



# Fundamentals of Information Theory

## ◀ About this course



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# About Myself

- Yayu Gao 高雅珣(鱼 yú)



拼音: [yú]   
部首: 玉  
释义: 珣, 读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、网络智能、6G技术、分布式AI
- 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



# Research Interest: Short-Distance Wireless Networks 短距无线网络



新一代无线短距通信技术

星闪点亮万物互联



NearLink

咫尺之间 颠覆体验

理论  
分析

网络通信  
领域研究

仿真  
平台

真实  
系统

## 研究方向

### 新关键技术

Multi-link access

Multi-AP coordination

OFDMA

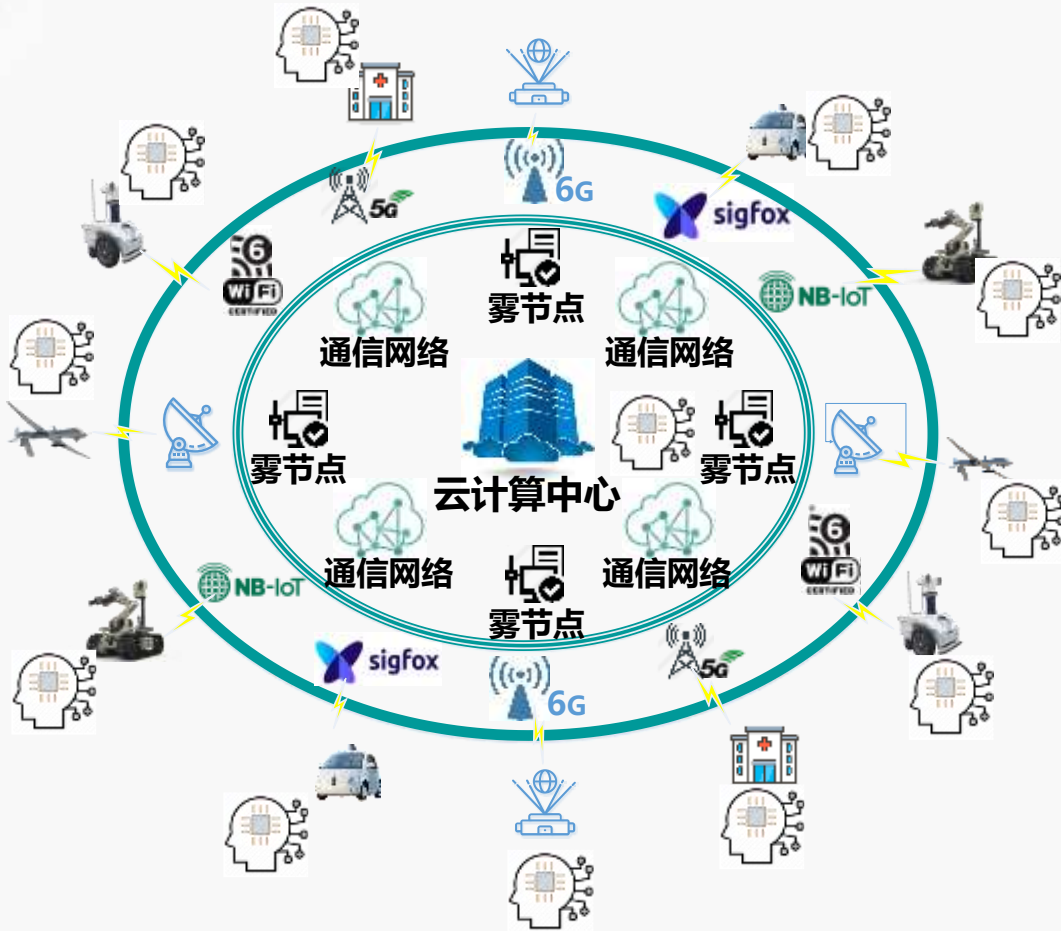
### 新研究问题

确定性时延WiFi

动态频谱接入

6 GHz频谱共享

# Research Interest: Network Intelligence 去中心化网络智能



目标：针对海量智能设备网络接入问题，面向多样化场景、个性化需求，研究自感知、自学习、自决策的去中心化信道接入、资源分配算法。

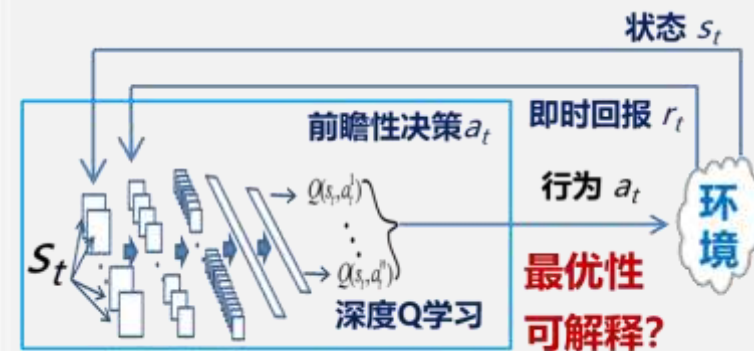
## 研究方向

设备侧：自学习、自感知、自优化

Model-based Access



Model-free Access



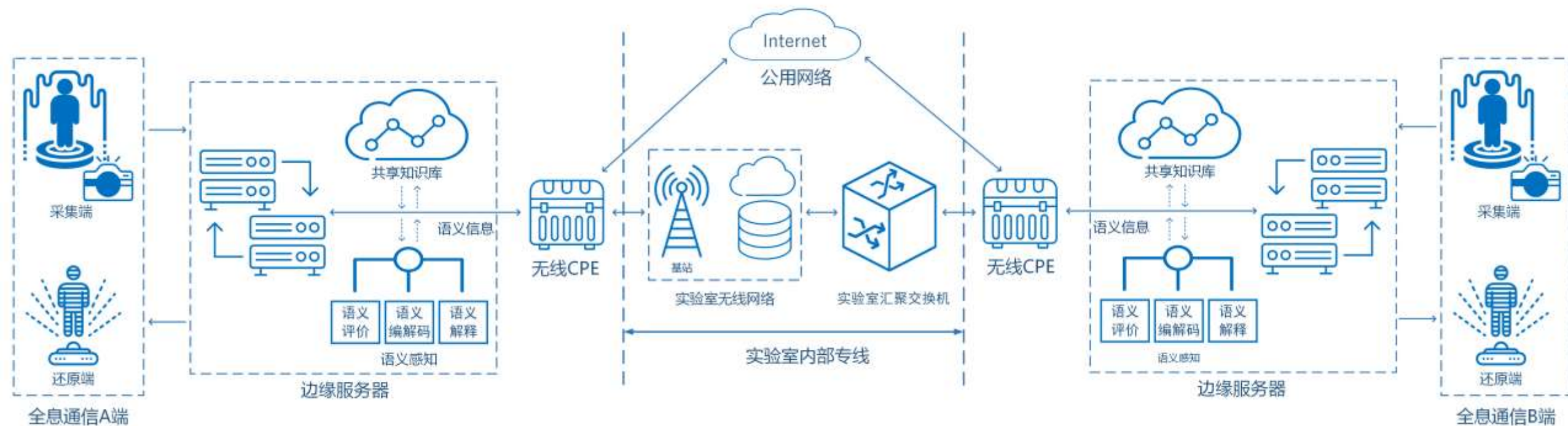
深度强化学习

联邦学习



# Research Interest: Semantic Communications 语义通信

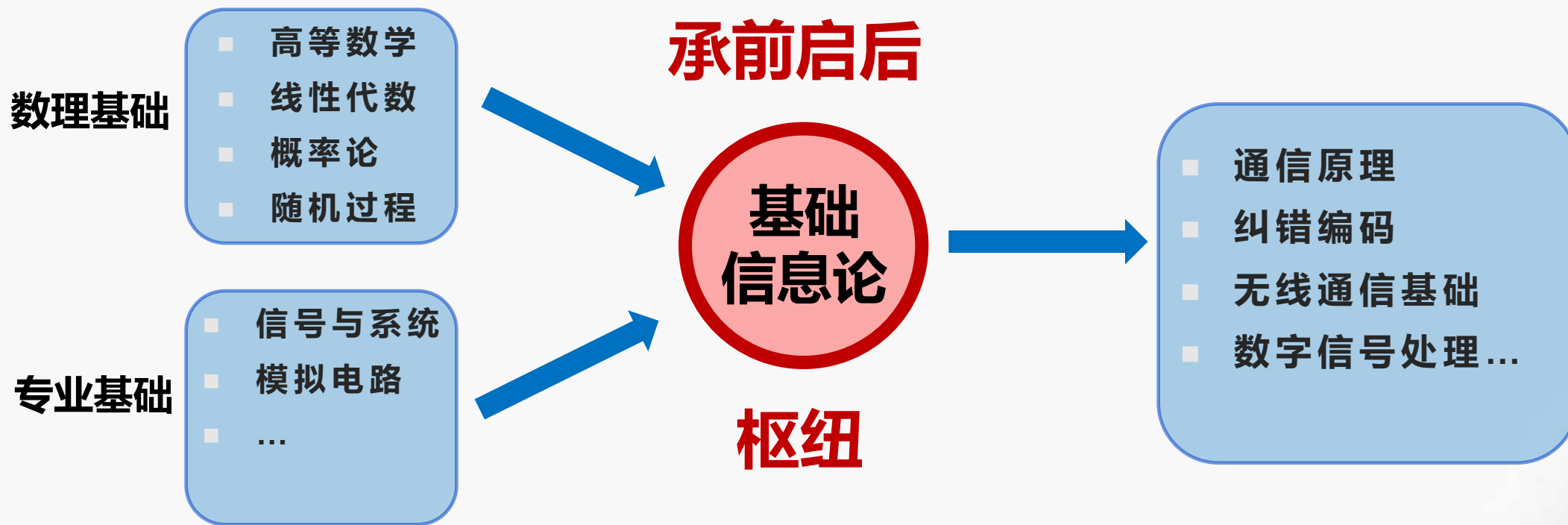
基于5G联创实验室的最新6G语义通信研究成果，研发面向全息通信业务的语义通信网络演示系统。



针对全息通信验证环境存在的超高清图像通信量过大，造成网络负载高、通信时延高等问题，设计并实现基于语义通信的全息通信演示环境，大幅降低网络通信负载，可为用户提供全息通话、全息会议、全息远程教学、全息直播等多元化的业务场景提供技术支撑。

# About this course

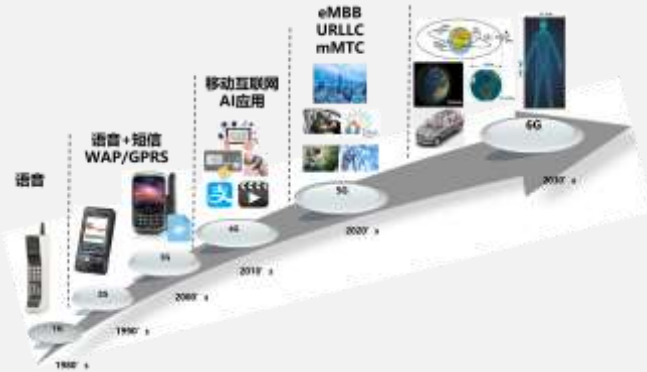
- 《基础信息论》是我院的九门**专业核心**课程之一。
- 2023年，《基础信息论》入选第二批国家级线下一流课程



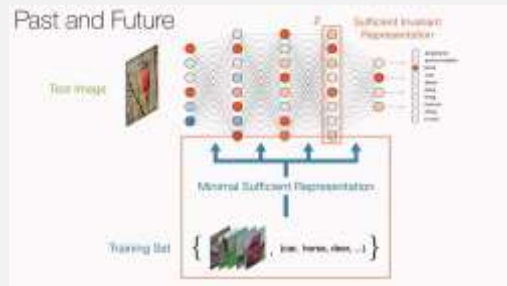
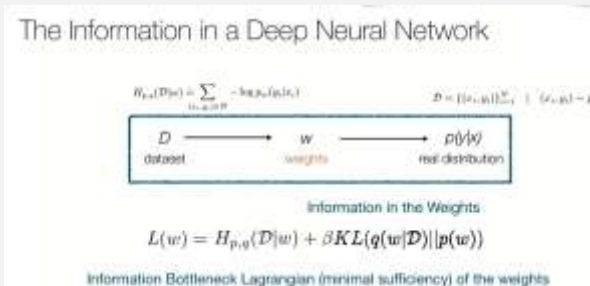
# Why should we learn Information Theory?

## 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



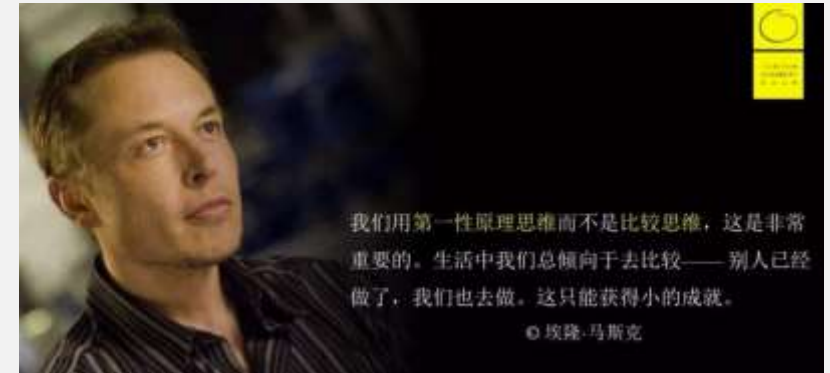
- 经典与现代结合：用信息论视角打开人工智能的黑箱？



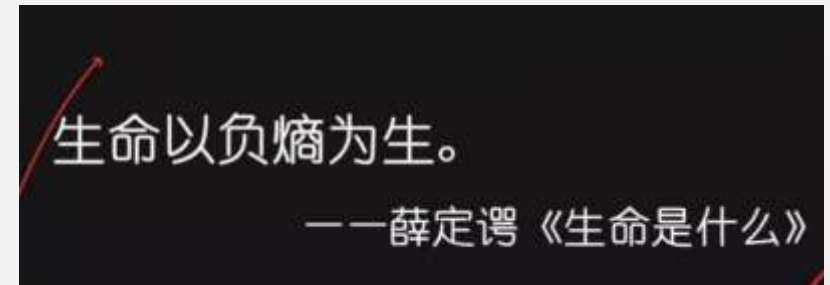
The Dynamics and Control of Differential Learning, Stefano Soatto

## 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



# What you will learn in this course?

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## ■ 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

Entropy


Theorems

Source  
Channel  
Rate Distortion

Applications

Coding  
Algorithms

# Course Grading

- **Prerequisite courses**
    - Probability Theory
    - Stochastic Process
  - **Course materials**
    - Textbook
    - Lecture notes
    - Reference books and papers
  - **Grading**
    - In-class assignment (10%)
    - Homework (15%)
    - Course Project (15%)
      - Algorithm Imp. P1 (5%)
      - Algorithm Imp. P2 (5%)
      - Literature Review on Advanced Topic (5%)
    - Final Exam (60%)
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- A blue vertical rectangle containing a white stylized 'A' and the letters 'AP' in white, representing the AP (Advanced Placement) logo.



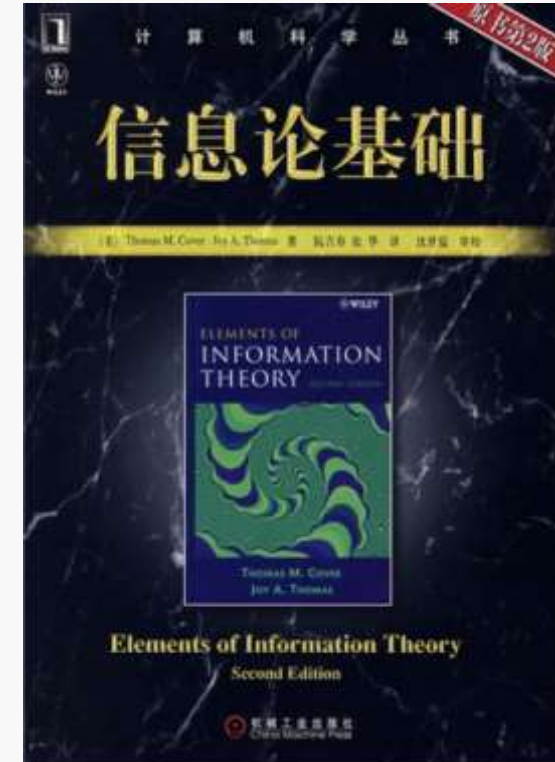
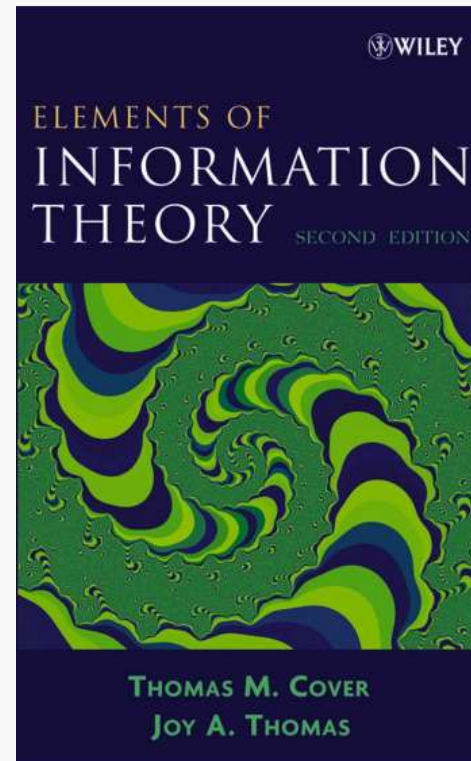
# Textbook: Elements of Information Theory

- 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.



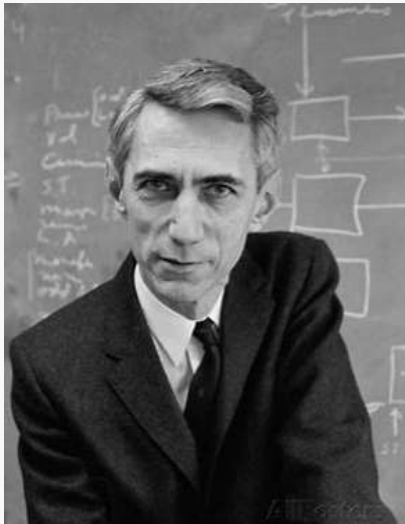
Thomas M. Cover  
Prof. @Stanford U.  
(1938-2012)

"The jewel in Stanford's crown."



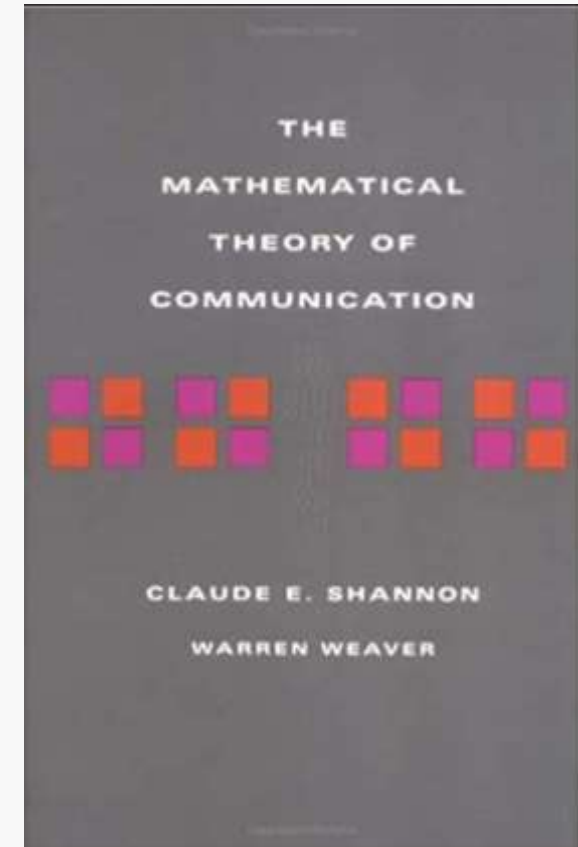
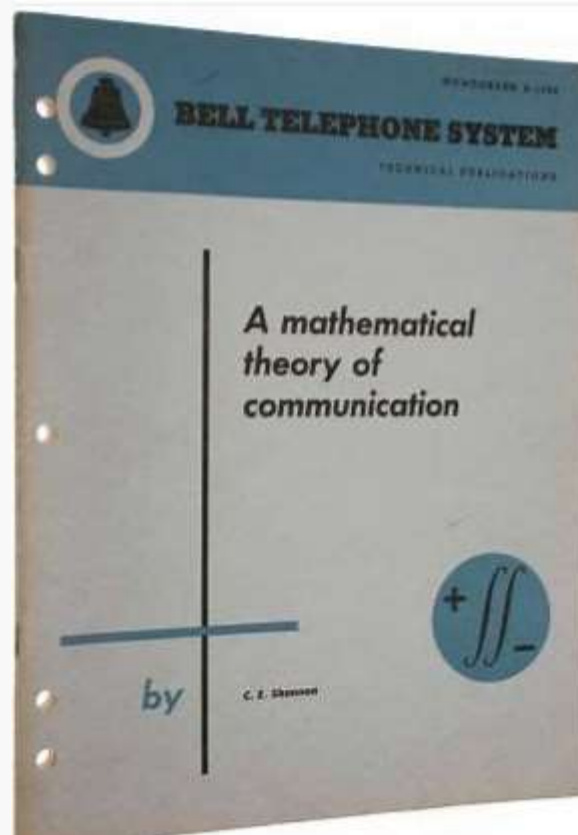
# Landmark paper in information theory

- 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.”



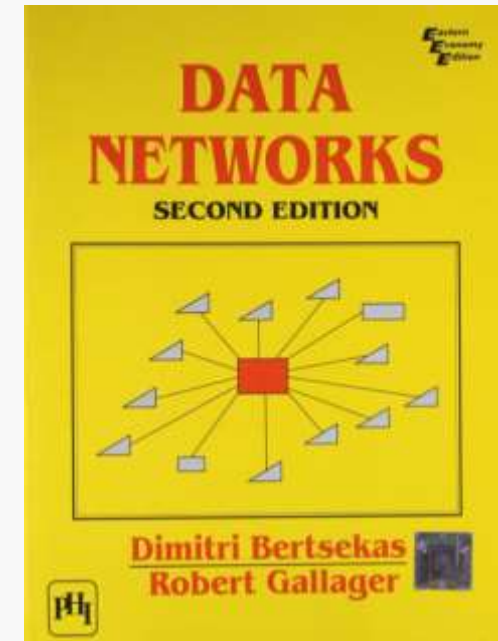
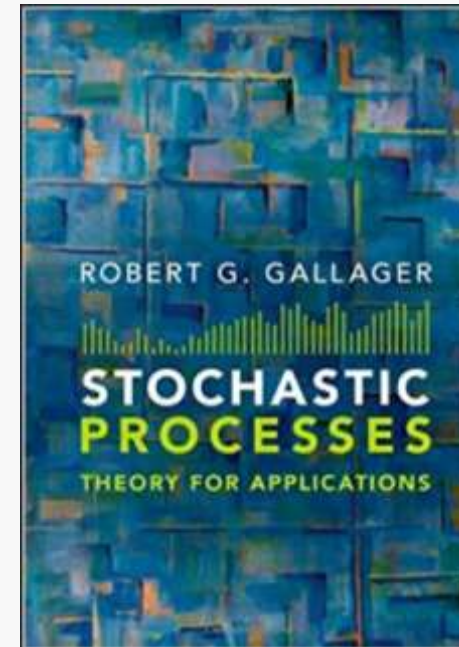
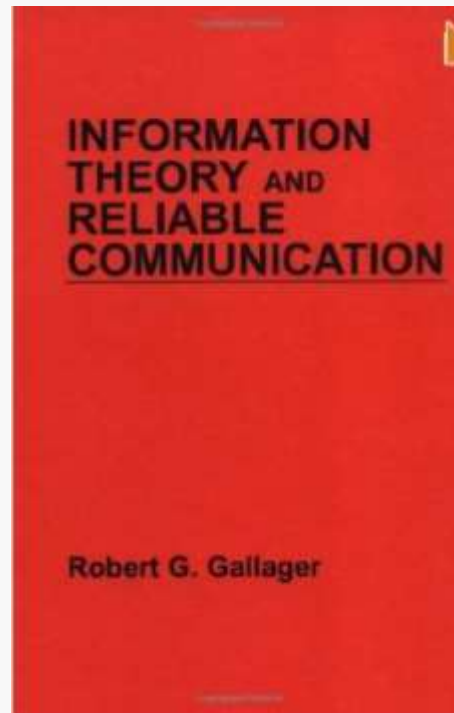


# Reference Books in English

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



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



"Fundamental Contributions to  
Communications Coding Techniques."

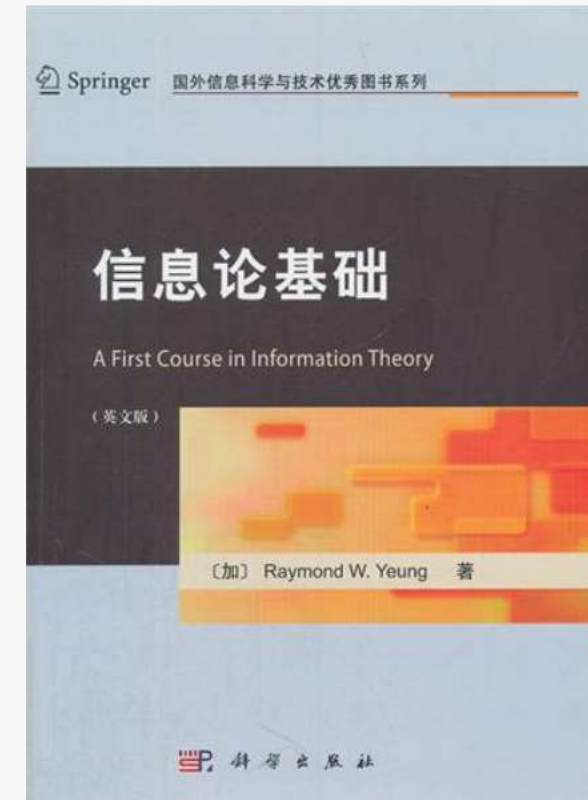
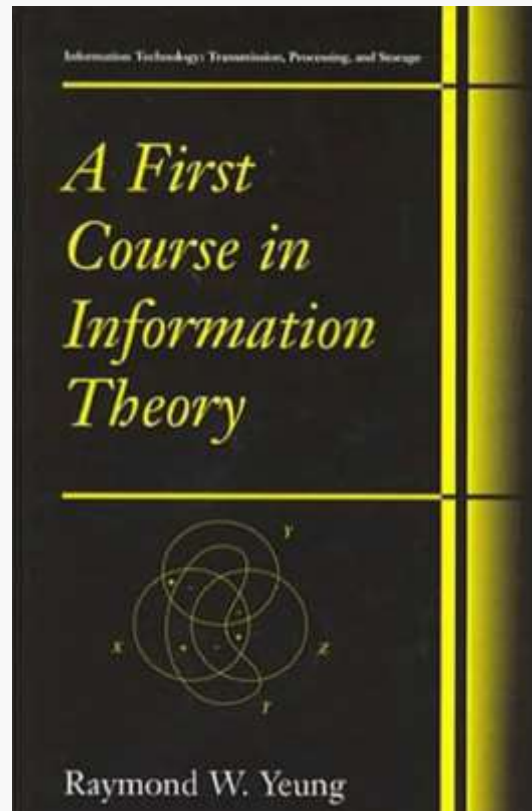
# Reference Books in English

- 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

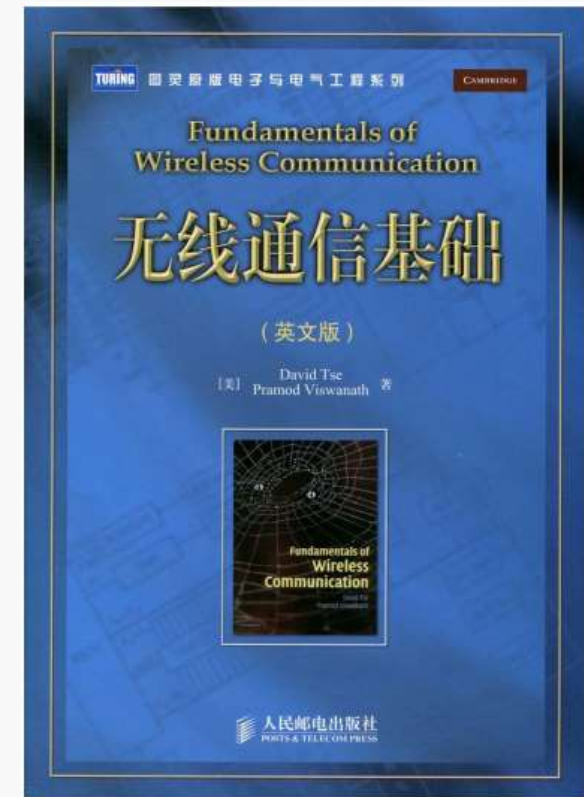
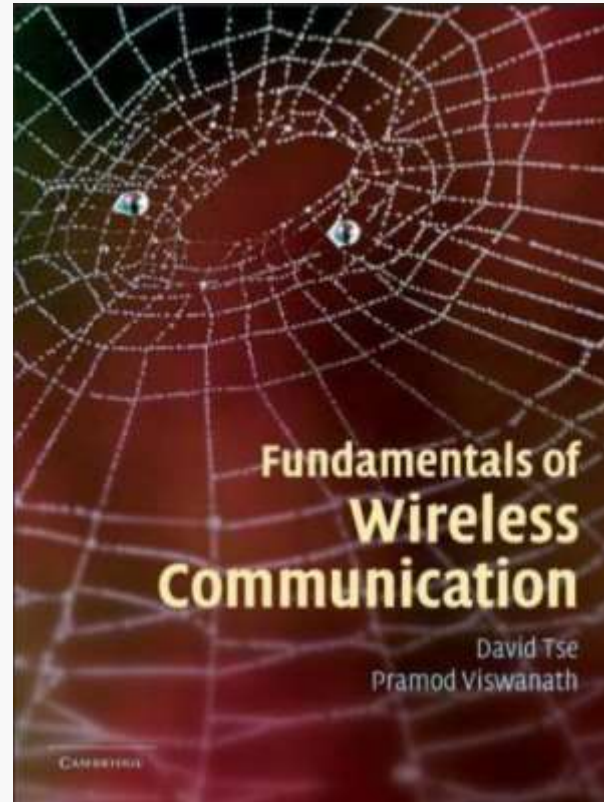
- David Tse and Pramod Viswanath, *Fundamentals of wireless communication*, Cambridge: Cambridge University Press, 2005.



D. Tse 谢雅正

Prof. @Stanford U., UCBerkley

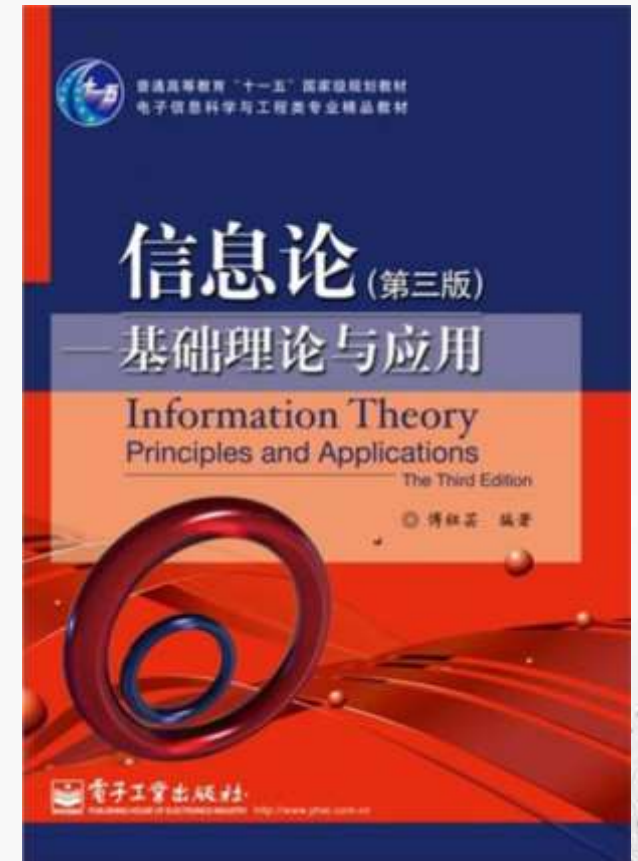
"Contributions to  
wireless network information theory."





# 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

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- 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](http://www.icourses.cn/sCourse/course_3257.html)

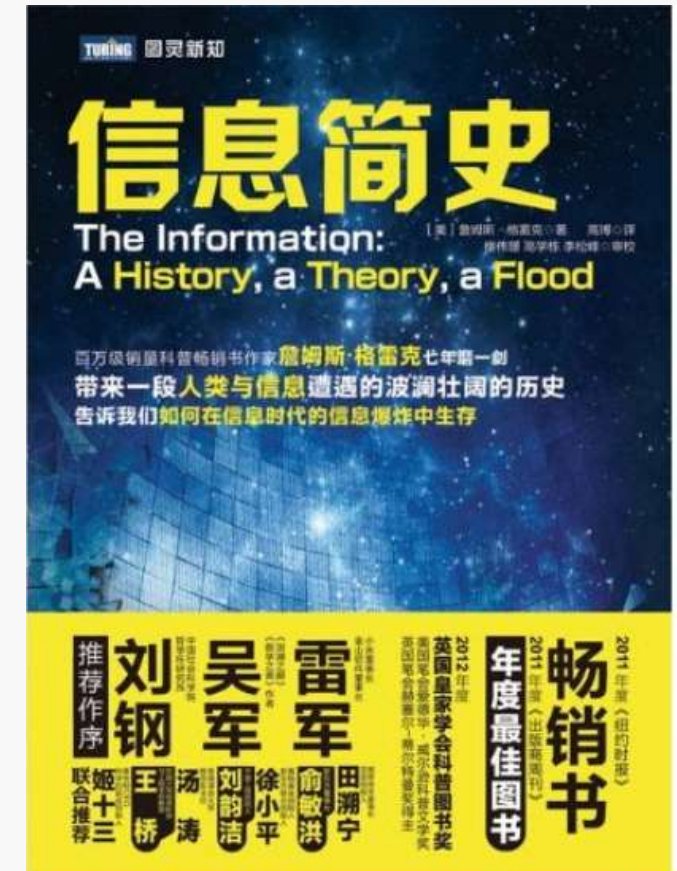
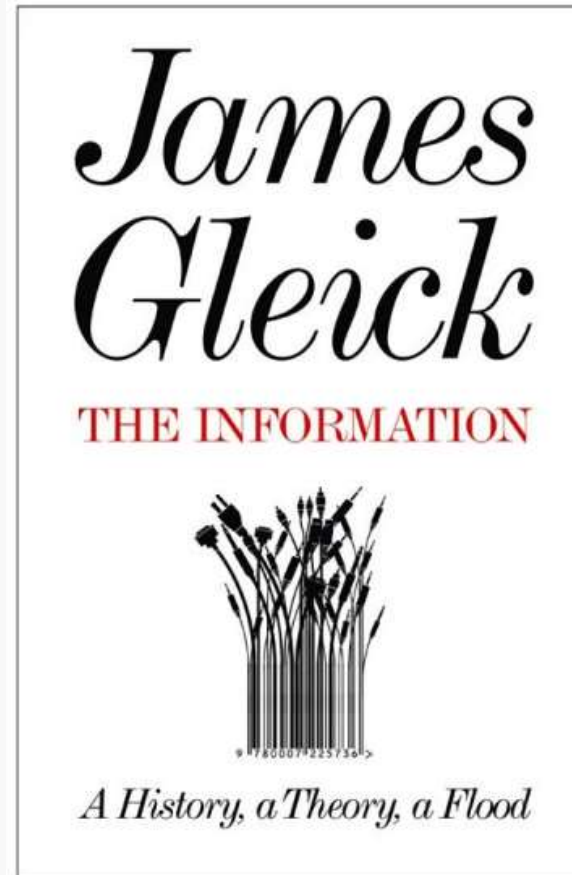
# Recommended Popular Science Readings

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

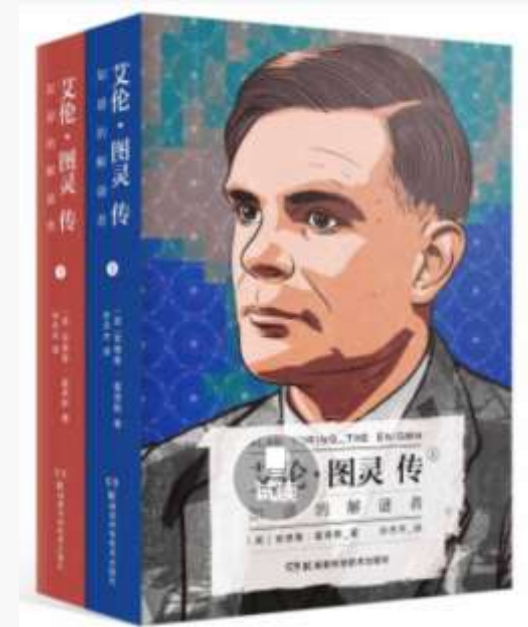
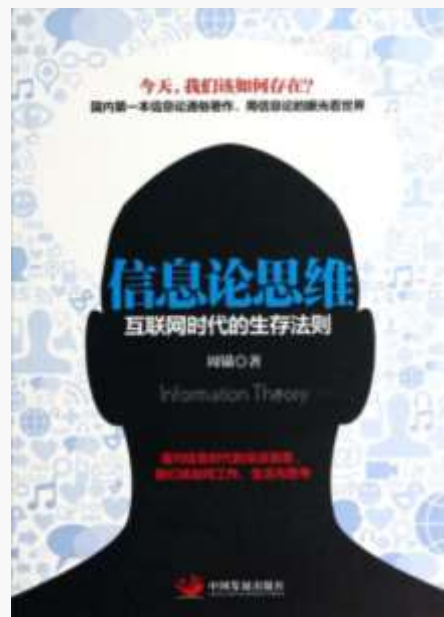
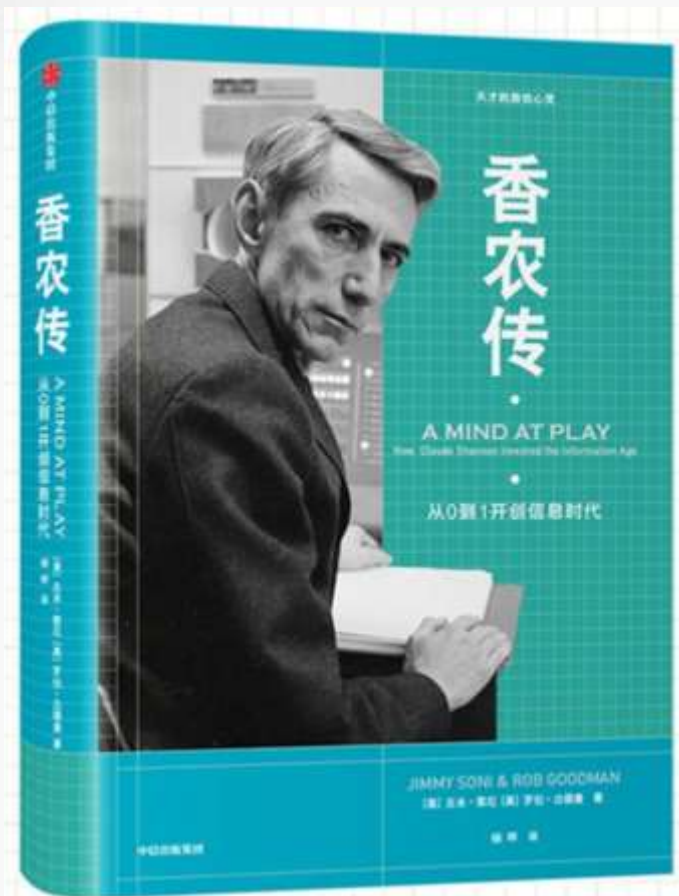


James Gleick  
Historian of science  
(1954-)

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



# Recommended Popular Science Readings





# Course Organization

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- **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

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- **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 (if there is any)



# Course Resources

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QQ Group



课堂名称：基础信息论2024-  
提高班-高雅琦  
课堂编号：589564810

微助教



课堂名称：基础信息论  
课堂编号：MU368

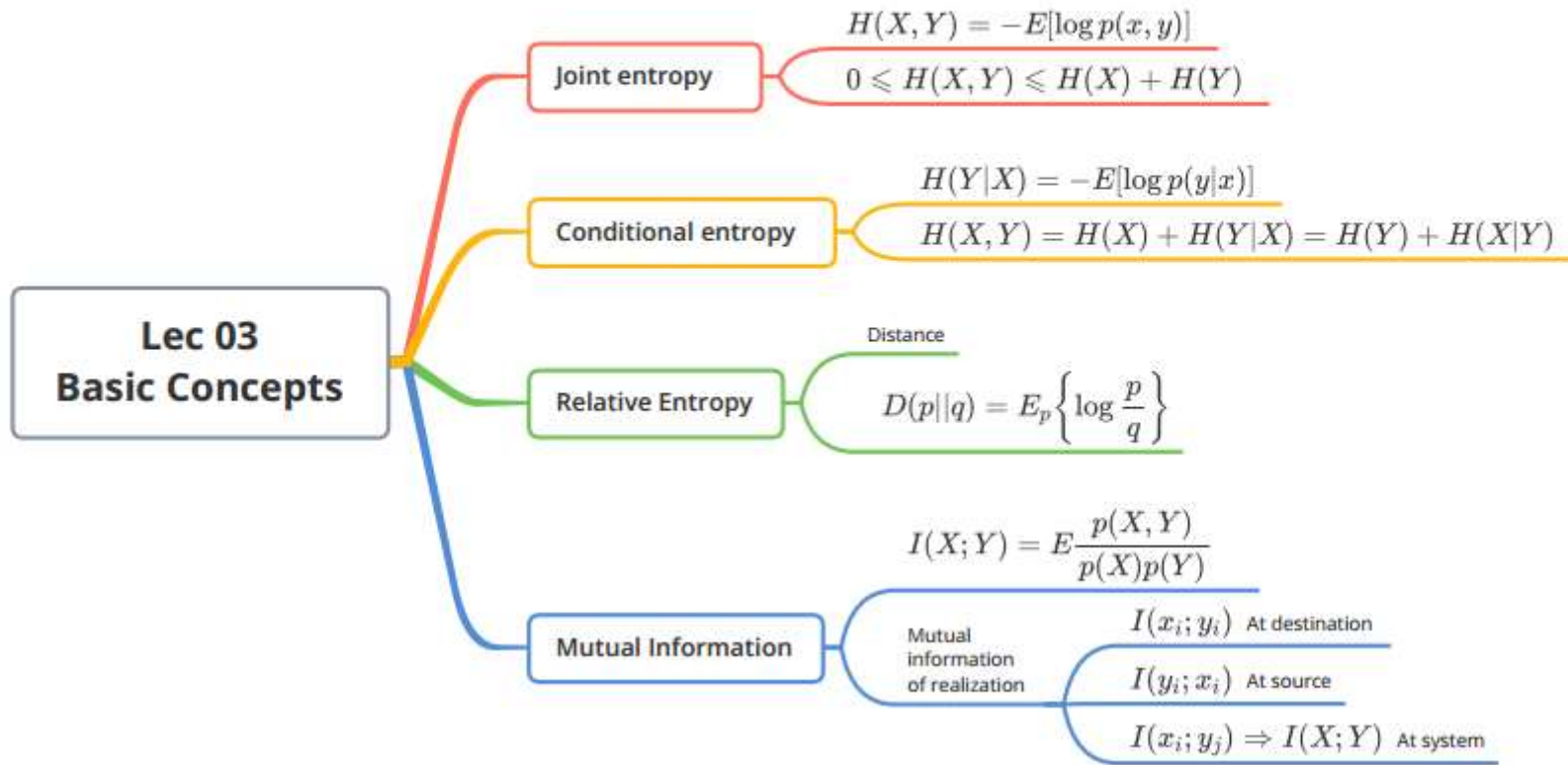
# Suggestions for In-class Notes

- 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

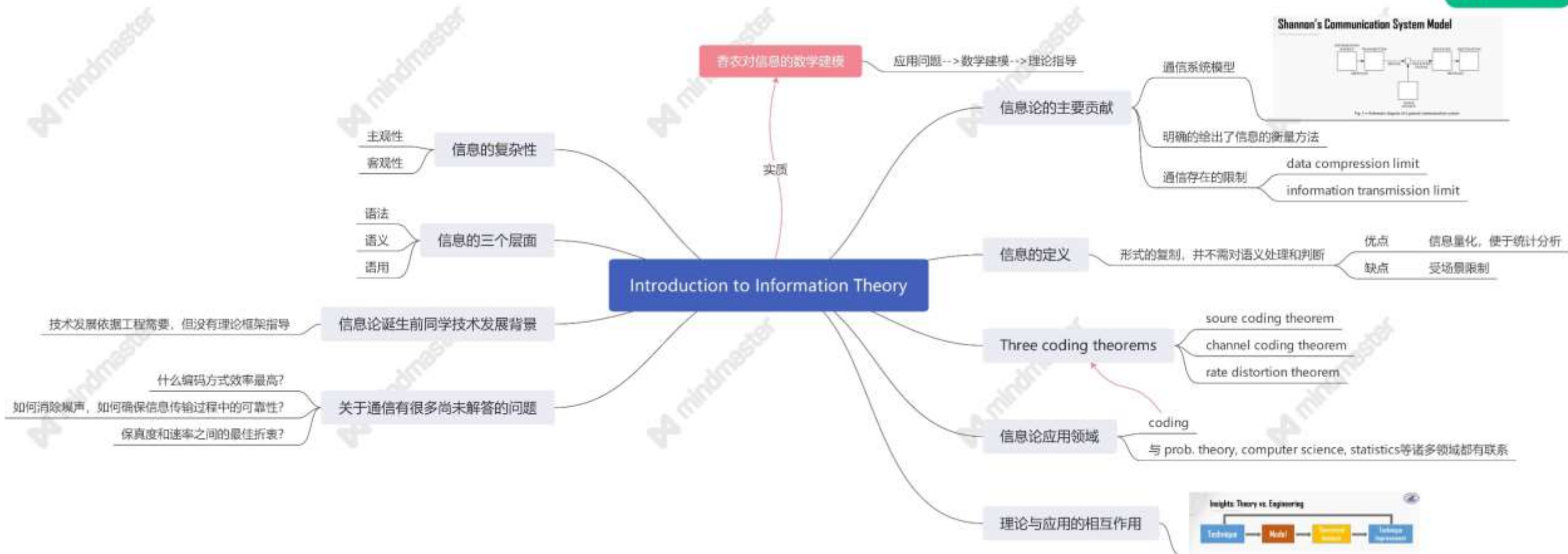
## MINDMAP



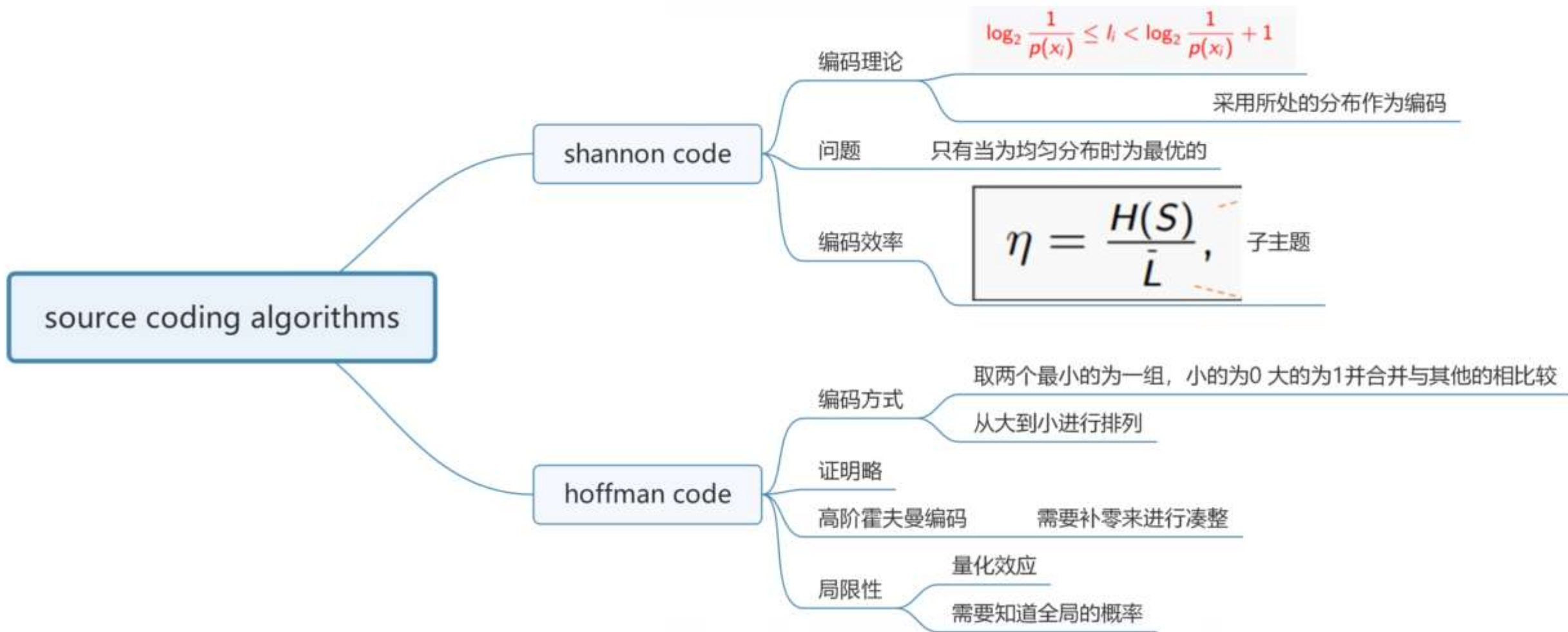


# Exemplary Notes Last Year

mindmaster



# Exemplary Notes Last Year





**Thank you!**

**The beginning of a beginning...**