Exploring Unsupervised Learning & ANN: Techniques and Practical

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Community Researcher of RL & LLM
Cohere for AI

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About Me

Gusti Triandi Winata

Latest Work Experiences:

- Researcher, Cohere for AI **2024 - present**
- MLE Consultant, Freeport Indonesia **2023 - 2024**
- Mid. MLE, eFishery **2022 - 2023**
- OSS Fellowship with Adobe, Major League Hacking **2021**

Education:

- Bandung Institute of Technology Graduated at **2021**
  Bachelor of Electrical and Computer Engineering
  Was a Bangkit Graduate of the first batch (2020)!

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Ground Rules

Observe the following rules to ensure a supportive, inclusive, and engaging classes

Give full attention in class

Mute your microphone when you're not talking

Keep your camera on

Turn on the CC Feature on Meet

Use raise hand or chat to ask questions

Make this room a safe place to learn and share

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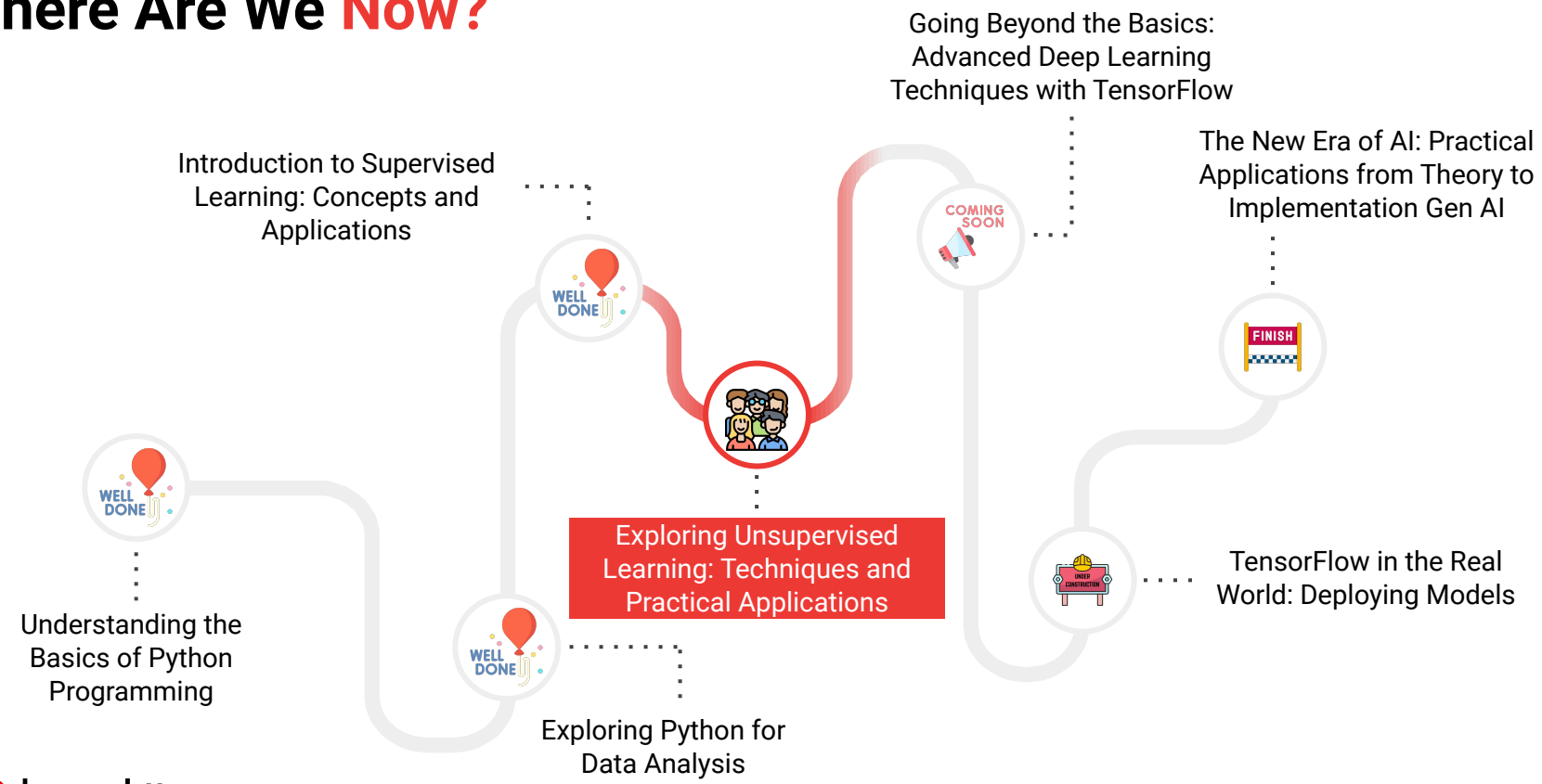
Where Are We Now?



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Learning Objectives

1. Explain basic concepts in Unsupervised Learning
2. Demonstrate how a clustering algorithm works
3. Demonstrate how recommendation system works
4. Elaborate basic concepts in ANN

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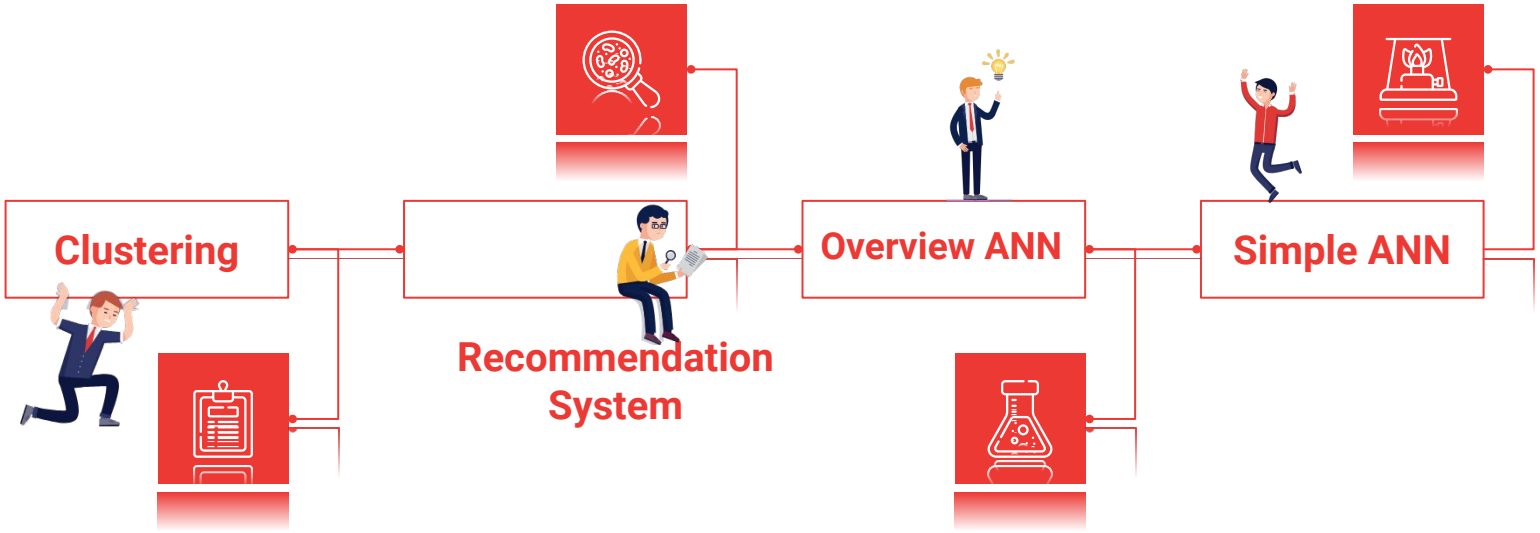
Today's Agenda



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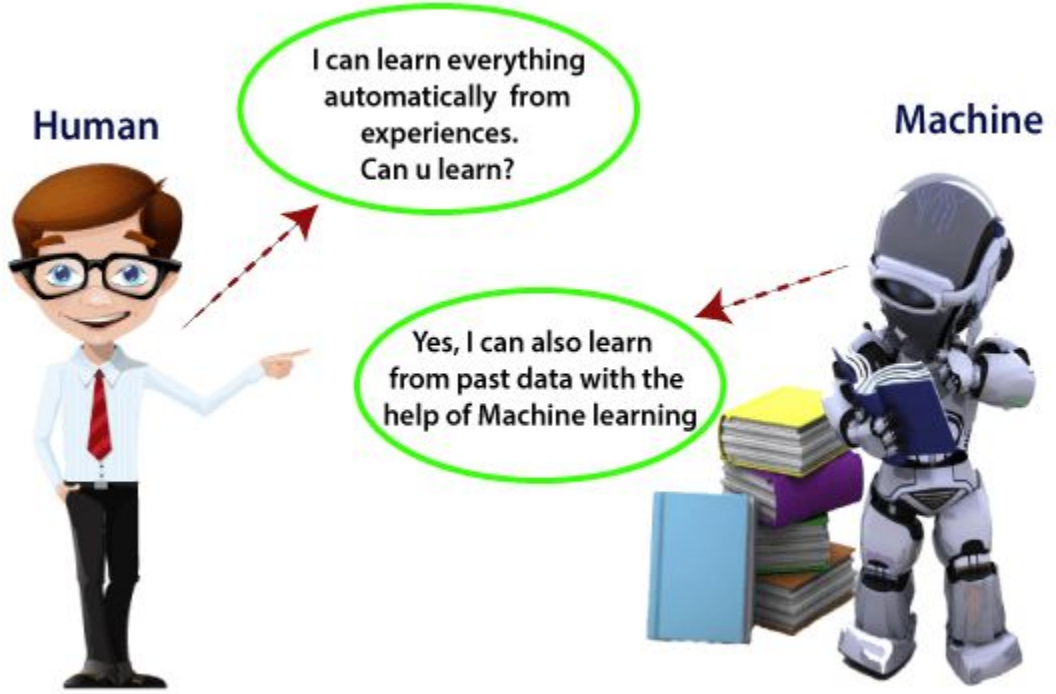
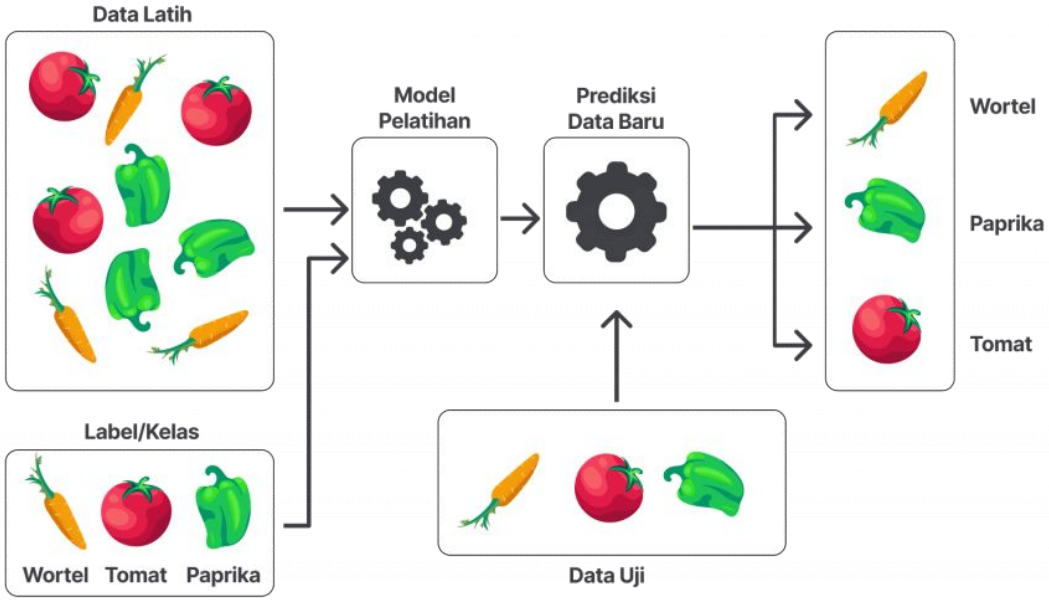
Flashback to Machine Learning



Flashback to Supervised Learning



Flashback to Supervised Learning

Unsupervised Learning in Real Life

An Expedition Into Unsupervised Learning

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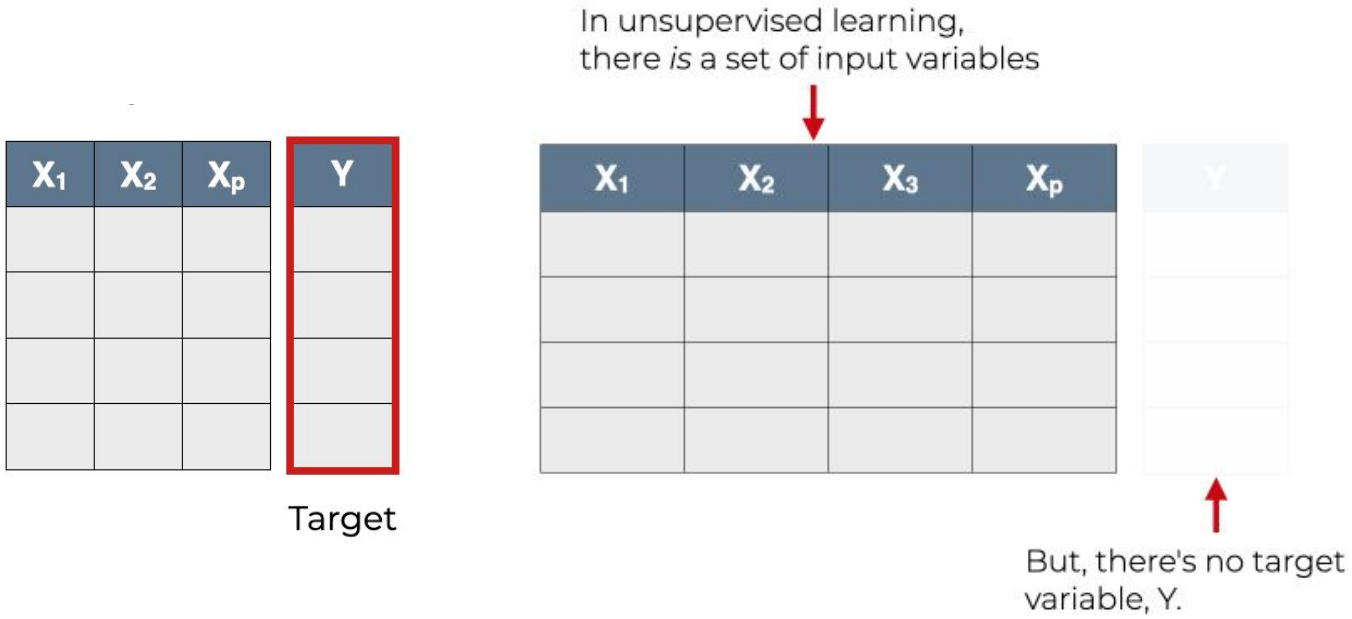
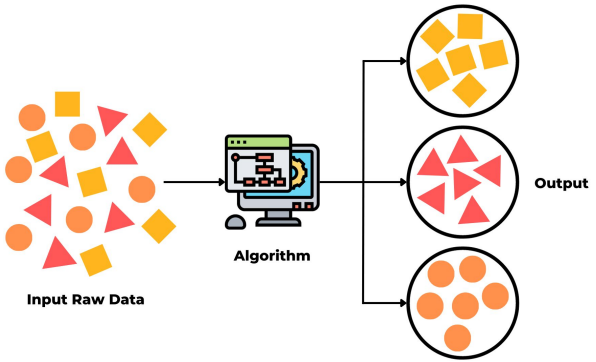
Data
Unsupervised Learning
Meaningful patterns

Supervised & Unsupervised Learning

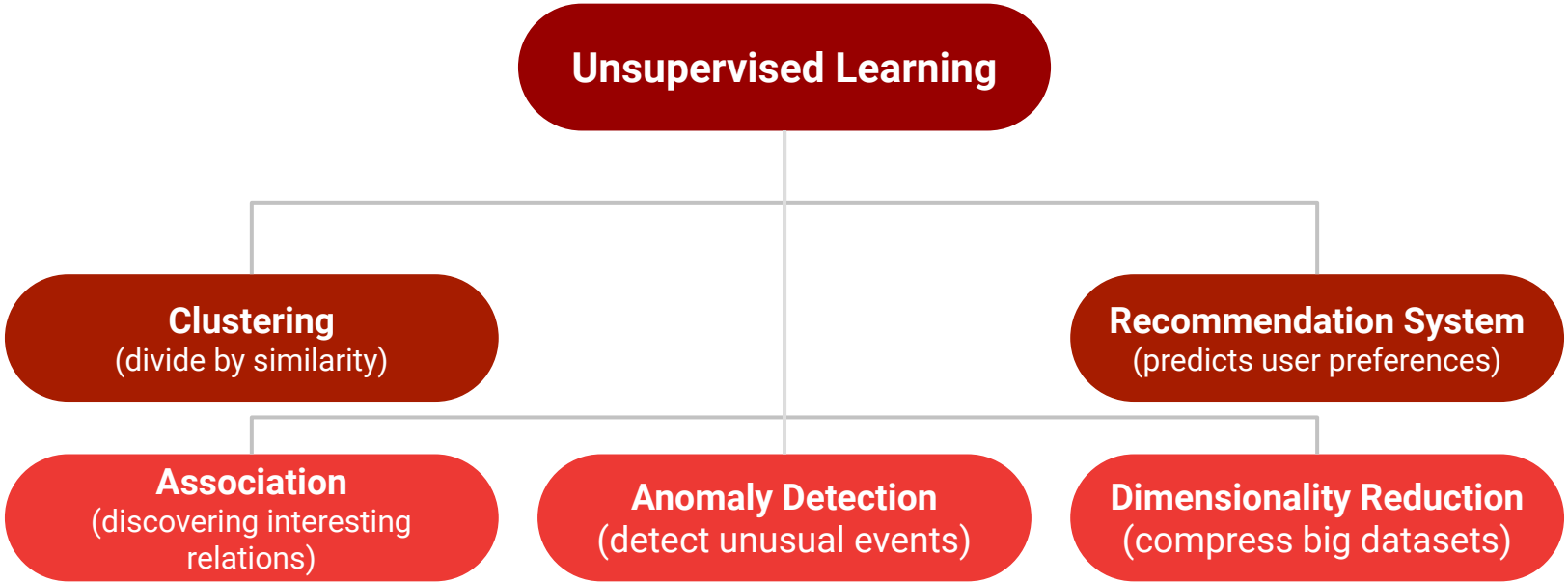


What is Unsupervised Learning?

- Unsupervised learning refers to algorithms that find **meaningful patterns** from **unlabeled data** or **not contain any correct answers**.
- The model will use meaningful patterns to to do specific tasks like **clustering, Anomaly detection, ect**.



Type of Unsupervised Learning



Initiating The Clustering Algorithm Expedition

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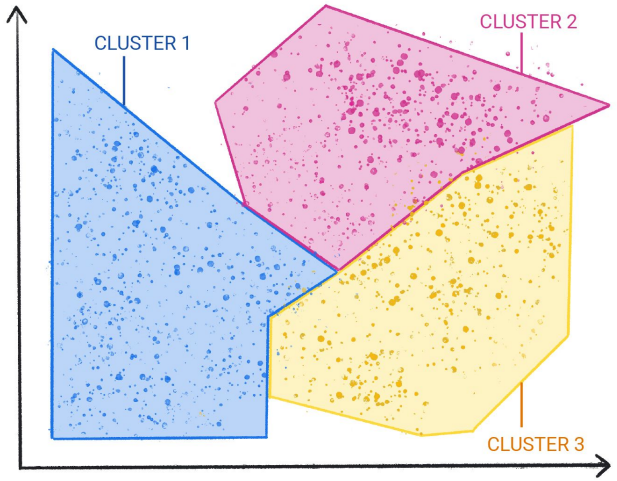
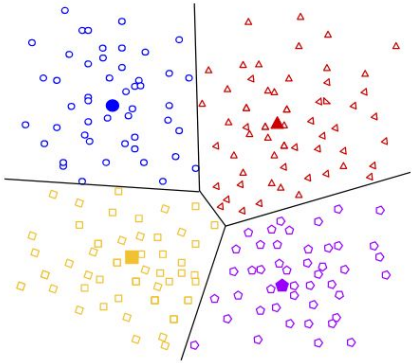
Clustering Algorithm

Grouping **unlabeled examples** into **clusters based on meaningful patterns** is called clustering.

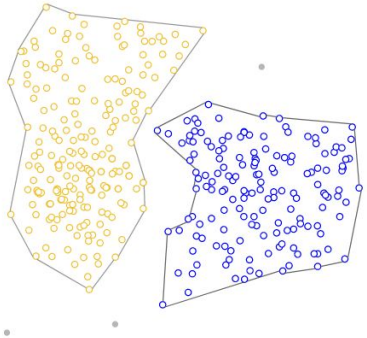
- Market segmentation
- Social network analysis
- Grouping similar news



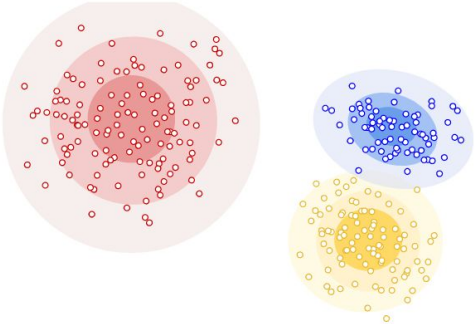
Type of Clustering Algorithm



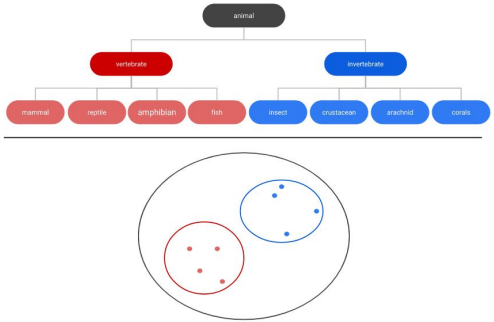
Centroid-based
Clustering



Density-based
Clustering



Distribution-based
Clustering

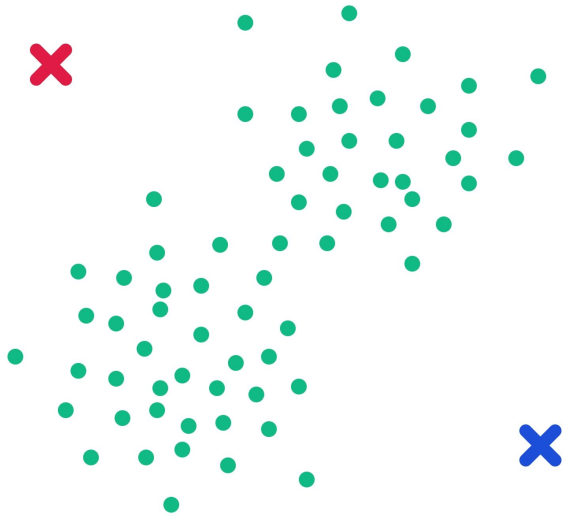


Hierarchical
Clustering

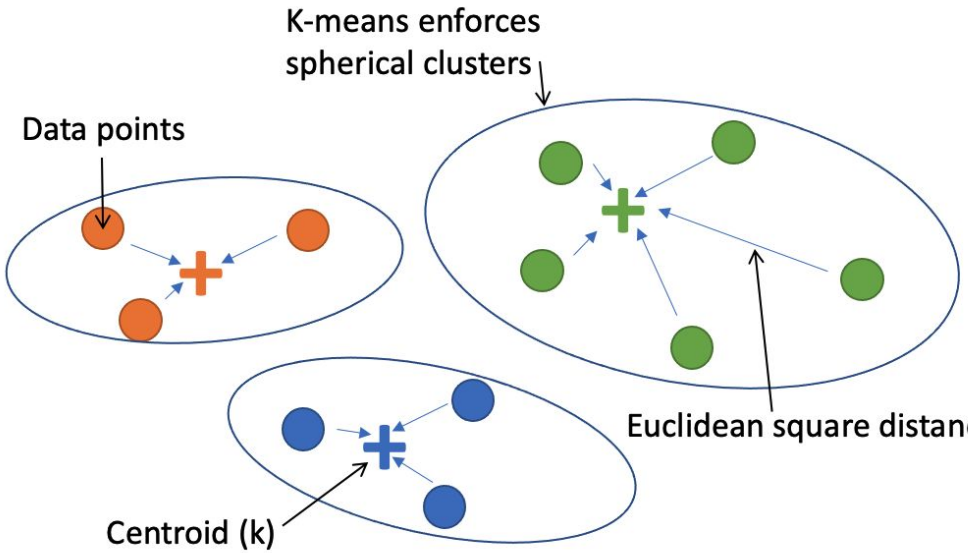
https://developers.google.com/machine-learning/clustering/clustering-algorithms

K-means Algorithm

- Randomly chooses **K cluster centroid**.
- Assigns each point to the **closest centroid** to get K initial clusters.
- For every cluster, **recomputes the centroid** by taking **the average (mean)** of all points in the cluster.
- **Repeats the calculation** of centroids and assignment of points **until the centroid points stop changing**.



Cost Function in K-means Algorithm



This function computes the **average of the squared distances** between each data point and the centroid of the cluster it belongs to.

$$J(c, \mu) = \frac{1}{m} \sum_{i=1}^{m} ||x^{(i)} - \mu_{c^{(i)}}||^2$$

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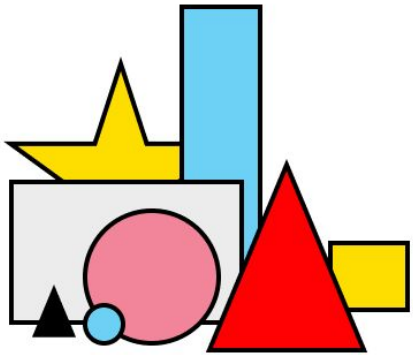
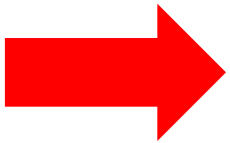
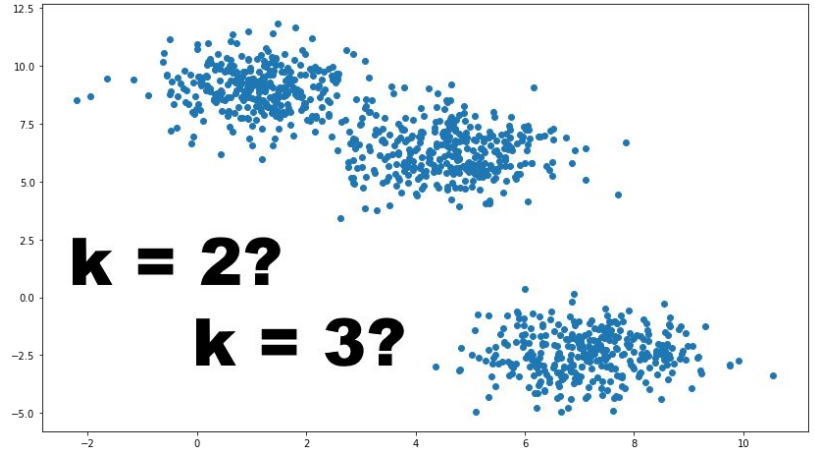
Clustering Algorithm



INPUT





How to Define K?

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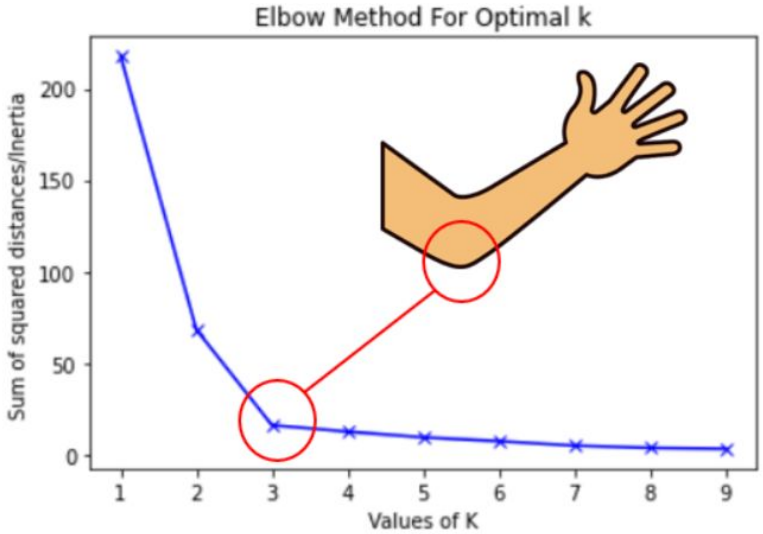
How to Choose the Number of Clusters

- **Inertia** is calculated by summing the squared distances.
- The **Elbow Method** is one of the most popular methods to **determine this optimal value of k**.
- In this method, we chose the value of k for which there is a **sharp and steep fall** of the inertia.



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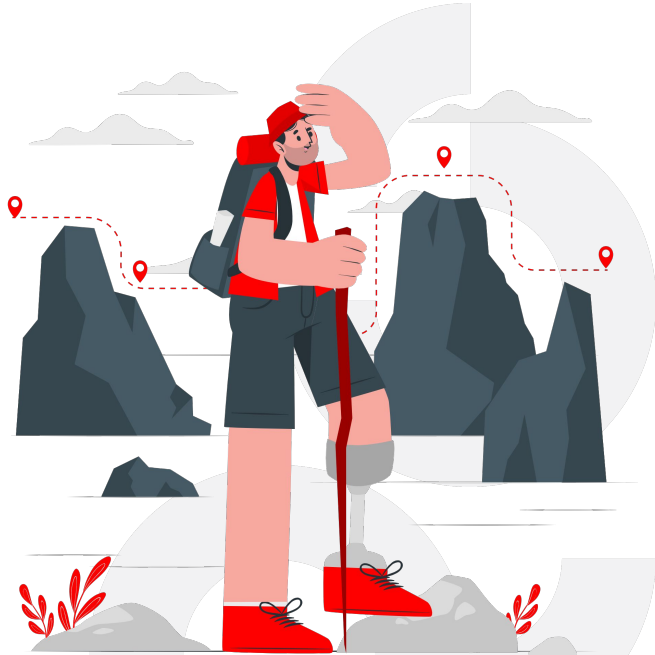
Additional reading: silhouette method

Clustering Lab

A Journey through Recommendation Systems



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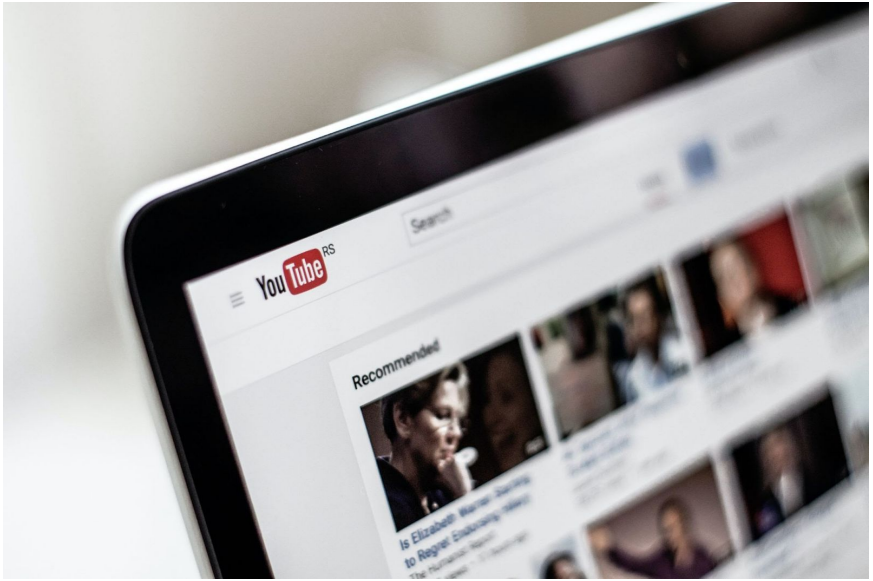
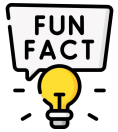
Recommendation System

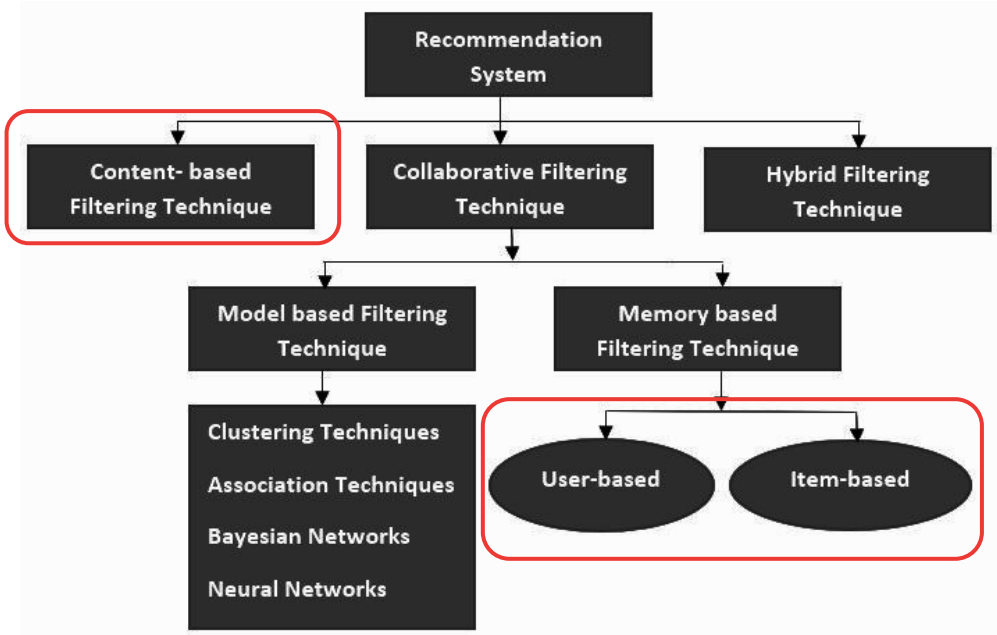
- A recommendation system predicts **ratings** or **preferences** a user might give to a product.
- Often these are sorted and presented as “**top-N**" recommendations.



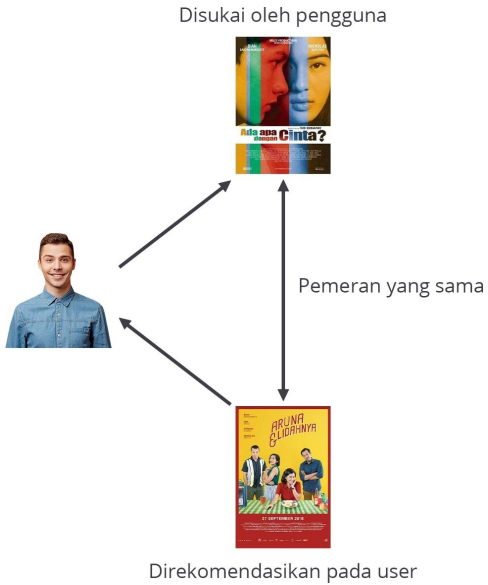
Recommendation System



In the context of machine learning, the development of a recommendation system can involve both supervised learning and/or unsupervised learning.



Type of Recommendation System



Content-Based Filtering

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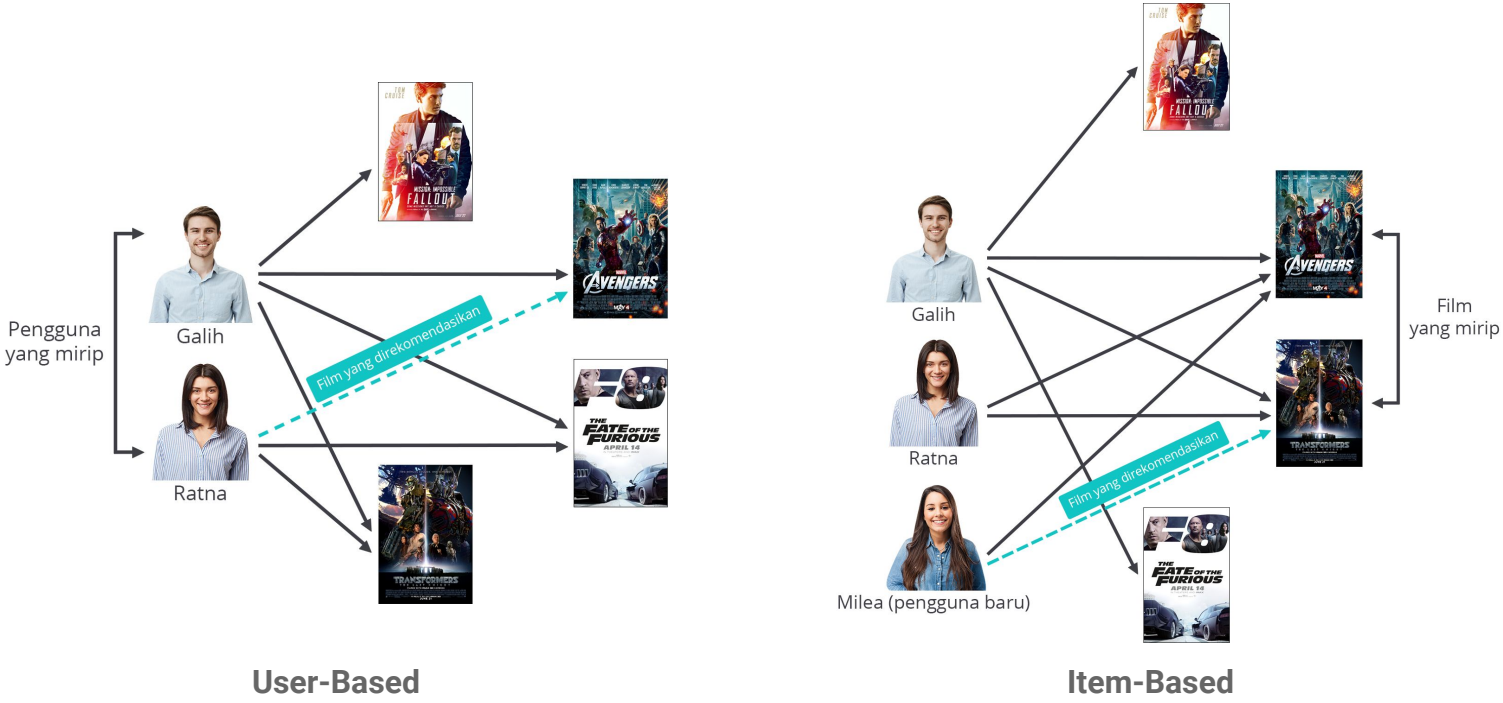
Type of Recommendation System



User-Based

Item-Based

Collaborative Filtering

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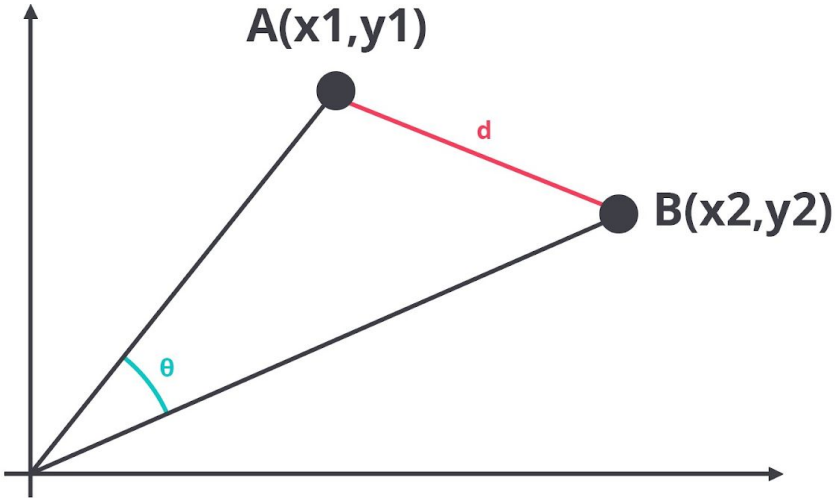
How to Calculate Similarity?



$$cos(\theta) = \frac{\vec{A}.\vec{B}}{\|\vec{A}\|\|\vec{B}\|} = \frac{\sum_{i=1}^{n} x_i y_i}{\sqrt{\sum_{i=1}^{n} x_i^2}\sqrt{\sum_{i=1}^{n} y_i^2}}$$

Cosine similarity

$$d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$$

Euclidean distance

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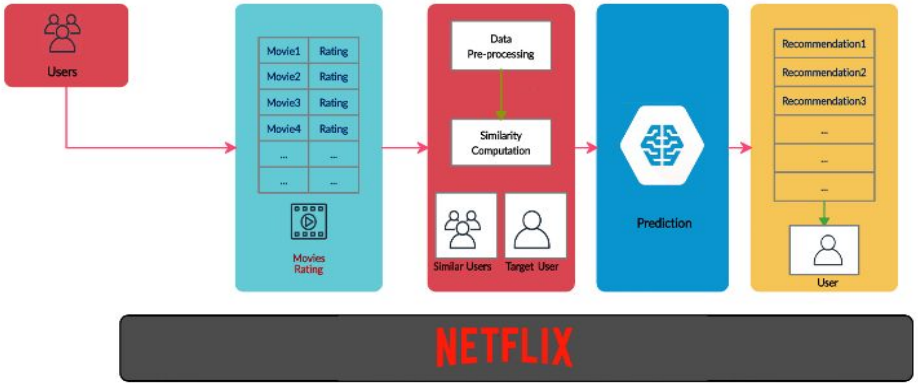
Additional reading

Implementation of Recommendation System



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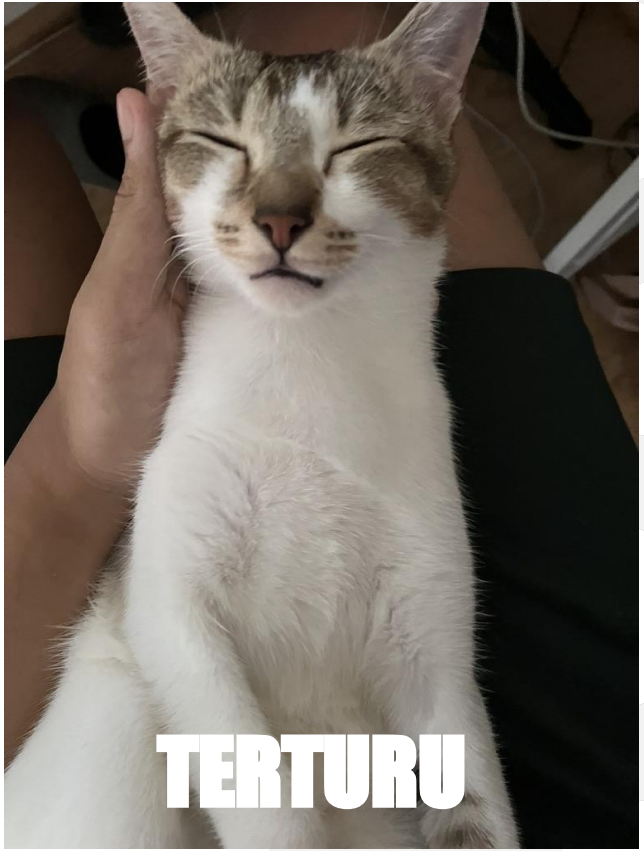
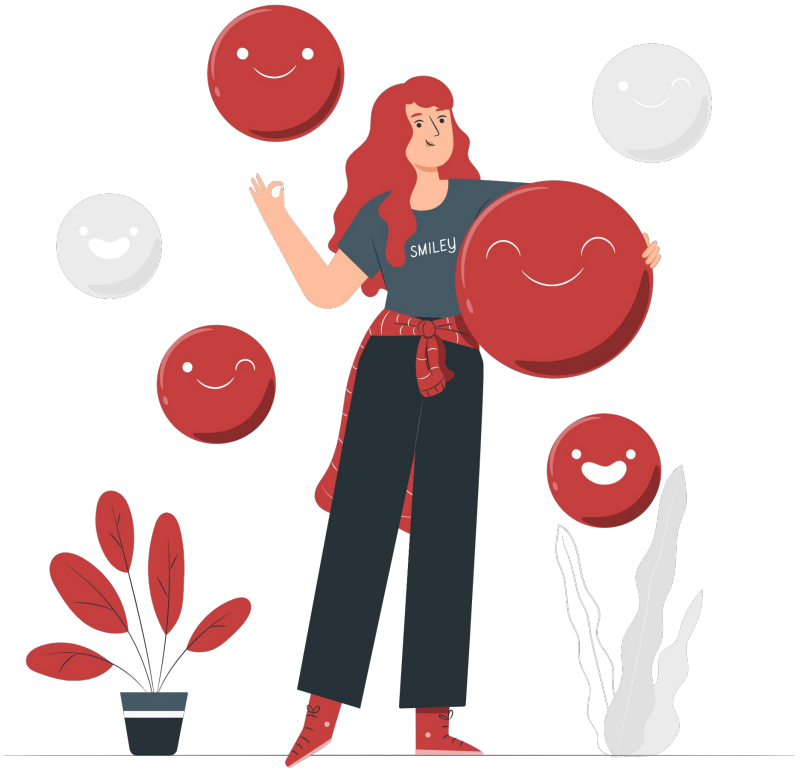
Applied Recommendation Techniques

Break Time!



How would you show what you have learned so far in **one emoji?**



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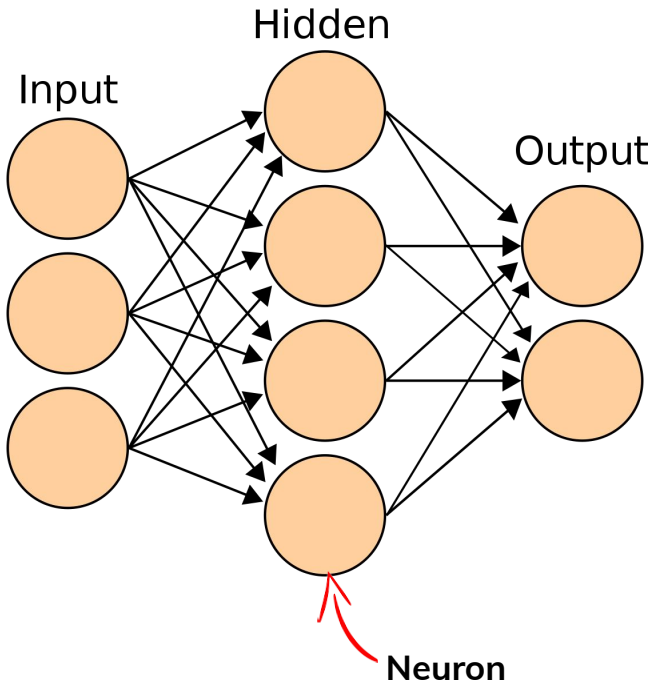
The Curse of the Silent Granny

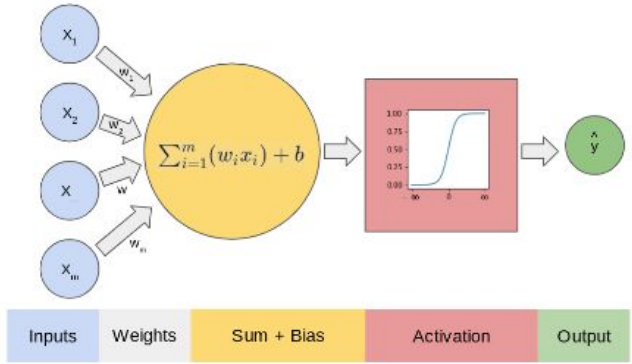
Initiating the Exploration of ANN

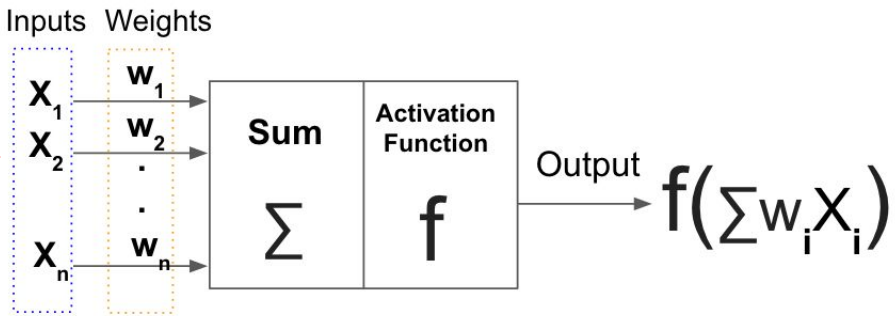
What is Artificial Neural Network?

Artificial neural networks (ANN) are **computational networks** inspired by the functioning of the human brain that can **extract patterns** from data to make a prediction.



How Neural Network Works?





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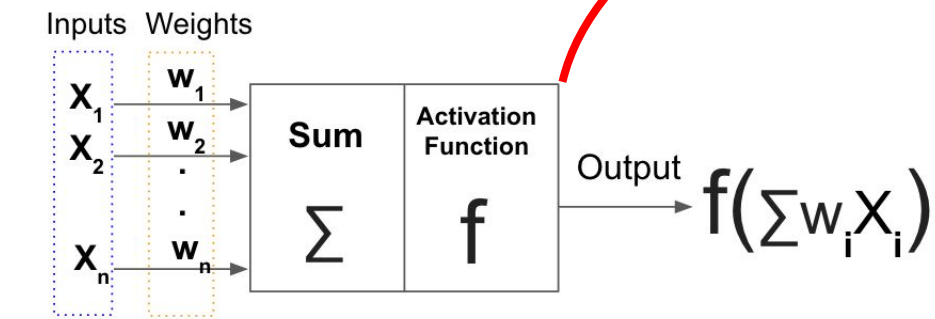
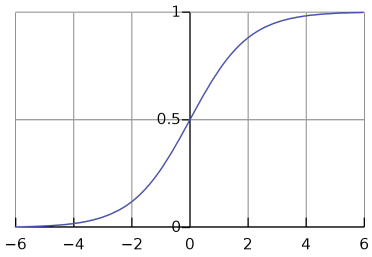
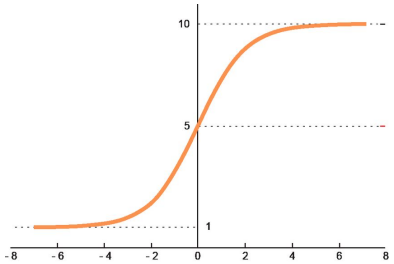
How Neural Network Works?



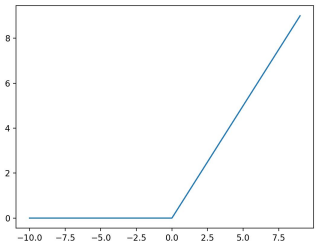
Sigmoid



Softmax



ReLu



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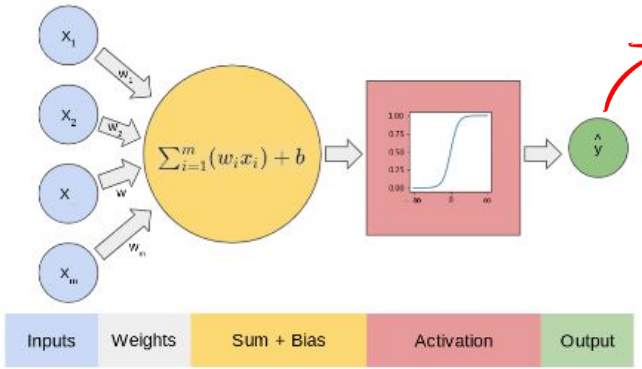
How Neural Network Works?



Evaluate the prediction

$$L(\hat{y}^{(i)}, y^{(i)}) = -y^{(i)} log(\hat{y}^{(i)}) - (1 - y^{(i)}) log(1 - \hat{y}^{(i)})$$

$$J(w, b) = -\frac{1}{m} \sum_{i=1}^{m} L(\hat{y}^{(i)}, y^{(i)})$$

Optimize w & b

$$w_{new} = w - \alpha \frac{\partial}{\partial w} J(w, b)$$

$$b_{new} = b - \alpha \frac{\partial}{\partial b} J(w, b)$$

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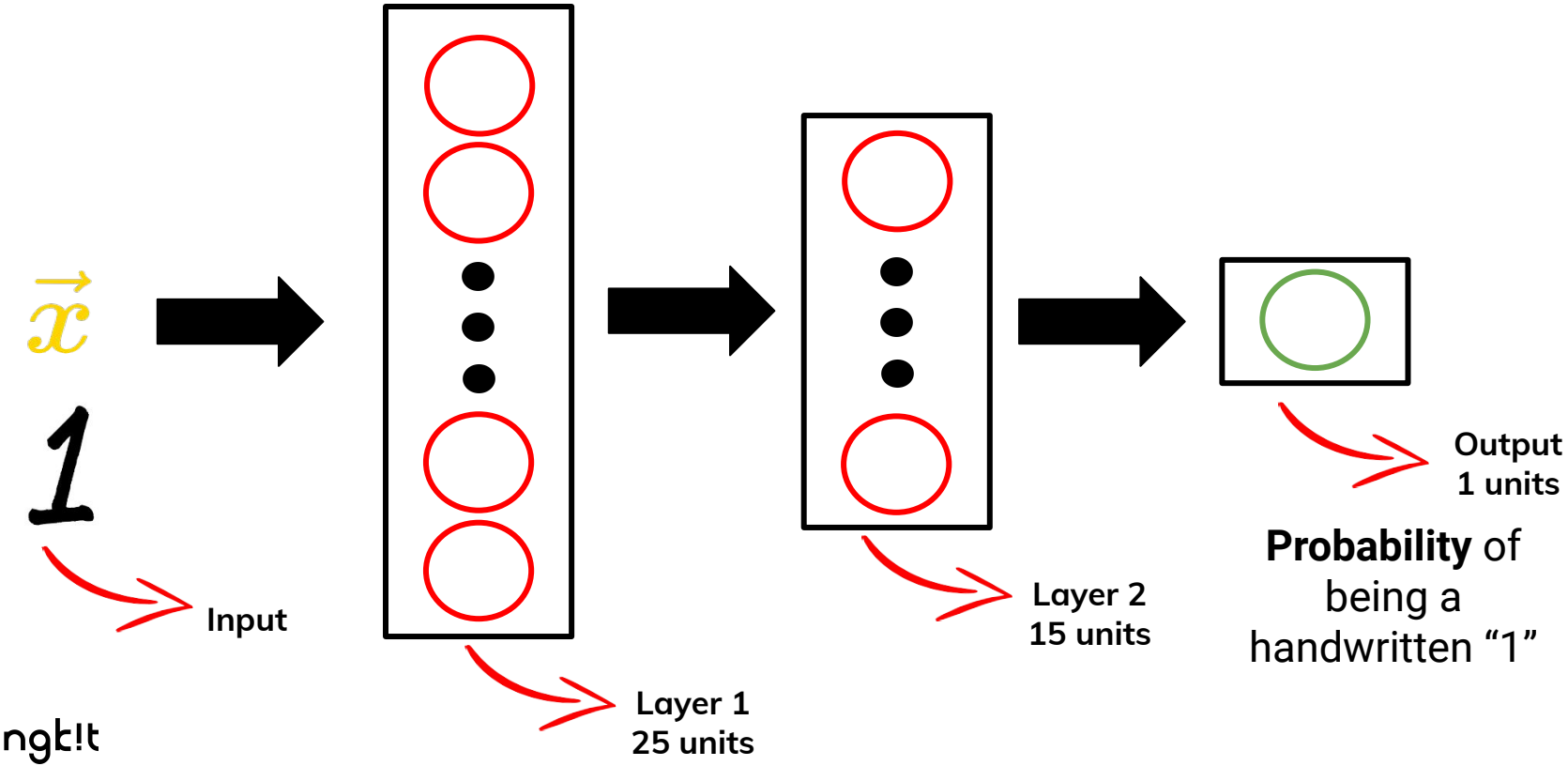
Typical ANN Model in Real Life



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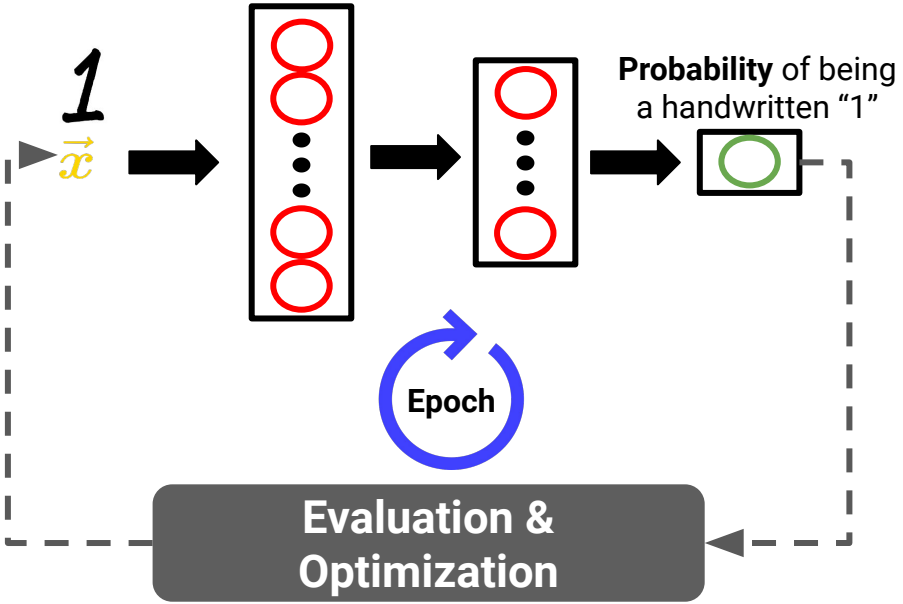
Training Flow in ANN Model



ANN processes input through layers to make predictions, then evaluates and optimizes itself over multiple epochs to improve accuracy.

How to Build Simple ANN?

```python
import numpy as np

# Activation functions and their derivatives
def relu(x):
    return np.maximum(0, x)

def relu_derivative(x):
    return np.where(x > 0, 1, 0)

def sigmoid(x):
    return 1 / (1 + np.exp(-x))

def sigmoid_derivative(x):
    return sigmoid(x) * (1 - sigmoid(x))

# Initialize weights and biases for the model
def initialize_parameters(input_size, hidden1_size, hidden2_size, output_size):
    np.random.seed(42)  # For reproducibility
    W1 = np.random.randn(input_size, hidden1_size) * 0.01
    b1 = np.zeros((1, hidden1_size))
    W2 = np.random.randn(hidden1_size, hidden2_size) * 0.01
    b2 = np.zeros((1, hidden2_size))
    W3 = np.random.randn(hidden2_size, output_size) * 0.01
    b3 = np.zeros((1, output_size))
    return W1, b1, W2, b2, W3, b3
```

```python
# Forward pass
def forward_pass(X, W1, b1, W2, b2, W3, b3):
    Z1 = np.dot(X, W1) + b1
    A1 = relu(Z1)
    Z2 = np.dot(A1, W2) + b2
    A2 = relu(Z2)
    Z3 = np.dot(A2, W3) + b3
    A3 = sigmoid(Z3)
    return Z1, A1, Z2, A2, Z3, A3

# Backpropagation
def backward_pass(X, Y, Z1, A1, Z2, A2, Z3, A3, W1, W2, W3):
    m = X.shape[0]
    dZ3 = A3 - Y
    dW3 = np.dot(A2.T, dZ3) / m
    db3 = np.sum(dZ3, axis=0, keepdims=True) / m

    dZ2 = np.dot(dZ3, W3.T) * relu_derivative(Z2)
    dW2 = np.dot(A1.T, dZ2) / m
    db2 = np.sum(dZ2, axis=0, keepdims=True) / m

    dZ1 = np.dot(dZ2, W2.T) * relu_derivative(Z1)
    dW1 = np.dot(X.T, dZ1) / m
    db1 = np.sum(dZ1, axis=0, keepdims=True) / m

    return dW1, db1, dW2, db2, dW3, db3
```

Initiate Function

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How to Build Simple ANN?

```python
# Model training
def train(X, Y, input_size, hidden1_size, hidden2_size, output_size, epochs, learning_rate):
    W1, b1, W2, b2, W3, b3 = initialize_parameters(input_size, hidden1_size, hidden2_size, output_size)

    for epoch in range(epochs):
        # Forward pass
        Z1, A1, Z2, A2, Z3, A3 = forward_pass(X, W1, b1, W2, b2, W3, b3)

        # Compute loss (binary cross-entropy)
        loss = -np.mean(Y * np.log(A3) + (1 - Y) * np.log(1 - A3))
        if epoch % 100 == 0:
            print(f'Epoch {epoch}, Loss: {loss}')

        # Backward pass
        dW1, db1, dW2, db2, dW3, db3 = backward_pass(X, Y, Z1, A1, Z2, A2, Z3, A3, W1, W2, W3)

        # Update parameters
        W1, b1, W2, b2, W3, b3 = update_parameters(W1, b1, W2, b2, W3, b3, dW1, db1, dW2, db2, dW3, db3, learning_rate)

    return W1, b1, W2, b2, W3, b3

# Example usage with dummy data
if __name__ == "__main__":
    # Create some dummy data for binary classification
    np.random.seed(42)
    X = np.random.rand(100, 10)  # 100 samples, 10 features
    Y = (np.sum(X, axis=1) > 5).astype(int).reshape(-1, 1)  # Labels (0 or 1)

    # Train the model
    trained_parameters = train(X, Y, input_size=10, hidden1_size=25, hidden2_size=15, output_size=1, epochs=1000, learning_rate=0.01)
```

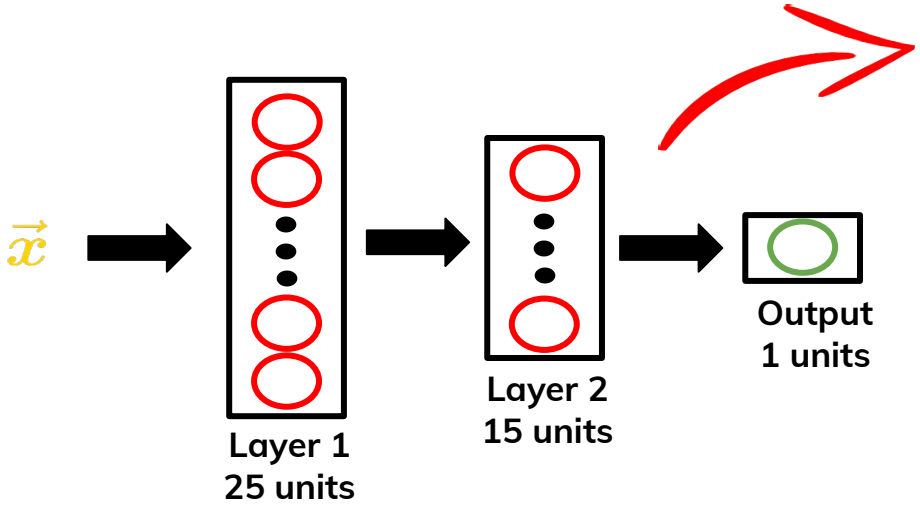

Train

Introduction to TensorFlow

- An **end-to-end open source** machine learning platform
- TensorFlow provides an easy way to build a **neural networks model**
- TensorFlow also supports **distributed computing**, **GPUs**, and **TPUs**.

```
pip install tensorflow
```

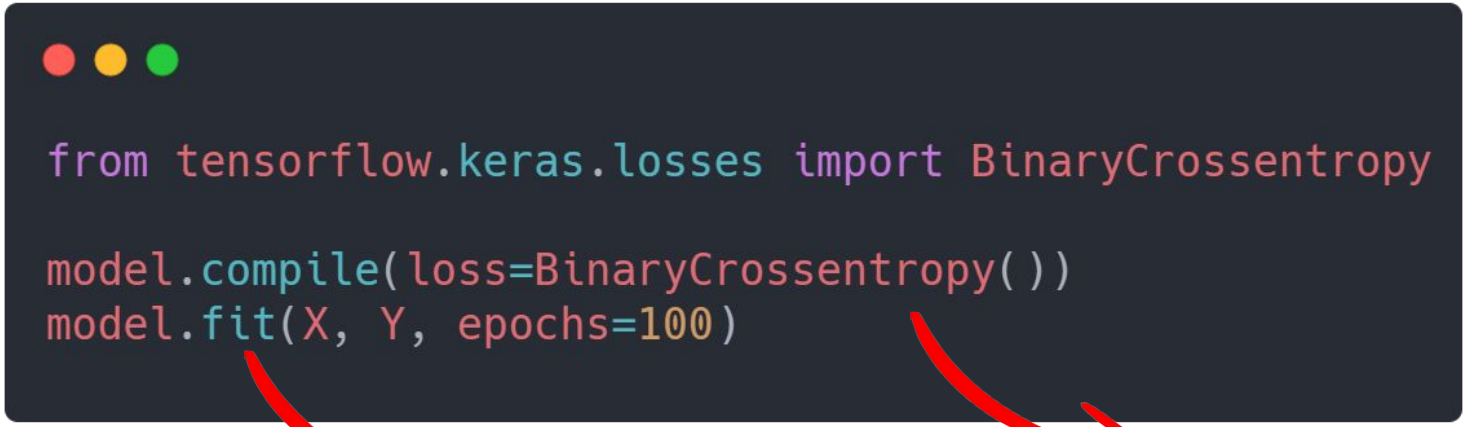
TensorFlow Implementation




```python
import tensorflow as tf
from tensorflow.keras import Sequential
from tensorflow.keras.layers import Dense

model = Sequential([
    Dense(units=25, activation='relu'),
    Dense(units=15, activation='relu'),
    Dense(units=1, activation='sigmoid')
])
```

How to Set Loss Function & Optimizer?



Neural Network
Exploration

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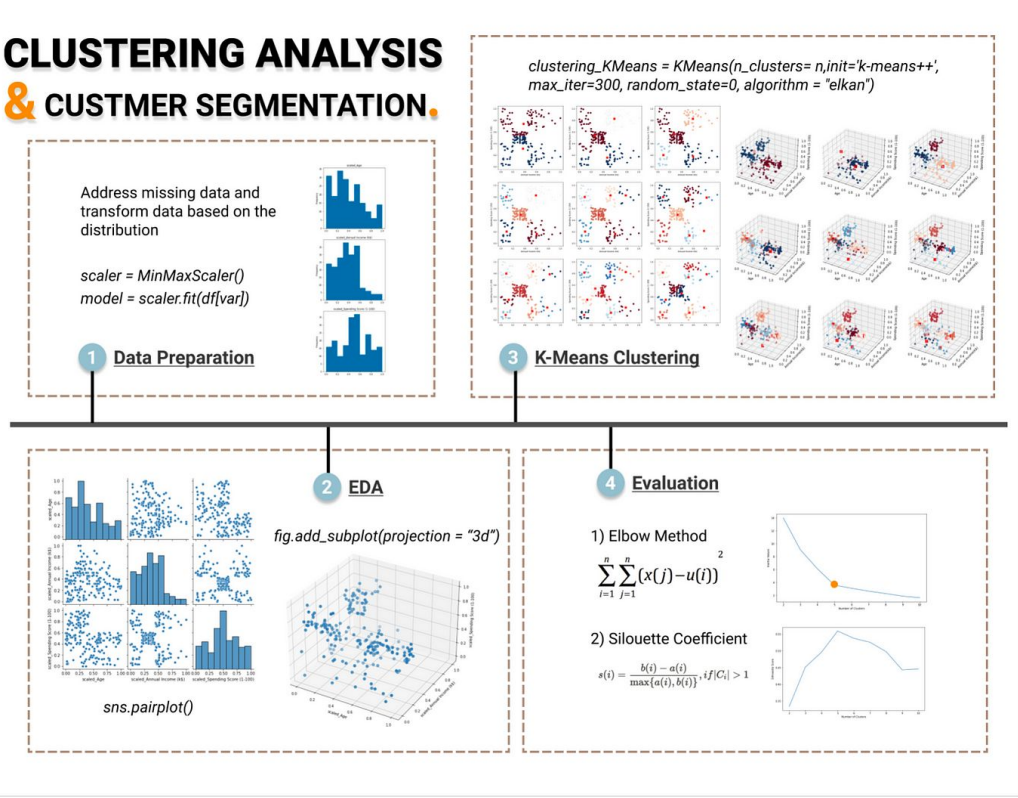
Intro & Industry Context



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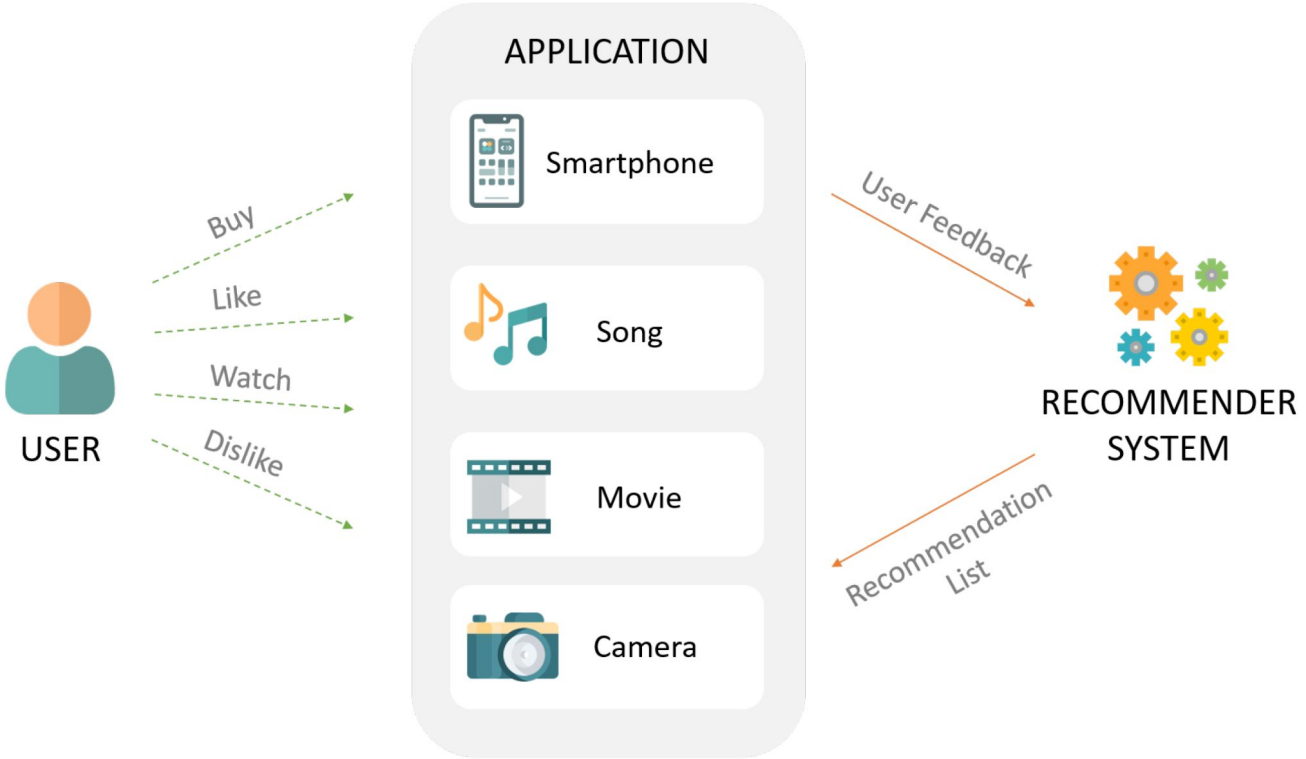
Intro & Industry Context



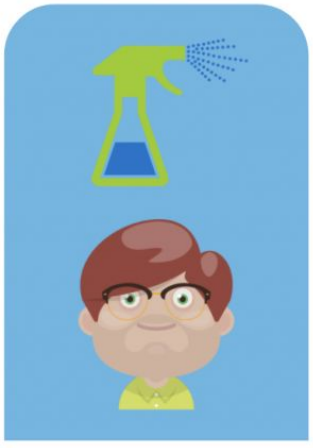
Intro & Industry Context

Breakfast & dinner - retired people

Traditional buyer

Large bills but no non-food products

Kids



Germaphobes & discount seekers

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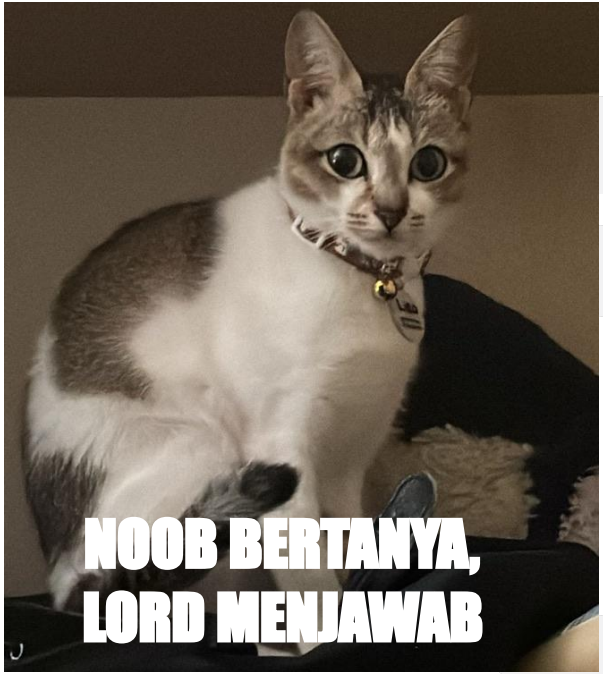
Discussions



Quiz and Feedback

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Conclusion

You have learned basic concepts in **unsupervised learning** and how **clustering algorithms** and **recommendation system** work.

In the end, you also learn the basic concept of **Artificial Neural Networks** & the implementation using **TensorFlow**.

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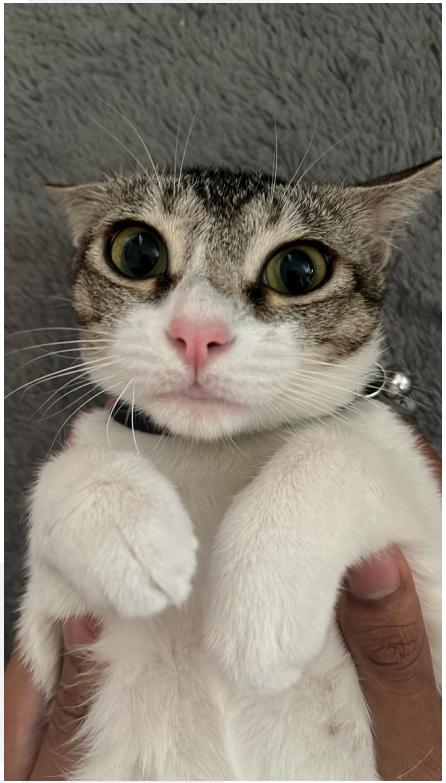
Thank You



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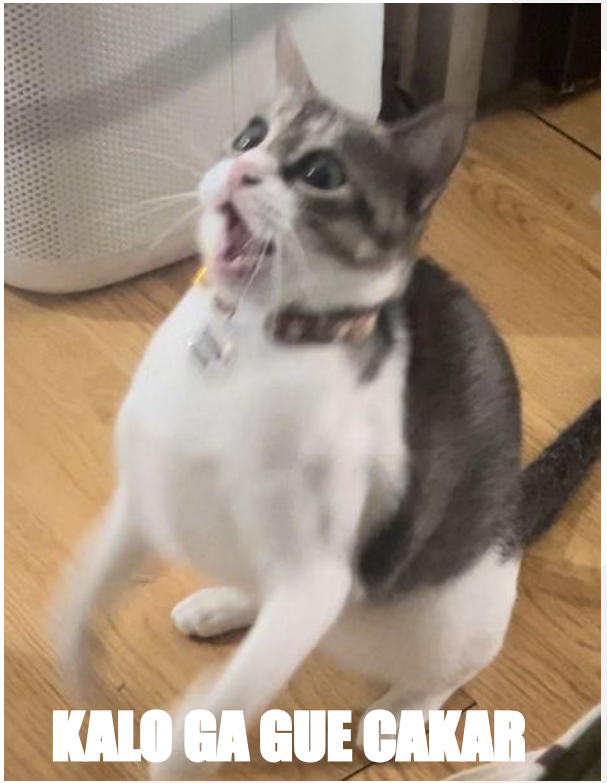

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