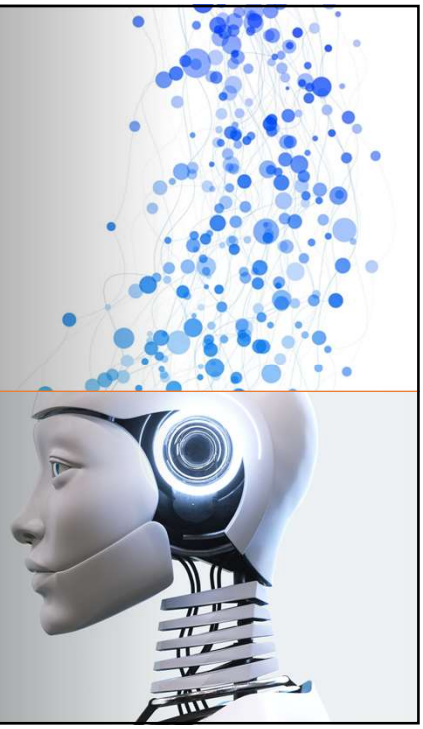
Machine Learning Foundations

An Introduction to your AI Journey

Sumudu Tennakoon, PhD



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Course Objective

Provide comprehensive understanding of the core principles of Machine Learning with hands-on training on applying machine learning to solve real-world problems.

A learner who completes this course should be able to define a machine learning problem, understand the solution path, and display the ability to carry out the end-to-end process of building a machine learning application.

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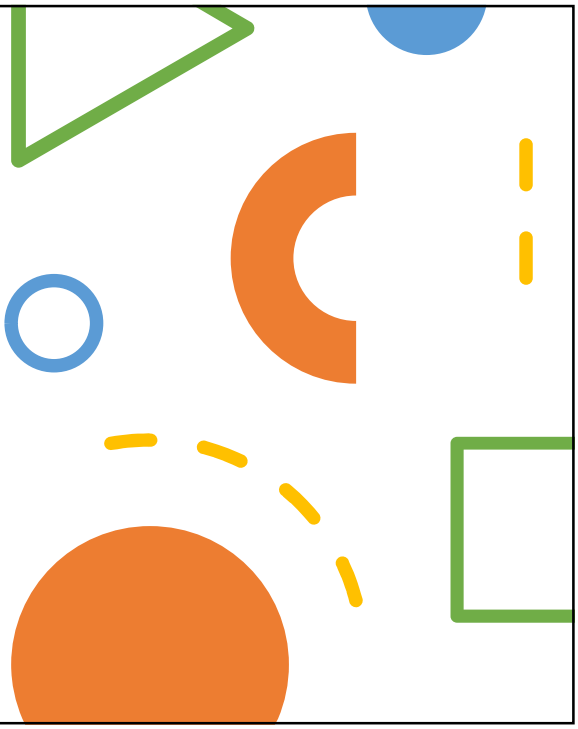
Machine Learning Career Prospectus

- Data Scientist
- AI Scientist
- ML/AI Engineer
- Data Engineer
- Data Analyst
- AI/ML Developer
- IoT Developer
- Solutions Architect
- Freelancer
- …



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Schedule and Format

Duration: 60 hours

Schedule: 3-month program/12 weeks, two sessions per week.

Format: Live/Recorded Lectures, Demonstrations, Hands-on Exercises/Labs.

Evaluation: Quizzes (2), Project (1)

Additional Practice: Students must spend extra time on exercises and the capstone project.

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Prerequisites

- Basics of computer programming, mathematics, and statistics.
- Basic knowledge in computer applications:
  - Spreadsheet
  - word processor
  - presentation authoring

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Platform and Data for Hands-on Exercises and Project

Programing Language: Python 3 will be used as the primary programming language in teaching, practice examples and assignments.

Python Libraries: Scikit-learn, TensorFlow, Pandas, NumPy, Matplotlib, Seaborn, Flask.

Applications/Tools: Jupyter Notebook/Lab, IDE (Spyder/VS Code/Atom/PyCharm), Spreadsheet (MS Excel/LibreOffice Calc).

Data: Data for exercises, case studies, and projects will be obtained from open data repositories.

Computing Environment: Cloud platform (will be decided on class consensus and service availability) or locally installed Python distribution in student's PC.

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Session Topics

#	Topic Name	Training Week #
1	Introduction to Machine Learning (ML), History, and Applications	1
2	Setting up a Computing Environment, Python and Required Libraries.	2
3	Knowledge Foundations to ML (Computing, Statistics, and Mathematics) *	2-3
4	Exploratory Data Analysis (EDA) and Feature Engineering *	4-5
5	Supervised and Unsupervised Learning (concepts)	6
6	Machine Learning Algorithms *	6-7
7	Explaining ML Models and Predictions (introduction) *	7
8	Deep Learning and Neural Networks (introduction) *	8
9	Design and Develop and Deploy ML Solutions *	9-10
10	Capstone Project *	11-12

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Evaluations and Grading

- **Completion Requirement:**
- 80 % Attendance (at least 19 out of 24 sessions)
- Final Grade > 70 %

- **Completion with Distinction:**
- Final Grade > 90 %

	Topic #	%
Quiz1 (Basic Concepts)	1-6	20
Quiz 2 (Advanced Concepts, Deep Learning and Application Building)	7-9	20
Deliverable and Project Report	10	50
Presentation (video narration)	10	10
		100

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Introduction to Machine Learning

History and core concepts of ML to navigate the future lessons.

Applications of ML.

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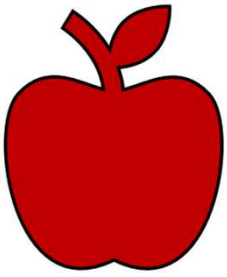
Example: Identify Objects

What facts you consider to identify these object?

Pineapple



Apple

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How we Learn ?

- Memorize Facts
  - Declarative Knowledge
  - Limited by memory and time to observe
- Infer (deduce new information from previously known facts)
  - Imperative Knowledge
  - Limited by accuracy of predictions and drifts (present is not behaving the same way as past)

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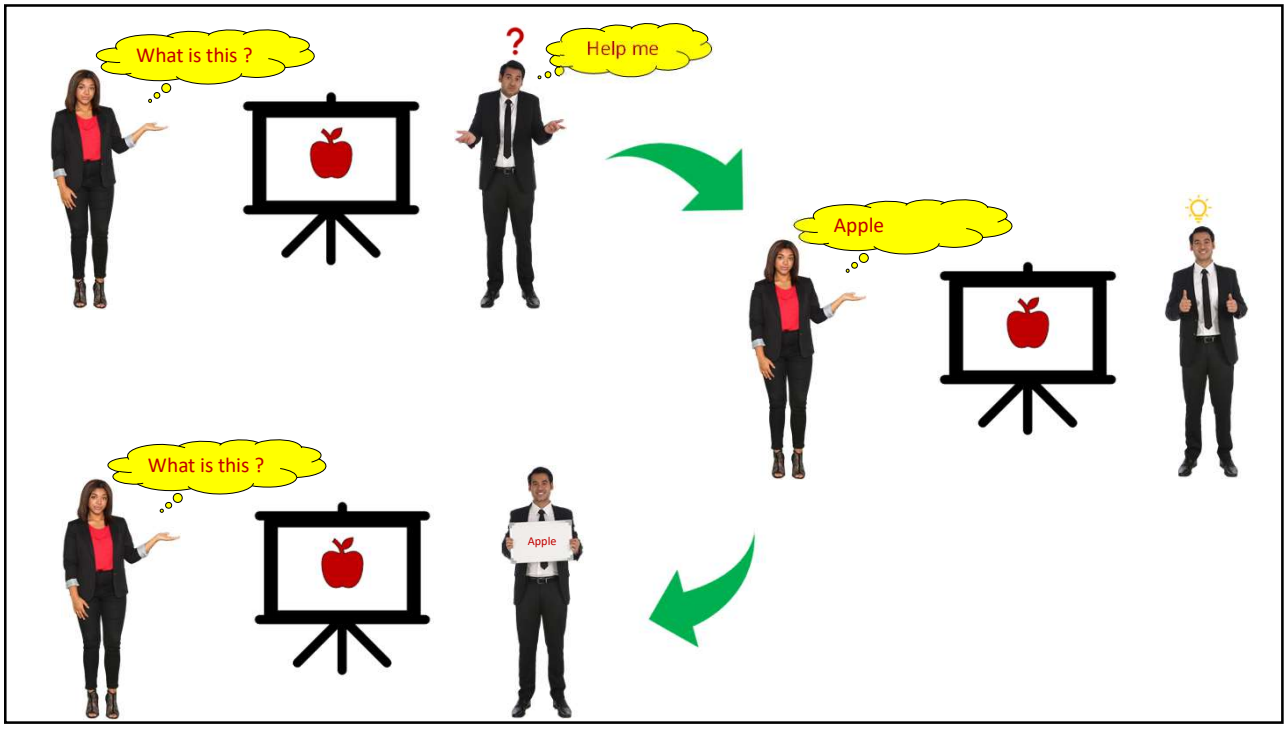

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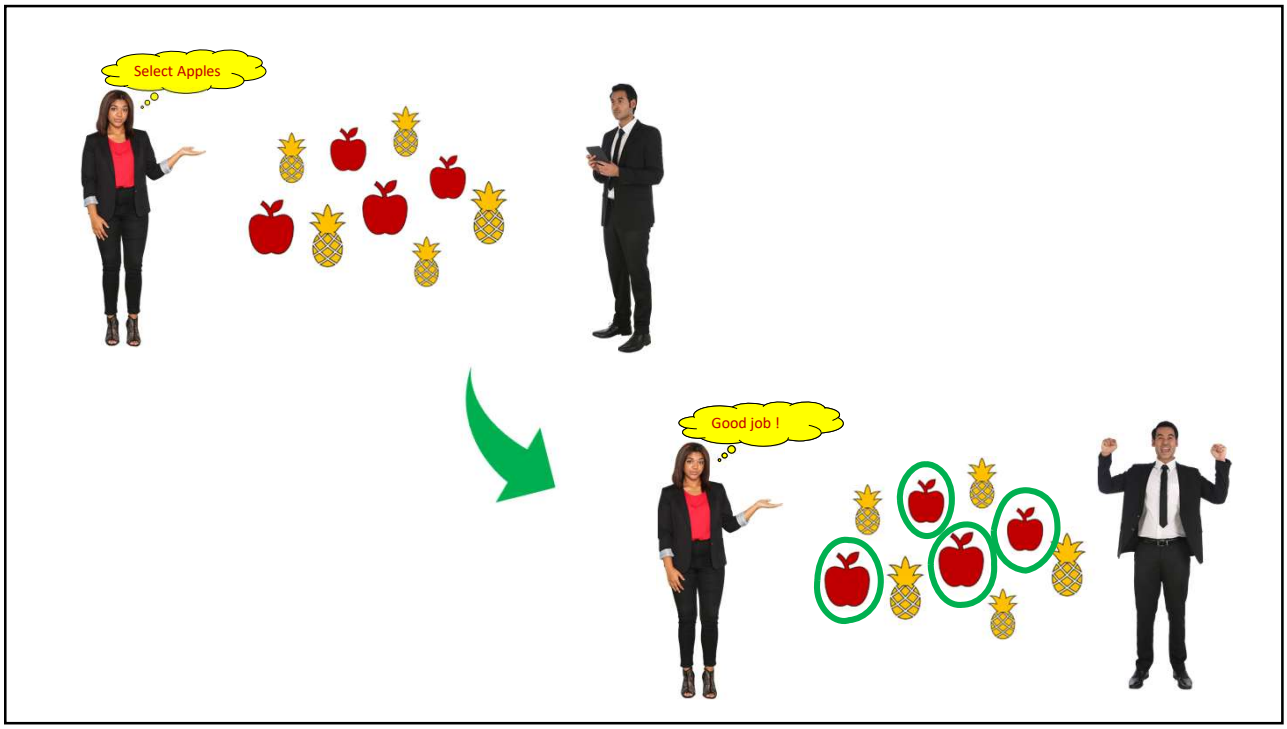

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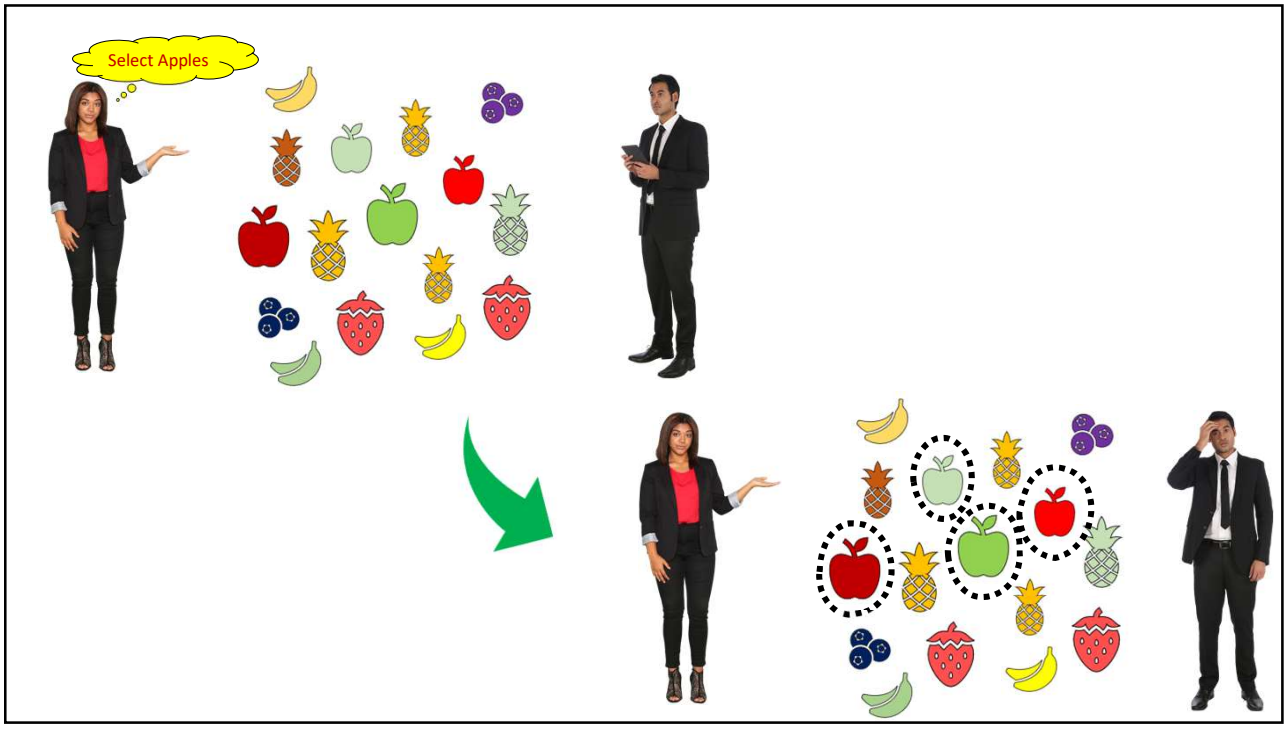

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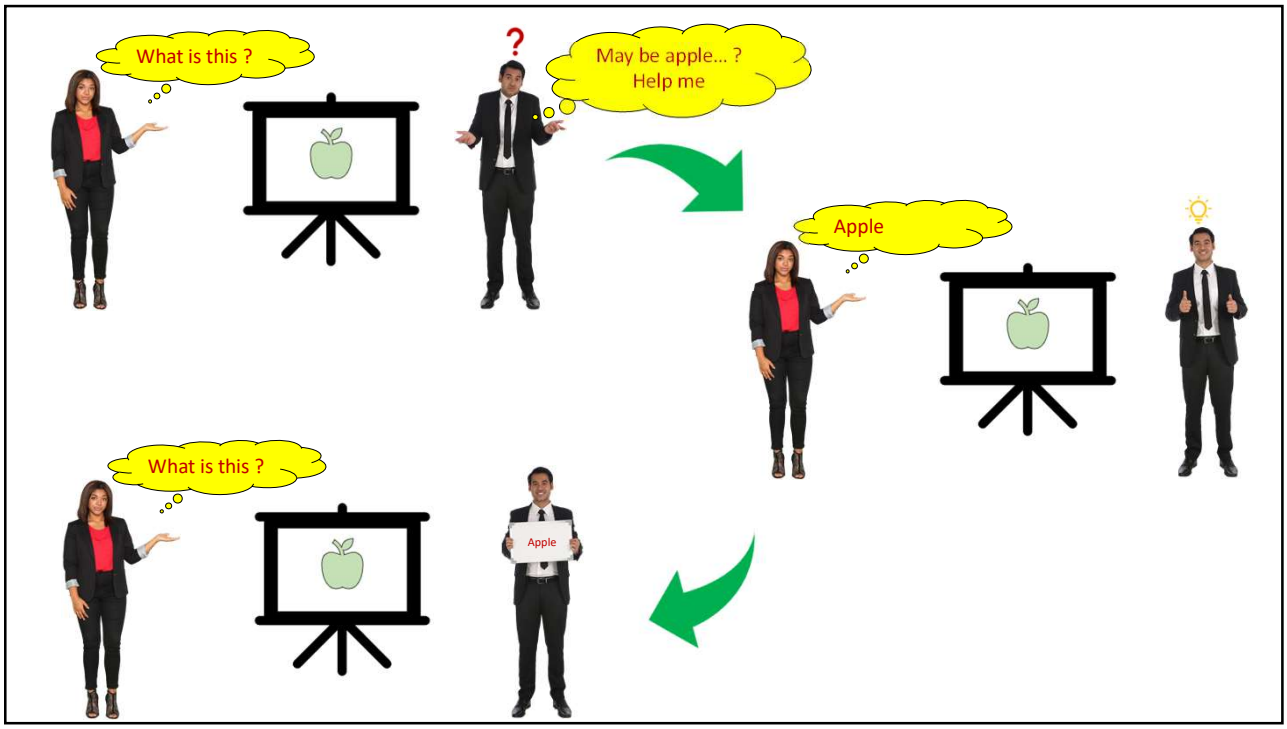

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Exercise

- What are the Observations/Measurements can be used to make a determination.
- Design a simple classifier logic.
- Is it easy tor difficult to converting this logic to a computer program (code)?
- What are the considerations when converting this logic to a computer program (code)?
- What are the points of failures in this approach?

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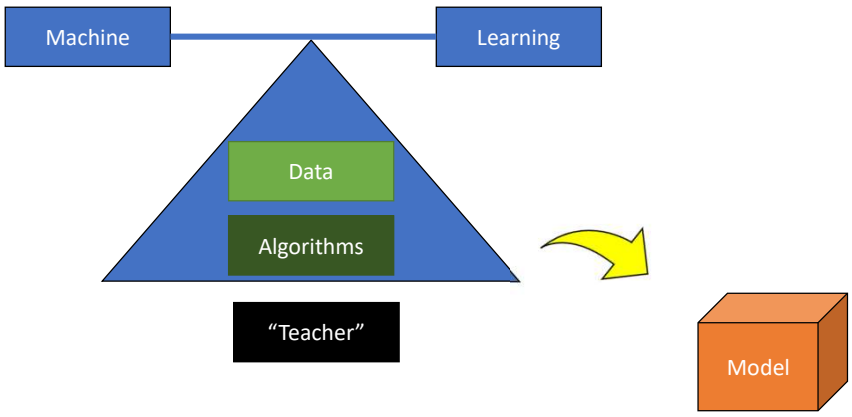
What is Machine Learning ?

- Learn from Data



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Machine learning model

"Machine learning models are built on mathematical algorithms and are trained using data and human expertise to help us accurately predict outcomes based on input data such as images, text, or language."

https://developer.nvidia.com/ai-models

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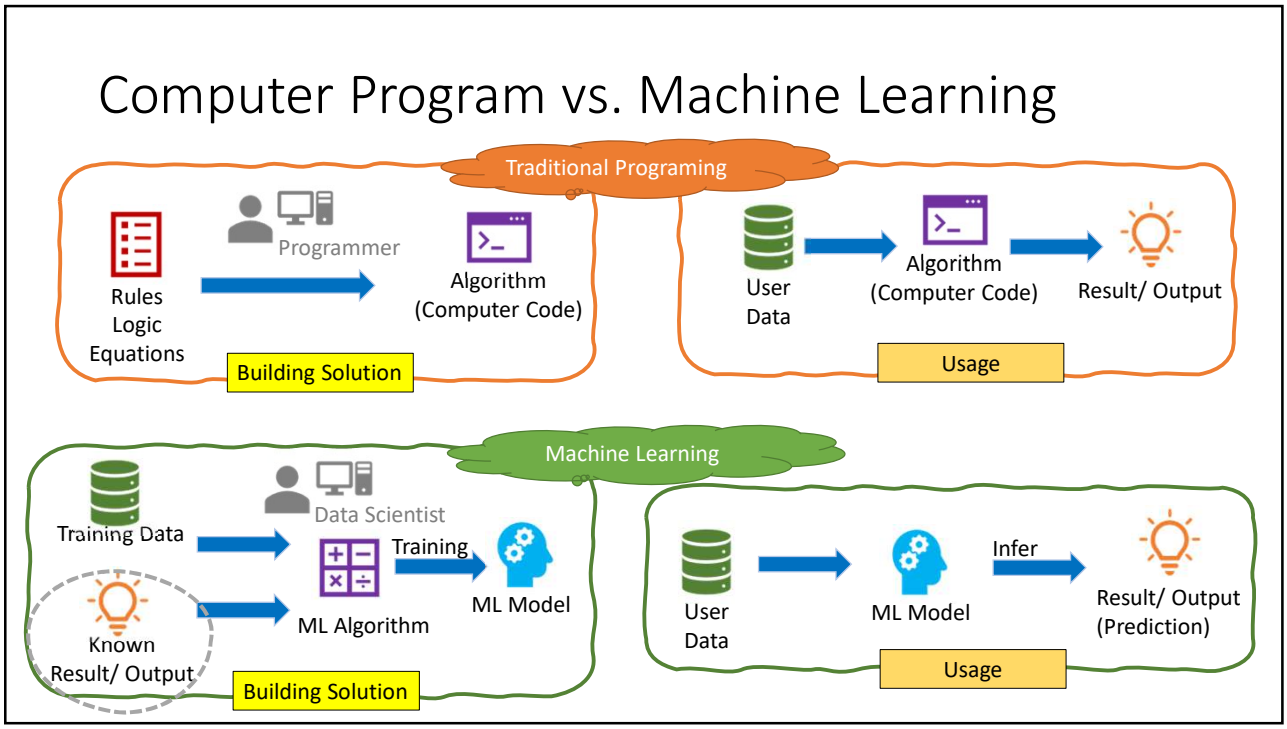

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What is Machine Learning?

"The field of study that gives computers the ability to learn without being explicitly programmed."

~ Arthur Samuel (1959)

Author of first self-learning program to learn how to play checkers by learning from experience (past movements and results)

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What is Machine Learning?

" A computer program is said to learn from experience E with respect to some class of **tasks T** and **performance measure P**, if its performance at tasks in T, as measured by P, improves with **experience E**."

~ Tom Mitchell (1997)

Example: playing checkers.

- E = the experience of playing many games of checkers
- T = the task of playing checkers.
- P = the probability that the program will win the next game.

Mitchell, T. (1997). *Machine Learning*. McGraw Hill. p. 2. ISBN 978-0-07-042807-2.

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AI and Machine Learning

- AI (Mimic Cognitive Functions of Human)
  - Computer Vision
  - Speech Recognition and Synthesis
  - Language Processing and Understanding
  - Motion
  - Decision Making
  - Prescribe or Predict
  - Reasoning
- Machine Learning (ML)
  - Machines learn on Data/Prior Knowledge
  - Statistical Modeling/Algorithms
  - Backbone of AI is Machine Learning
  - Algorithms to Find meanings of data
  - Find Relationships
  - Making Predictions
  - Problem-Solution Types
    - Classification
    - Regression
    - Clustering

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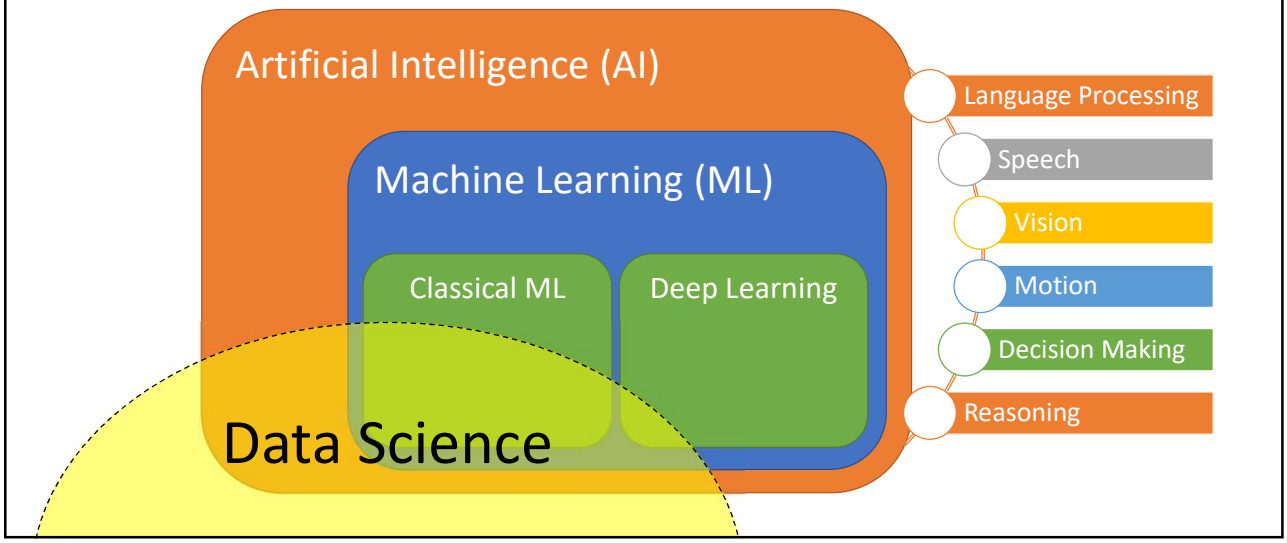
Machine Learning/Deep Learning/AI



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Levels of AI

Artificial General Intelligence (AGI) known as "Strong AI"

- AGI is the ability to solve *any* problem rather than finding a solution to a particular problem.
- Machine can understand or learn any intellectual task that a human being can.
- The machine can think and perform tasks on its own, just like a human being.
- In the Movies! We are not there yet.

Weak Artificial Intelligence (Weak AI),

- Implements a limited part of human cognitive abilities.
- **Narrow AI** is a special case of Weak AI focused on a specific problem or task.
- Currently, existing AI systems are likely operating as a narrow AI.
- devices cannot follow these tasks independently but are made to look intelligent (simulate human behavior).

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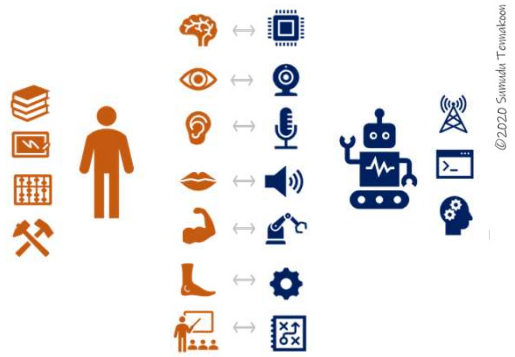
Building Blocks of an AI System

- Image recognition (computer vision)
- Signal processing (sound, sensor data feed, etc.)
- Speech Recognition (Speech to text/STT)
- Natural language processing (NLP)
- Visual Synthesis (Computer Graphics)
- Sound Synthesis (Text to Speech/TTS)
- Software/Algorithms
- Applications (Anomaly Detection, Classification, Prediction, Pattern Recognition)
- Memory (Storage, RAM, Cache)
- Processor (GPU, CPU, TPU)
- Connectivity (Wi-Fi, Satellite, 5G, ethernet, etc.)
- Hardware (Computer, Mechanical Components, etc.)



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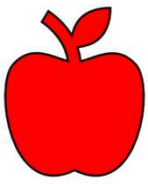
Exercise



What are Observations/Measurements can be used to make a determination.

Design a simple classifier logic.

Is it easy or difficult to converting this logic to a computer program (code)?

What are the considerations when converting this logic to a code?

What are the points of failure in this approach?

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Input and Output ?

Input → (Features/Attributes)

Color	red	yellow
Weight	50 g	200 g
Diameter	10 cm	20 cm

Output → Apple (A) / Pineapple (P)

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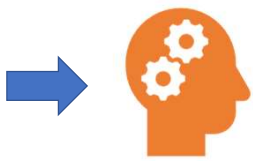
$$y = f(X)$$

Independent Variables

$X = [x1, x2, x3, \ldots.]$

$\{Color, Diameter, Weight\}$



Dependent Variable

y

$\{Apple, Pineapple\}$

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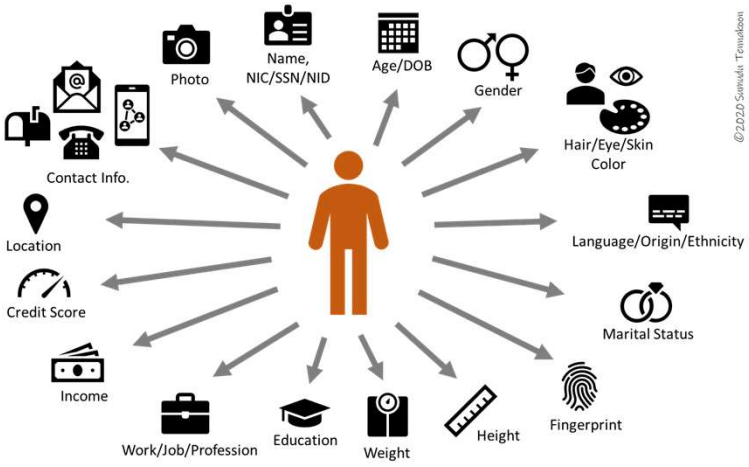
Features/Attributes



https://pub.towardsai.net/data-science-for-everyone-getting-to-know-your-data-part-1-bb8b6d7782b1

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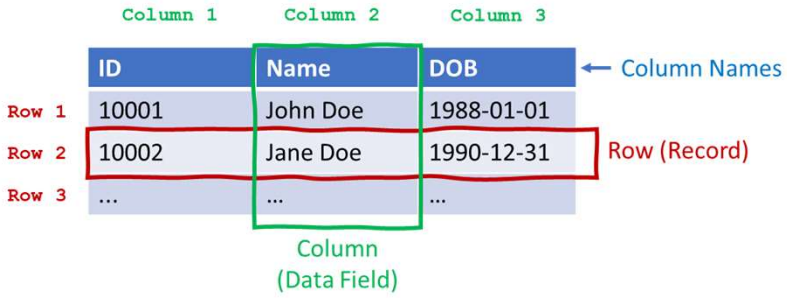
Tabular Data



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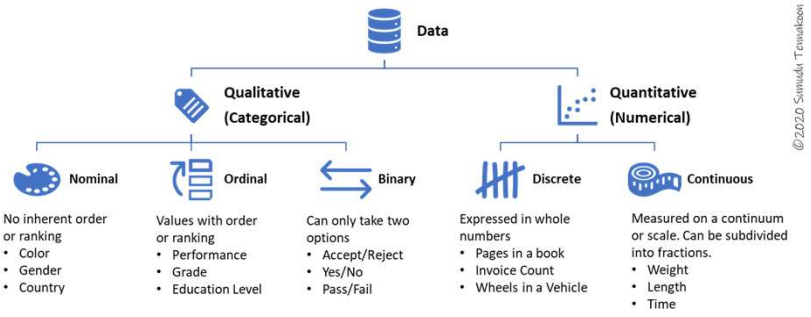
Understanding Data



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Machine Learning Approaches

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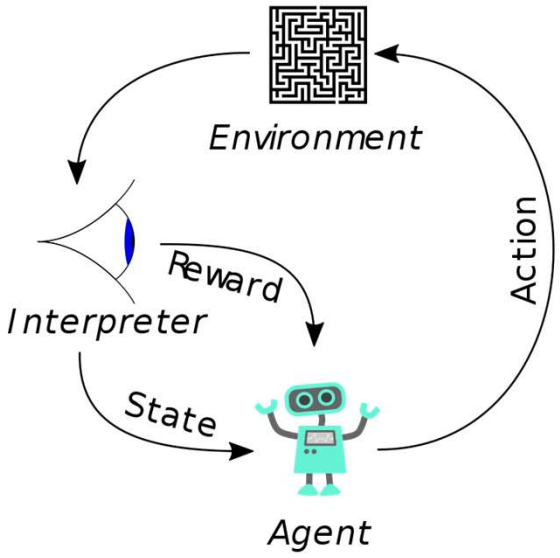

https://en.wikipedia.org/wiki/Reinforcement_learning

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Types of ML Algorithms

Regression

Linear

Polynomial

Classification

Tree Classifiers

Logistic Regression

Support Vector Machines (SVM)

Clustering

K-Means

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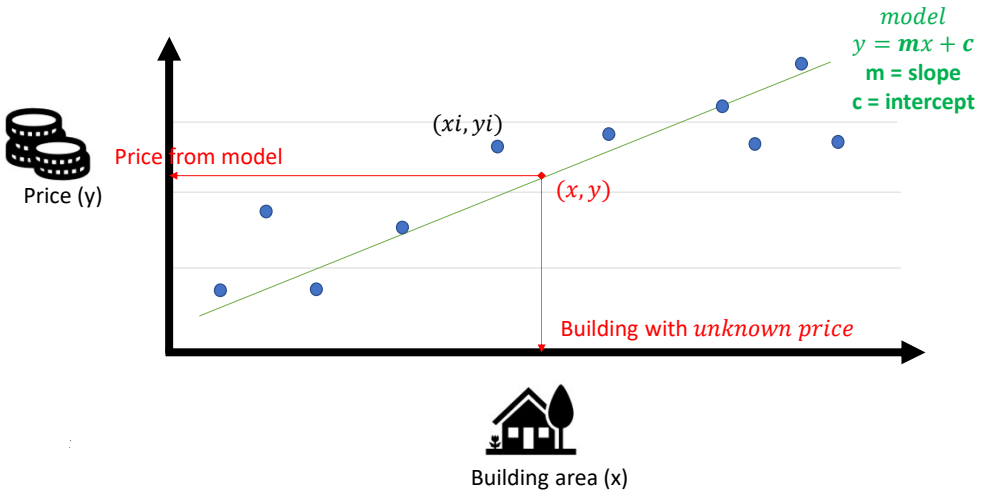
Regression



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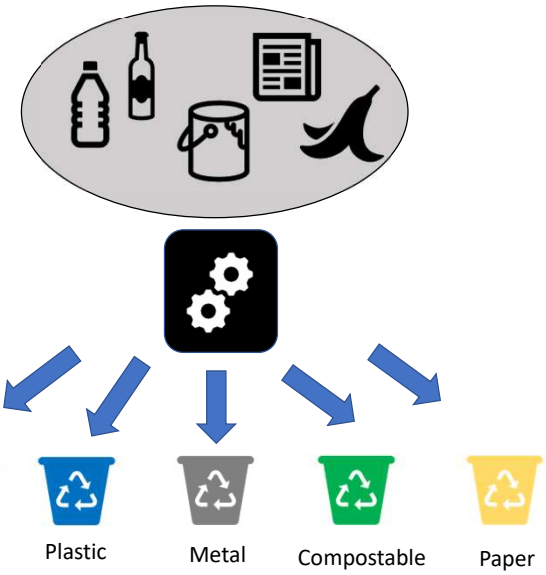
Classification



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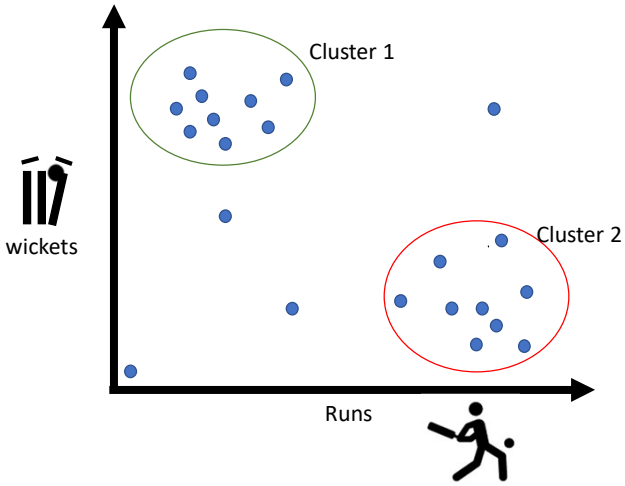
Clustering



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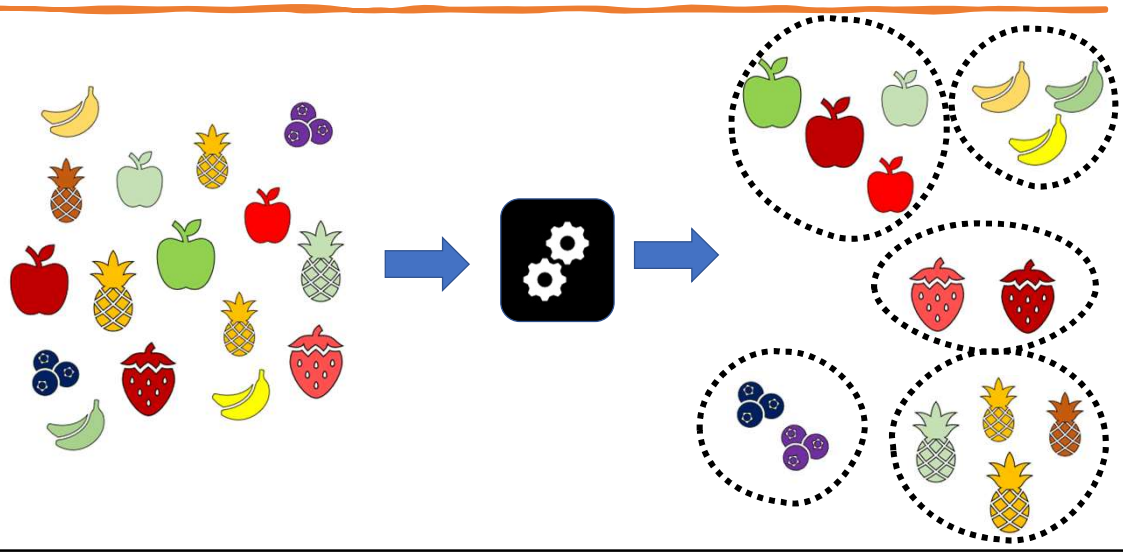
Clustering



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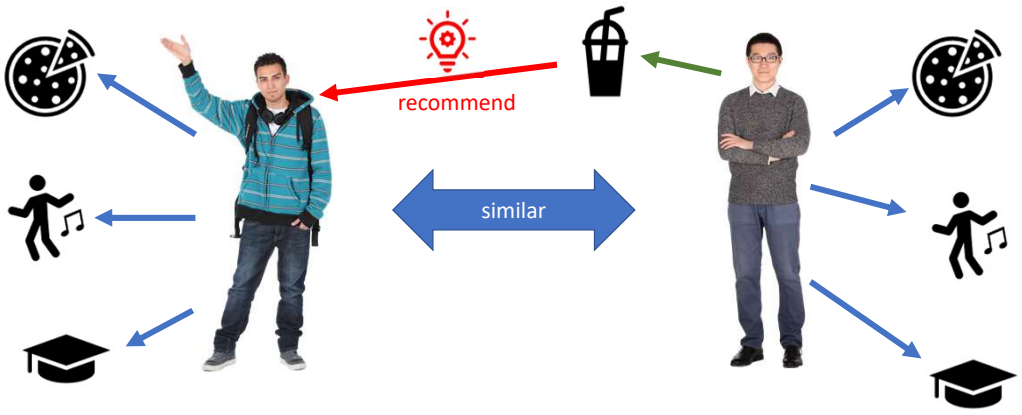
Recommender Systems



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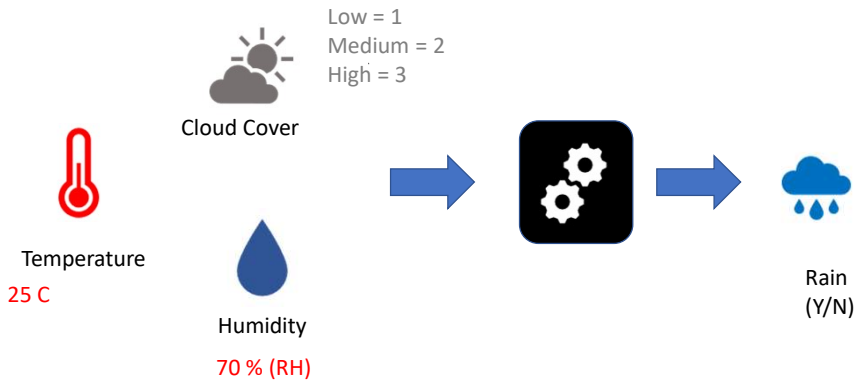
Prediction



$$y = f(X)\,?$$

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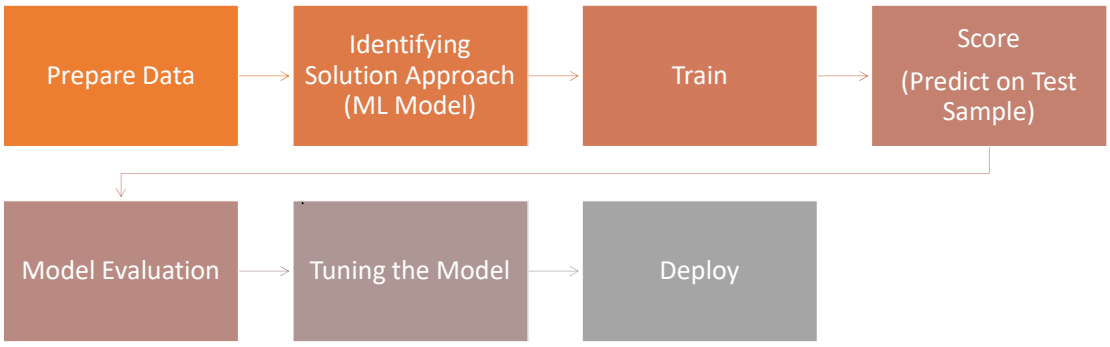
Steps of Building ML Model



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Why we need Machine Learning?

- Simulate human intelligence
- Automation
- Help humans with informed decision making
- Solve multidimensional problems
- Predict future outcome based on historical observations

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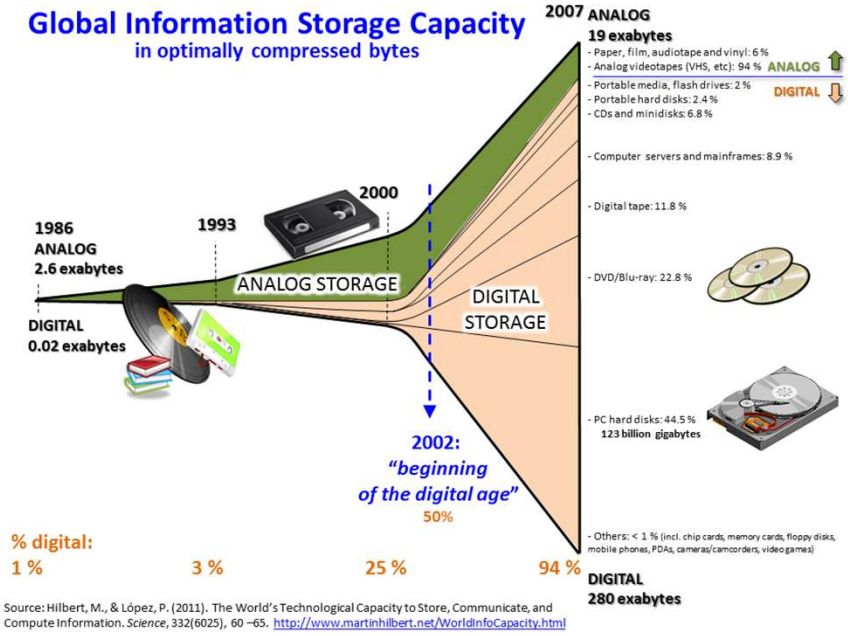

Scholz, R.. "Sustainable Digital Environments: What Major Challenges Is Humankind Facing?" Sustainability 8 (2016): 1-31.

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Machine Learning Applications

- Spam Email Filtering
- Approve or Reject Loan Application
- Predicting Stock Price
- Credit Card Fraud Detection
- Recommending Items to Purchase (Advertising)

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Application Areas

- Finance
- Marketing
- Information Technology
- Cyber Security
- Agriculture
- Government
- Automobile
- Manufacturing
- Retail
- Entertainment
- …

Everywhere!

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Why should everyone get familiar with ML?

- Applications of machine learning are all around us.
- ML is used in many industries and domains.
- Job opportunities.
- It is fun to learn and helps train your brain.

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Machine Learning Career Prospectus

- Data Scientist
- AI Scientist
- ML/AI Engineer
- Data Engineer
- Data Analyst
- AI/ML Developer
- IoT Developer
- Solutions Architect
- …

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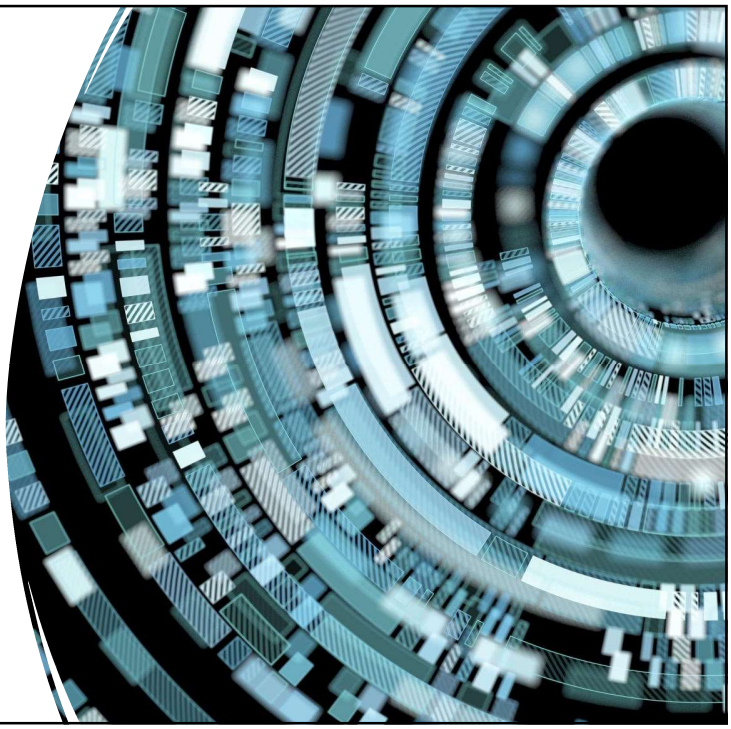
Setting up Computing Environment



Cloud Computing Platform (Google Colab)

Python (Install, Libraries)

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Install Python in Local Computer

- Python: https://www.python.org/downloads/
- Anaconda Python: https://www.anaconda.com/products/individual
- Python: Libraries: https://www.anaconda.com/open-source

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Python Libraries

- Data Handling
  - **Pandas**
  - Dask (distributed)
- Machine Learning
  - **Scikit-learn**
  - **TensorFlow**
  - PyTorch
- Visualizing
  - **Matplotlib**
  - Seaborn
- Numerical and Scientific Computing
  - **SciPy**
  - **NumPy**
- Machine Learning Model Interpretation
  - **LIME**
  - **SHAP**
- Web Services/API
  - **Flask**
  - Django

scikit-image
image processing in python

TensorFlow

SciPy

matplotlib

jupyter

pillow

NumPy

pandas

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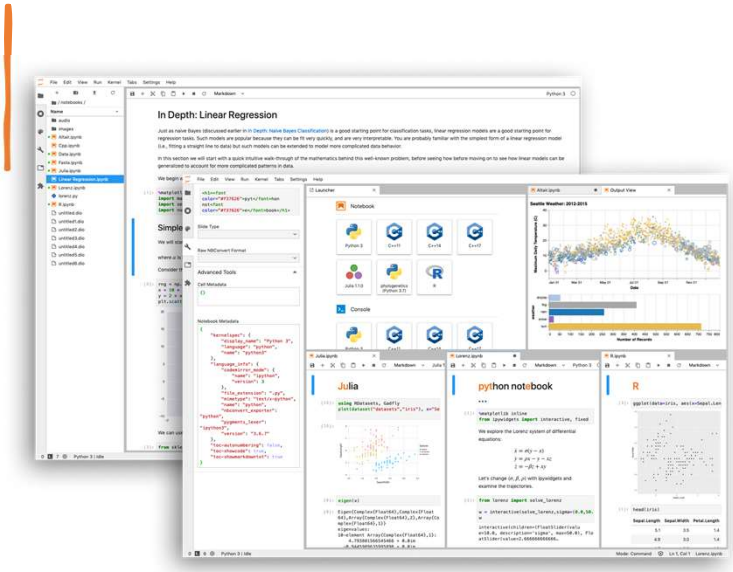
Jupiter Notebook/Lab



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Google Colab

https://colab.research.google.com

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Getting Started

- Creating New Notebook
- Opening Notebook from GitHub
- Opening Notebook from file

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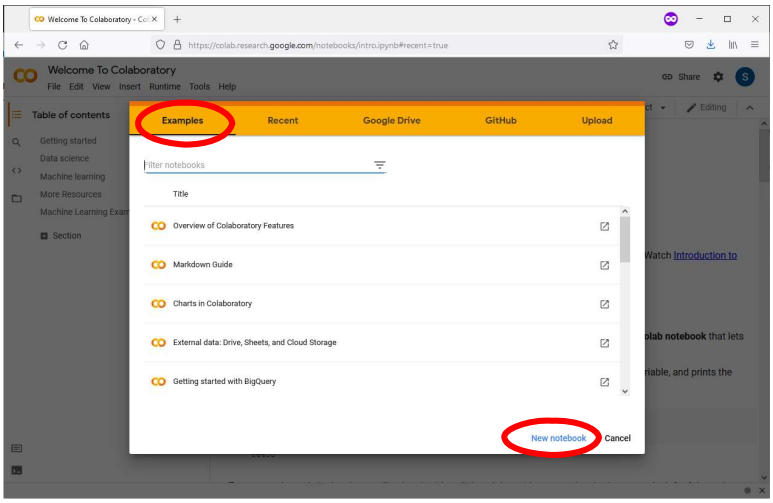
Creating New Notebook



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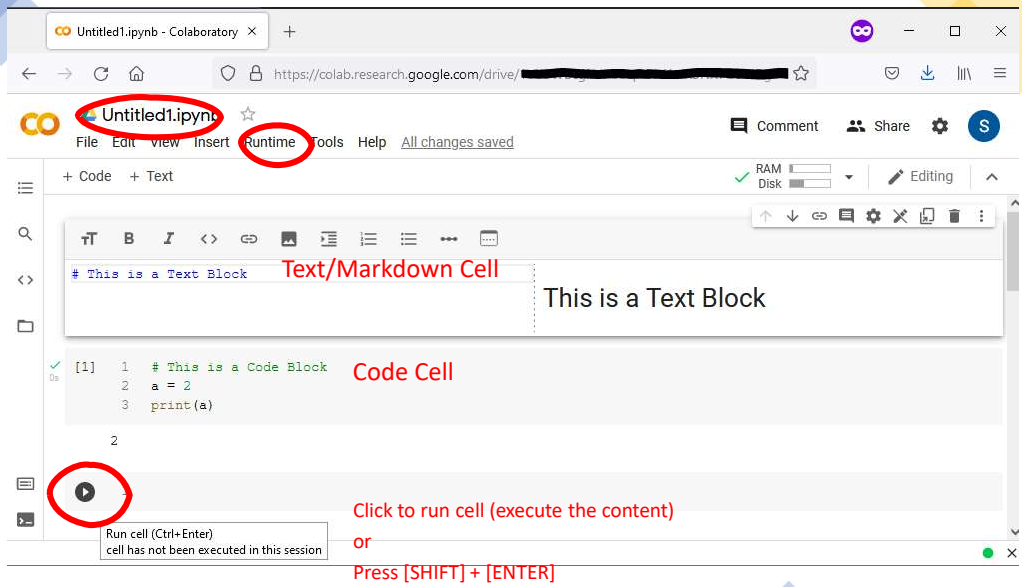

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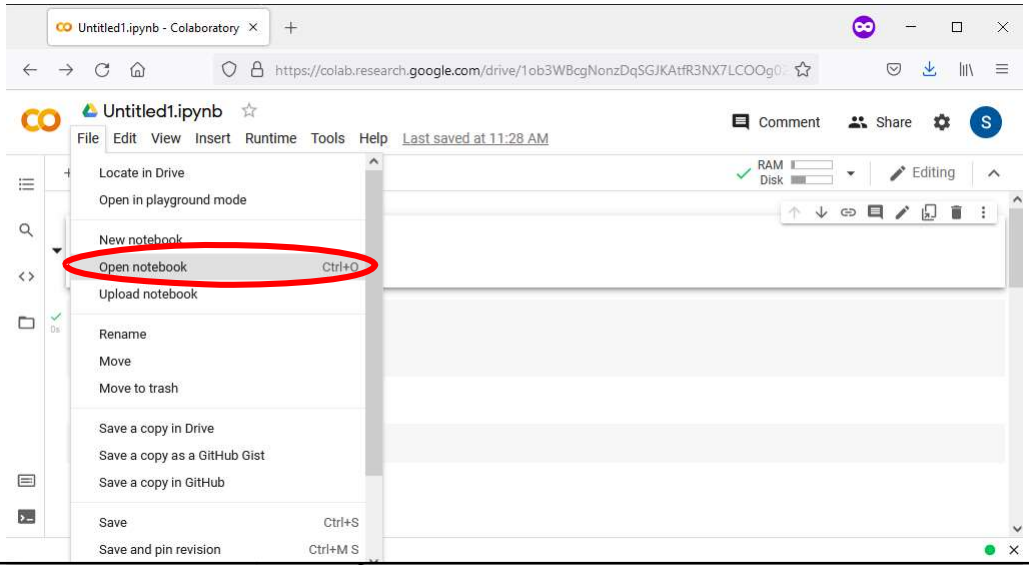
Open Notebook



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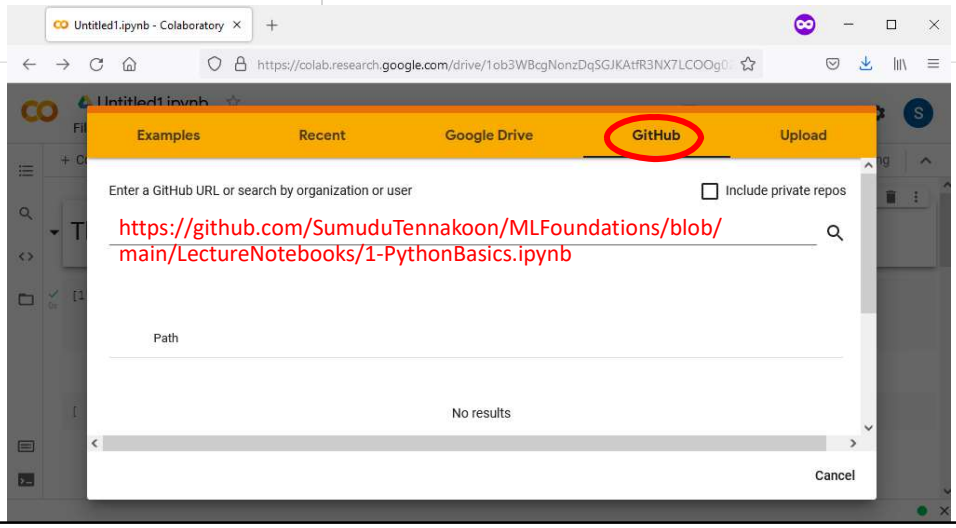
Open Notebook from GitHub



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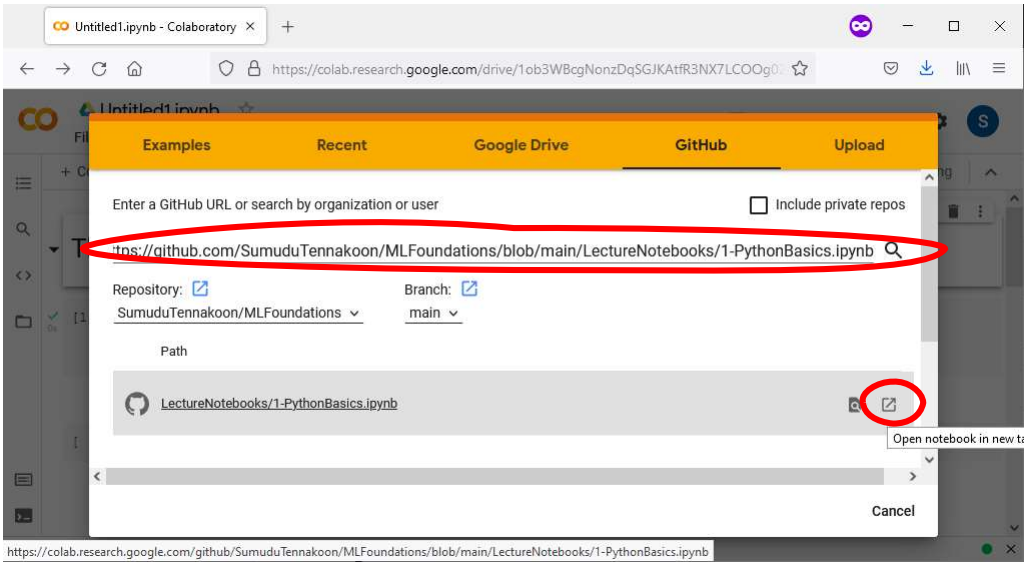
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Examples
Recent
Google Drive
GitHub
Upload
Enter a GitHub URL or search by organization or user
Include private repos
https://github.com/SumuduTennakoon/MLFoundations/blob/main/LectureNotebooks/1-PythonBasics.ipynb
Repository:
SumuduTennakoon/MLFoundations
Branch:
main
Path
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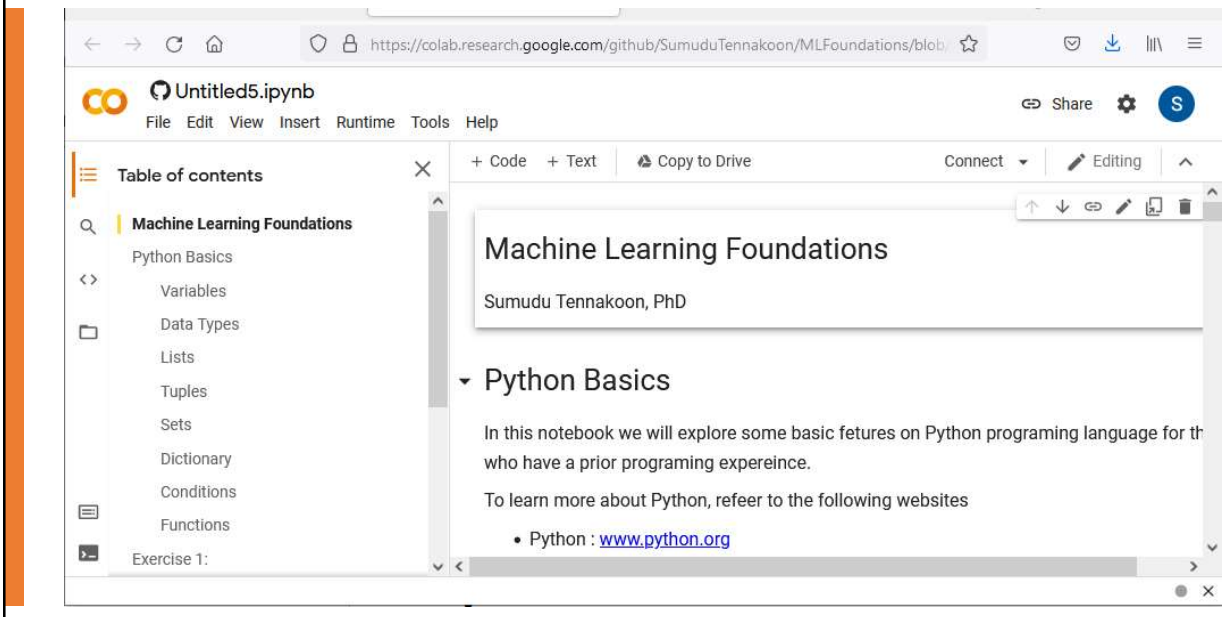
https://colab.research.google.com/github/SumuduTennakoon/MLFoundations/blob
Untitled5.ipynb
File Edit View Insert Runtime Tools Help
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Connect
Editing
Machine Learning Foundations
Python Basics
Variables
Data Types
Lists
Tuples
Sets
Dictionary
Conditions
Functions
Exercise 1:
Machine Learning Foundations
Sumudu Tennakoon, PhD
Python Basics
In this notebook we will explore some basic fetures on Python programing language for th
who have a prior programing expereince.
To learn more about Python, refeer to the following websites
Python : www.python.org

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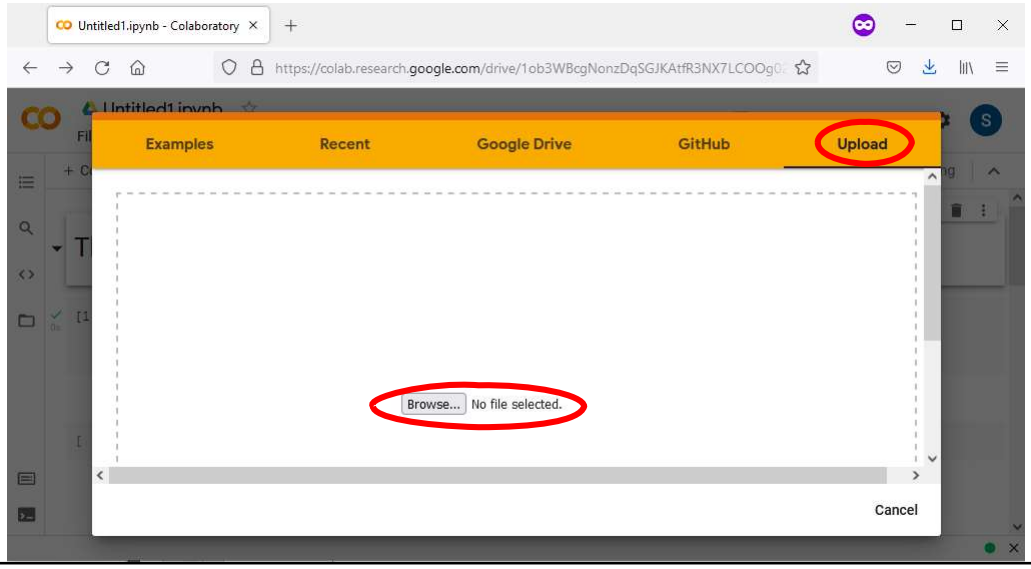
Upload Notebook (.ipynb file)



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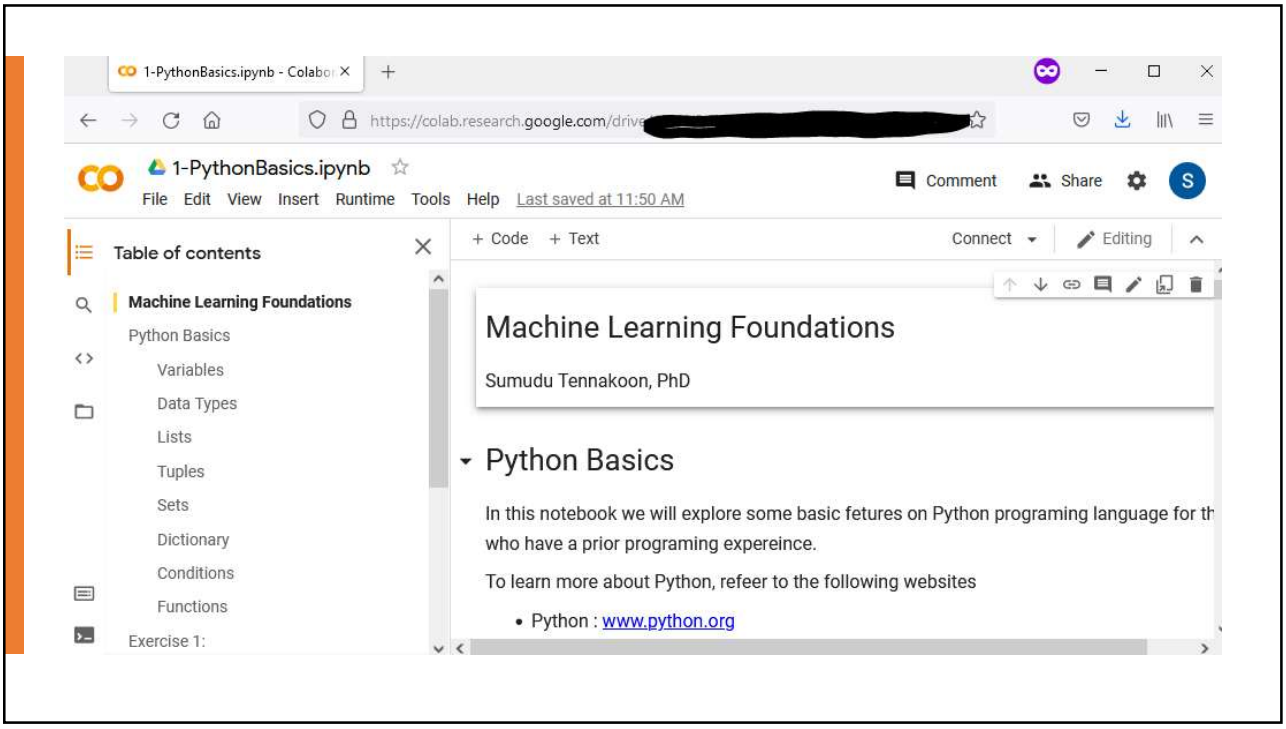

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GitHub Link to Lecture Notebooks

Folder:
https://github.com/sumudutennakoon/mlfoundations/tree/main/lecturenotebooks

Python basics notebook:
https://github.com/sumudutennakoon/mlfoundations/blob/main/lecturenotebooks/1-pythonbasics.ipynb

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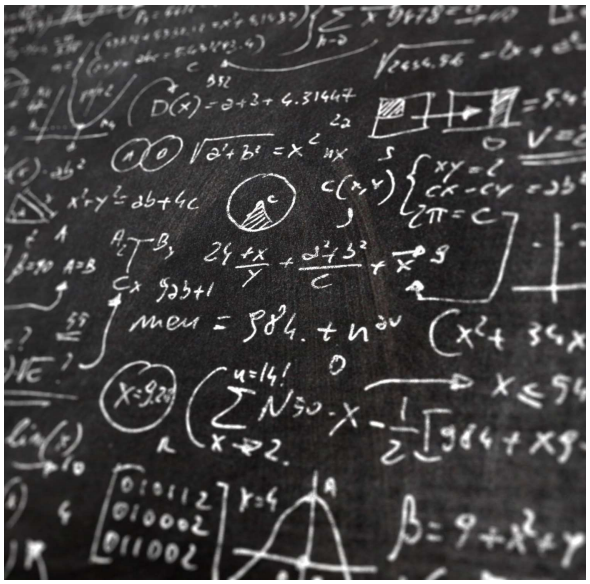
Mathematics for Machine Learning



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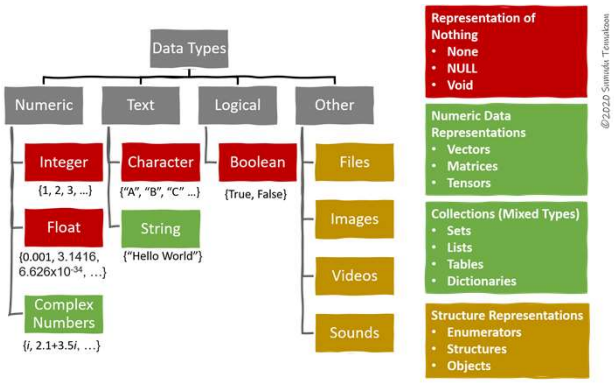
Data Types and Representations



https://pub.towardsai.net/data-science-for-everyone-getting-to-know-your-data-part-1-bb8b6d7782b1

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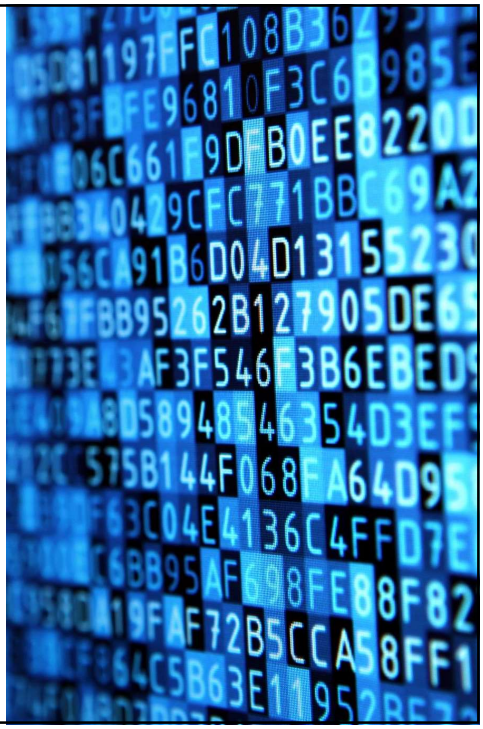
Data Representations

- In computing everything must convert into numbers !
- Numeric Data Structures:
  - Scalars: 3.14
  - Vectors: [1,2,3]
  - Matrices: [[1,2], [3,4]]
  - Tensors: [[[1,2], [3,4]] , [[5,6], [7,8]]]



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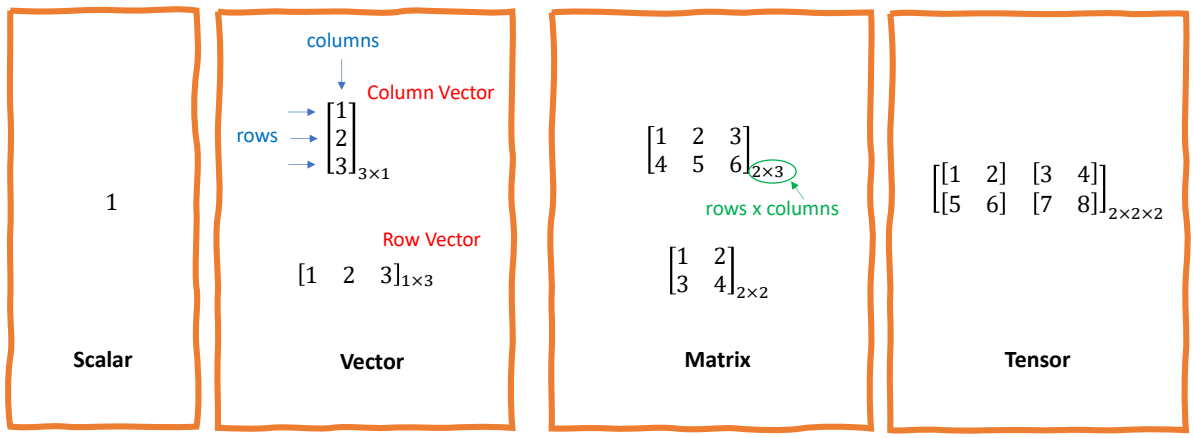
Vectors and Matrices



- *Temperature*
- *Mass*
- Speed

- *Distance [x, y, z]*
- *Velocity [Vx, Vy, Vz]*

What's a Tensor? - YouTube

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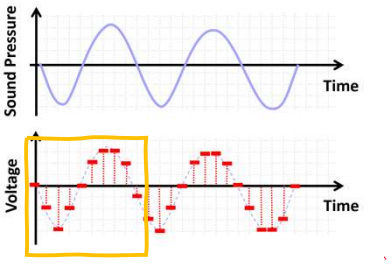
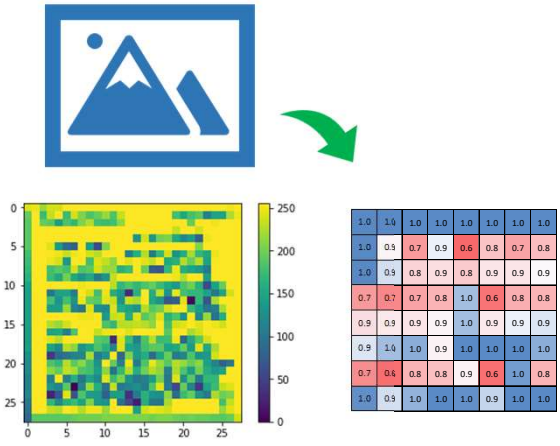
Why we need Vectors, Matrices and Tensors in Machine Learning?



$$signal = [0 \quad -2 \quad -4 \quad -2 \quad 0 \quad 2 \quad 3 \quad 3 \quad 2 \quad -1 \quad -3]$$
$$time = [0 \quad 1 \quad 2 \quad 3 \quad 4 \quad 5 \quad 6 \quad 7 \quad 8 \quad 9 \quad 10]$$



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