AMT223β/IMT223β
Applied Probability Theory (Information Theory)
Semester II, 2013

Lecturer : Dr. N Yapage
Department of Mathematics
University of Ruhuna

Tutorial Instructor : Ms. T Amadoru
Department of Mathematics
University of Ruhuna

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What is Information Theory?

Founding father Claude E Shannon, an Electrical Engineer at the Bell laboratories in USA published a paper "A mathematical theory of communication" in 1948.

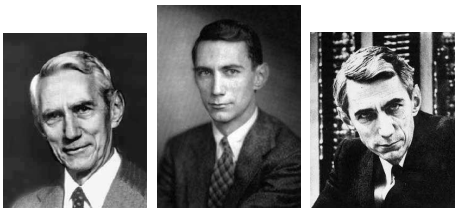

Figure 1: Images of Claude Elwood Shannon

`The fundamental problem in communication is that of reproducing at one point either exactly or approximately a message selected at another point.`

`Claude E Shannon, 1948`

Information theory answers two basic questions :

- How to compress data efficiently (information storage)
- How to transmit information reliably (information transmission)

Besides this, Information theory is interdisciplinary, multi disciplinary, and cross disciplinary. The core of information theory is mathematics. It is a new branch of applied mathematics.

Prerequisites

Prior exposure to Elementary Probability Theory / Statistics, Elementary Linear Algebra, Calculus of single variable / several variable functions, and Real Analysis would be useful but is not assumed. But you are expected to have Mathematical maturity, and Willingness to think.

Course Objectives

- How mathematics is used to quantify information and model a communication system
- To investigate connections among information theory and other fields of science and mathematics
- To discuss some applications of information theory

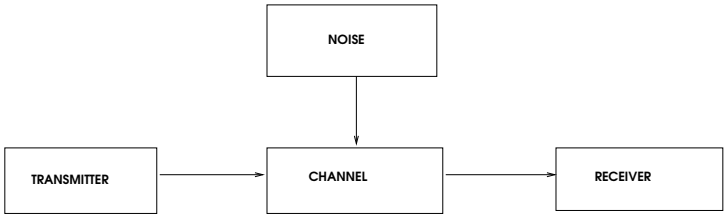

Figure 2: A very simple communication system

Tentative Course Structure

- Introduction to information theory, Claude E Shannon - the (founder) father of information theory, Elementary probability theory
- How to quantify information - Shannon's information measures: entropy, joint entropy, conditional entropy, relative entropy (a.k.a. Kullback-Leibler divergence), mutual information, conditional mutual information, Relationship between entropy and mutual information, Convex / Concave functions, Jensen's inequality and its consequences, Log sum inequality and its applications, Data processing inequality
- Communication channels: how to model a communication channel
  - channel capacity: examples : Noiseless Binary Channel, Binary Symmetric Channel (BSC), Binary Erasure Channel (BEC) etc.
- Shannon's noiseless & noisy coding theorems, Asymptotic Equipartition Property (AEP) - Information theoretic version of the Law of Large Numbers (LLN)
- Information measures for continuous random variables : differential entropy etc.
- Data compression - Kraft inequality, Huffman coding etc.
- Information theoretic cryptography (if time permits)
- Brief introduction to quantum extension of information theory, quantum computer science etc. (if time permits)

Schedule and Form of Assessment

Schedule

Lectures : 30 hrs and Tutorial classes : 15 hrs. Two lectures (2 hrs) & one tutorial class (1 hr) per week

- Lectures : Thursday 13.00 - 15.00 hrs and Tutorial class : Tuesday 08.00 - 09.00 hr

Form of Assessment

- End of semester examination

References

(1) A First Course in Probability, Sheldon Ross, Pearson Education, 2002.

(2) Elements of Information Theory, T. M. Cover and J. A. Thomas, Wiley-Interscience, 2006.

(3) A First Course in Information Theory, R. W. Yeung, Kluwer Academic / Plenum Publishers, 2002.

(4) Probability and Information, David Applebaum, Cambridge University Press, 1996.