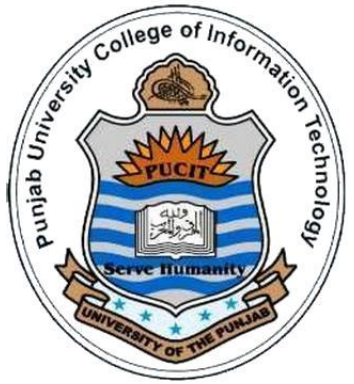

Machine Learning

Dr. Muhammad Adeel Nisar

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Contact

Contact Hours
In Class Contact Hours Tuesdays & Thursdays – 1.5 x 2 = 3 Hours
Outside Class Meeting Hours Thursdays: 14:00 to 16:00

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Course Outline

- Detailed course outline is available on Google classroom
- **Main Topics**: Introduction to Machine Learning, Supervised, Unsupervised, Semi-supervised Machine Learning, Applications of Machine Learning, Linear Regression, Polynomial Regression, Logistic Regression, Bayes Theorem, Naïve Bayes Classifier, Support Vector Machines, Neural Networks: Forward and Backpropagation, Convolutional Neural Networks, Clustering, Dimensionality Reduction: Principal Component Analysis
- **Additional Topics**: Introduction to the Python programming language and its libraries and packages: NumPy, Matplotlib, Scikit-learn, PyTorch, Tensorflow.

Text and Reference Book(s)

- **A1: Python for Everybody by Dr. Charles R. Severance**
- **A2: Starting Out with Python by Tony Gaddis**
- **B1: The Hundred-Page Machine Learning Book by Andriy Burkov**
- **B2: Hands On Machine Learning with Scikit Learn, Keras and TensorFlow 2e by Aurélien Géron**
- B3: Introduction to Machine Learning by Ethem Alpaydin
- B4: Deep Learning with Python by François Chollet
- B5: Deep Learning by Ian Goodfellow, Yoshua Bengio, and Aaron Courville
-

Reference Material

- R1: https://www.youtube.com/watch?v=gb262LDH1So (Machine Learning by Andrew Ng) OR https://youtu.be/vStJoetOxJg?si=qiOMZaH3DUw1E742
- R2: https://www.deeplearningbook.org/
- R3: https://www.w3schools.com/ai/default.asp
- R4: https://www.w3schools.com/python/
- R5: https://numpy.org/
- R6: https://matplotlib.org/
- R7: https://scikit-learn.org/
- R8: https://pytorch.org/tutorials/
- R9: https://www.tensorflow.org/learn

Course Evaluation

- Sessional 25% (Quizzes, Assignments, Project)
- Midterm Exam 35%
- Final Term Exam 40%

Introduction to the Course

- Why Do you Need to Learn Machine Learning?
- What is Machine Learning?
- Applications of Machine Learning
- Machine Learning Life-Cycle
- Types of Machine Learning

Let's Begin with Some Questions

- **x** is an input integer number
- Its output **y** is either Positive or Negative *(Finding Category)*
- I want to check its output.
- What is the rule?
- **If (x >= 0) then y = Positive otherwise y = Negative**

Another Question

- **x** is an input integer number
- I want to check whether its output **y** is Even or Odd
- What is the rule?
- **If (x % 2 == 0) then y = Even otherwise y = Odd**

Another Question

- **Gender Classification** using Facial Images [1]
- Input **x** is an Image
- Output **y is a label "**Male" or "Female"
- Rule?
- [1] https://peteradekolu.medium.com/gender-classification-of-facial-images-using-cnn-in-python-19fff3e986a

Labeled Facial Images

Another Question

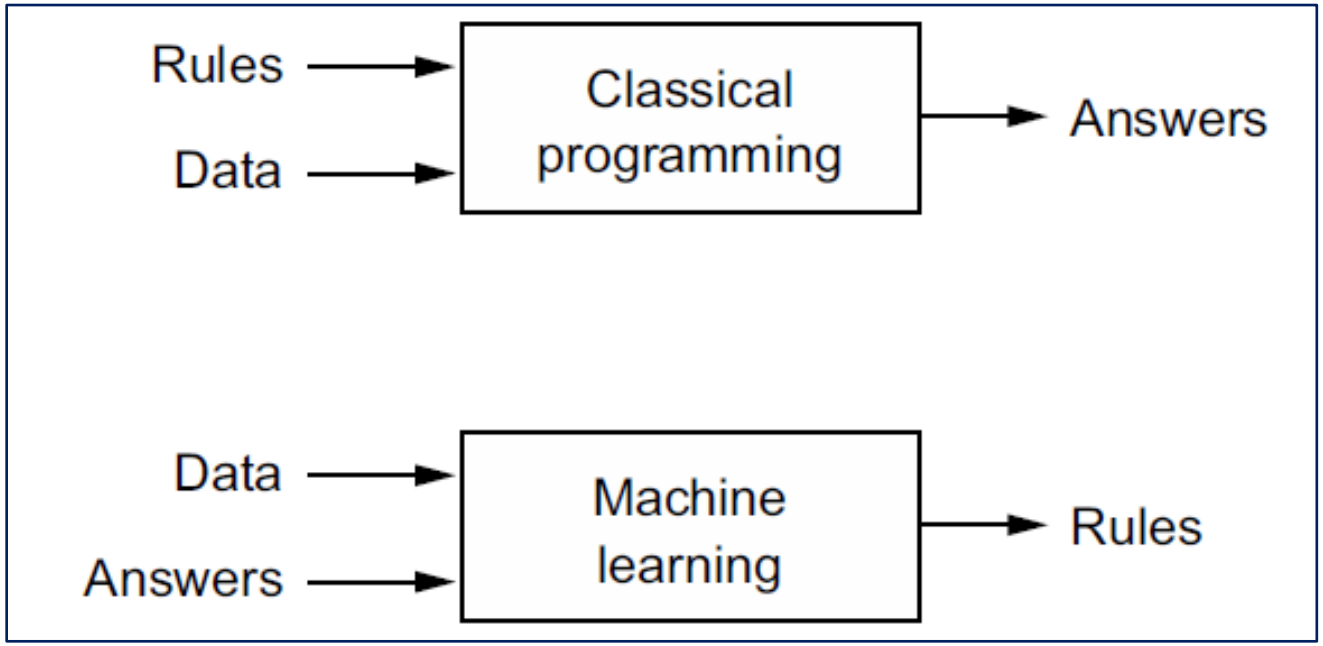
- **Cats vs Dogs [2]**

Rule?

VS

[2] https://www-edlab.cs.umass.edu/~smaji/cmpsci670/fa14/hw/recognition/

Why Machine Learning?



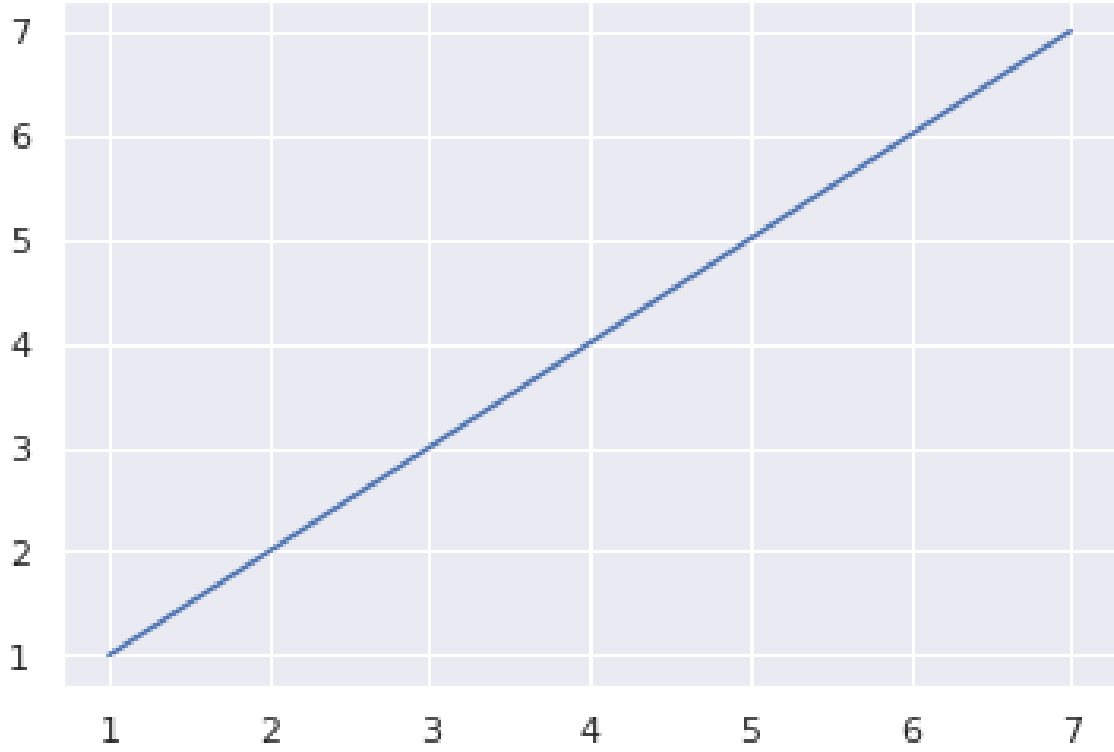
Finding Data Pattern

- **Exploratory Data Analysis**

- **x** = [1, 2, 3, 4, 5, 6, 7]
- **y = f(x)** = [1, 2, 3, 4, 5, 6, 7]

Exploratory Data Analysis

- **x** = [1, 2, 3, 4, 5, 6, 7]
- **y** = [1, 2, 3, 4, 5, 6, 7]
- x = 3.5?
- y` = 3.5



Exploratory Data Analysis

- **x** = [1, 2, 3, 4, 5, 6, 7]
- **y** = [2, 4, 6, 8, 10, 12, 14]
- x = 3.5?

Exploratory Data Analysis

- **x** = [1, 2, 3, 4, 5, 6, 7]
- **y** = [2, 4, 6, 8, 10, 12, 14]
- x = 3.5?
- **y** = [3, 5, 7, 9, 11, 13, 15]

Exploratory Data Analysis

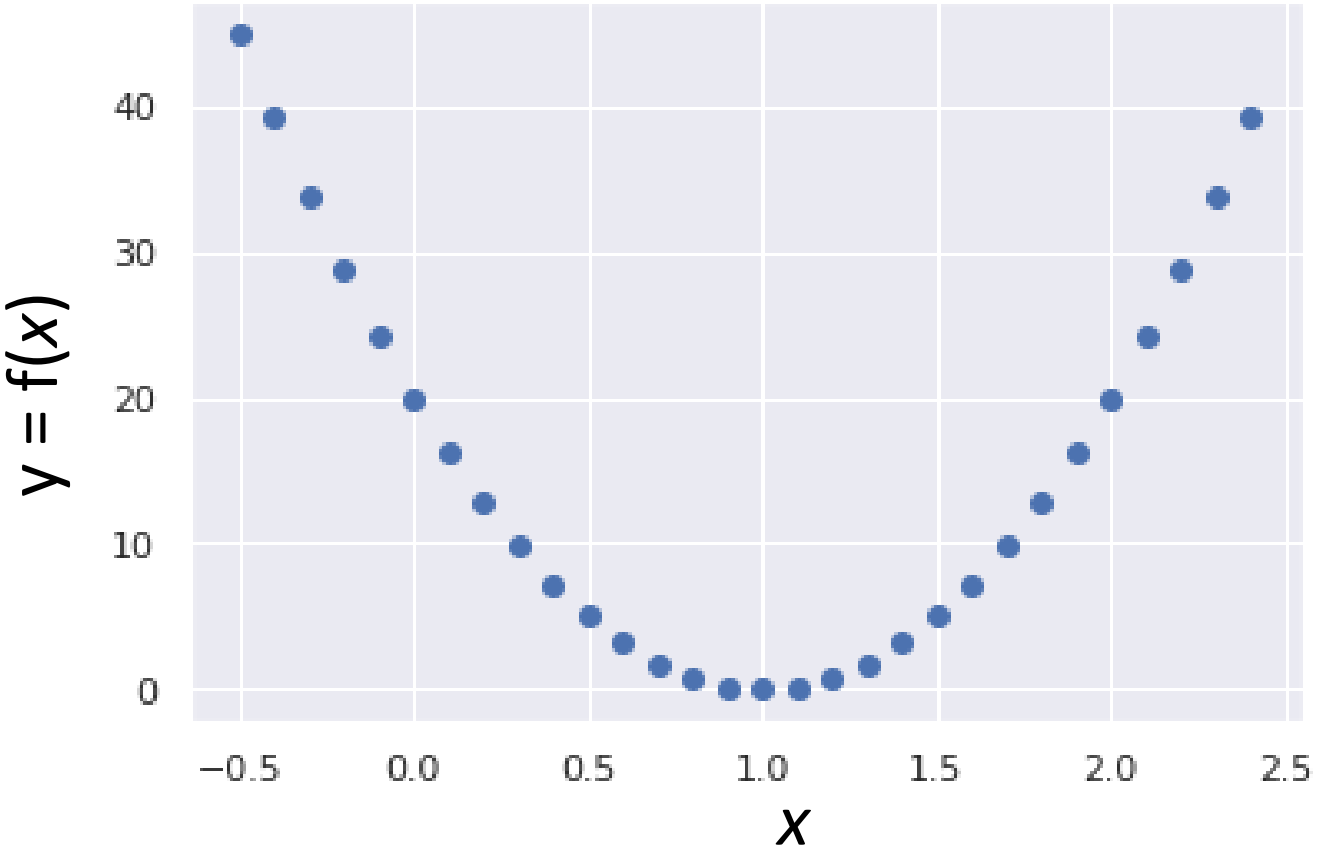
- x = [-0.5, -0.25, 0.0, 0.25, 0.5, 0.75, 1.0, 1.25, 1.5, 1.75, 2.0, 2.25]
- $y = f(x)$ =[45.0, 31.25, 20.0, 11.25, 5.0, 1.25, 0.0, 1.25, 5.0, 11.25, 20.0, 31.25]

y = f(x)

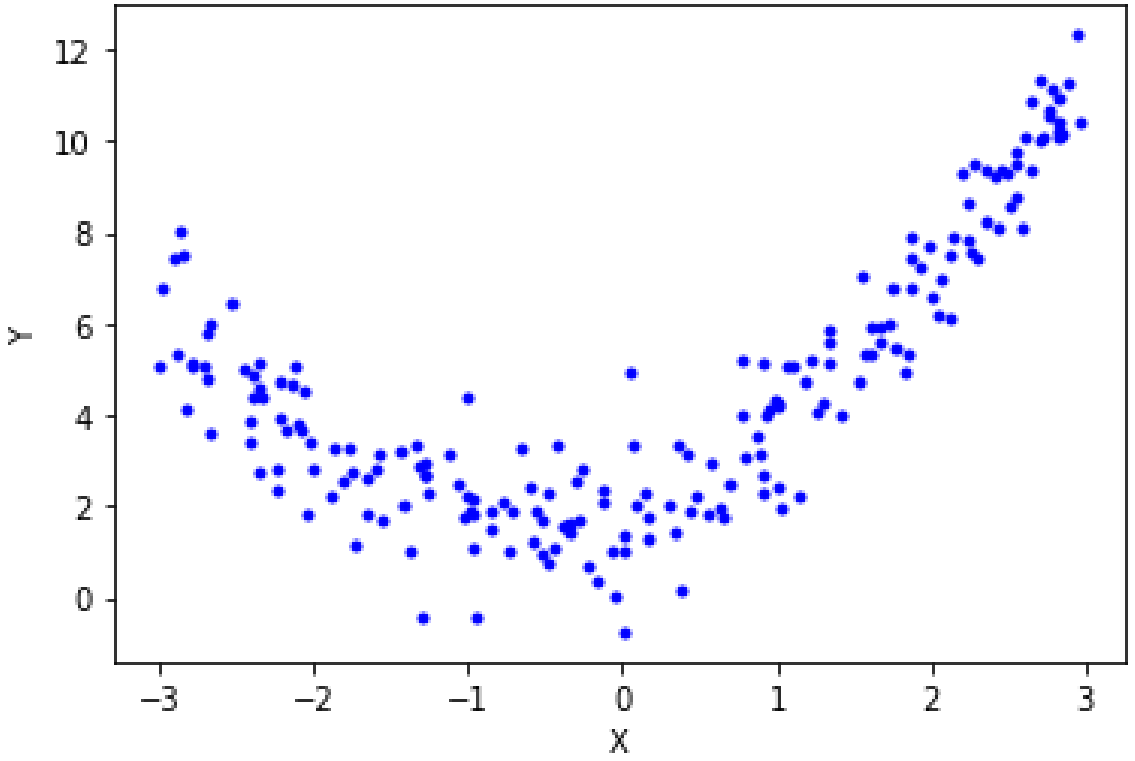
x

Exploratory Data Analysis

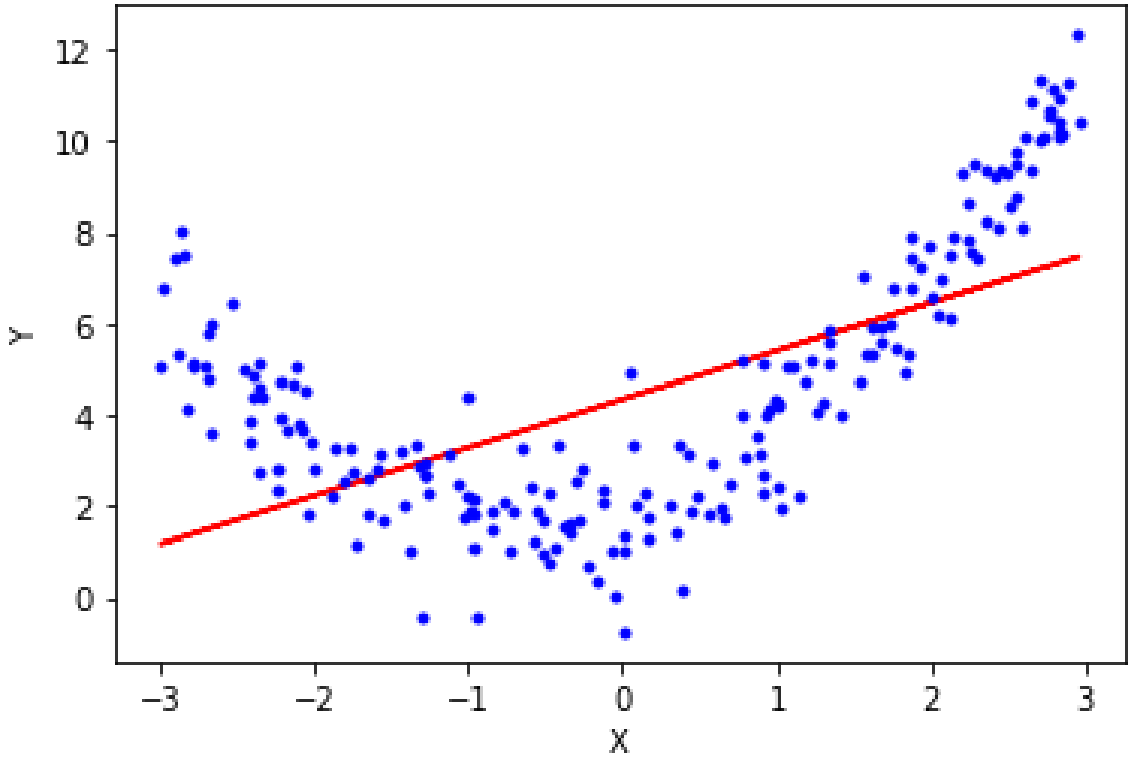
- x = [-0.5, -0.25, 0.0, 0.25, 0.5, 0.75, 1.0, 1.25, 1.5, 1.75, 2.0, 2.25]
- $y = f(x)$ =[45.0, 31.25, 20.0, 11.25, 5.0, 1.25, 0.0, 1.25, 5.0, 11.25, 20.0, 31.25]



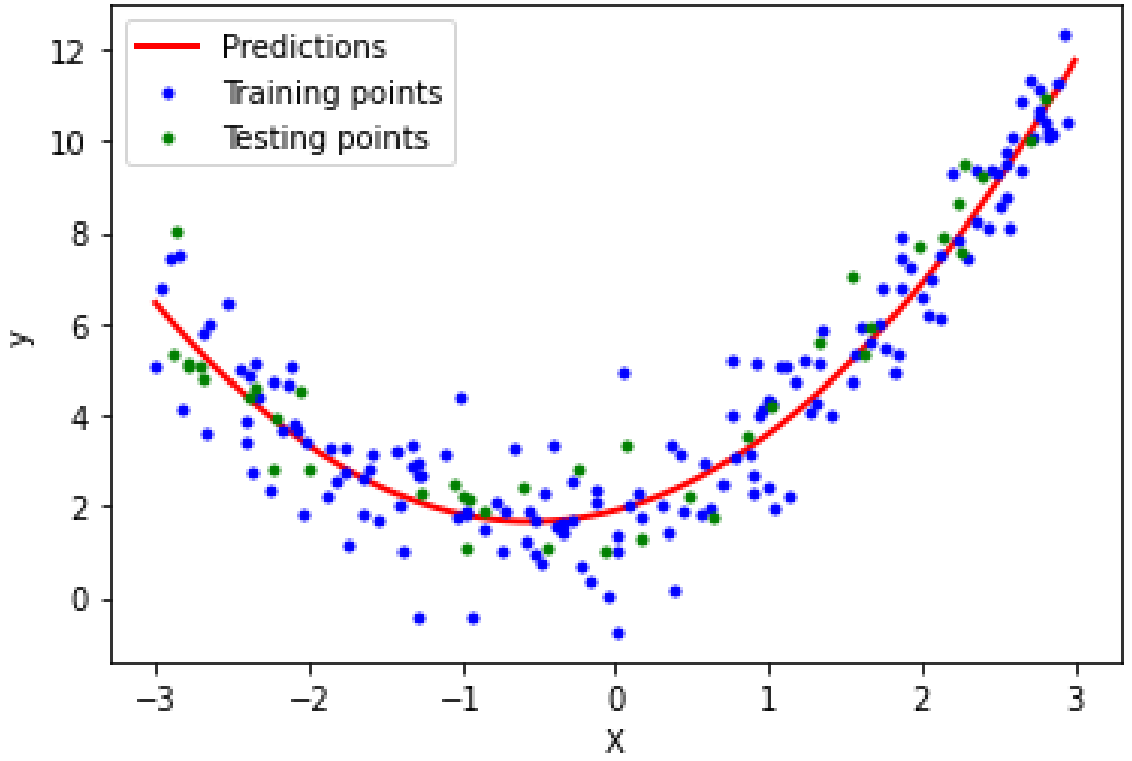
Exploratory Data Analysis



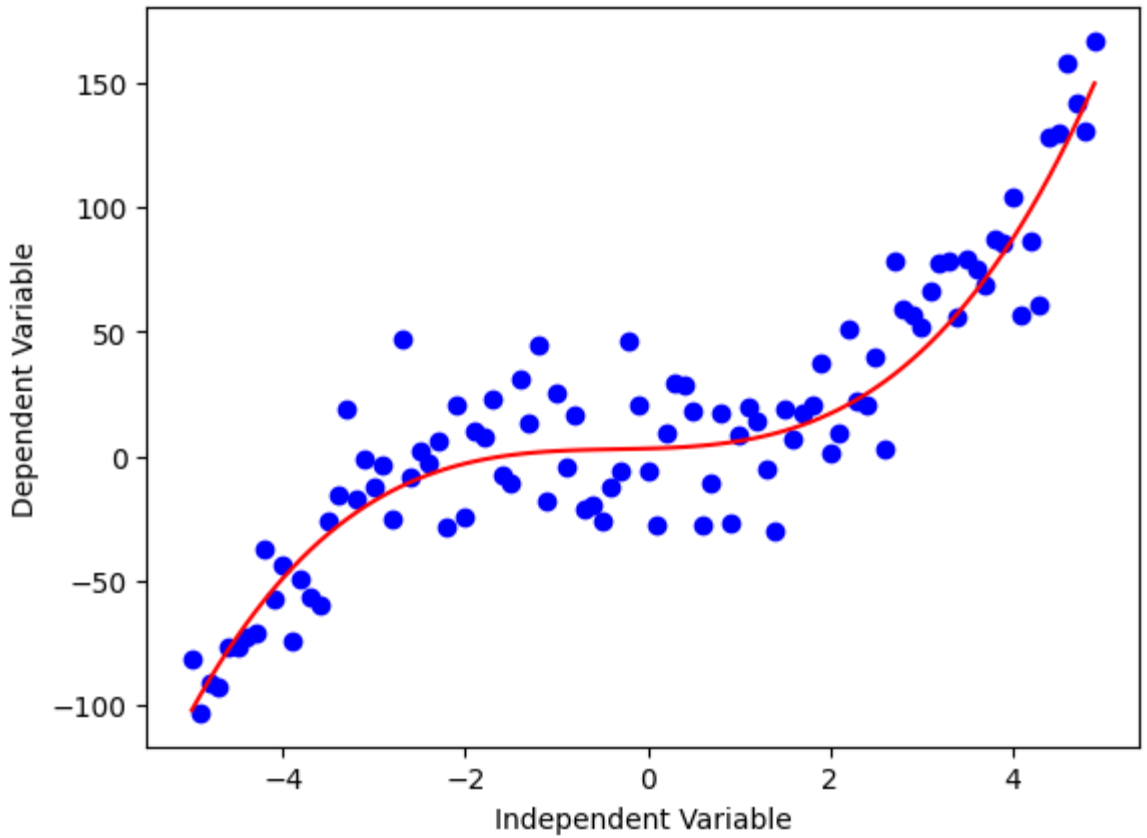
Exploratory Data Analysis



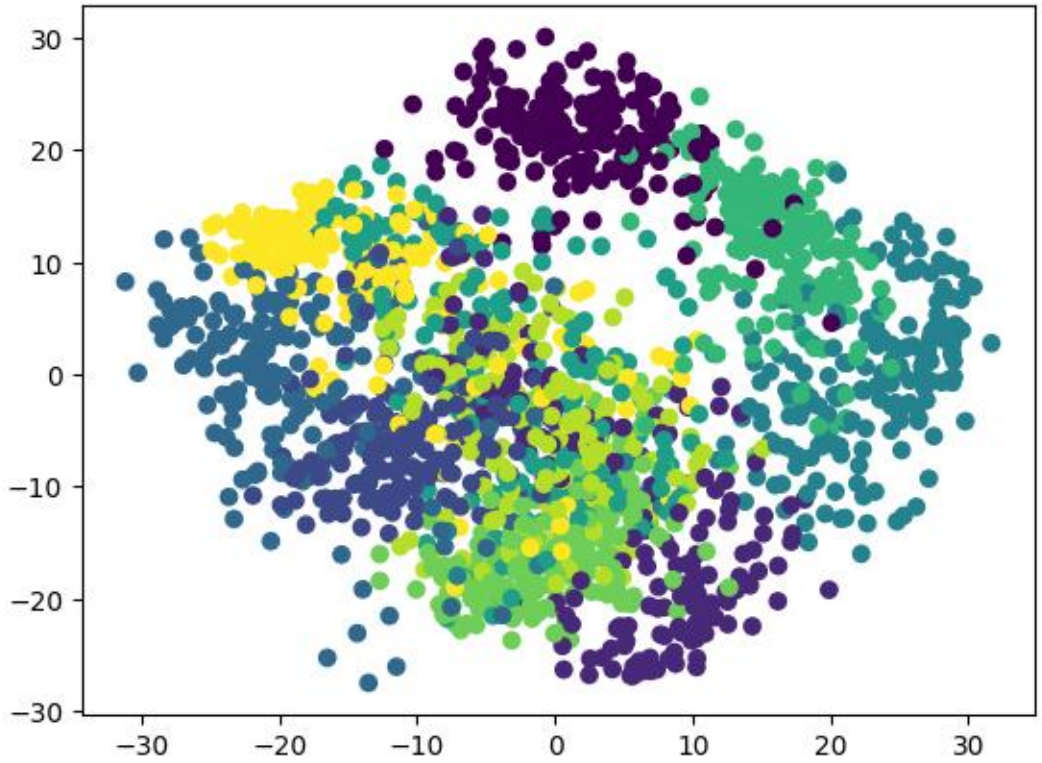
Exploratory Data Analysis



Exploratory Data Analysis

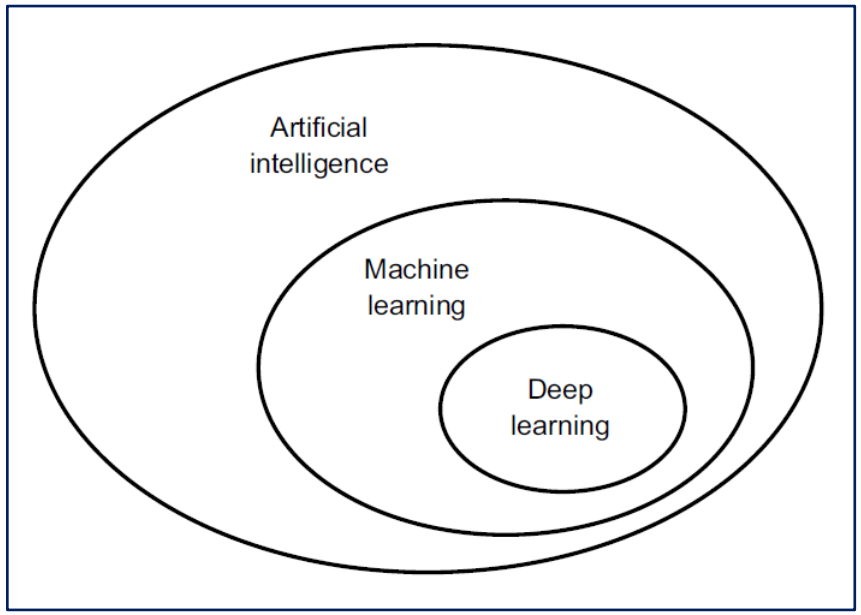


Can You Find The Pattern?

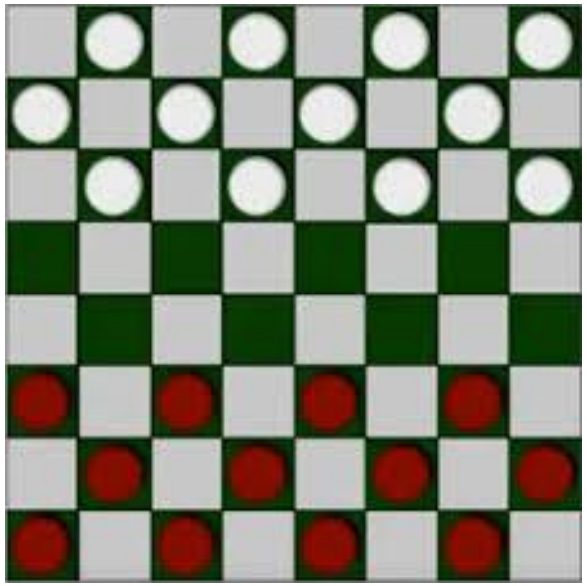


What is Machine Learning?

- Machine learning (ML) is a branch of Artificial Intelligence (AI).



- Arthur Samuel (1959) defined ML as "Field of study that gives computers the ability to learn without being explicitly programmed"
    - Samuels wrote a checkers playing program
        - Had the program play 10000 games against itself
        - Work out which board positions were good and bad depending on wins/losses



What is Machine Learning?

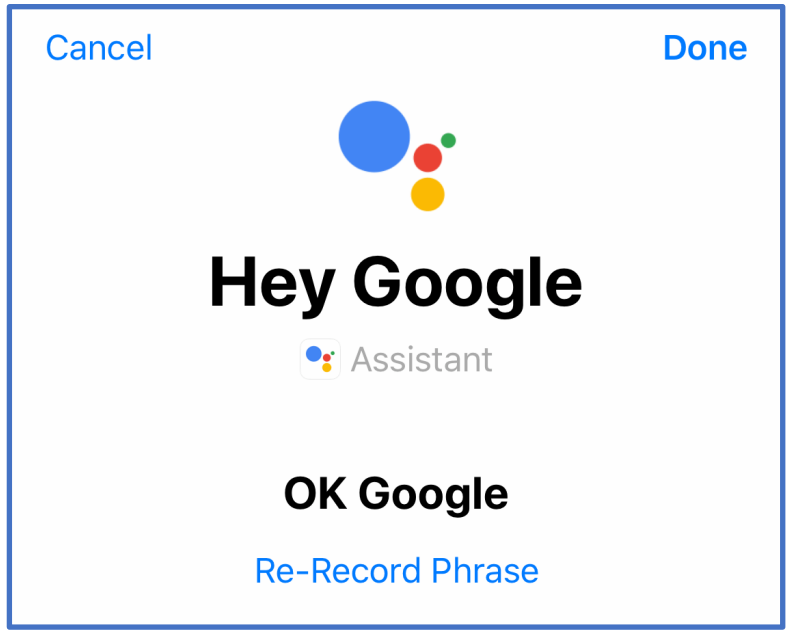
- Tom Michel (1999) defines ML as a well posed learning problem: "A computer program is said to learn from experience E with respect to some class of tasks T and performance measure P, if its performance at tasks in T, as measured by P, improves with experience E."

The checkers example,

- E = 10000s games
- T is playing checkers
- P is probability of winning

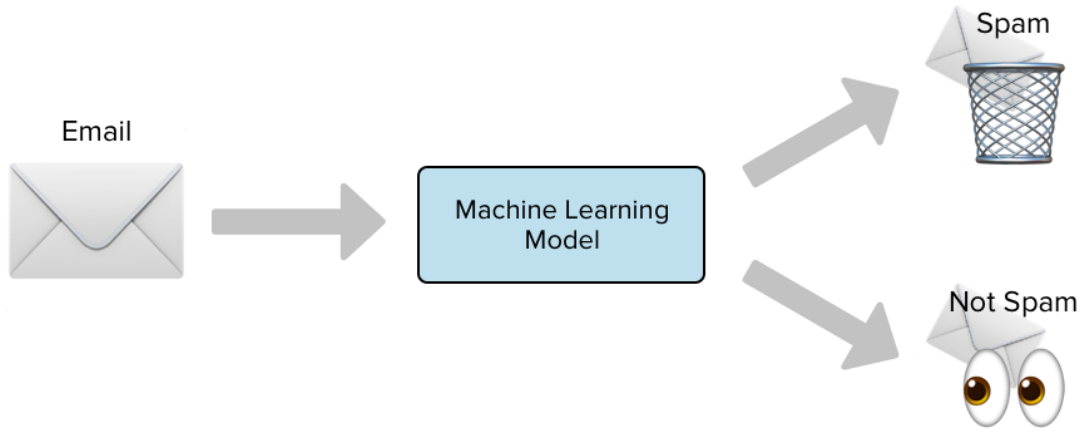
Applications of Machine Learning

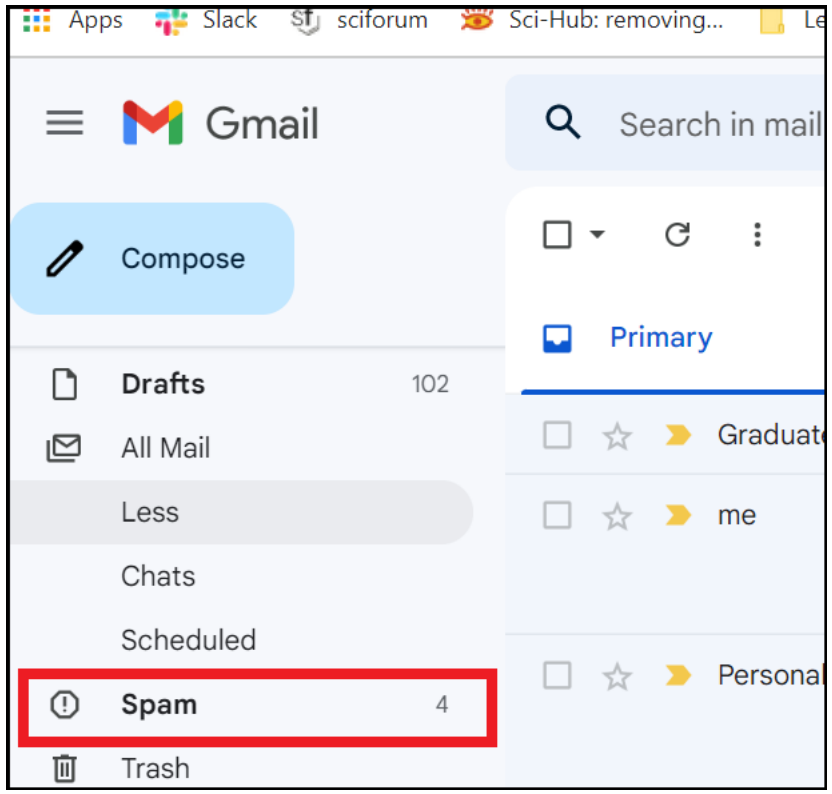
- Virtual Personal Assistant



Applications of Machine Learning

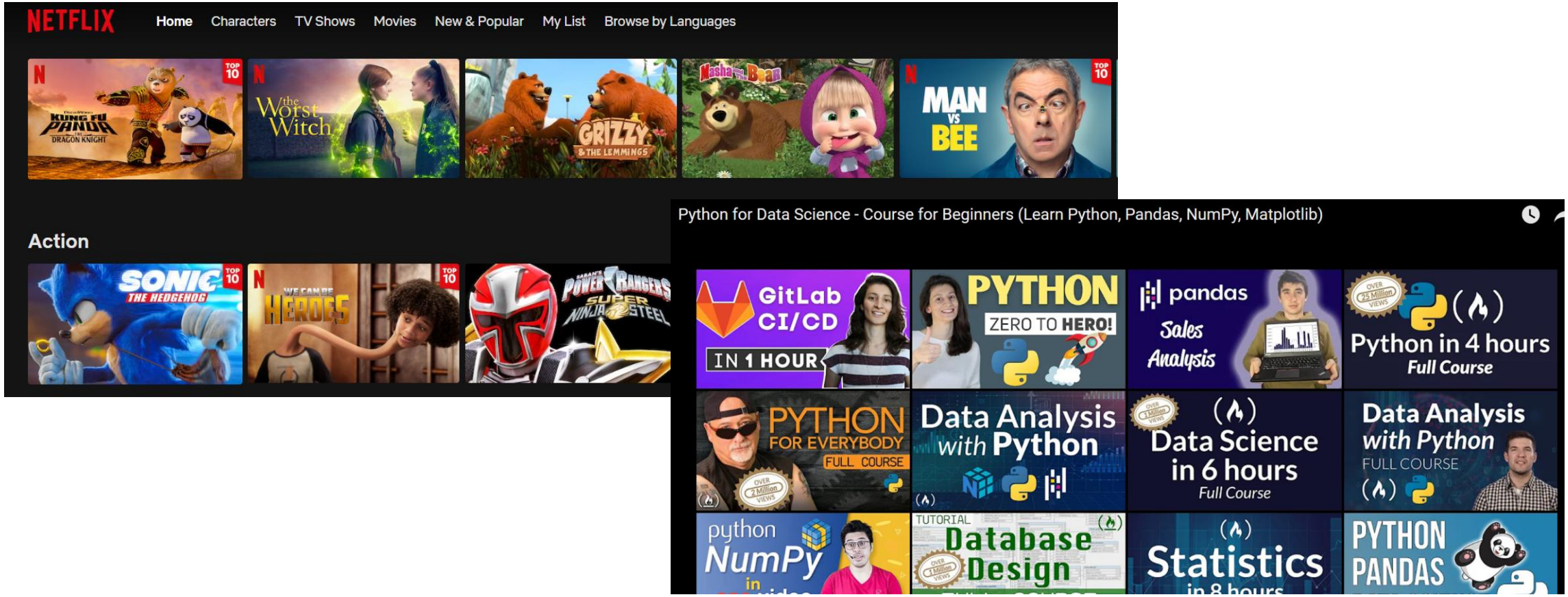
- Spam Filtering





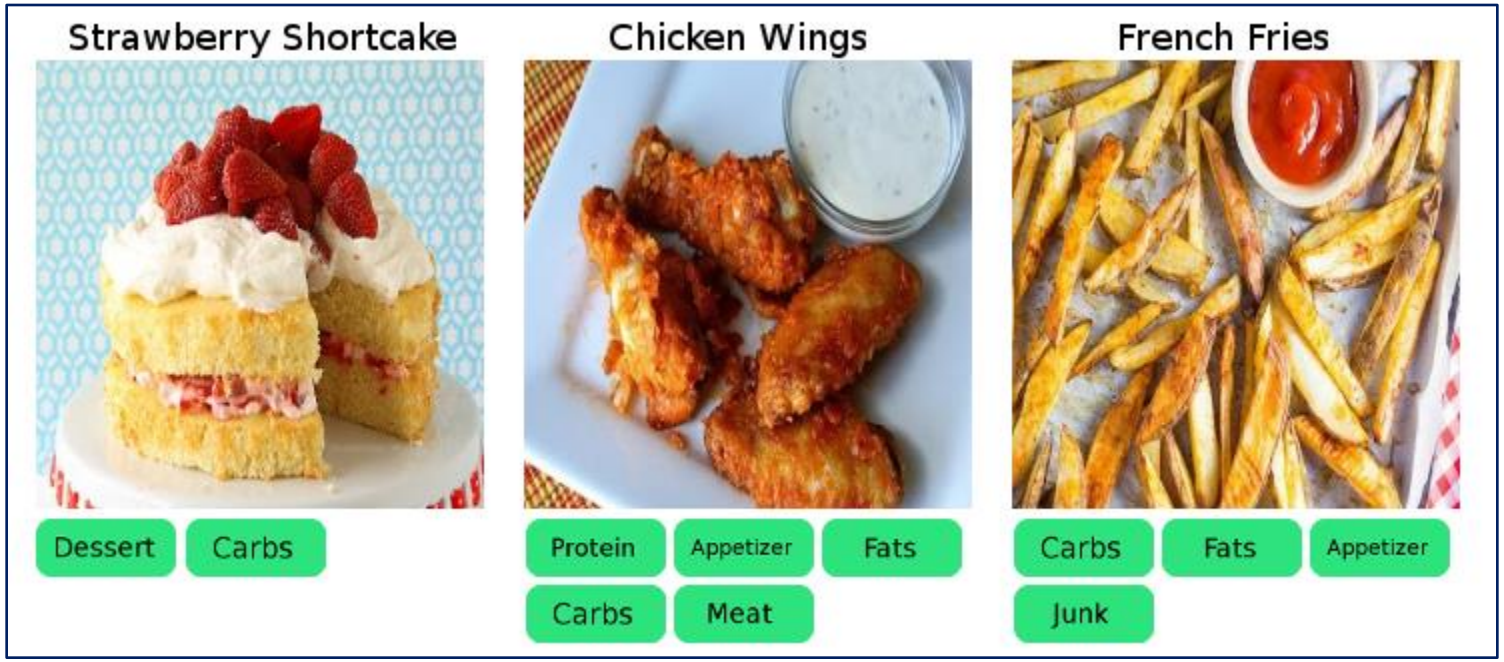
Applications of Machine Learning

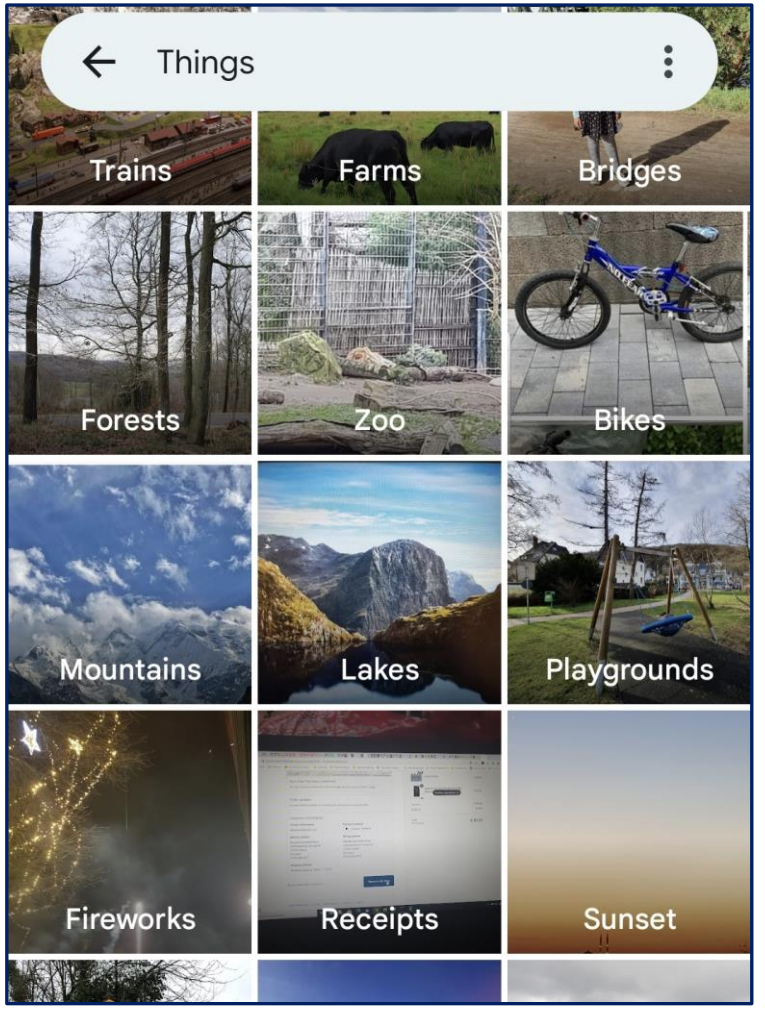
- Recommendation System



Applications of Machine Learning

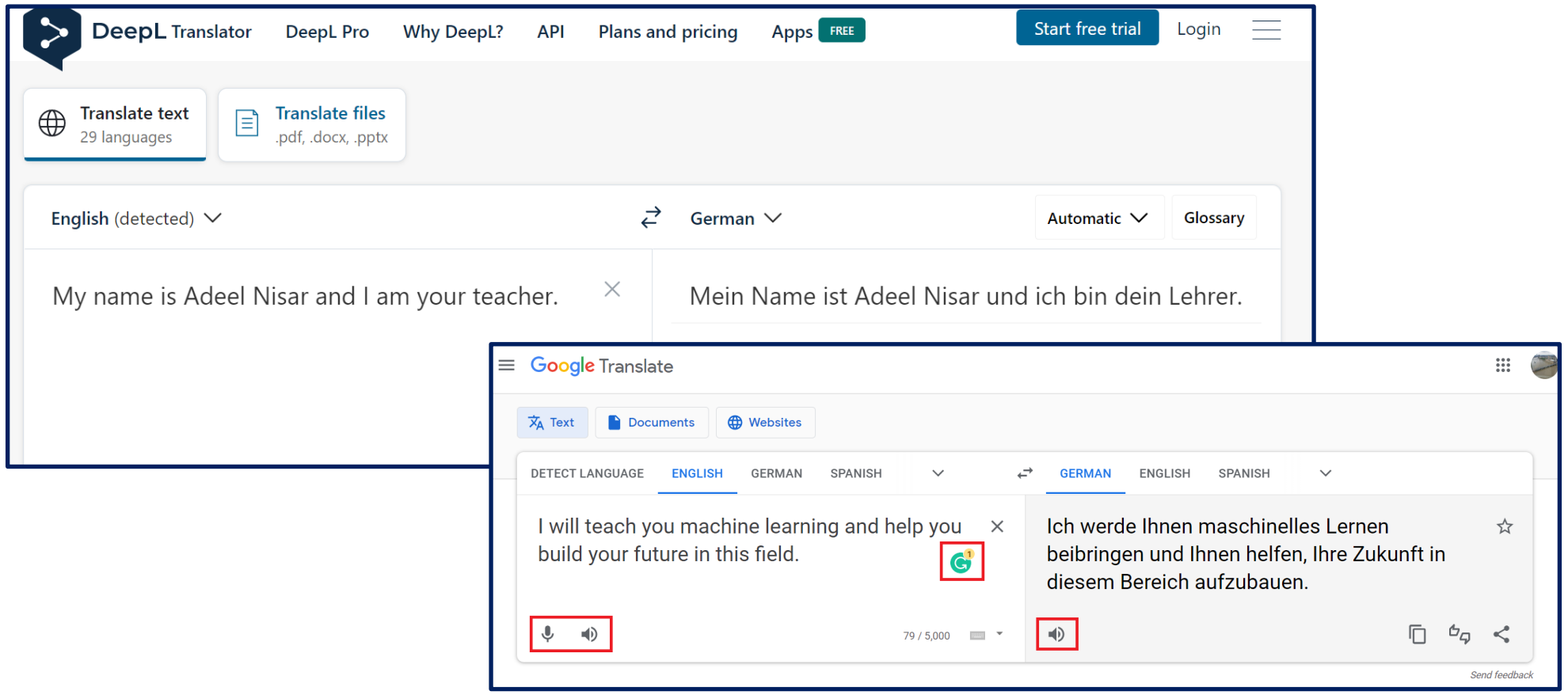
- Photo-tagging/Image Understanding





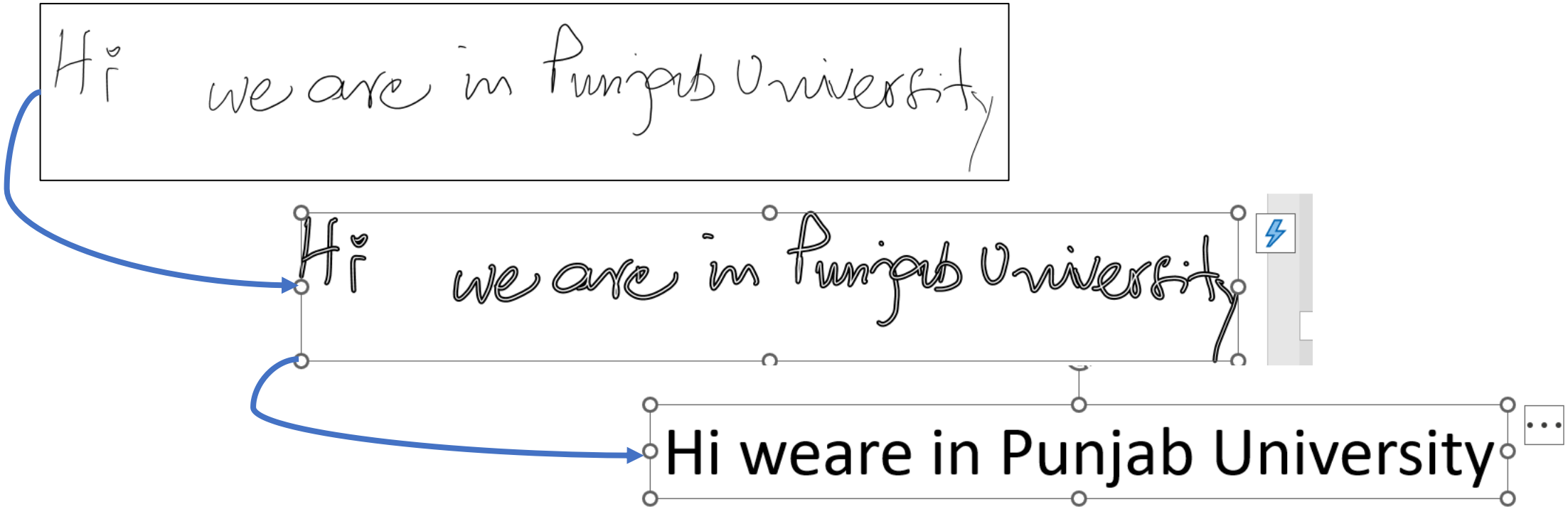
Applications of Machine Learning

- Translation / Text and Speech Recognition



Applications of Machine Learning

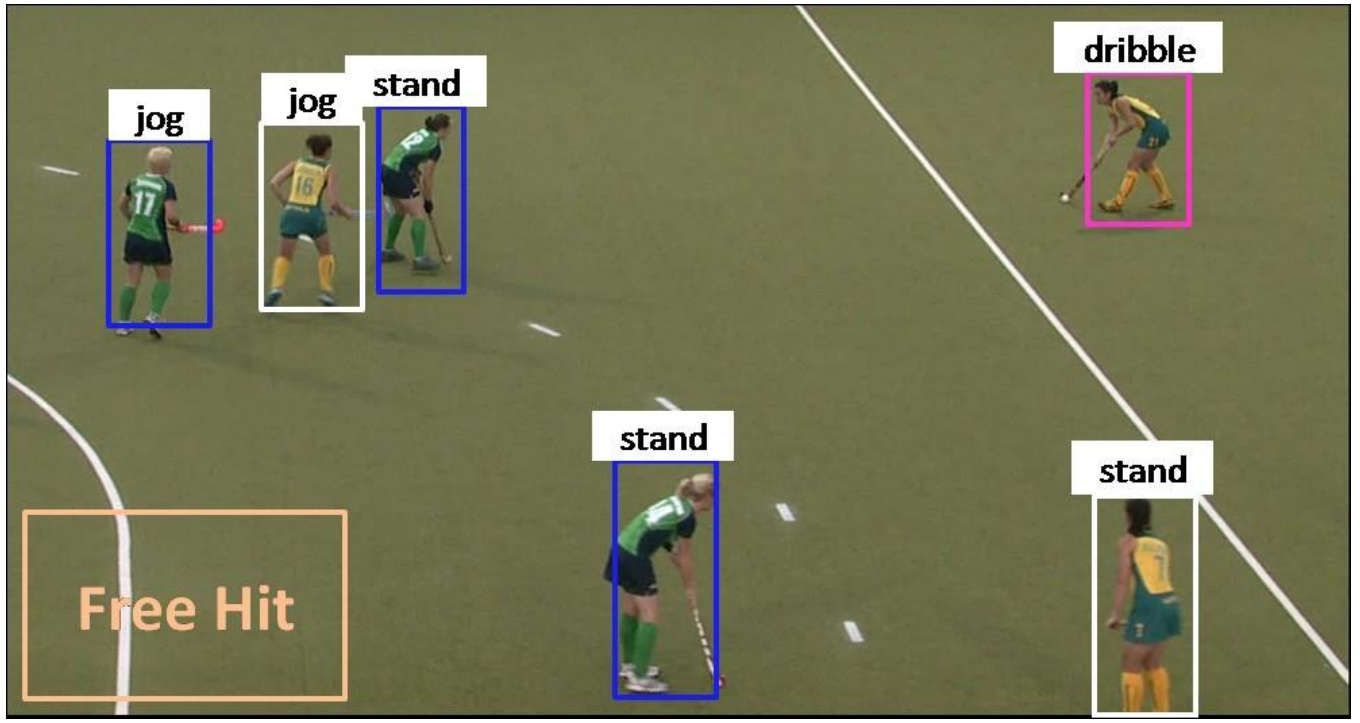
- Handwriting Recognition



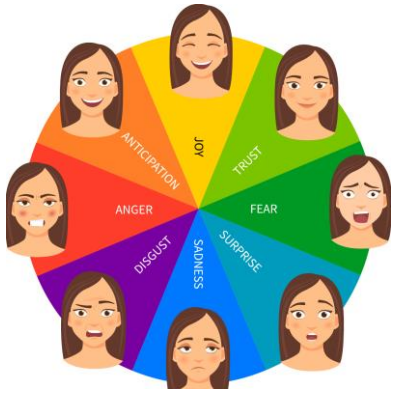
Applications of Machine Learning

Activity Recognition / Video Data Understanding

- Video Cameras



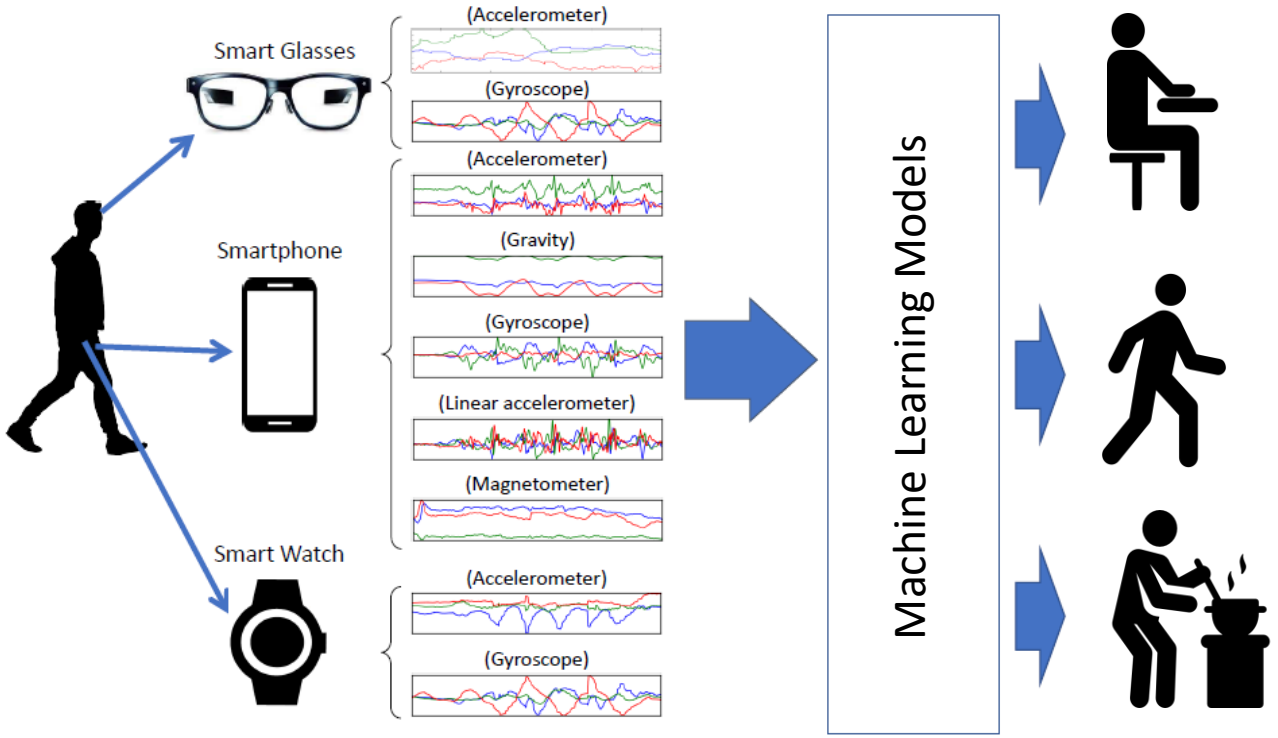
Applications of ML in Health Informatics



Applications of Machine Learning

Activity Recognition / Sensors Data Understanding

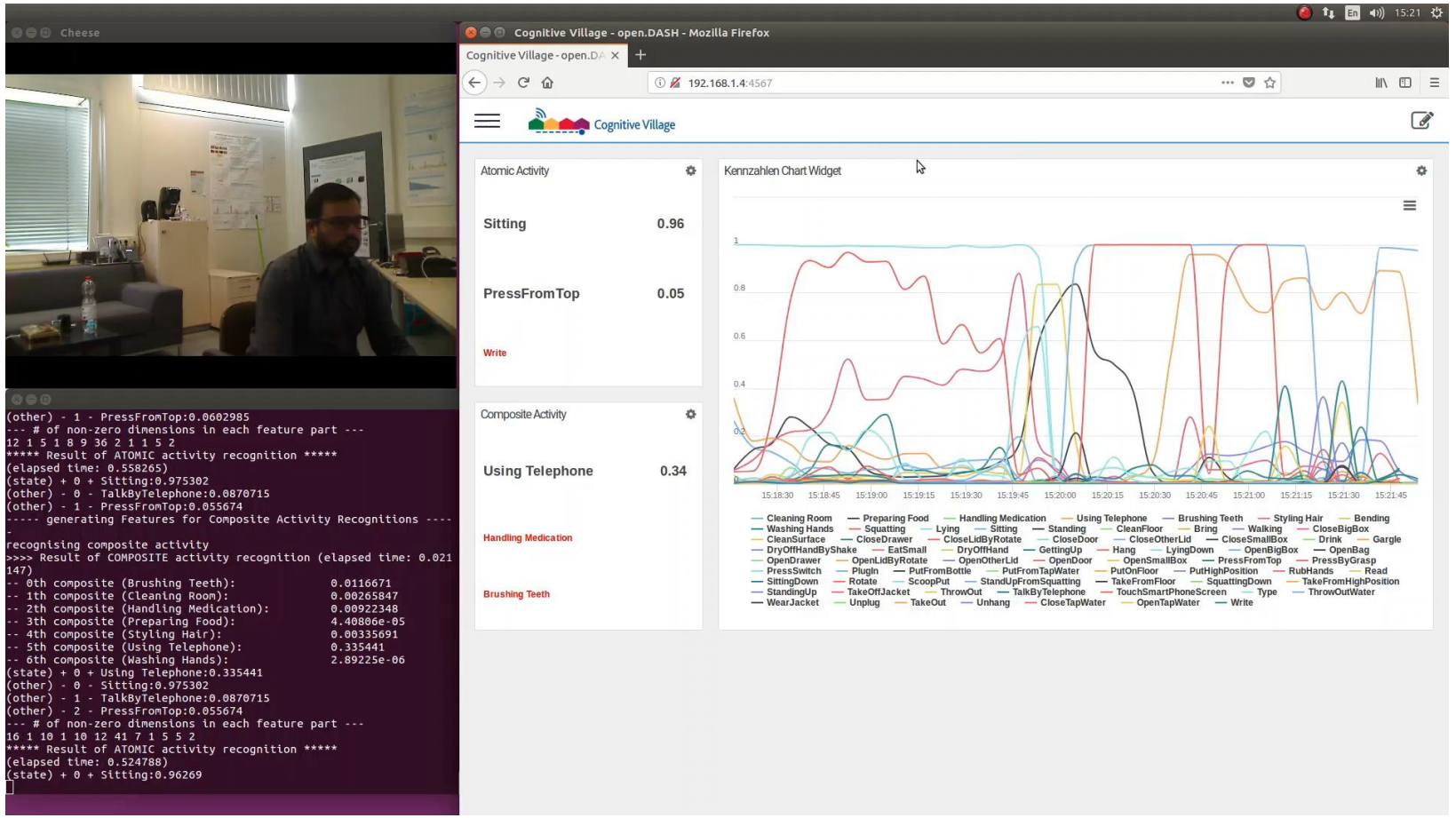
- Inertial Sensors



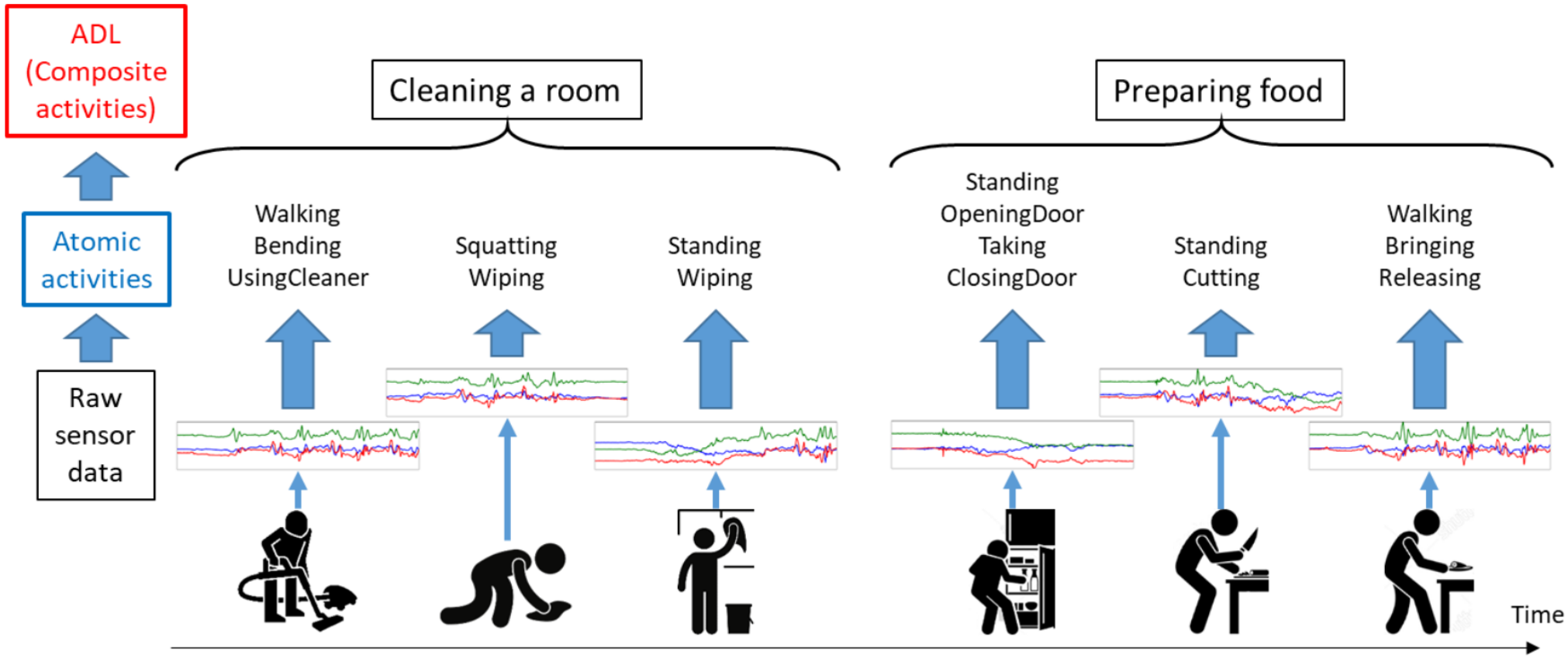
Applications of Machine Learning

Recognition of Daily Activities

https://youtu.be/s5wZP4ArZtU



Applications of Machine Learning

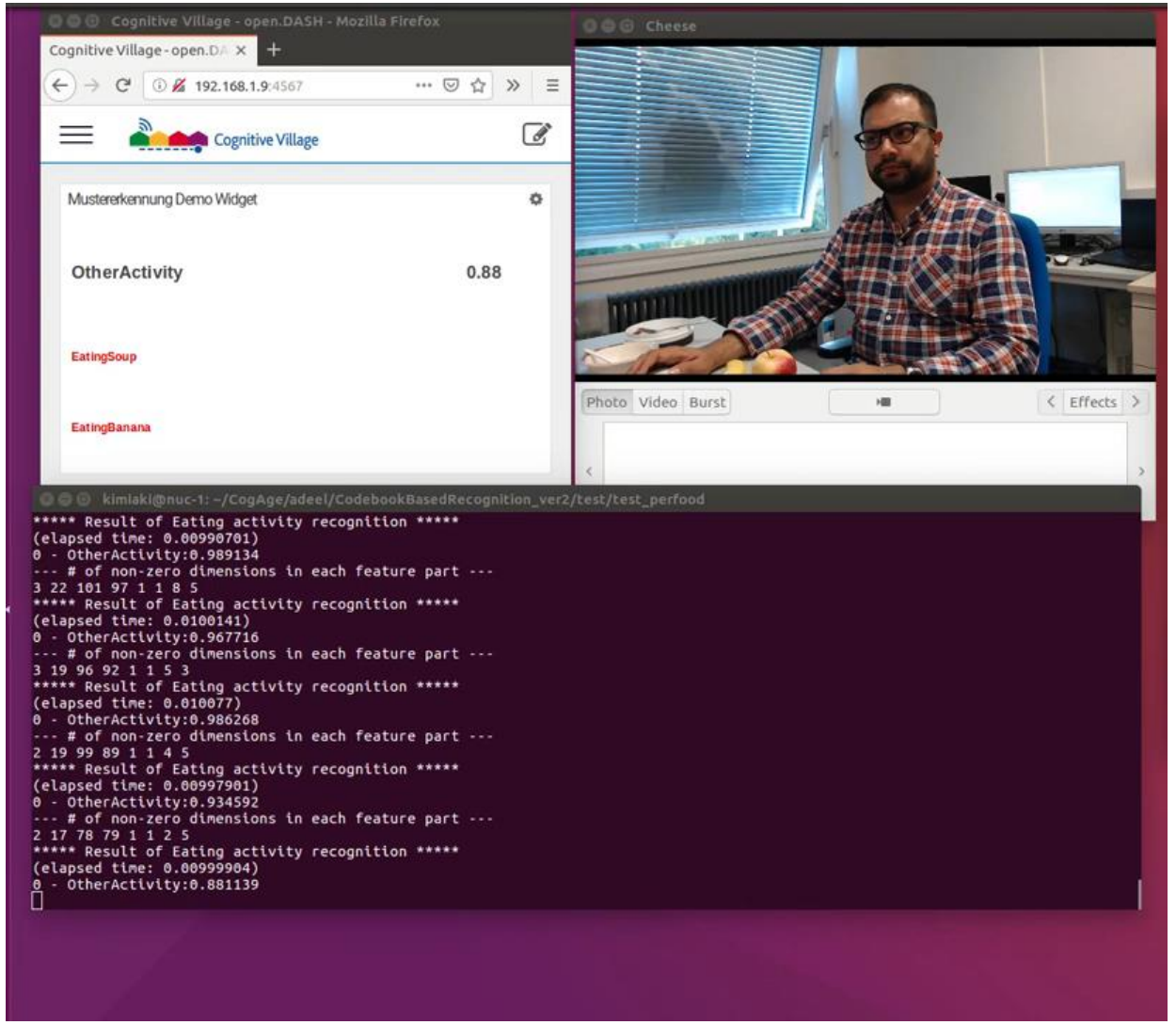


Recognition of Daily Activities

Applications of Machine Learning

Recognition of Eating Activities

https://youtu.be/J4QLzRRmCY8



Machine Learning Life-Cycle

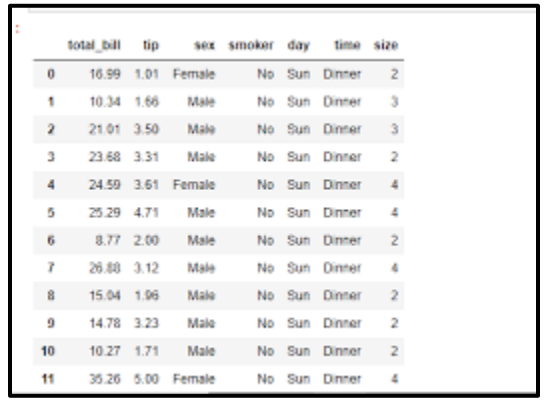
- Data Acquisition
- Data Preparation
- Feature Extraction
- Train Model
- Test Model
- Evaluate and Improve

Data Acquisition

- Types of data
  - Electronic Records/ Tabular data

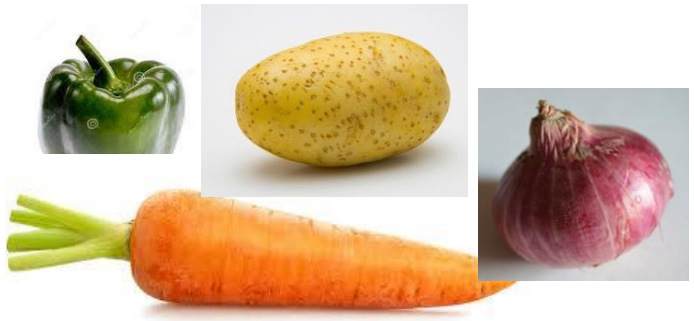
studies

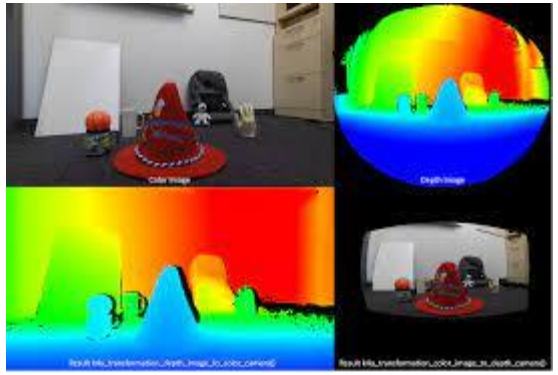
Data source	Sample size	References
Single psychiatric inpatient unit	728–2,010	82, 97
Specialized center/clinic	544–10,017	15, 40
Prison network	370,511	8
Single hospital	467–55,492	23, 47
Multiple hospitals	1,074–25,241	53, 105
Multiple primary care practices	7,925–345,143	44, 74
Health care system	2,537–919,873	25, 48
Consortium	8,709–233,844	28, 83
Centralized anonymized repository	923–5,244,402	39, 101



	total_bill	tip	sex	smoker	day	time	size
0	16.99	1.01	Female	No	Sun	Dinner	2
1	10.34	1.66	Male	No	Sun	Dinner	3
2	21.01	3.50	Male	No	Sun	Dinner	3
3	23.68	3.31	Male	No	Sun	Dinner	2
4	24.59	3.61	Female	No	Sun	Dinner	4
5	25.29	4.71	Male	No	Sun	Dinner	4
6	8.77	2.00	Male	No	Sun	Dinner	2
7	26.88	3.12	Male	No	Sun	Dinner	4
8	15.04	1.96	Male	No	Sun	Dinner	2
9	14.78	3.23	Male	No	Sun	Dinner	2
10	10.27	1.71	Male	No	Sun	Dinner	2
11	35.26	5.00	Female	No	Sun	Dinner	4

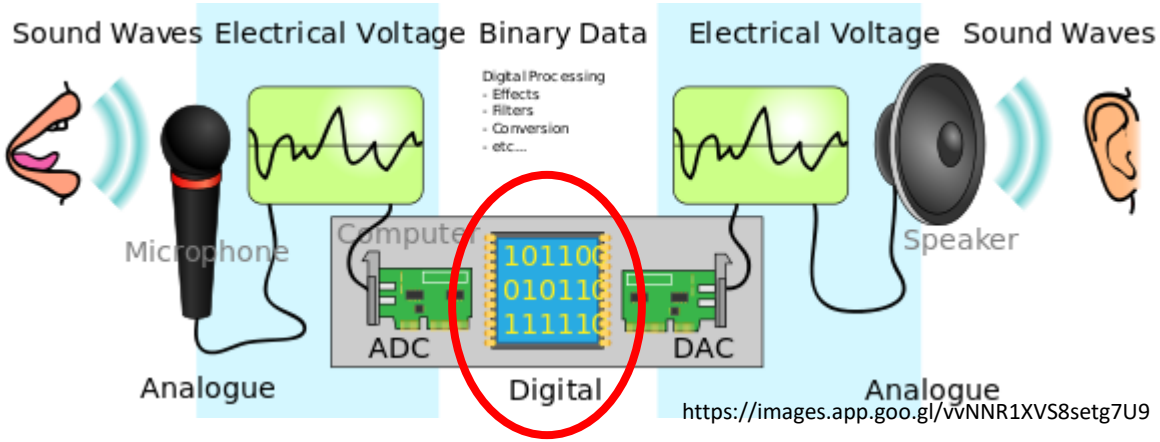
  - Images





Data Acquisition

- Types of data
  - Audio
  - Sensors Data



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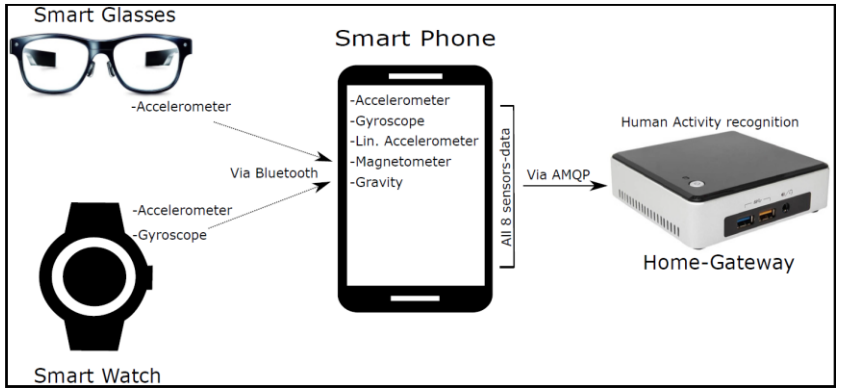
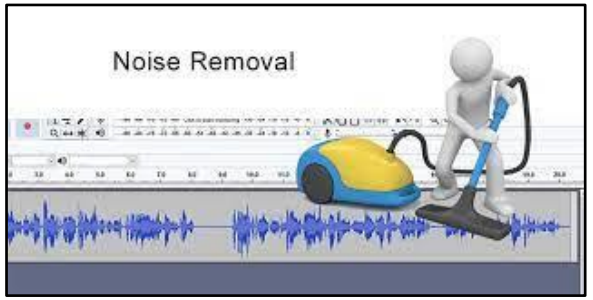


https://instock.pk/emotiv-epoc-14-channel-mobile-eeg.html

https://images.app.goo.gl/m5uUHz9keixcwV3u8

Data Preparation

- Noise Removal



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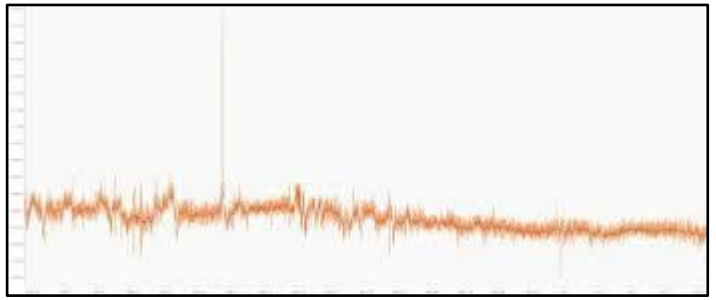


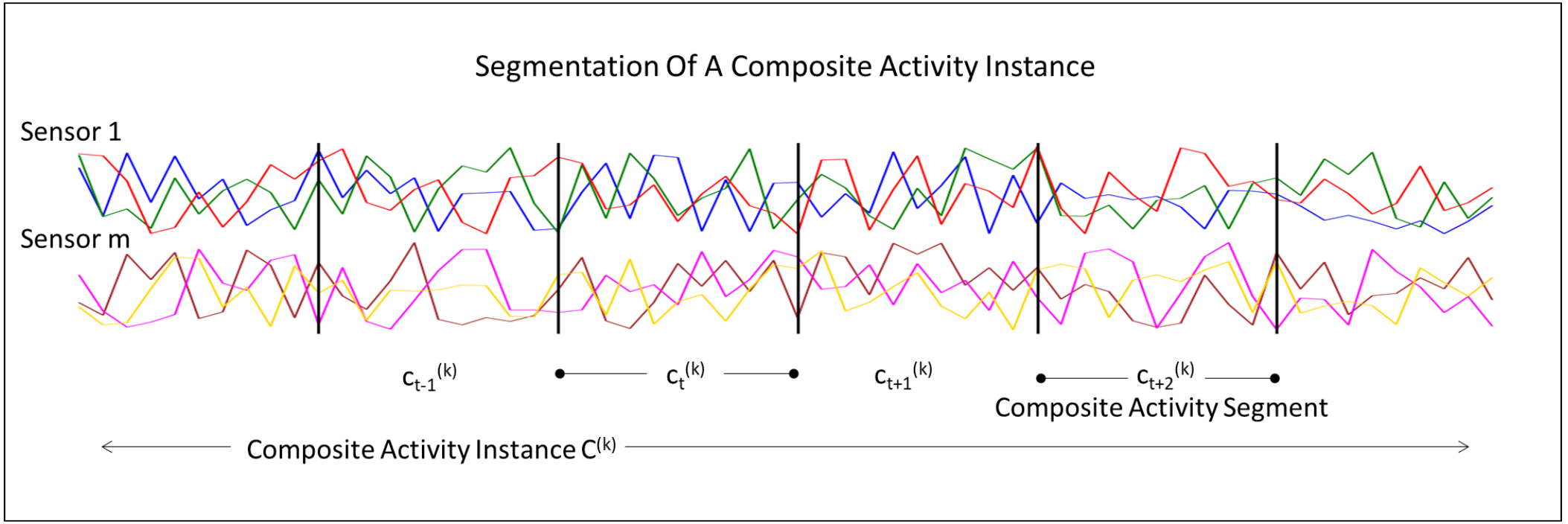
https://images.app.goo.gl/MtPN7BpxiHyYBj9T9

https://images.app.goo.gl/Ny4gD1d5cRFpGm1n7

- Python Libraries for noise removal
  - https://pypi.org/project/noisereduce/
  - https://scikit-image.org/docs/stable/auto_examples/filters/plot_denoise.html

Data Preparation

- Segmentation



Sensor-Based Human Activity Recognition for Assistive Health Technologies by Dr. Muhammad Adeel Nisar, Logos Verlag Berlin GmbH, 2023

Types of Machine Learning

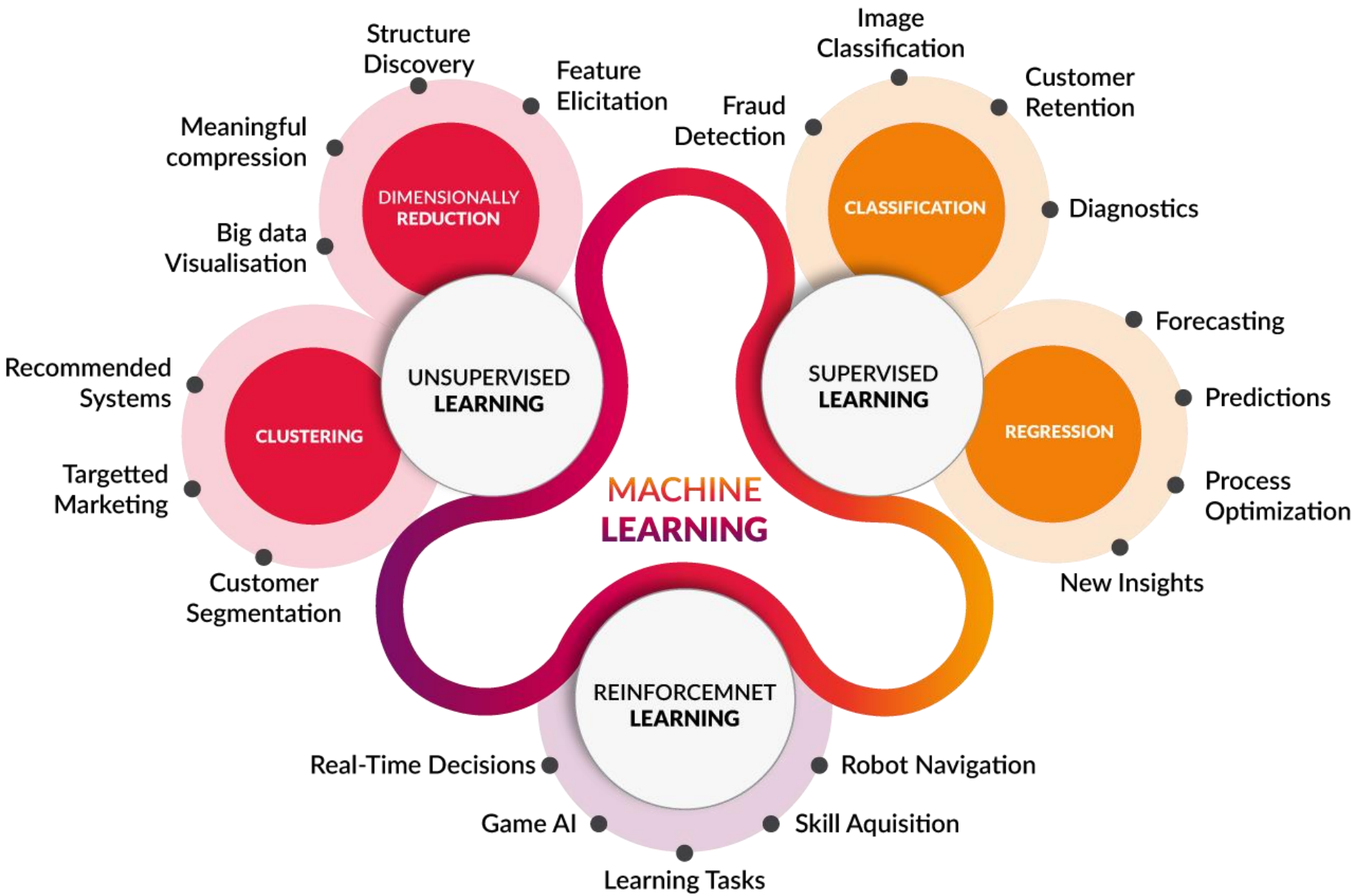
- **Supervised Machine Learning** assumes that a set of labelled training data is available and the classifier is designed by exploiting this a-priori known information.
- Two further types
  - Regression
    - Linear Regression
    - Nonlinear Regression
  - Classification
    - Logistic Regression
    - Naïve Bayes
    - Support Vector Machines etc

Types of Machine Learning

- **Unsupervised Machine Learning** clusters unlabeled training data described by feature vectors into similar groups
  - Clustering
    - K-Means Clustering
  - Dimensionality Reduction
    - Principal Component Analysis
    - Autoencoders

Types of Machine Learning

- In **Semi-supervised Machine Learning** the dataset contains both labeled and unlabeled examples. Usually, the quantity of unlabeled examples is much higher than the number of labeled examples. The goal of a semi-supervised learning algorithm is the same as the goal of the supervised learning algorithm.
- **Reinforcement Learning** solves a particular kind of problems where decision making is sequential, and the goal is long-term, such as game playing, robotics, resource management, or logistics.


MACHINE LEARNING
UNSUPERVISED LEARNING
SUPERVISED LEARNING
REINFORCEMNET LEARNING
DIMENSIONALLY REDUCTION
CLUSTERING
CLASSIFICATION
REGRESSION
Structure Discovery
Feature Elicitation
Meaningful compression
Big data Visualisation
Recommended Systems
Targetted Marketing
Customer Segmentation
Image Classification
Customer Retention
Fraud Detection
Diagnostics
Forecasting
Predictions
Process Optimization
New Insights
Real-Time Decisions
Robot Navigation
Game AI
Skill Aquisition
Learning Tasks

Homework

- Python Programming
  - (Input/Output, Processing, Selection, Repetition, Functions)
    - Book A1: Chapter 2 to 5
    - Book A2: Chapter 2 to 5
- Machine Learning
  - Resource R1
  - Book B1: 1.1, 1.2