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INFORMATION THEORY

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2015-2016

PART A: Overview

✓ Introduction

Information theory is a branch of mathematics that overlaps into communications engineering, biology, medical science, sociology, and psychology. The theory is devoted to the discovery and exploration of mathematical laws that govern the behavior of data as it is transferred, stored, or retrieved.

Whenever data is transmitted, stored, or retrieved, there are a number of variables such as bandwidth, noise, data transfer rate, storage capacity, number of channels, propagation delay, signal-to-noise ratio, accuracy (or error rate), intelligibility, and reliability. In audio systems, additional variables include fidelity and dynamic range. In video systems, image resolution, contrast, color depth, color realism, distortion, and the number of frames per second are significant variables. One of the most important applications of information theory is to determine the optimum system design for a given practical scenario.

In general, Information theory it's a mathematical equations which express three fundamental concepts:

1. **Measure of information** is entropy, which is usually expressed by the average number of bits needed to store or communicate one symbol in a message.
2. **Channel capacity** is the tight upper bound on the rate at which information can be reliably transmitted over a communications channel. By the noisy-channel coding theorem, the channel capacity of a given channel is the limiting information rate (in units of information per unit time) that can be achieved with random small error probability.
3. **Coding theory** is concerned with finding explicit methods, called *codes*, for increasing the efficiency and reducing the error rate of data communication over noisy channels to near the Channel capacity. These codes can be roughly subdivided into data compression (source coding) and error-correction (channel coding) techniques.

The connection between the above concepts is the bases for the information theory.

✓ Information theory Applications

The fundamental topics of information theory include:

- Lossless data compression (e.g. ZIP files).
- Lossy data compression (e.g. MP3s and JPEGs).
- Channel coding (e.g. for Digital Subscriber Line (DSL)).
- This field is at the intersection of mathematics, statistics, physics, computer science, neurobiology, and electrical engineering. Its impact has been crucial to the success of the Voyager missions to deep space, the invention of the compact disc (CD), the feasibility of mobile phones, the development of the Internet, the study

of linguistics and of human perception, the understanding of black holes, and numerous other fields.

- Important sub-fields of information theory are source coding, algorithmic complexity theory, channel coding, algorithmic information theory, information theoretic security, and measures of information.

✓ Probability Background

o Introduction to the probability

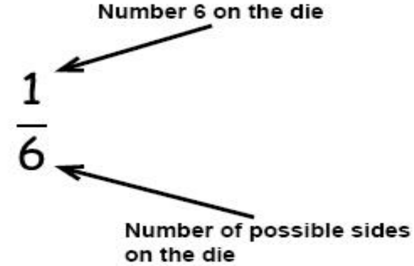
Probability is a branch of mathematics that deals with calculating the likelihood of a given event's occurrence, which is expressed as a number between 1 and 0. In its simplest form, probability is a type of ratio where we compare how many times an outcome can occur compared to all possible outcomes.
Probability can be expressed as: the number of occurrences of a wanted out comes divided by the number of occurrences *plus* the number of failures of occurrences (***this adds up to the total of possible outcomes***). In order to measure probabilities, mathematicians have devised the following formula for finding the probability of an event.
Note: The occurrences of events here should have the same chances.

$$\text{Probability} = \frac{\textbf{The number of wanted outcomes}}{\textbf{the number of possible outcomes}}$$

The probability of event A symbolized by: *P(A)*.
The number of wanted out comes symbolized by *M*.
The number of possible out comes symbolized by *N*.

$$\mathbf{P(A)} = \frac{\mathbf{M}}{\mathbf{N}}$$

Example: What is the probability to get a 6 when you roll a die?
A die has 6 sides, 1 side contain the number 6 that give us 1 wanted outcome in 6 possible outcomes.



Example: What is the probability of getting a "5" or "6" when rolling a dice?

Number of wanted out comes: 2 ("5" or "6")

Total number of outcomes is: 6 ("1", "2", "3", "4", "5", and "6")

So the **probability** = $\frac{2}{6} = \frac{1}{3}$ = 0.333…