Information Theory

Michael J. Watts

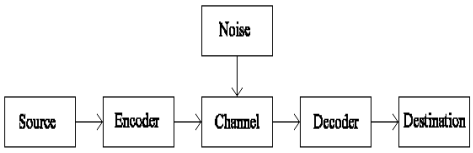
http://mike.watts.net.nz

Lecture Outline

- What is information theory?
- Communications Systems
- Measuring Information and uncertainty
- Information entropy and encoding

What is Information Theory?

- Area of applied mathematics
- Concerned with the analysis of a "communications system"



Components of Communications Systems

- Source
  - Where the information is coming from
- Encoder
  - Encodes the information and transmits it as a signal
- Channel
  - Medium over which information is transmitted

Components of Communications Systems

- Noise
  - Random interference added to signal
- Decoder
  - Receives the information and decodes it for the destination
- Destination
  - What is receiving the information

Information Theory

- Information theory analyses the flow of information through these systems
- How much information can go through it
- How the information can be encoded
- Must quantify information first

Information Theory

- Definitions of information
  - Data used to make a decision
  - Data that informs
- Information tells you something you did not already know

Quantity of Information

- Assume we have a random variable *X*
- *X* can have exactly *N* states
- Each state has a probability *P(n)*
- Probability of the state occurring determines its uncertainty
- As *P(n)* approaches 0.5, uncertainty approaches 1

Quantity of Information

- High uncertainty == more information
- The more uncertain an event is, the more information is conveyed when it occurs
  - Surprise!
- Entropy is the total uncertainty over all variables
  - Total uncertainty of the system

Encoding

- Encoding is representing symbols as bits
- Number of bits is proportional to number of symbols
  - Size of alphabet
- Min. bits / symbol(N) = bits * uncertainty(N)
  - More certain == fewer bits
  - Efficient encoding == fewer average bits
  - Data compression

Error Correction

- Noise complicates things
  - Definition of noise
- Error correcting codes account for noise
  - Correct a change in any one bit
- Add bits to an encoding scheme
  - Additional bits represent the information
  - Hamming code
- Used in CD's and elsewhere

Summary

- Information theory deals with the transmission and encoding of symbols (information)
- Information is measured as how “surprising” a symbol is
- Applications in telecommunications and compression
- Noise can interfere with a signal
- Error correction is needed