Introduction to Information Theory

Information Theory is a branch of mathematics that has many applications in the field of computer science. Such as in cryptography, machine learning and project management.

What is Information Theory?

Information theory is the study of how information can be efficiently stored, transmitted, processed.

What is Information?

Information is what allows one mind to influence another. It is the data that is transmitted from one mind to another during a communication process.

How to measure Information?

- Bits: measure of surprise, the more surprising an event is, the more information it contains.

Information measure formula

$$I(x) = -log_2(p(x))$$

WTF is this formula? Let's dissect it.

- $I(x)$ is the information contained in the event x.
- $p(x)$ is the probability of the event x.
- log_2 is the logarithm base 2.

To discover the information (I) contained in the event x, we need to know the probability of the event x and apply it to the log_2 function.

Example

Let's assume the probability to snow in 3 different brazilian cities: ❄️ ❄️ 🇧🇷

City	Probability	Information
São Paulo	1%	$I(SP) = -log_2(0.01) = 6.6439$ bits.
Rio de Janeiro	0.001%	$I(RJ) = -log_2(0.0001) = 13.2877$ bits.
São Joaquim	80%	$I(SJ) = -log_2(0.8) = 0.3219$ bits.

- Notice that the more surprising an event is, the more information it contains.
- No one would be surprised if it snowed in São Joaquim, but if it snowed in São Paulo or Rio de Janeiro, it would be a big surprise, would be an event with a lot of information.

Entropy

- Amount of disorder in a system.
- As things grow, the entropy grows together.
- More information available = more disorder.

Entropy and chaos

- Entropy is a measure of chaos. The more entropy, the more chaotic the system.

Stephen Hawking

> "The increase of disorder or entropy is what distinguishes the past from the future, giving a direction to time."

You can't run away from entropy, deal with it

- Entropy is a natural law of the universe. It is a measure of disorder.
- Do your fast-growing company is more chaotic now than it was when you started? Yes, it is.
- Why? Because it is growing.
- What is the solution? Try to keep the chaos under control as eliminating it is impossible.

Entropy and Information

- Entropy is an important concept in information theory. Probably the most important concept.

Entropy formula

$$H(X) = -\sum_{i=1}^{n} p(x_i) log_2(p(x_i))$$

WTF is this formula[2] ? Let's dissect it.

- $H(X)$ is the entropy of the random variable X.
- $p(x_i)$ is the probability of the event x_i.
- log_2 is the logarithm base 2.

To discover the entropy (H) of the random variable X, we need to know the probability of each event x_i and apply it to the formula.

Example

You are a data scientist building a decision tree to predict which ad you should show to an user based on its profile. You have 3 possible ads to show to the user:

Ad	Probability
Ad 1	0.6
Ad 2	0.3
Ad 3	0.1

You want to reduce the entropy of the system, so you need to know how much entropy you have now.

$$H(X) = -0.6log_2(0.6) - 0.3log_2(0.3) - 0.1log_2(0.1)$$
$$H(X) = 0.5219 + 0.1542 + 0.4685$$
$$H(X) = 1.1446$$

How to interpret this result?

- The entropy of the system is 1.1446 bits.

How to reduce the entropy?

- You can reduce the entropy by showing the ad with the highest probability.

But why is it bad to show the ad with the lowest probability?

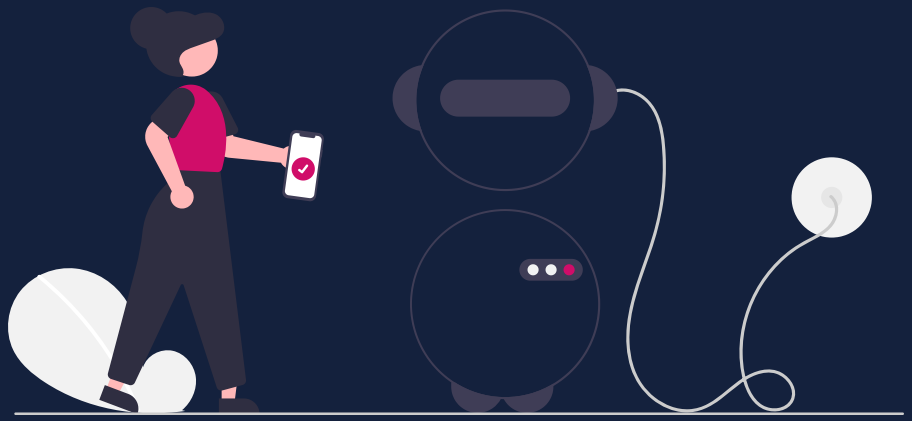
- Because it is the least surprising ad. Probably the user has already seen it many times.

Information Theory Applications

- Cryptography
- Machine Learning
- Project Management
- Data Compression

Cryptography

Machine Learning



Project Management

Data Compression

Thank you!

Thank you for your attention. I hope you enjoyed this talk. If you have any questions, please feel free to contact me.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