

# Machine Learning Foundations

## An Introduction to your AI Journey

Sumudu Tennakoon, PhD



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## Course Objective

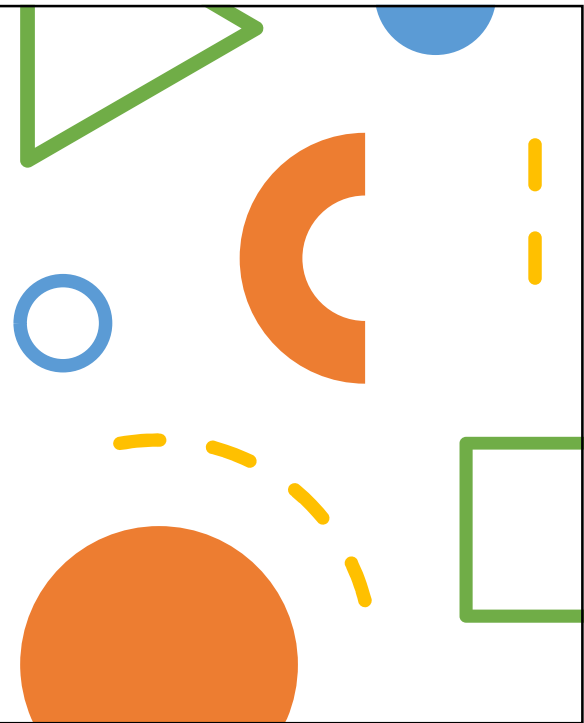
Provide comprehensive understanding of the core principles of Machine Learning with hands-on training on applying machine learning to solve real-world problems.

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

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**Duration:** 60 hours

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

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

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**Evaluation:** Quizzes (2), Project (1)

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

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# Prerequisites

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- 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

**Programming 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.



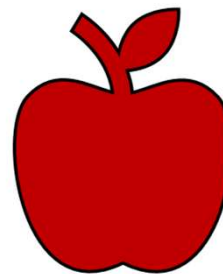
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## Example: Identify Objects

What facts you consider to identify these object?



**Pineapple**



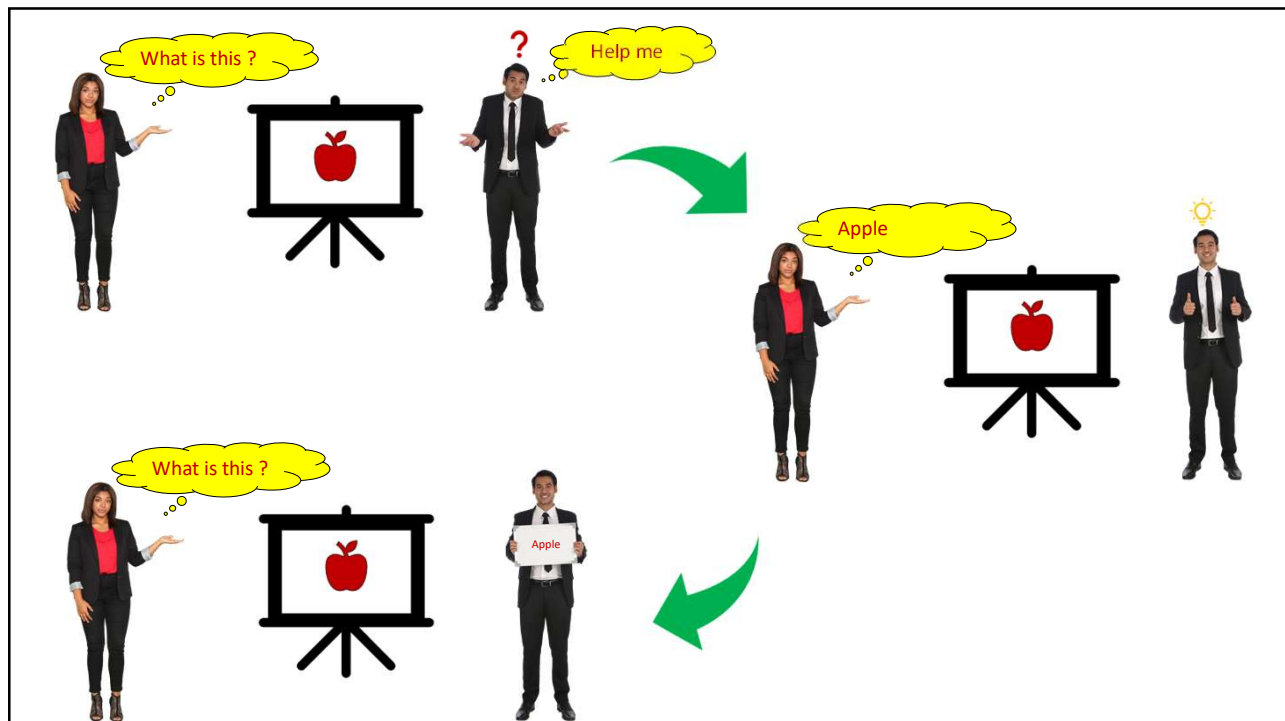
**Apple**

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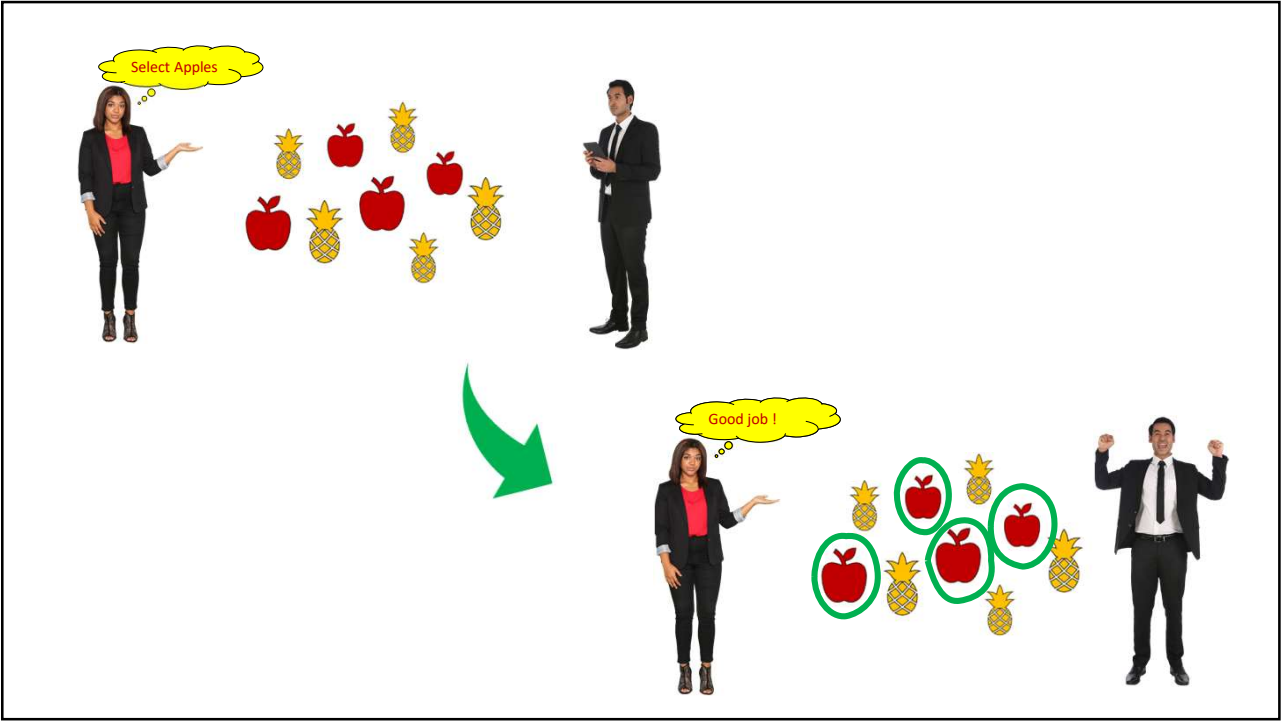
## How we Learn ?

- 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)

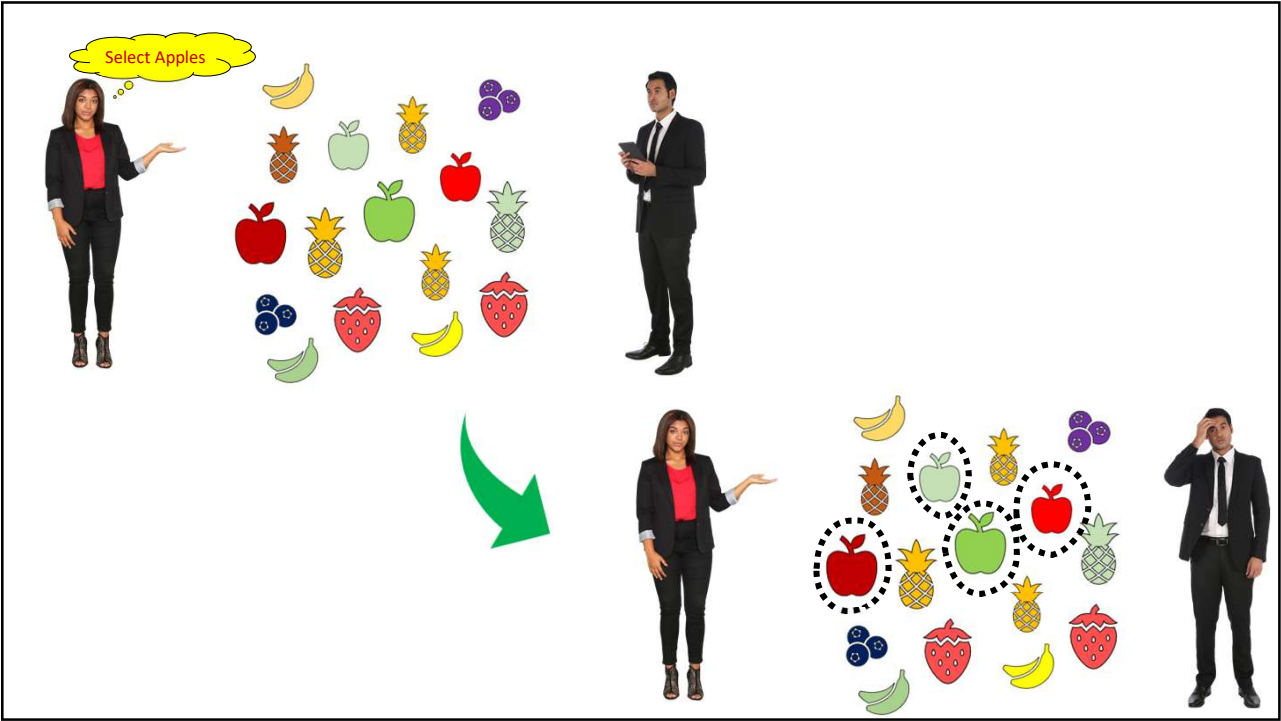
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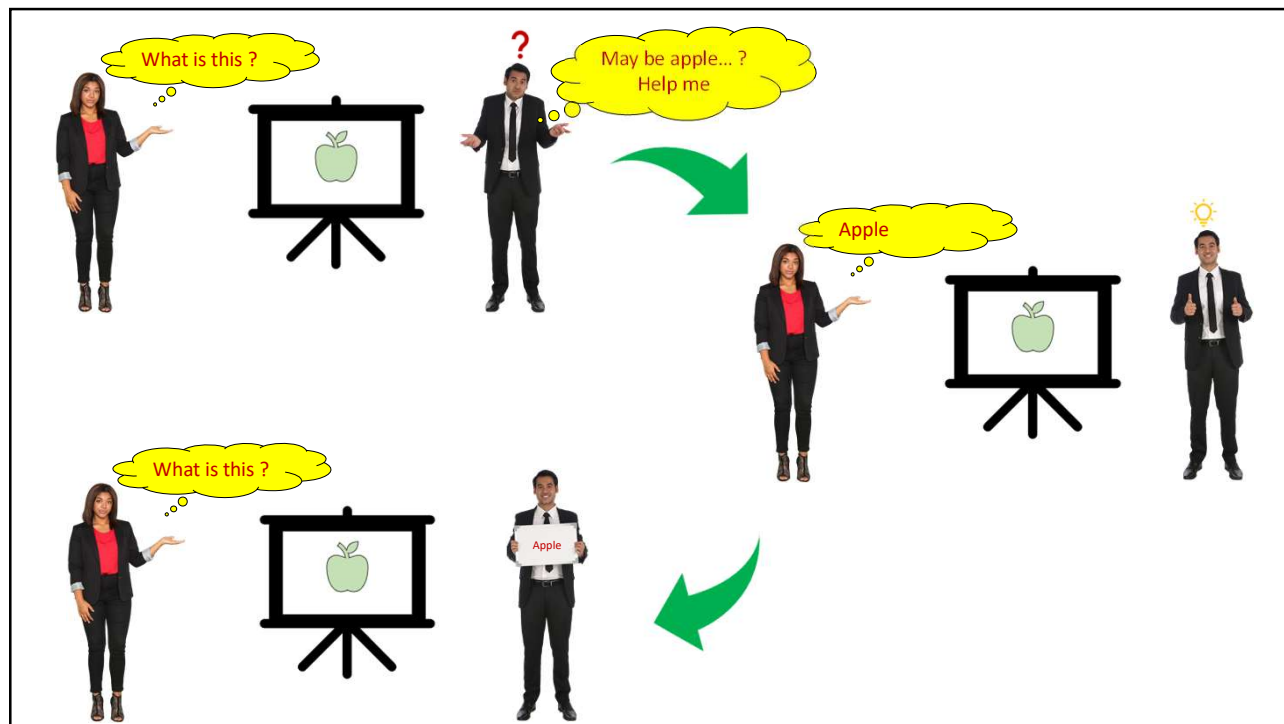
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## Exercise

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

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Design a simple classifier logic.

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

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What are the considerations when converting this logic to a computer program (code)?

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What are the points of failures in this approach?

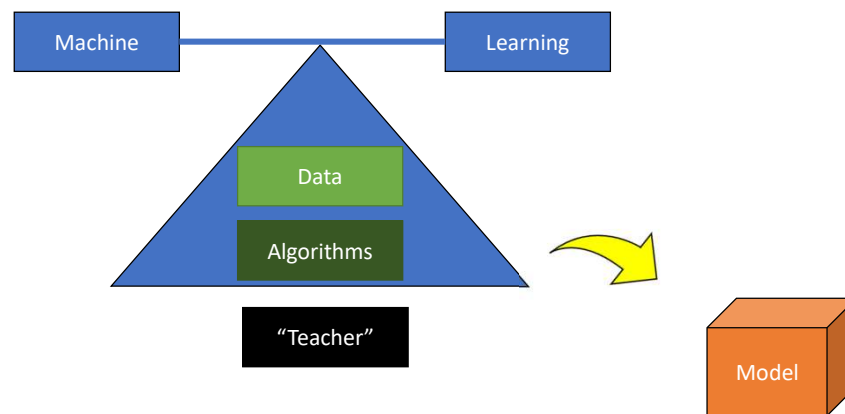
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# What is Machine Learning ?

- Learn from Data



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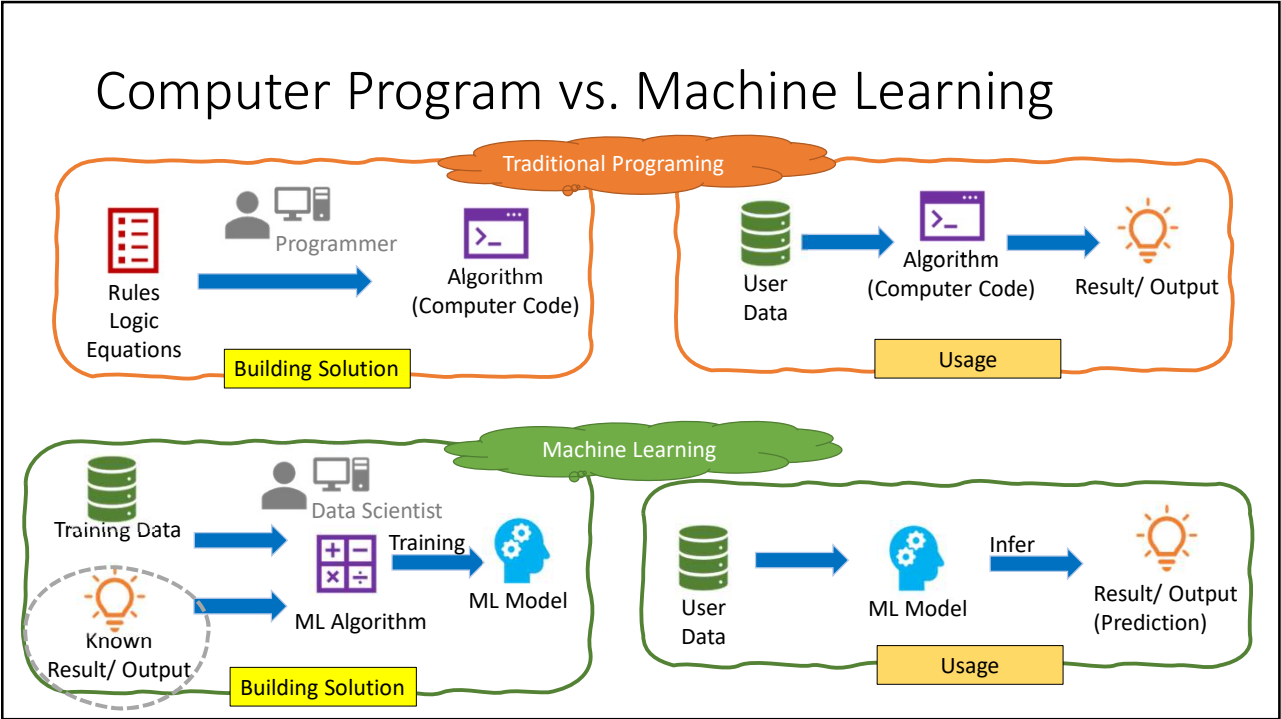
## Machine learning model



“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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## 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.

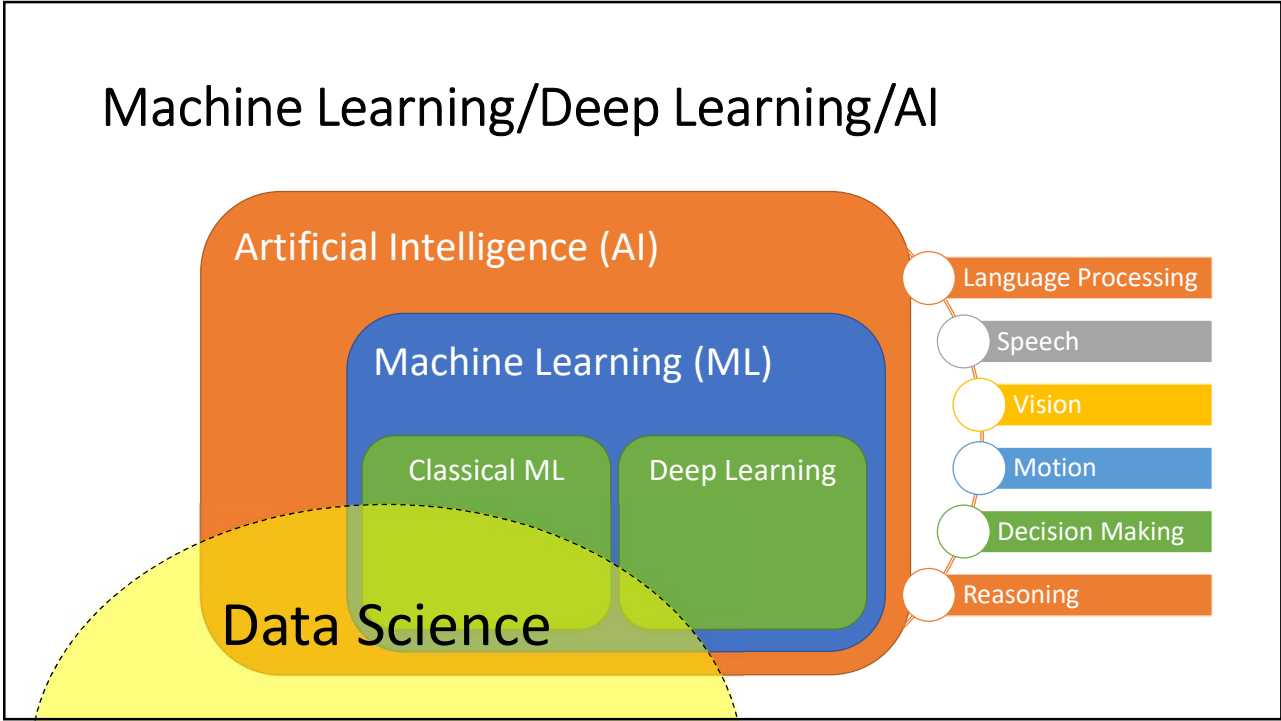
Mitchell, T. (1997). *Machine Learning*. McGraw Hill.  
p. 2. [ISBN 978-0-07-042807-2](https://doi.org/10.1007/978-0-07-042807-2).

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# AI and Machine Learning

- |   |   |
|---|---|
| <ul style="list-style-type: none"> <li>• AI (Mimic Cognitive Functions of Human)             <ul style="list-style-type: none"> <li>• Computer Vision</li> <li>• Speech Recognition and Synthesis</li> <li>• Language Processing and Understanding</li> <li>• Motion</li> <li>• Decision Making</li> <li>• Prescribe or Predict</li> <li>• Reasoning</li> </ul> </li> </ul> | <ul style="list-style-type: none"> <li>• Machine Learning (ML)             <ul style="list-style-type: none"> <li>• Machines learn on Data/Prior Knowledge</li> <li>• Statistical Modeling/Algorithms</li> <li>• Backbone of AI is Machine Learning</li> <li>• Algorithms to Find meanings of data</li> <li>• Find Relationships</li> <li>• Making Predictions</li> <li>• Problem-Solution Types                 <ul style="list-style-type: none"> <li>• Classification</li> <li>• Regression</li> <li>• Clustering</li> </ul> </li> </ul> </li> </ul> |
|---|---|

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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),**

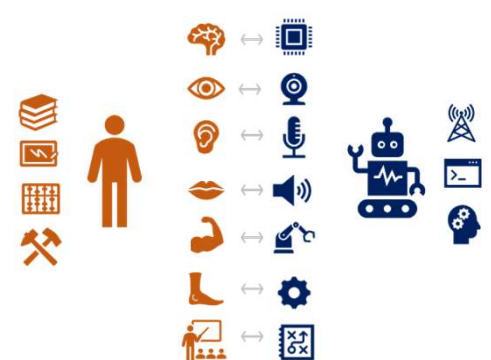
- Implements a limited part of human cognitive abilities.
- **Narrow AI** is a special case of Weak AI focused on a specific problem or task.
- Currently, existing AI systems are likely operating as a narrow AI.
- devices cannot follow these tasks independently but are made to look intelligent (simulate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

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# Building Blocks of an AI System



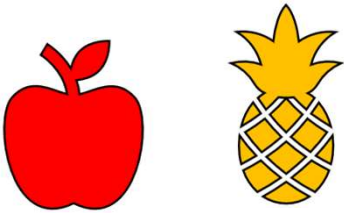
- Image recognition (computer vision)
- Signal processing (sound, sensor data feed, etc.)
- Speech Recognition (Speech to text/STT)
- Natural language processing (NLP)
- Visual Synthesis (Computer Graphics)
- Sound Synthesis (Text to Speech/TTS)
- Software/Algorithms
- Applications (Anomaly Detection, 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.


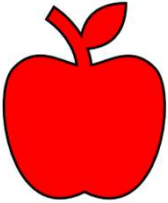
Is it easy or difficult to converting this logic to a computer program (code)?

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 ?



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

Input →  
(Features/Attributes)

Output →  
Apple (A)  
Pineapple (P)


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$$y = f(X)$$

Independent Variables

$X = [x_1, x_2, x_3, \dots]$

{Color, Diameter, Weight}



Dependent Variable

$y$

{Apple, Pineapple}

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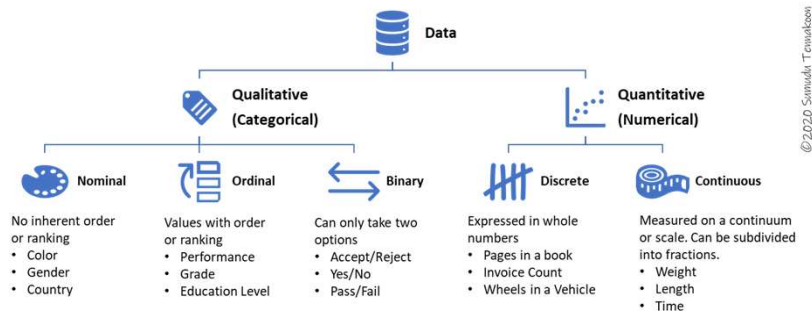
Tabular Data

	Column 1	Column 2	Column 3	
	ID	Name	DOB	← Column Names
Row 1	10001	John Doe	1988-01-01	
Row 2	10002	Jane Doe	1990-12-31	Row (Record)
Row 3	...	...	...	

Column (Data Field)

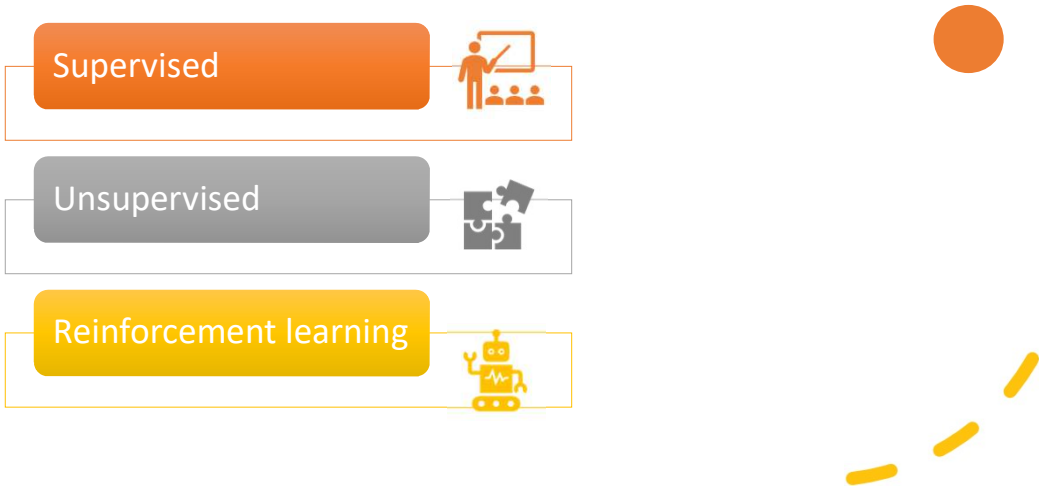
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# Understanding Data



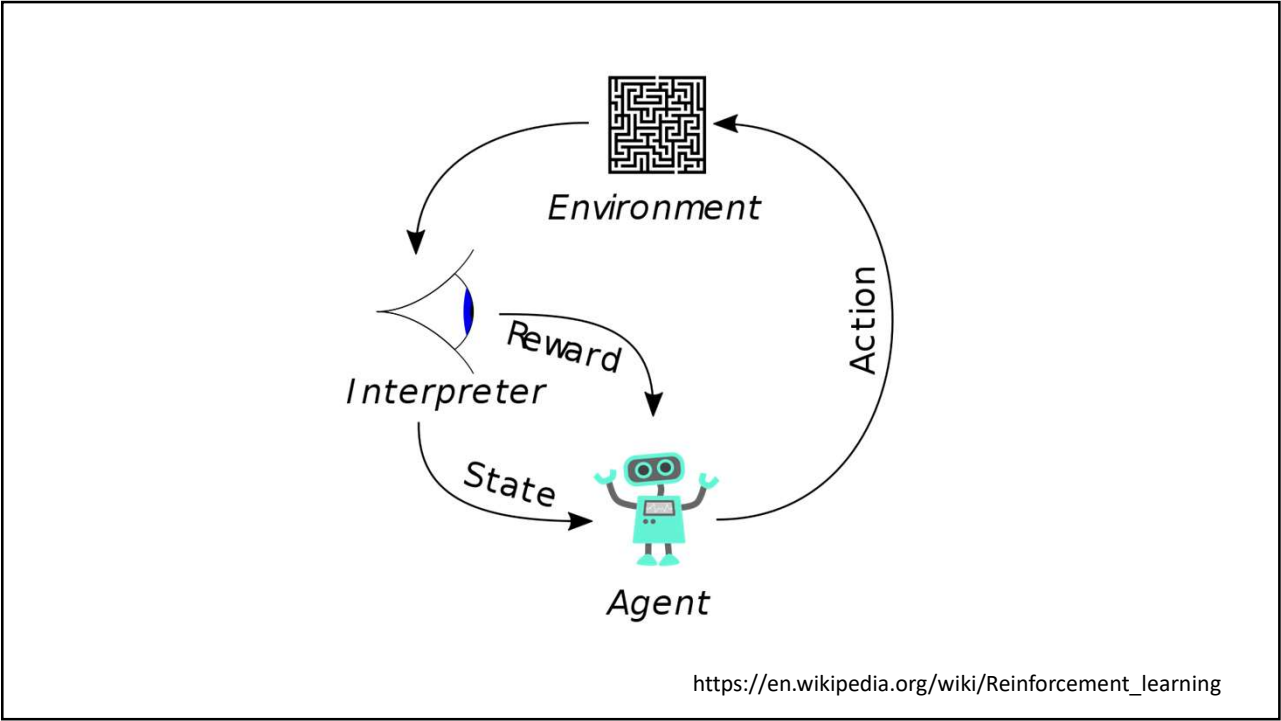
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# Machine Learning Approaches



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# Types of ML Algorithms


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**Regression**  
Linear  
Polynomial

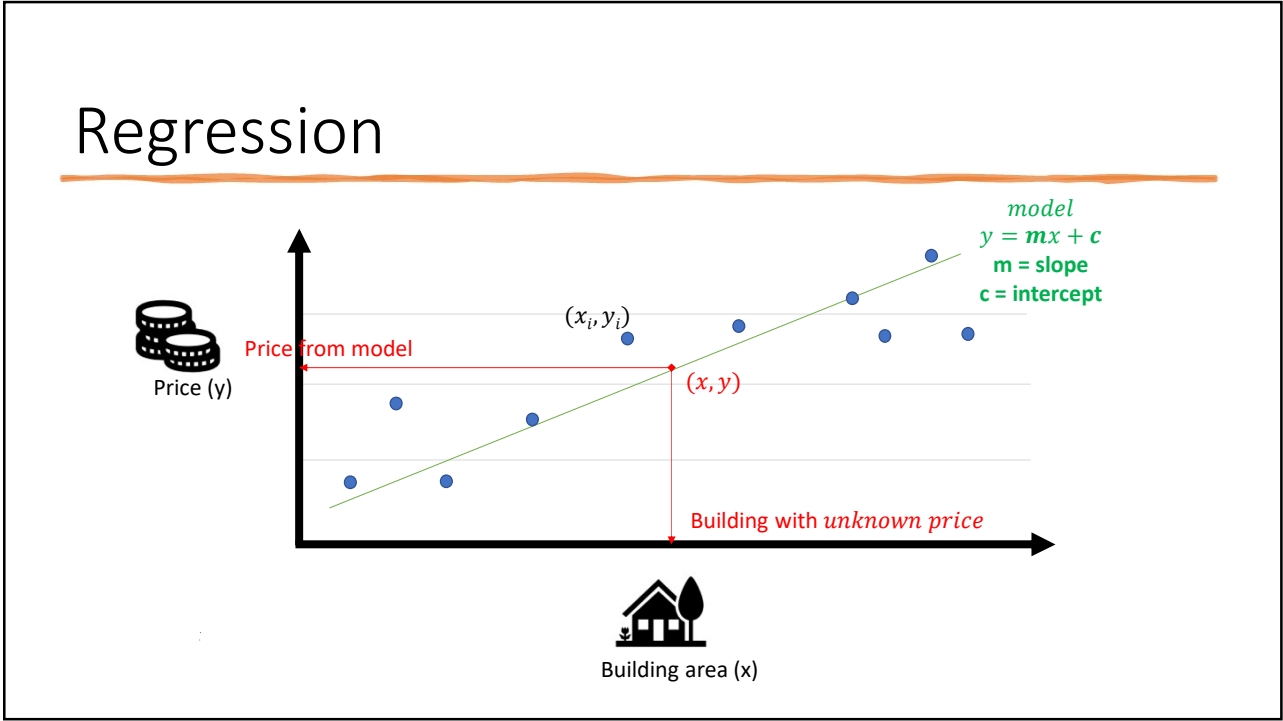


**Classification**  
Tree Classifiers  
Logistic Regression  
Support Vector Machines (SVM)

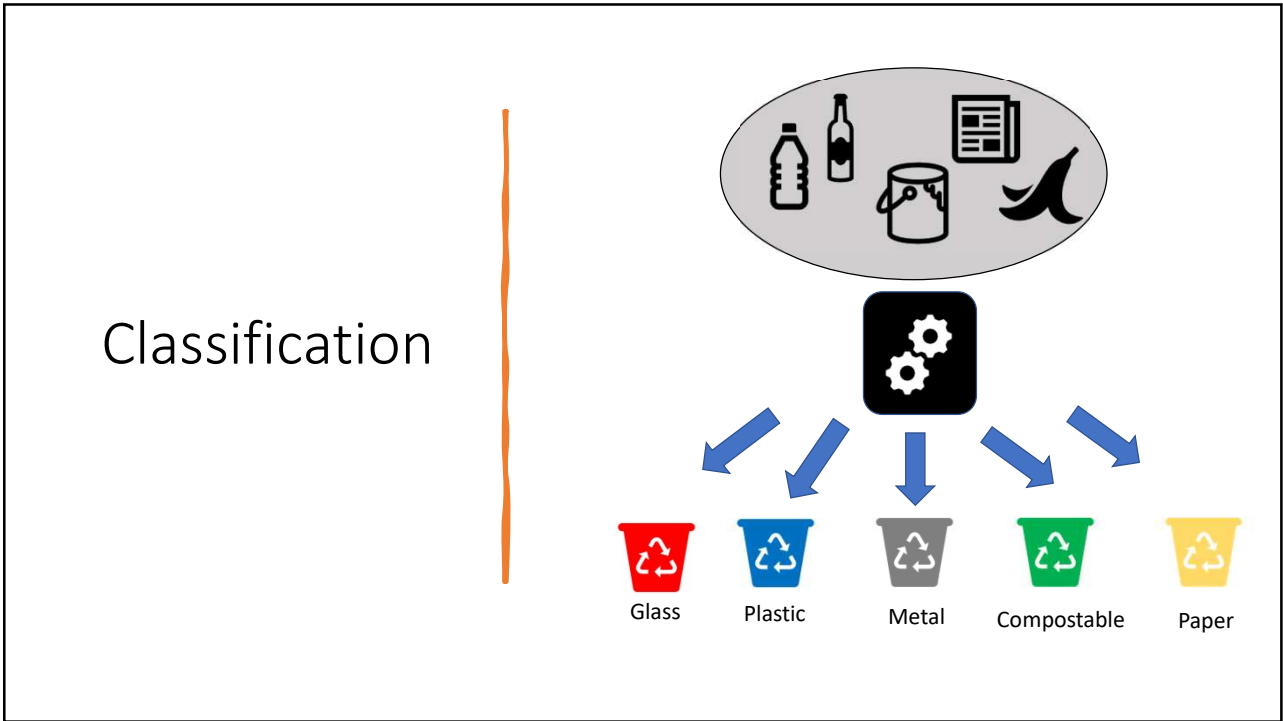


**Clustering**  
K-Means

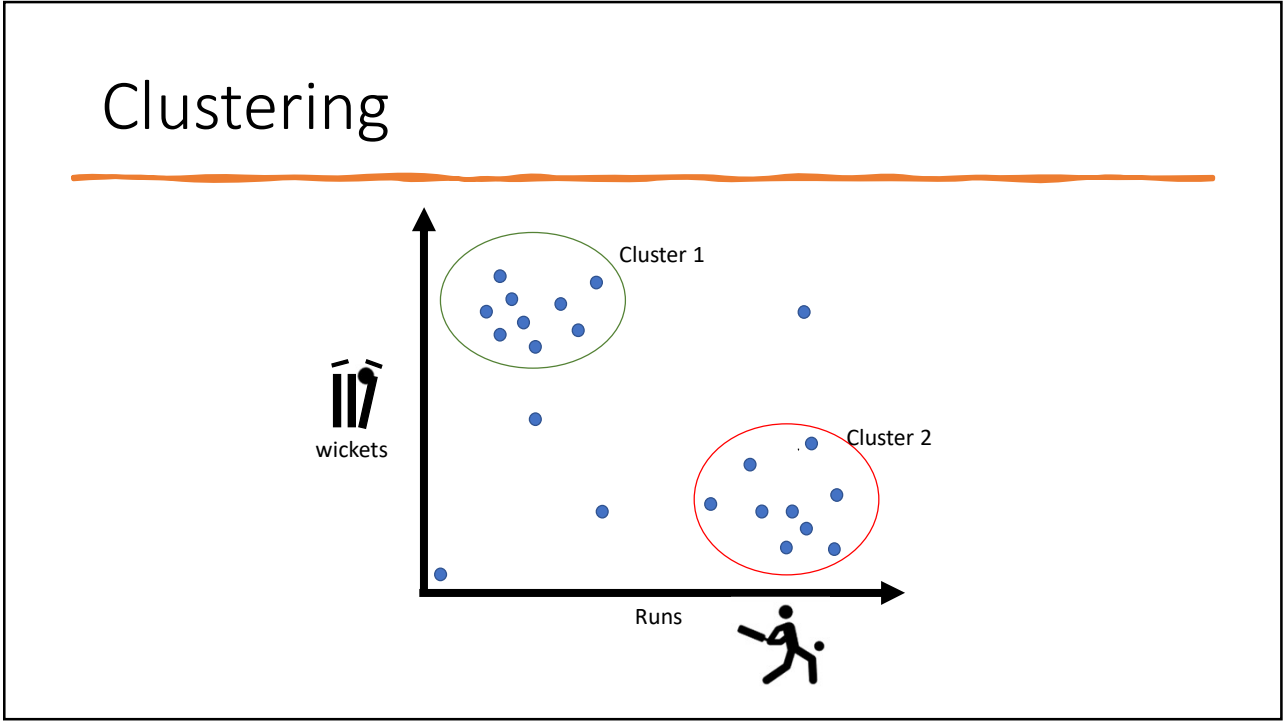
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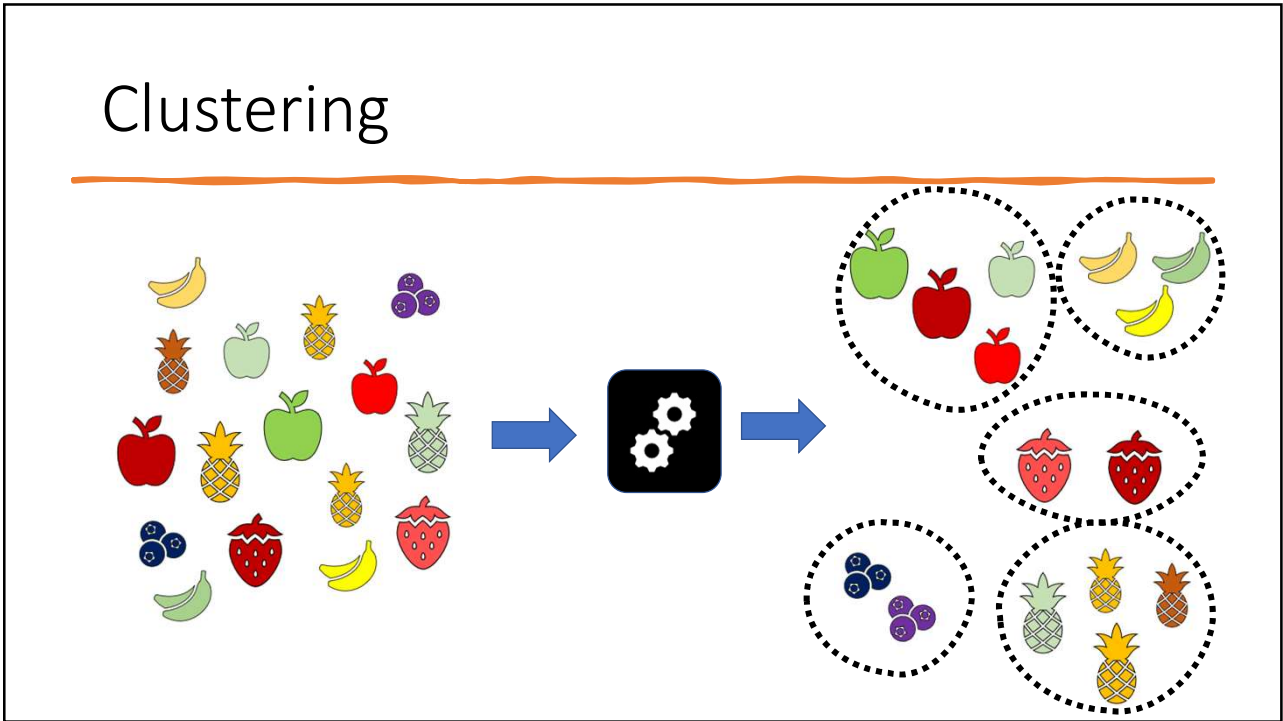
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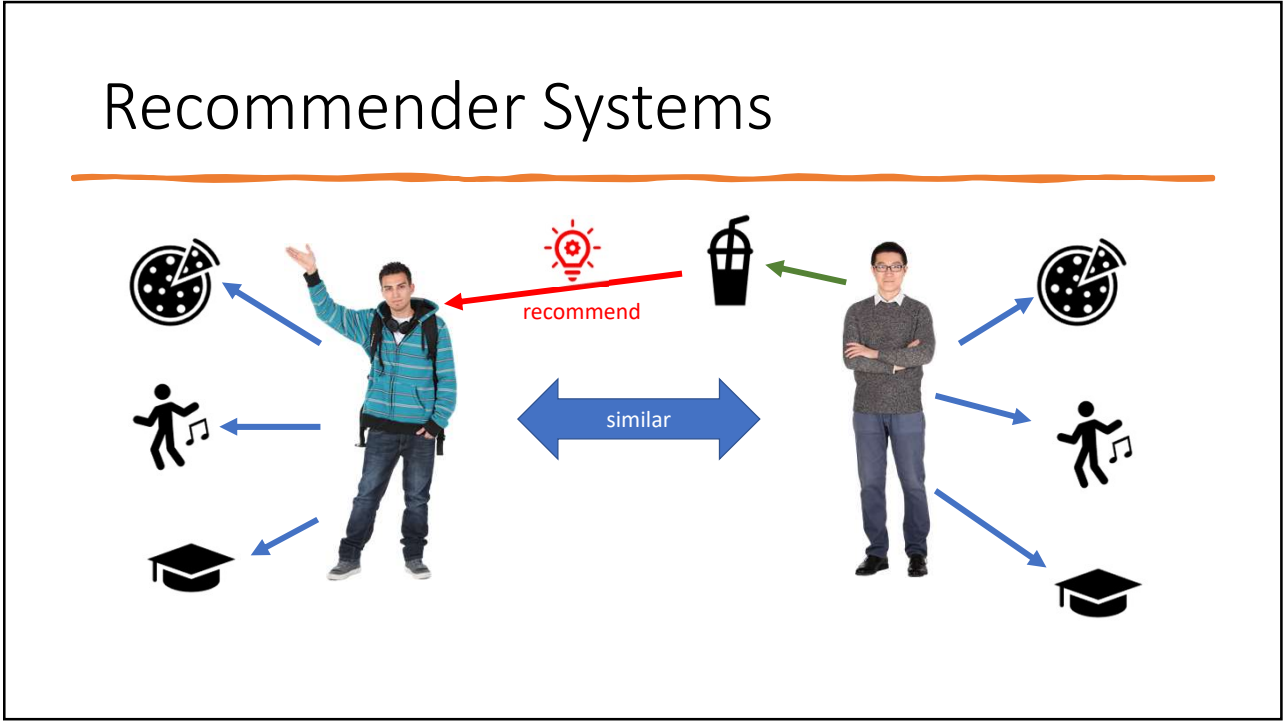
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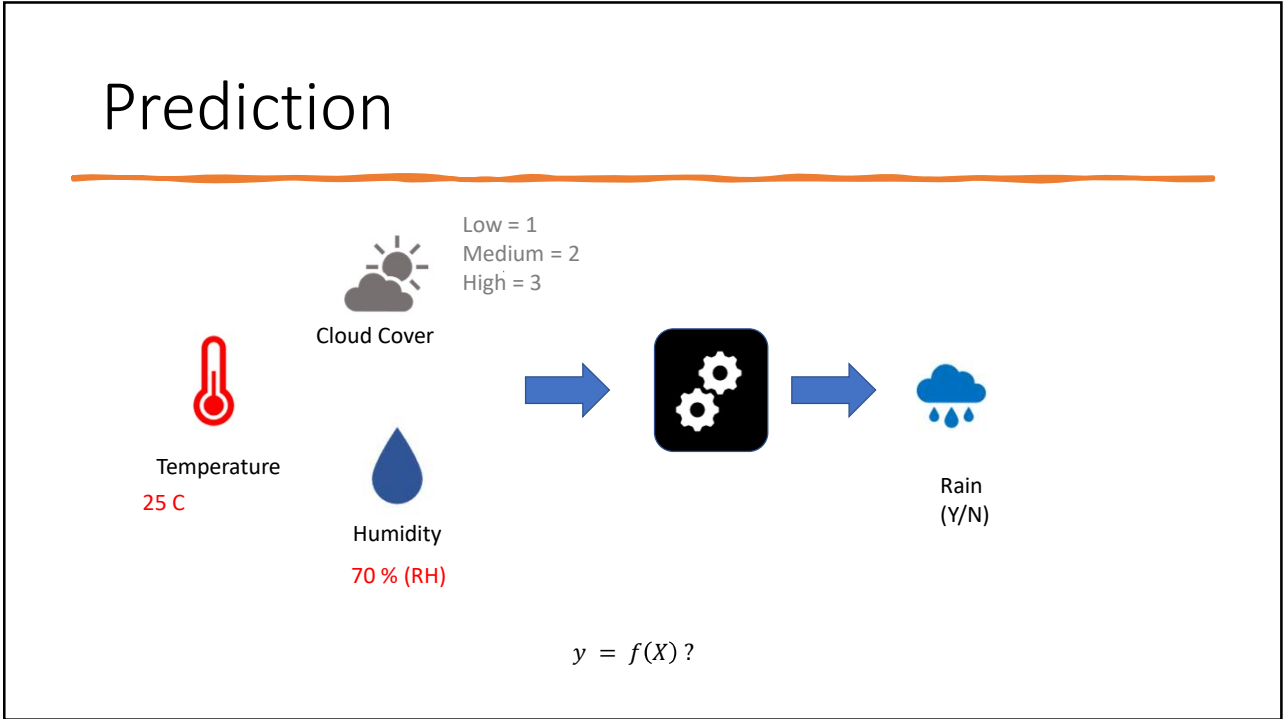
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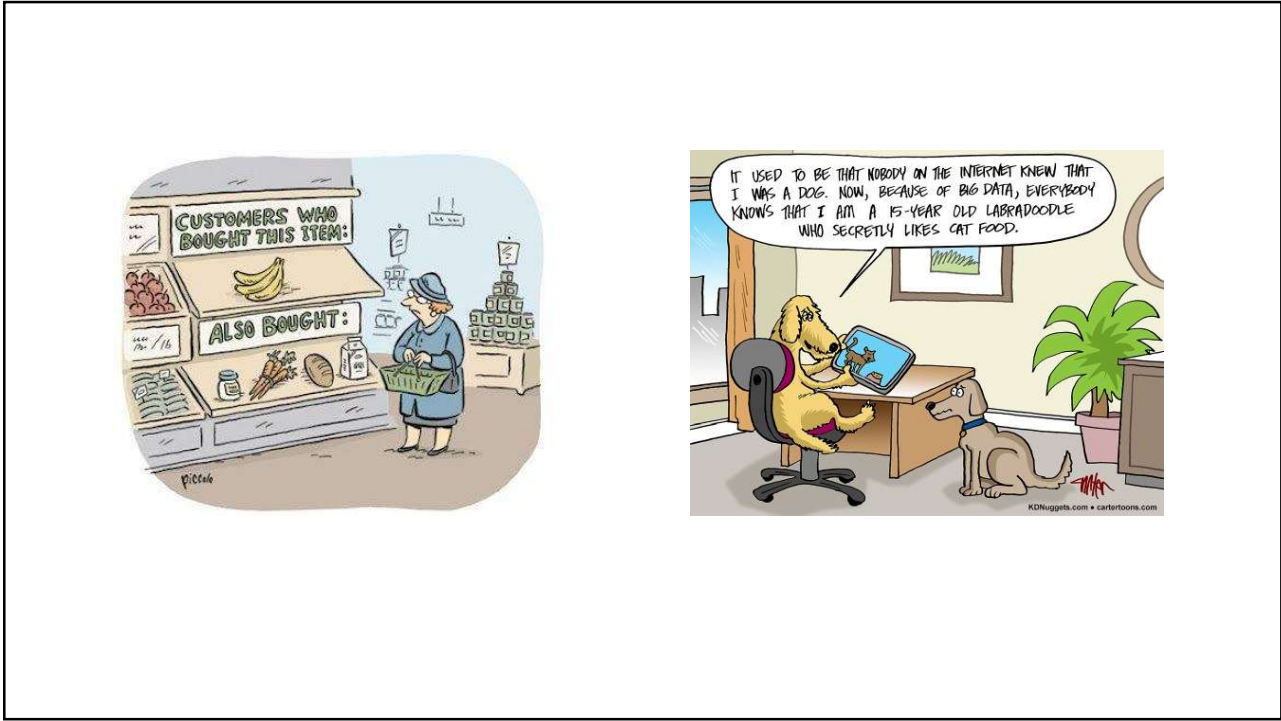
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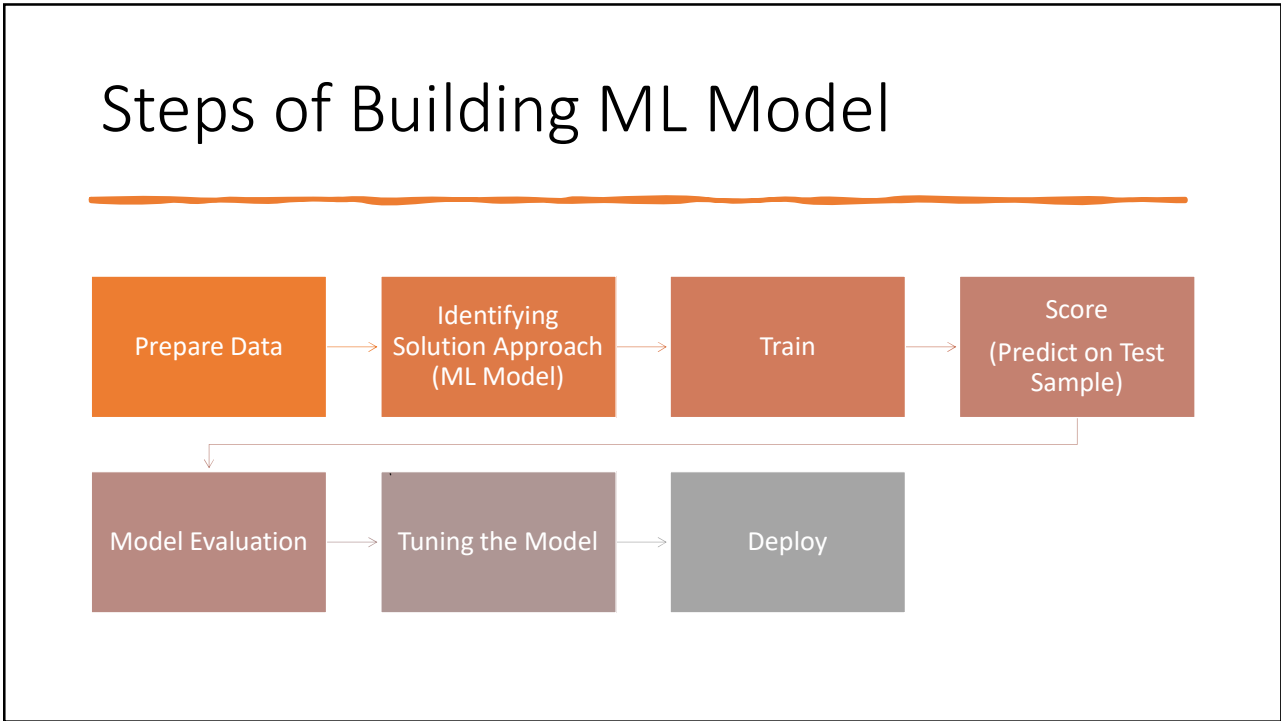
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Why we need Machine Learning?

Simulate human intelligence

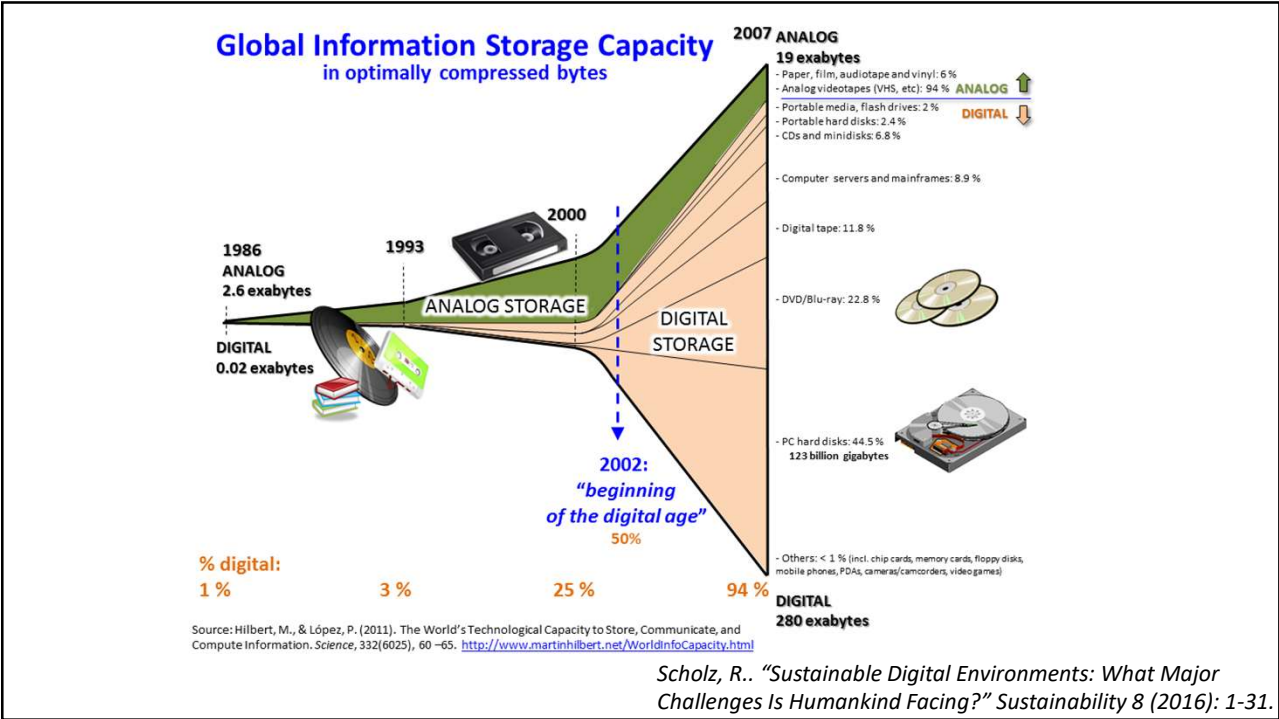
Automation

Help humans with informed decision making

Solve multidimensional problems

Predict future outcome based on historical observations

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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.



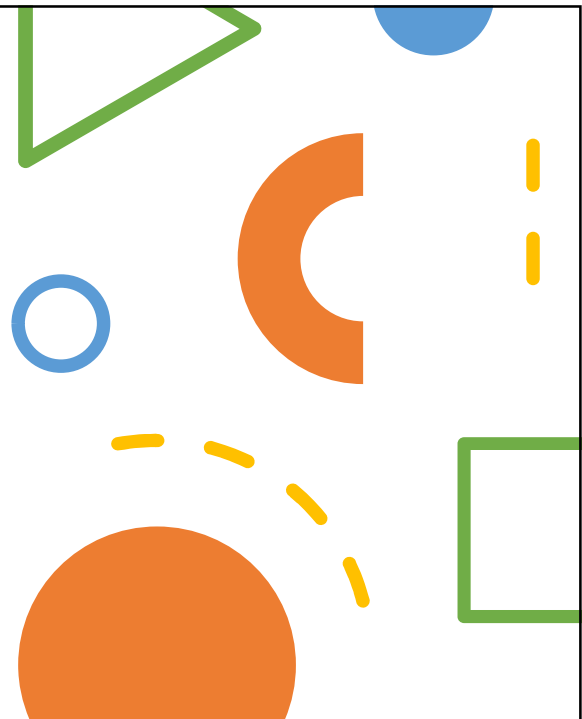
It is fun to learn and helps train your brain.



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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

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Cloud Computing Platform  
(Google Colab)

Python (Install, Libraries)




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# Install Python in Local Computer

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- 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

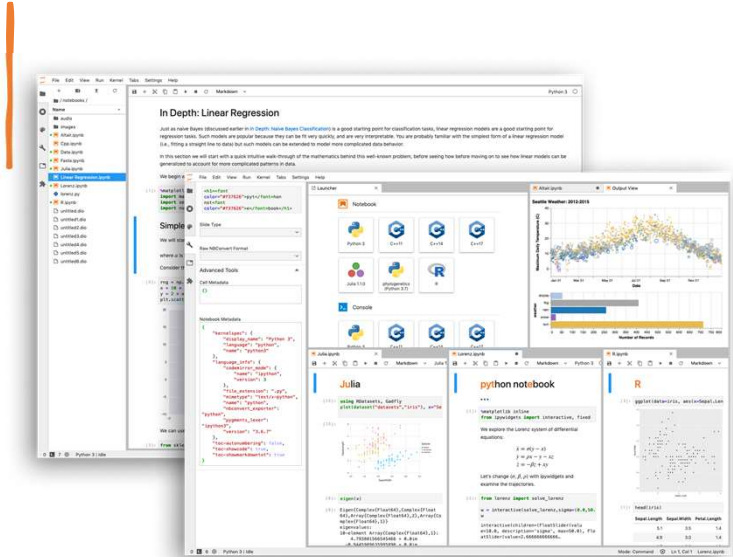
- Data Handling
  - Pandas
  - Dask (distributed)
- Machine Learning
  - Scikit-learn
  - TensorFlow
  - PyTorch
- Visualizing
  - Matplotlib
  - Seaborn
- Numerical and Scientific Computing
  - SciPy
  - NumPy
- Machine Learning Model Interpretation
  - LIME
  - SHAP
- Web Services/API
  - Flask
  -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



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# Jupyter Notebook/Lab





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# Google Colab

<https://colab.research.google.com>

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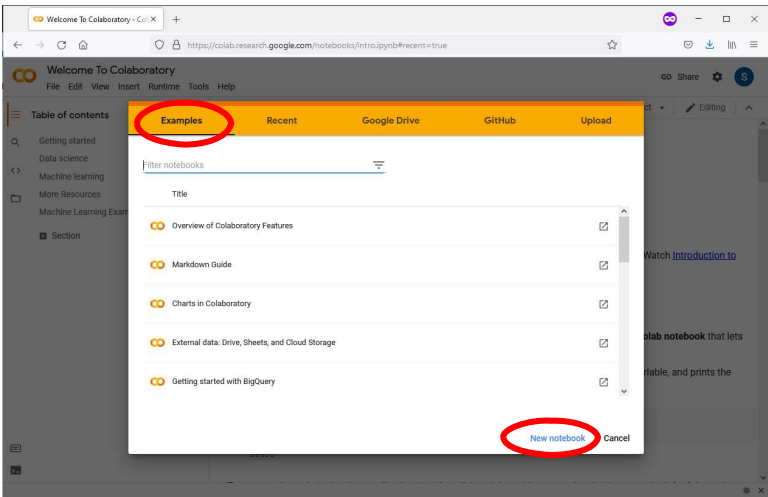


## Getting Started

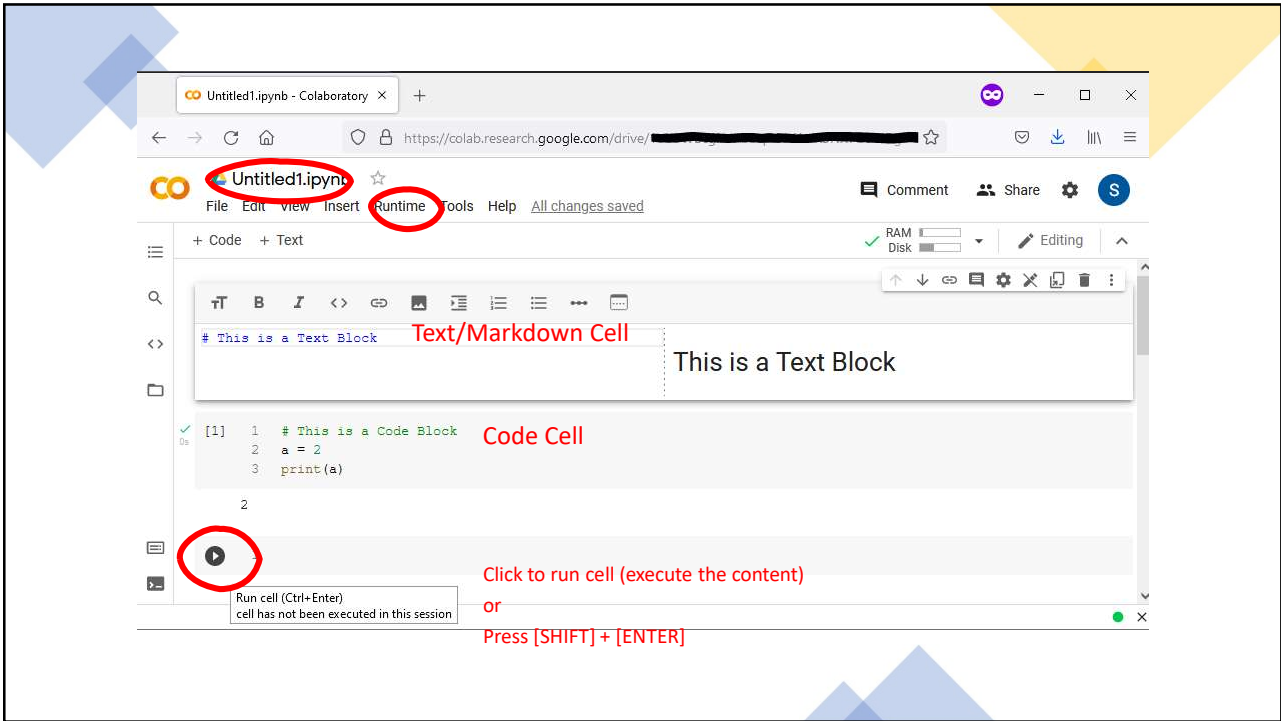
- Creating New Notebook
- Opening Notebook from GitHub
- Opening Notebook from file

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# Creating New Notebook

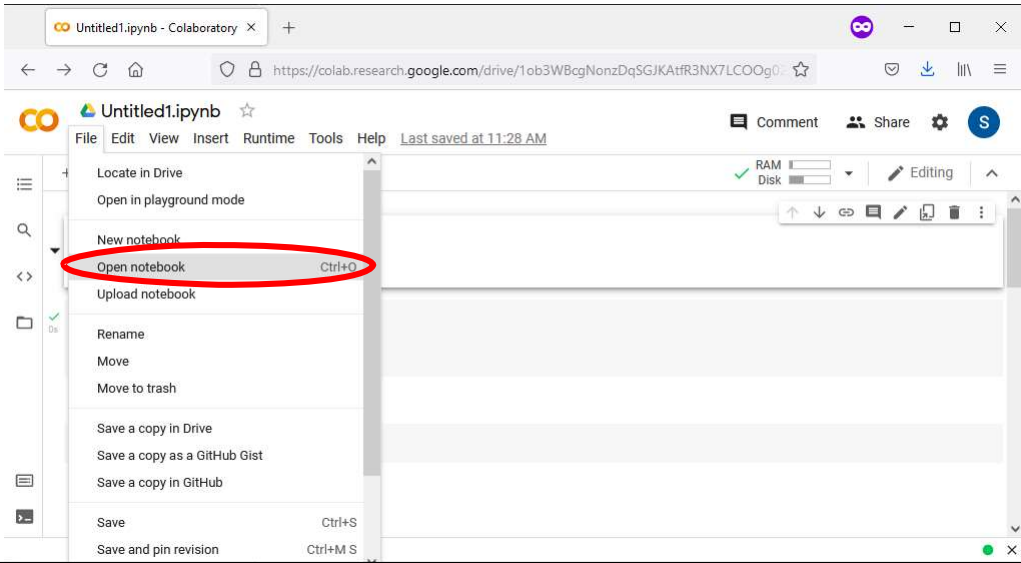


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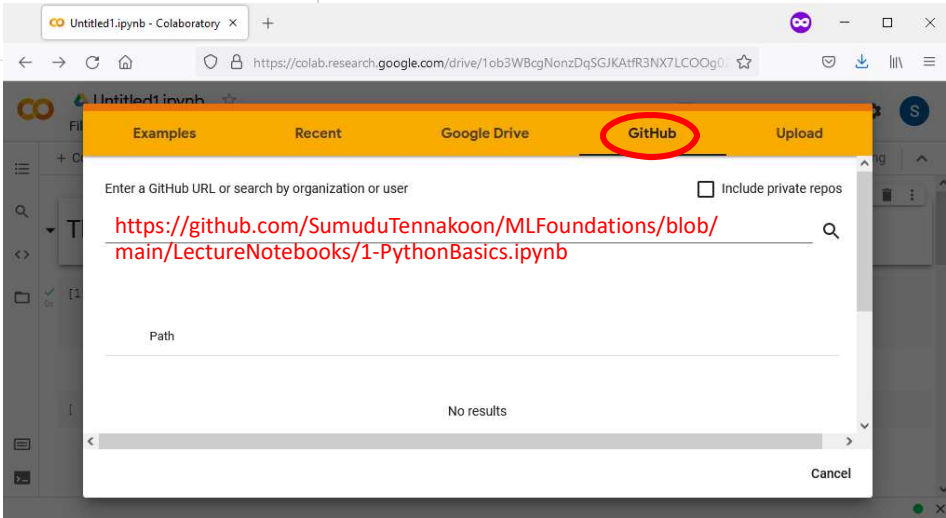
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# Open Notebook

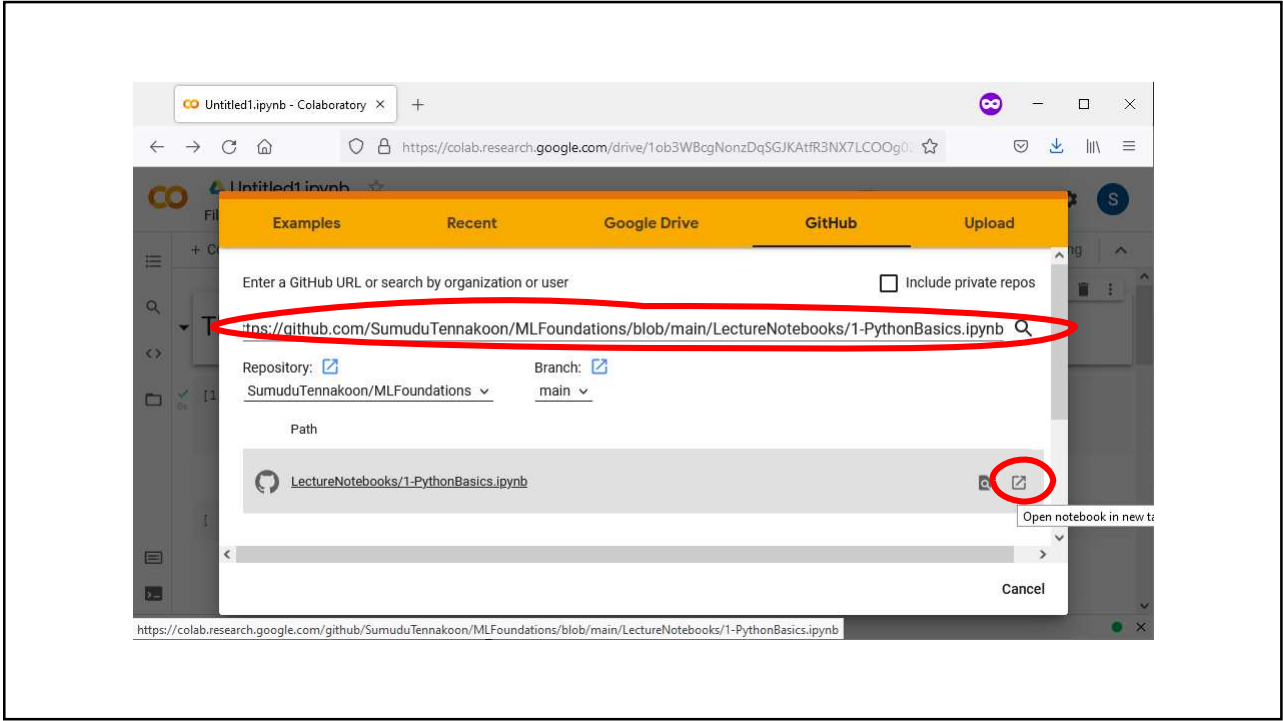


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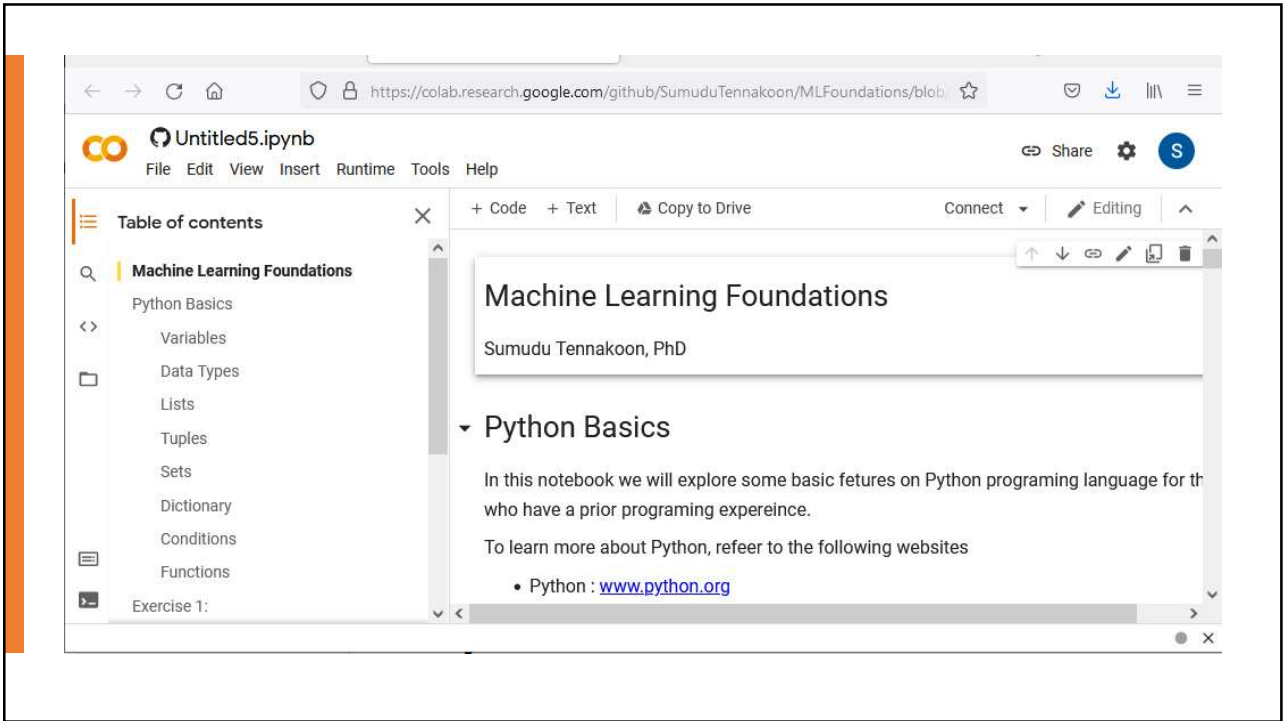
## Open Notebook from GitHub



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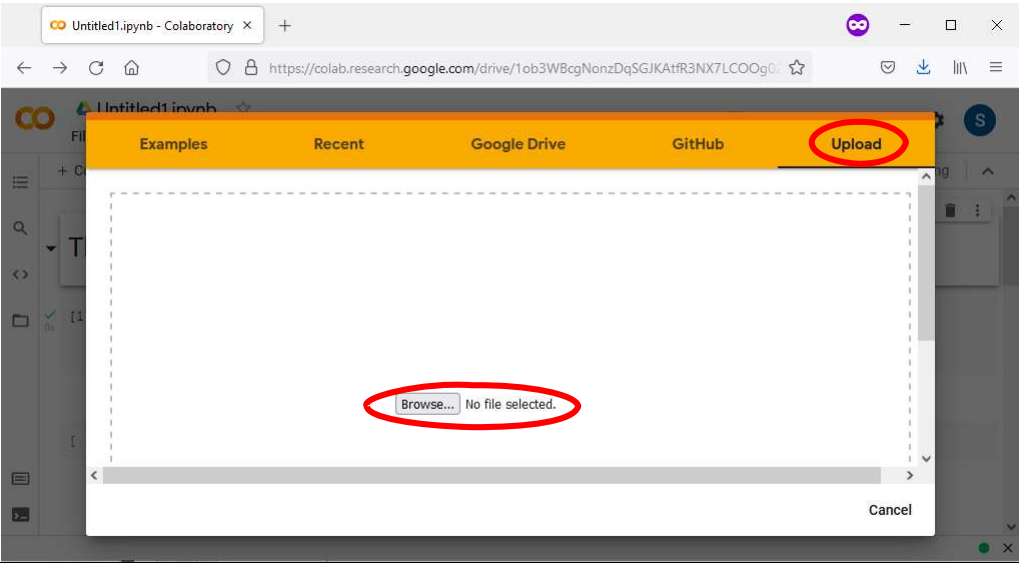


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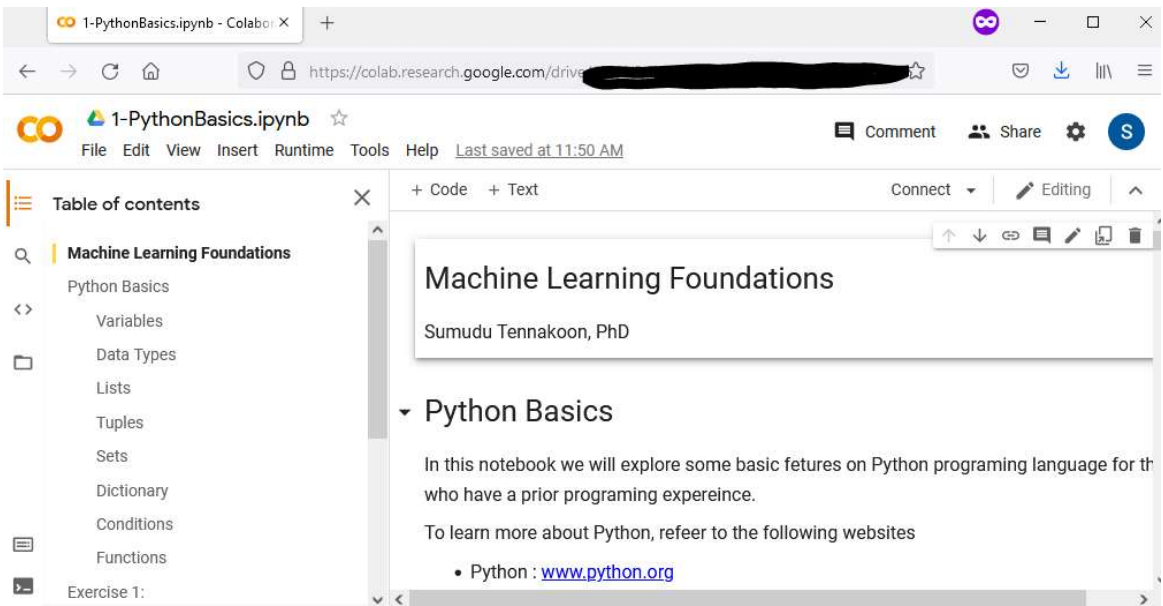


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# Upload Notebook (.ipynb file)



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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>