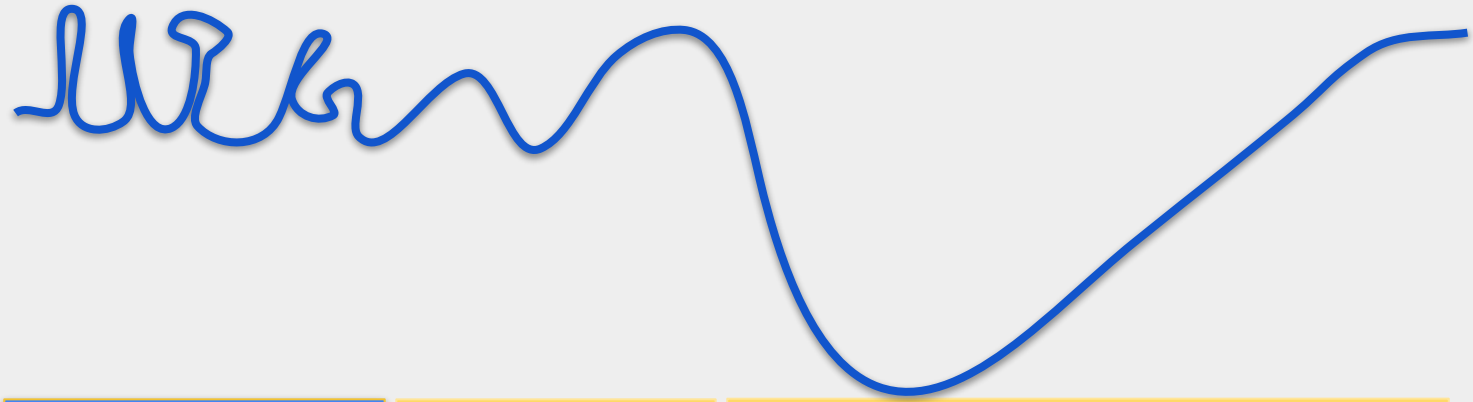
Computing with Signals



DA 623

Jan - May 2024

IIT Guwahati

Instructors: Neeraj Sharma

Lecture-01

- Signal, signal, everywhere
- Curious about communication signals

Ants

Pheromones

Chimps

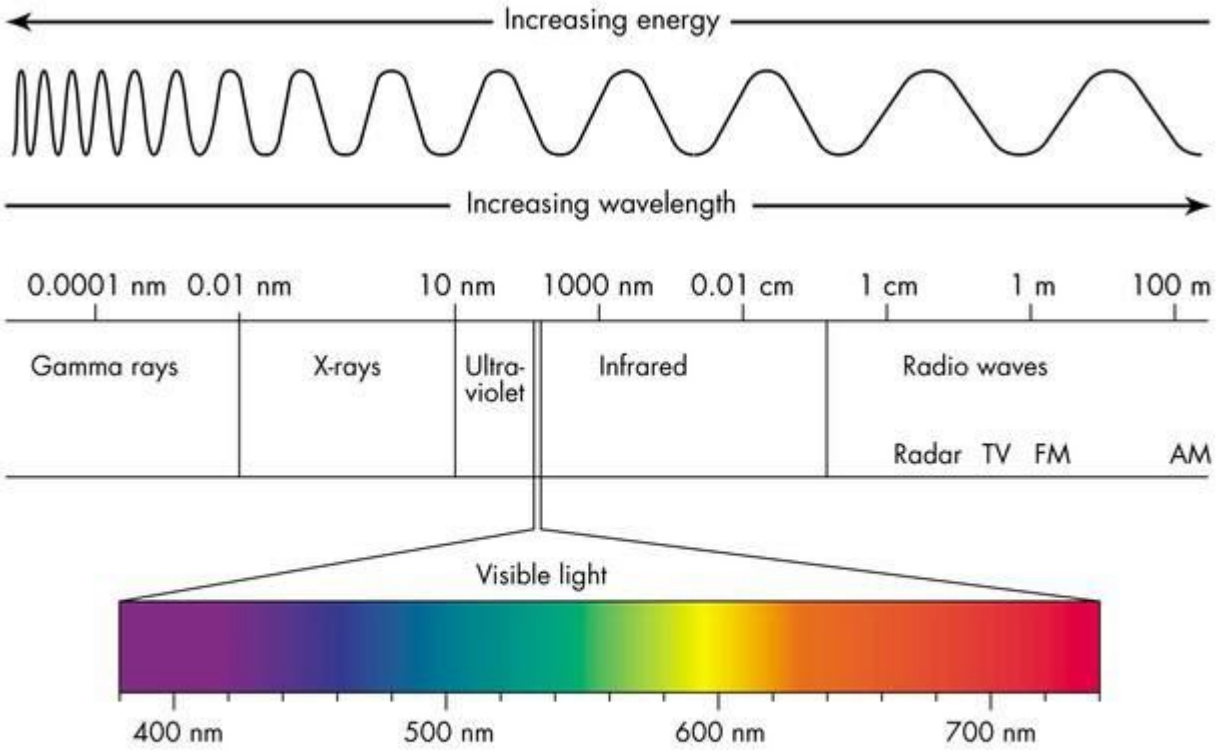
Facial Expressions

Humans

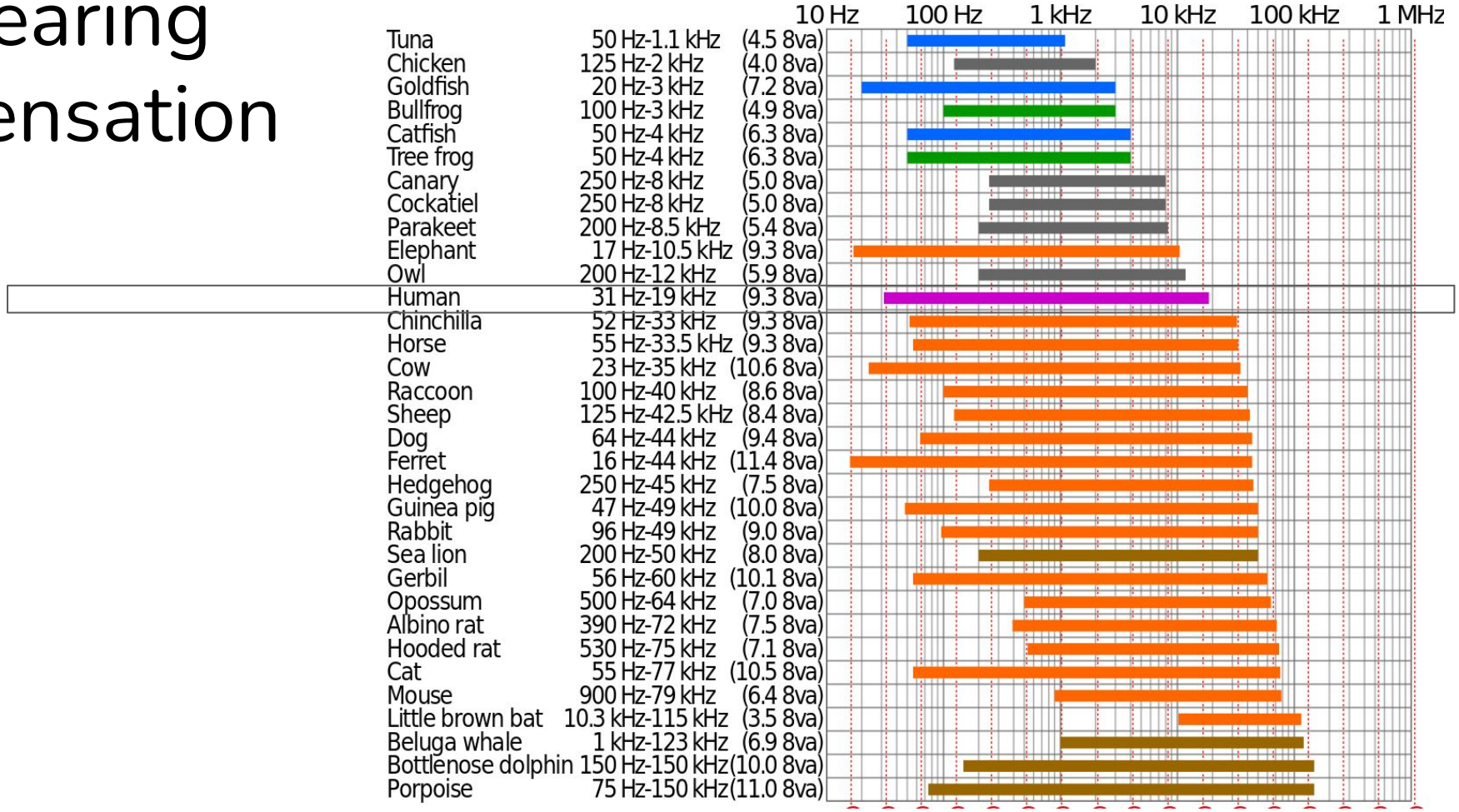
Spoken language

Written
Visual

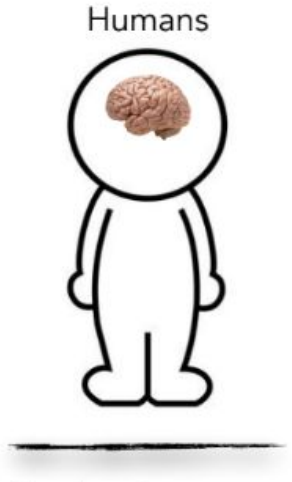
Visual Sensation

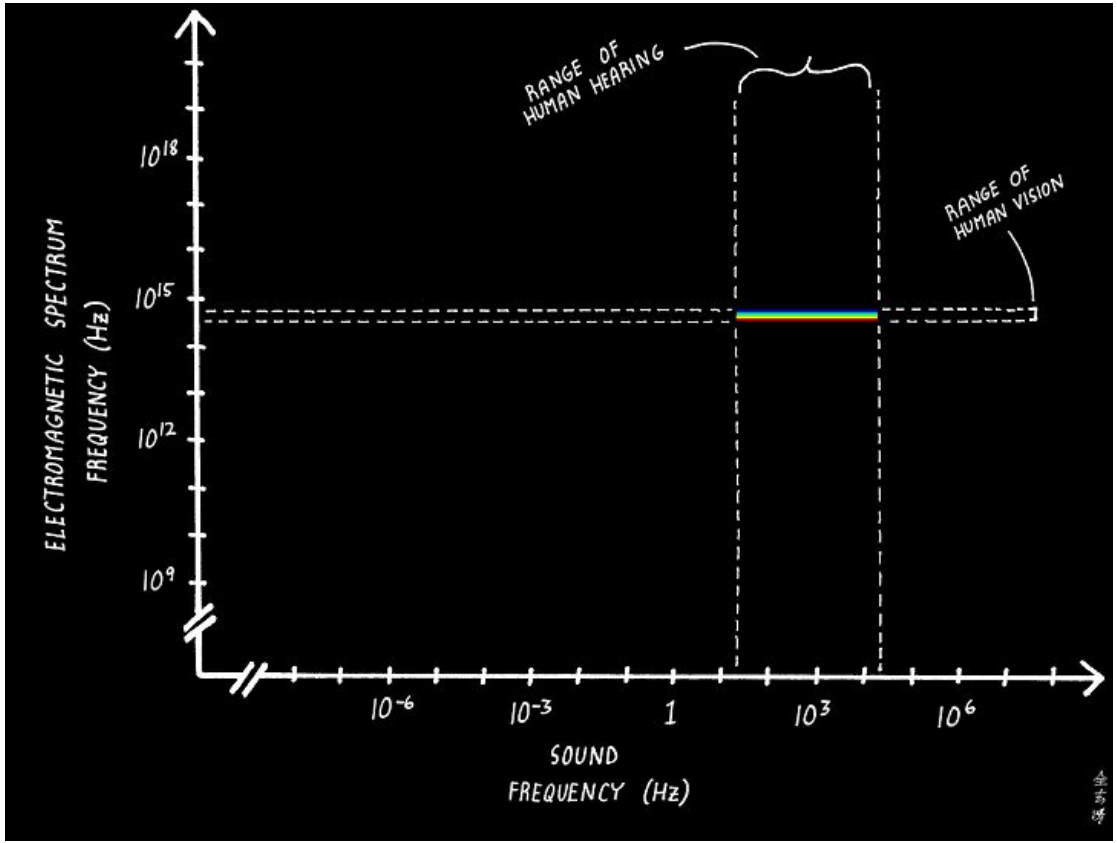


Hearing Sensation



Our Visual-Sonic world?





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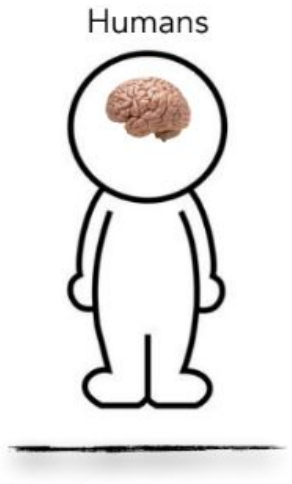

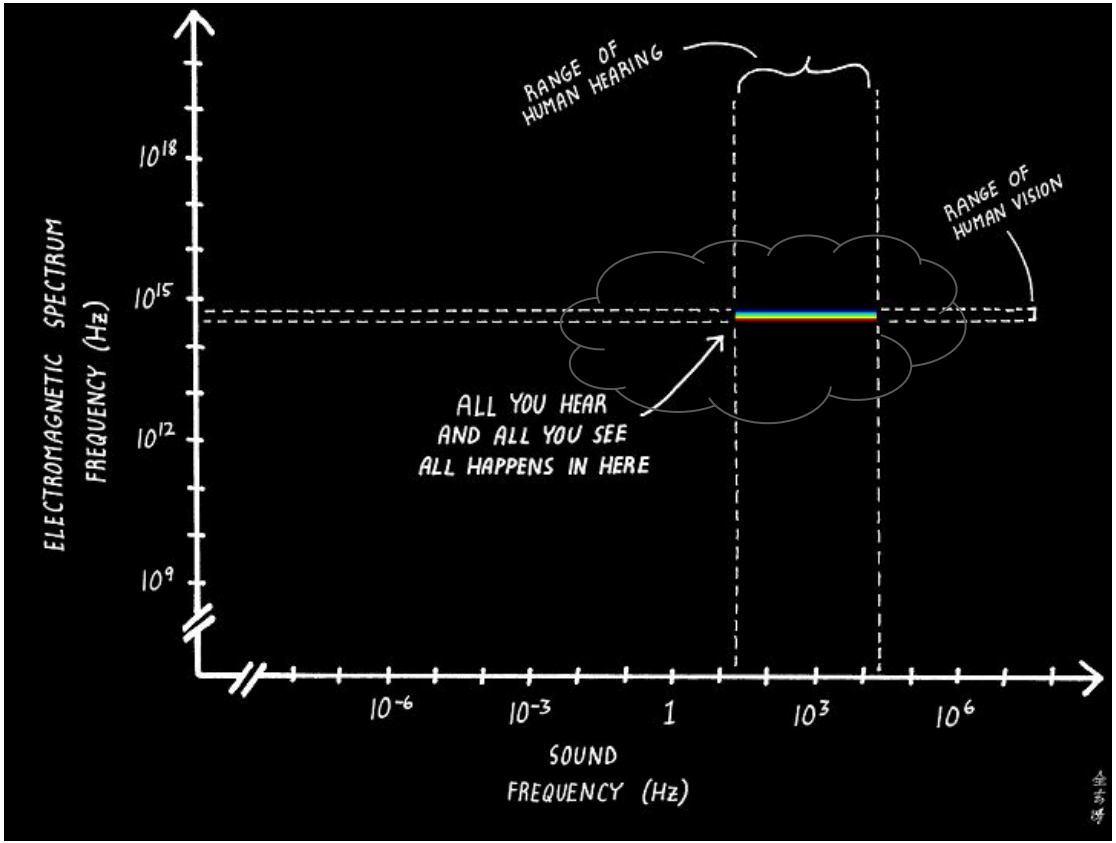

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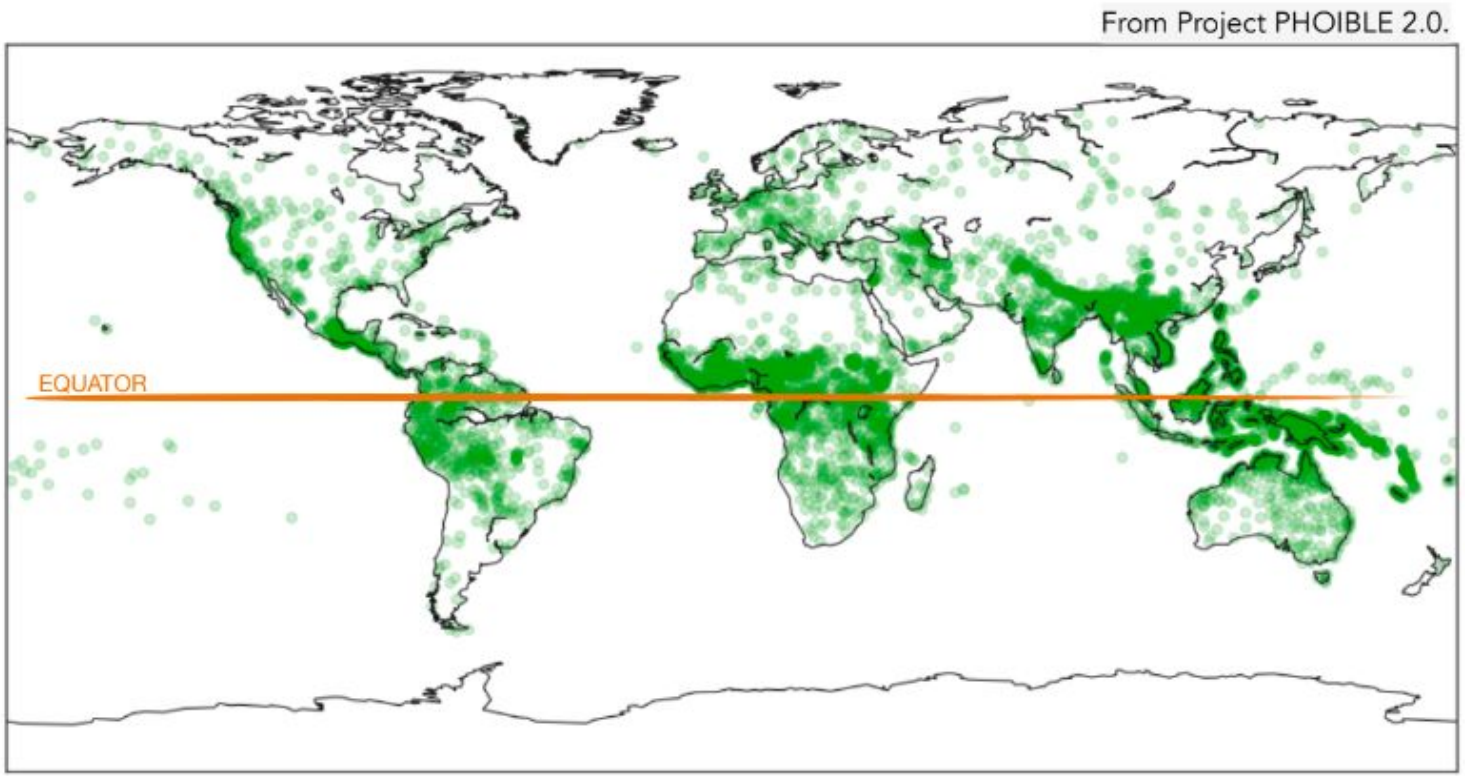
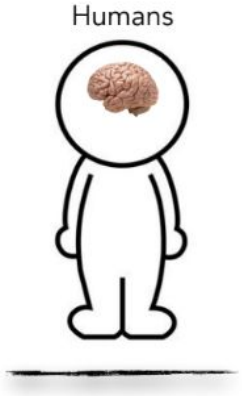
Humankind boasts of **7000 plus** spoken languages!



Perception

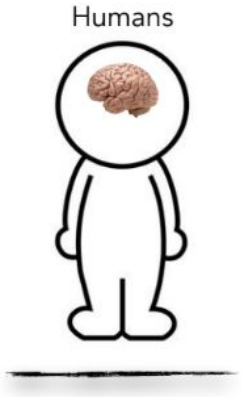
Visual
Sonic
Haptic
Odour



Humans have distinct sensing mechanism for each.
[Eyes, Ears, Skin, Nose]

Multi-modal perception

Visual
Sonic
Haptic
Odour



Is our perception a result of combining sensation received from individual modalities?

Humans have distinct sensing mechanism for each modality.
[Eyes, Ears, Skin, Nose]

Signal - what’s that?

- Lets’ hear your thoughts - what is signal for you?

Signal - what's that?

- Lets' hear your thoughts - what is signal for you?
  - something varying with time
  - something that is output from a physical system
  - something varying over space
  - something that conveys information
  - …. and more!

Signal - formally

- a signal, represented as a function of one or more variables, may be defined as an observable change in a quantifiable entity [1].

(conveys information)

Nice! we all are on same page now - let's proceed!

[1] Pragnan Chakravorty, "What is a signal?", Lecture Notes, IEEE Signal Proc. Magazine, 2018

About Me

- Assistant Professor
  - Mehta Family School of Data Science and AI, IIT G
  - `https://neerajww.github.io/`
- Before this
  - Schooling in Bhubaneswar
  - BTech from CET, Bhubaneswar
  - Masters, PhD, IISc Bangalore
  - Postdocs - IISc, Carnegie Mellon, Fraunhofer Audio Labs
- Learning, and contributing (a reason for this course)

What’s going on Earth?

About Google Books
• Overview

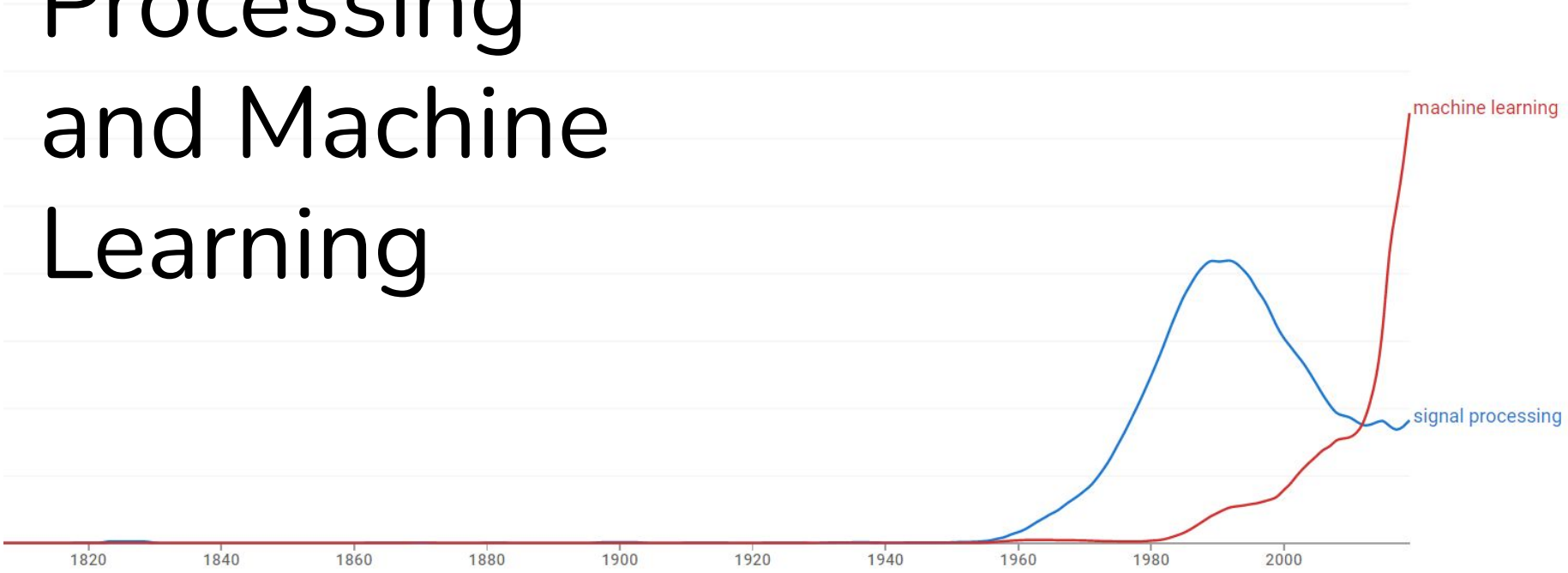
Google Books Library Project – An enhanced card catalog of the world's books

Google Books Ngram Viewer

signal processing, machine learning

1800 - 2019 | English (2019) | Case-Insensitive | Smoothing

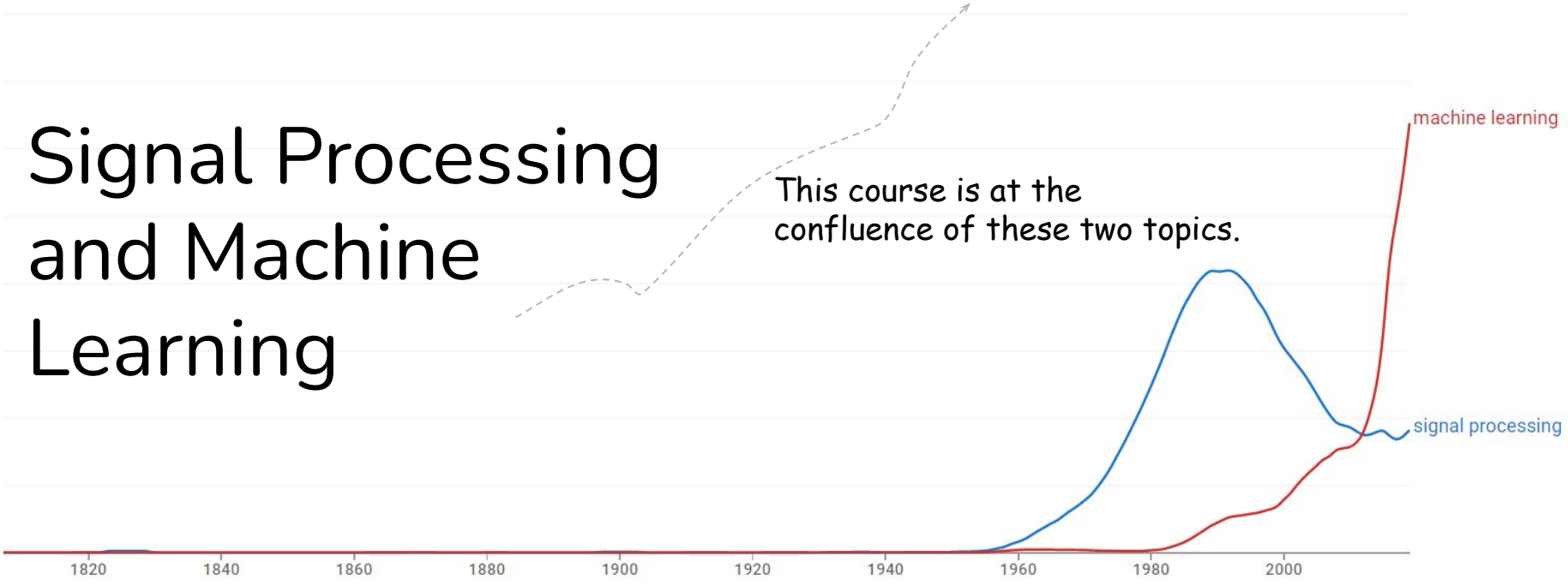
Signal Processing and Machine Learning

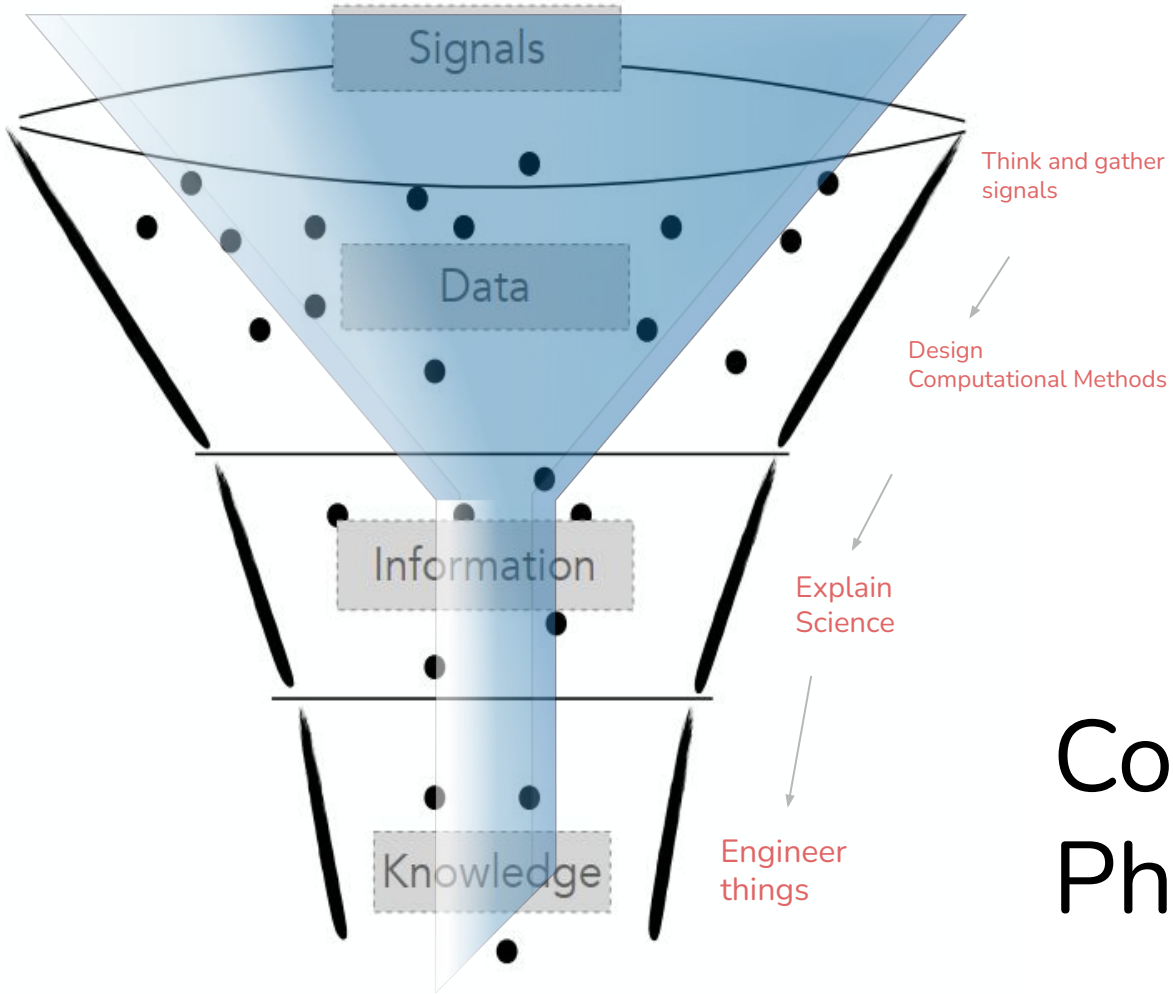


Computing with Signals

Signal Processing and Machine Learning

This course is at the confluence of these two topics.





Course Philosophy

"An experiment is a question which science poses to nature,

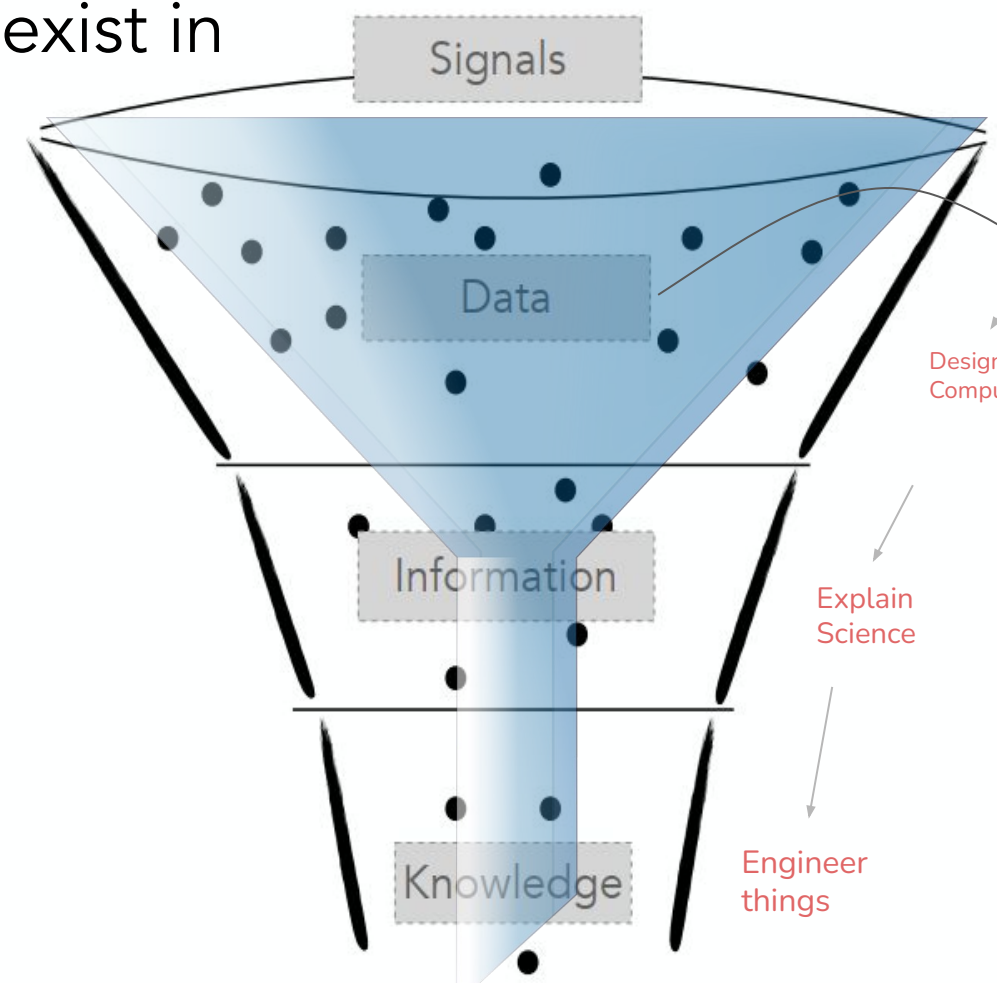
a measurement is the recording of nature's answer."

Max Planck
(German Theoretical Physicist)

Signals exist in nature.

Data is what we measure.

Signals exist in nature.



What is Data?

Think and gather signals

Design Computational Methods

Explain Science

Engineer things

Course Philosophy

What is “Data”?

- Word comes from the Latin word “datum” - something given
- Data is a plural form of the word datum

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- Word comes from the Latin word “datum” - something given
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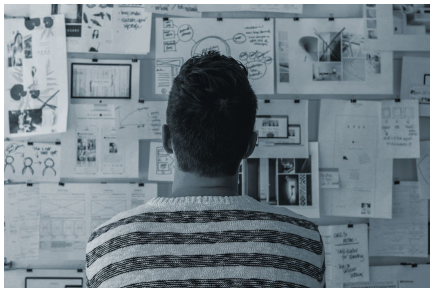
Over time, "data" became more commonly used in English to refer to pieces of information or facts that are collected, stored, and analyzed for various purposes.

What is Data?

- Word comes from Latin language
- Plural form of the word "datum"
- Meant "something given" or "a fact"

In practice:

- Gathered through observation, measurement, or research



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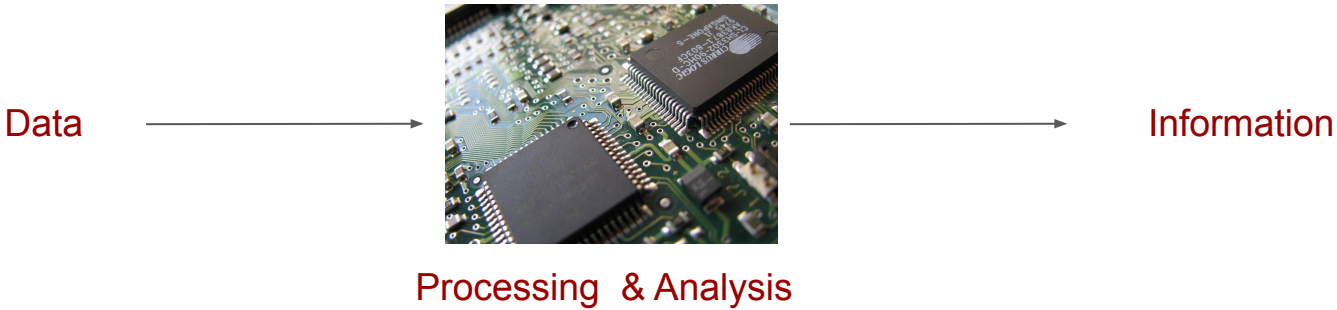

Mathematics for Analyzing Data

Serves as fundamental toolkit for analyzing and making sense of data.

Syllabus

Part-1: Foundations of Signal Processing

1. Introduction to (recorded) signals
2. Human perception of signals: hearing, vision and brain
3. Signal representations: continuous, Fourier series, Taylor series, sampling, discrete-time, and basis functions
4. DSP Methods: LTI system, convolution, DFT, DCT

Part-2: Advance Signal Processing

1. Time-frequency analysis
2. Spectral Estimation, Filtering, artifacts, and Kalman Filtering
3. Compressive Sensing

Part-3: Machine Learning on Signals

1. Dictionary Learning
2. Dimensionality Reduction: Concept and approaches
3. Modelling: What is a model? Why use a model? What are types of models?
4. Model fitting using deterministic and probabilistic approaches
5. Classifiers: Logistic regression to DNNs, and ending at CNNs

Part-4: Hands-on Development & Research

1. Project: Pursued by students - Runs through out the course - Topics: Theory and Applications of SP and ML
2. Paper: Pursued by students - Paper Reading and Understanding - Critiquing through Presentation

We will have a course website and MS Teams

More on logistics - grading, projects, paper

- Coming soon!

We have a course website: https://neerajww.github.io/da623/ and MS Teams