Information Theory

Master of Logic 2017/18
2nd Block, Nov/Dec 2017

first class: Tuesday, 31 October 2017 9:00

http://homepages.cwi.nl/~schaffne/courses/inftheory/2017/
What is communication?

Alice

I want to send 1001

Bob

I think Alice sent 1001
Generic communication block diagram

Source ➔ Encoder ➔ Channel ➔ Decoder ➔ Destination

Noise

What is communication?

"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

I want to send 1001

I think A sent 1001

ECE 534 by Natasha Devroye
History of (wireless) communication

- **Smoke signals**
- **1861:** Maxwell’s equations
- **1900:** Marconi demonstrates wireless telegraph
- **1920s:** Edwin Howard Armstrong demonstrates FM radio
Big Open Questions

• mostly analog
• ad-hoc engineering, tailored to each application
• is there a general methodology for designing communication systems?
• can we communicate reliably in noise?
• how fast can we communicate?
Claude Elwood Shannon
1916 - 2001

- Father of Information Theory
- Bell Labs, professor at MIT
- arguably, the first person to really define and use “bits”
- juggling, unicycling, chess
- ultimate machine
• Introduced a new field: Information Theory

- What is communication?
- What is information?
- How much can we compress information?
- How fast can we communicate?
Main Contributions of Inf Theory

**Source coding**
- source = random variable
- ultimate data compression limit is the source’s entropy $H$

**Channel coding**
- channel = conditional distributions
- ultimate transmission rate is the channel capacity $C$

Reliable communication possible $\iff H < C$
Applications

- Communication Theory
- Computer Science (e.g. in cryptography)
- Physics (thermodynamics)
- Philosophy of Science (Occam’s Razor)
- Economics (investments)
- Biology (genetics, bio-informatics)
Topics Overview

• Entropy and Mutual Information
• Entropy Diagrams
• Data Compression / Source Coding
• Perfectly Secure Encryption
• Error-Correction
• Zero-Error Information Theory
• Noisy-Channel Theorem
• Quantum Information Theory
Prerequisites

• contents of Basic Probability: Theory
• no programming skills required
Questions ?