Activity Recognition 2
Entropy

Mobile Computing

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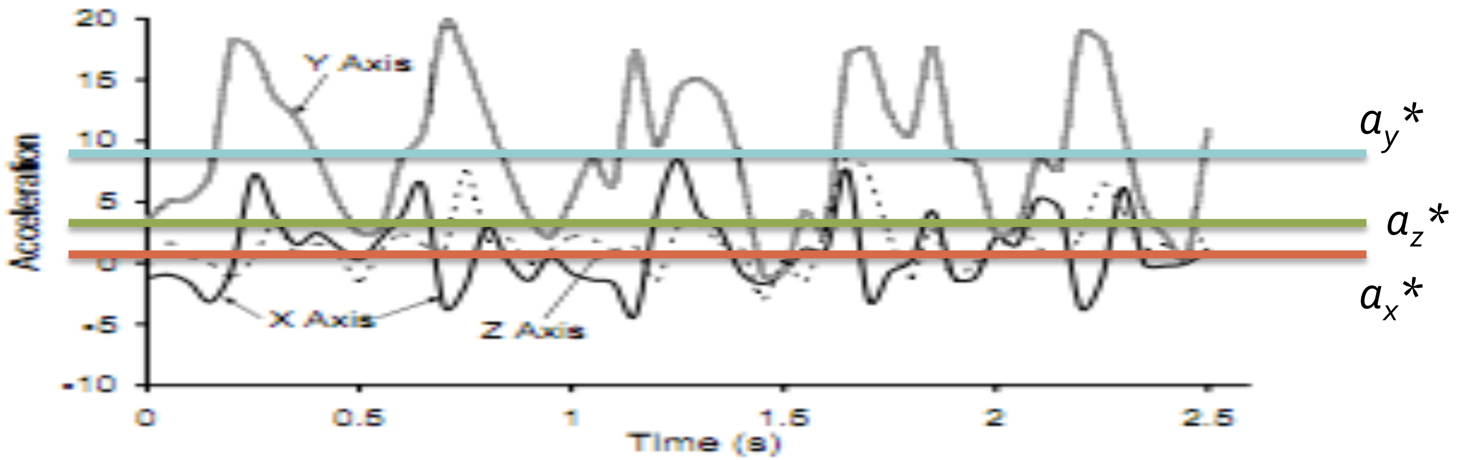
REVIEW: FEATURES
FREQUENCY-DOMAIN
FOURIER TRANSFORM

First step: Feature

- Raw data is not appropriate for analysis
- Feature: (statistical) characteristic of data
- Best feature-set depends on the problem
- Examples
  - Average
  - Variance
  - Energy
  - Entropy
  - Correlation

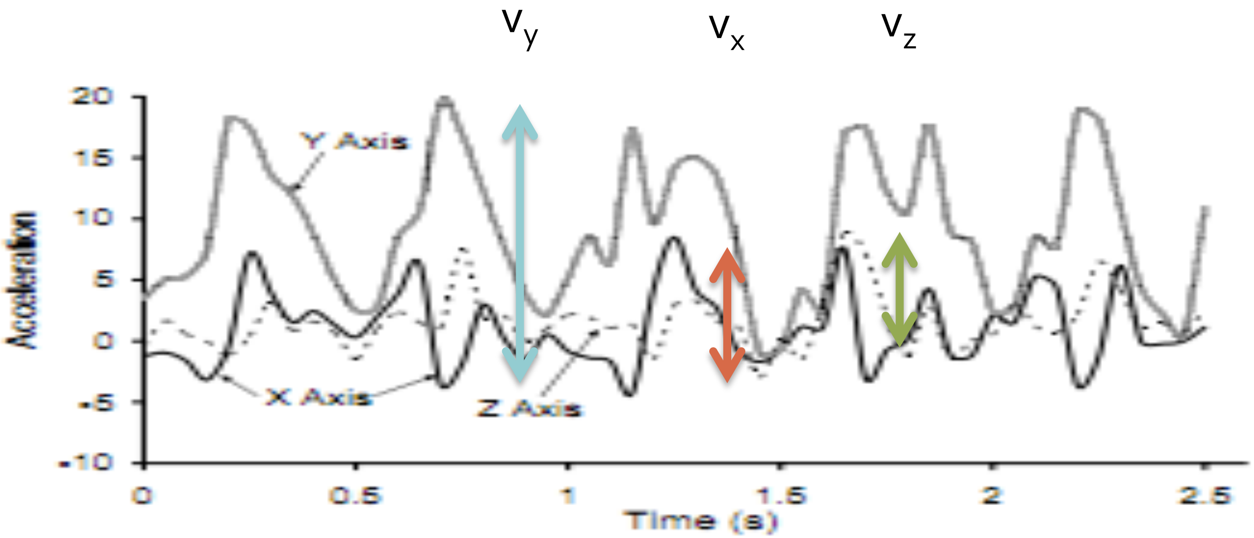
Features

- Signal average
  - (a_x^*, a_y^*, a_z^*), $a_x^* = \frac{a_1 + a_2 + \cdots + a_n}{n}$
  - the orientation w.r.t. gravity direction



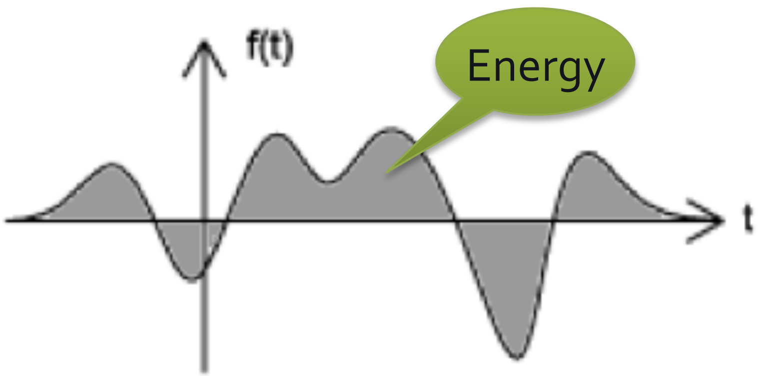
Features

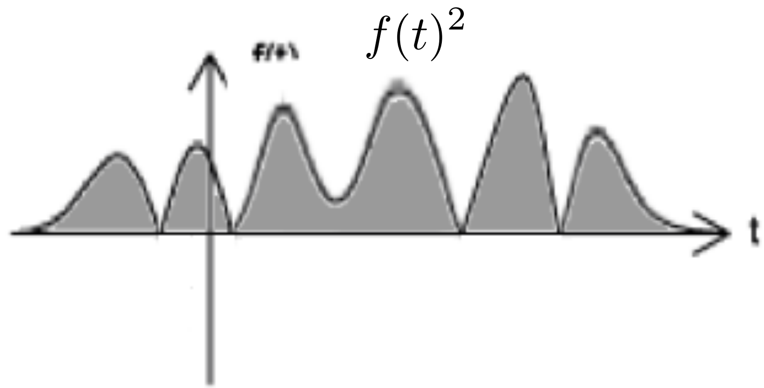
- Variance:
  - Deviation from the average
  - (v_x, v_y, v_z),
  - Level of instability



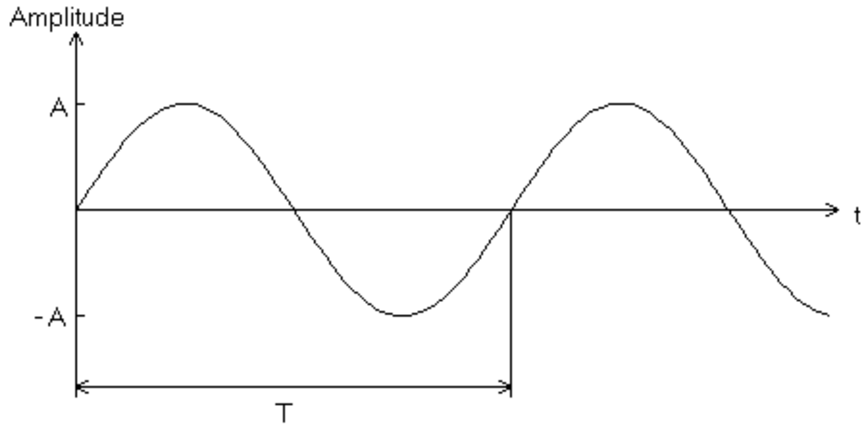
Features

- Signal energy (in signal processing)
  - Area between the signal and the time axis
  - Integrate square of *f*
  -

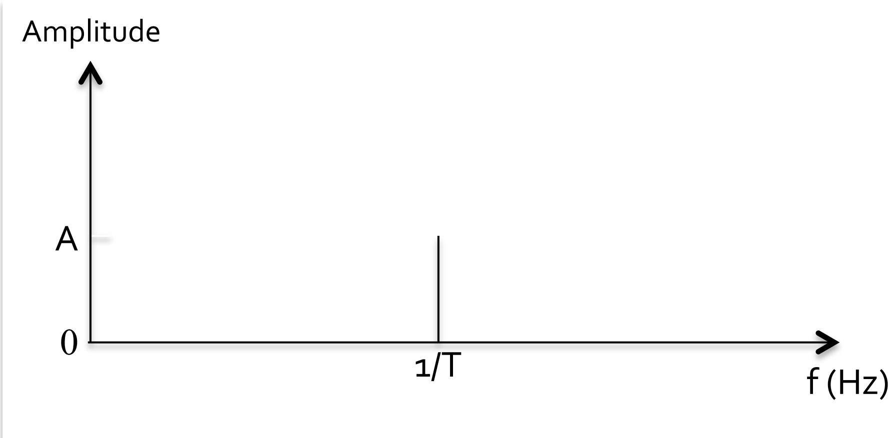




- Time domain representation is a projection of the signal (in time-freq-amp space) onto the time plane



- Frequency domain rep. is a projection of the signal (only positive amplitude part) onto the frequency plane



Fourier Transform
Fourier Series

Quiz

- Provide definition, how to compute, and interpretation of the following accelerometer features
  - Signal average, variance, energy, entropy, correlation,…

Quiz

- Describe time-domain representation and frequency-domain representation of a signal

Quiz

- Explain how Fourier Transform can convert a signal representation from time-domain to frequency-domain

Entropy

- Original concept from Thermodynamics
  - Level of Randomness or disorder, having tendency
- Definition in Information Theory
  - measure of the amount of (new) information contained in a message
  - H(M)
- Proposed by Claude Shannon
  - "Father of Information Theory"
  - Proved perfect secrecy of One-time Pad

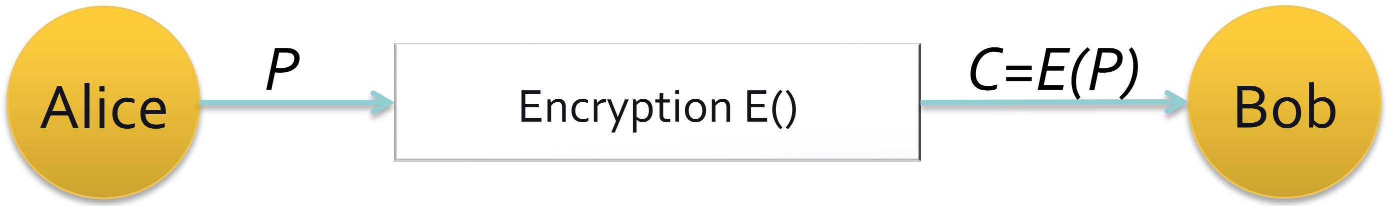
Shannon's Entropy

- Communication Theory

  - How much information can be delivered at most?
    - Channel capacity
  - How well a coding scheme can deliver information?
  - How much information can be delivered with noise?

Shannon's Entropy

- Cryptography



  - H(P): Information contained in the plaintext P
  - H(P|C): Information contained in P when ciphertext C is known
  - Perfect secrecy: No additional information is given about P even if a ciphertext C is given to the adversary
    - H(P) = H(P|C)   for One-time Pad

Amount of Information

- Which one has more information?
  - "I am a boy"
  - "I am a boy in Korea"
  - "I am a boy in Korea, who goes to MJU"
- Length?

Amount of Information

- Which one has more information?
  - "I am a human"
  - "I am a boy"
  - "I am John"
- Information ≠ message size
  - We can assume all message has the same length
  - "   I am a boy "

Amount of Information

- What is the probability of a college student to say
  - “I am a boy?”
- What is the probability of a college student to say
  - “I am John?”
- Information(“I am John”) > Information(“I am a boy”)
- *Rare message implies more information*

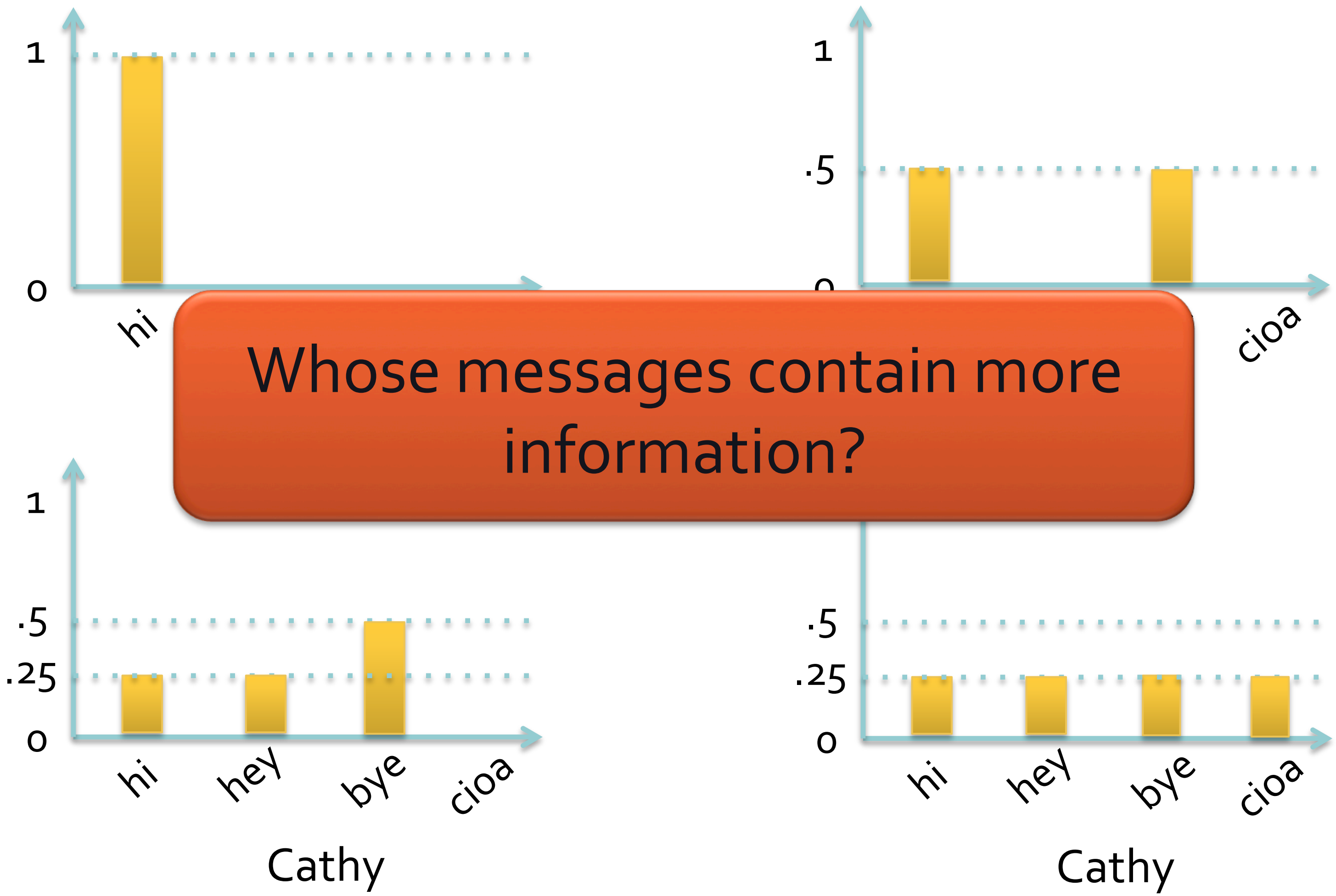
Speaker Model

- What is speaking?
  - Pick a message from the message database
  - Each message has a probability to be chosen
- *A speaker whose words are difficult to expect says more information*

Message Distribution

- Speakers have different message distribution
  - There are 4 messages possible: “hi”, “hey”, “bye”, “ciao”
  - Alice always says “hi”
  - Bob says only “hi” or “bye” with same probability
  - Cathy says “bye” half the time, and “hi” and “hey” half the time with equal probability
  - David says “hi”, “hey”, “bye”, “ciao” with equal probability

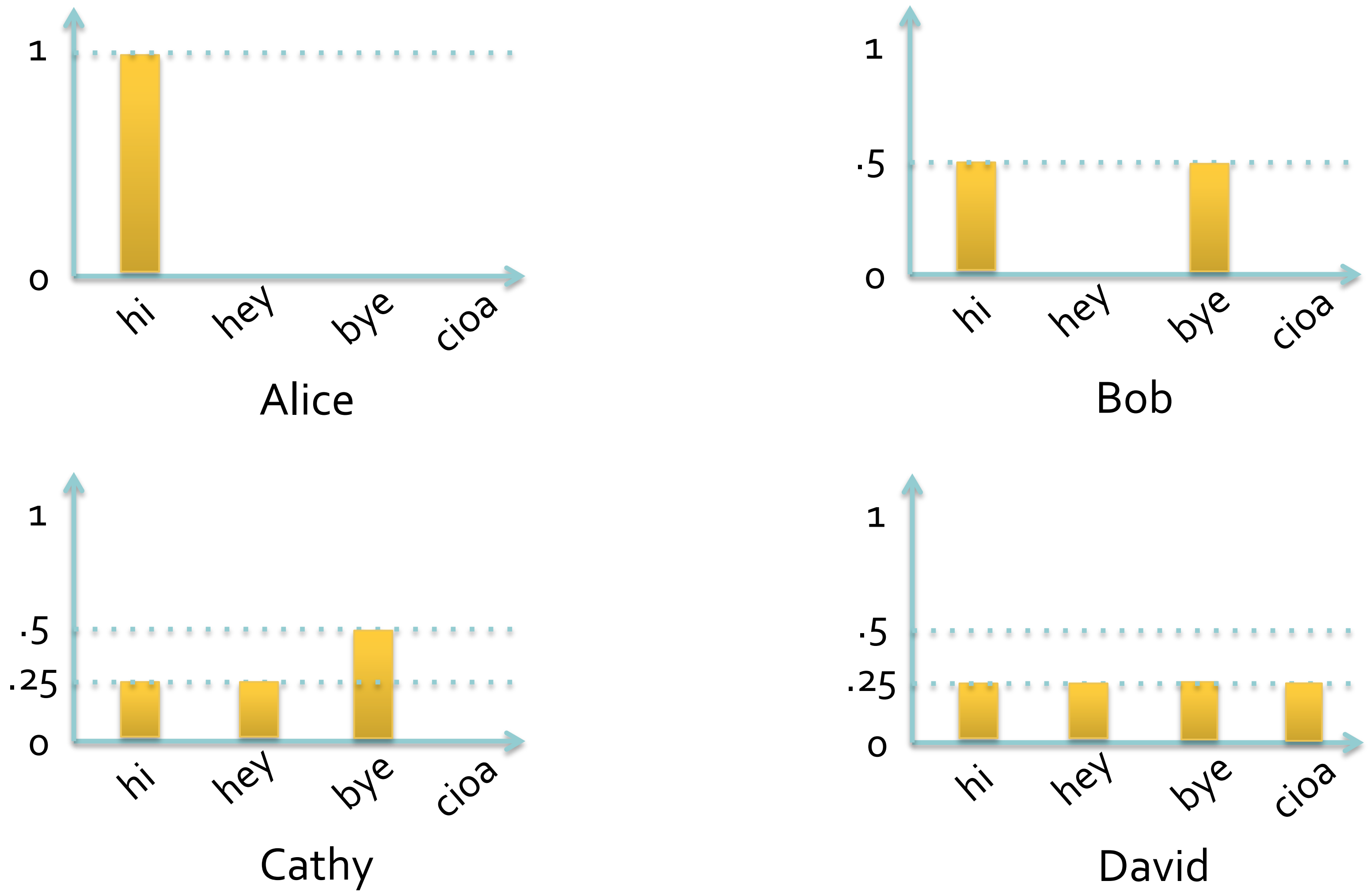
Message Distribution



Entropy: Formula

- The entropy (in bits) of a discrete random variable M:
- Interpretation
  - Average # of bits to express each message
- Maximized when uniform
  - p_m is the same for all messages

Entropy of A, B, C, D

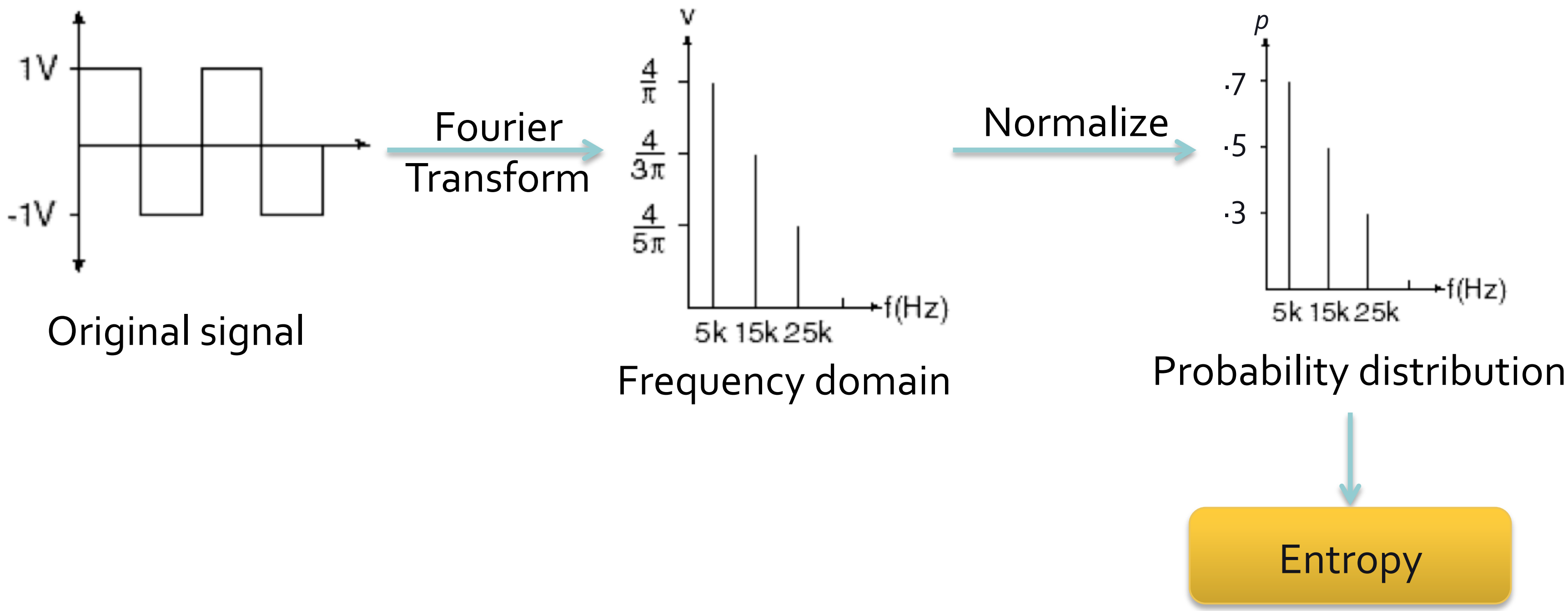


Features (revisited)

- Frequency-domain entropy
  - Differentiate between walking and cycling
- What is *frequency domain*?
- What is *Entropy*?
- What is *frequency-domain entropy*?

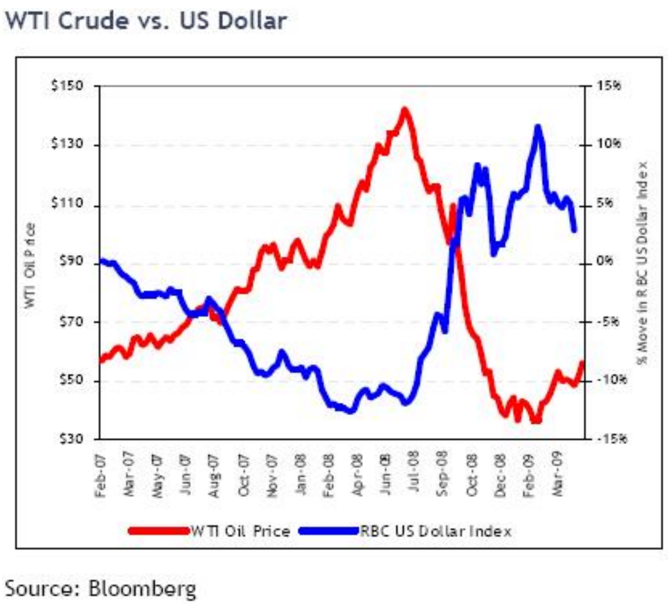
Frequency-domain Entropy

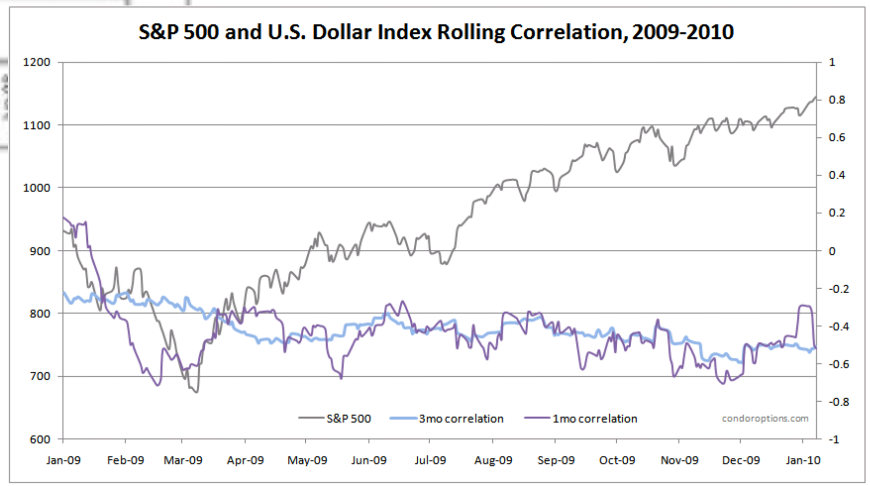
- Given a signal in time-domain, convert to frequency-domain, normalize it, then compute entropy



Correlation

- Degree of dependency between two signals





Correlation Coefficient

- Given two random variables X, Y, corr-coef is

- Given two series of *n* measurements x_i *and* y_i

- Interpretation
  - *+1: perfect dependency*
  - *0: no dependency*
  - *-1: opposite dependency*