编码方式
      - 取两个最小的为一组，小的为0 大的为1并合并与其他的相比较
      - 从大到小进行排列
    - 证明略
    - 高阶霍夫曼编码　需要补零来进行凑整
    - 局限性
      - 量化效应
      - 需要知道全局的概率

Thank you!

The beginning of a beginning...