
# Fuzzy Logic & Neural Networks (CS-514)

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# Learning Processes

- In machine learning and neural networks, learning processes involve algorithms that adjust the parameters of models based on data input, feedback, and performance metrics.
- The learning process is a complex, interactive process that involves several components, including:
- Attention
- Memory
- Language
- Processing and organizing
- Graphomotor (writing)
- Higher order thinking

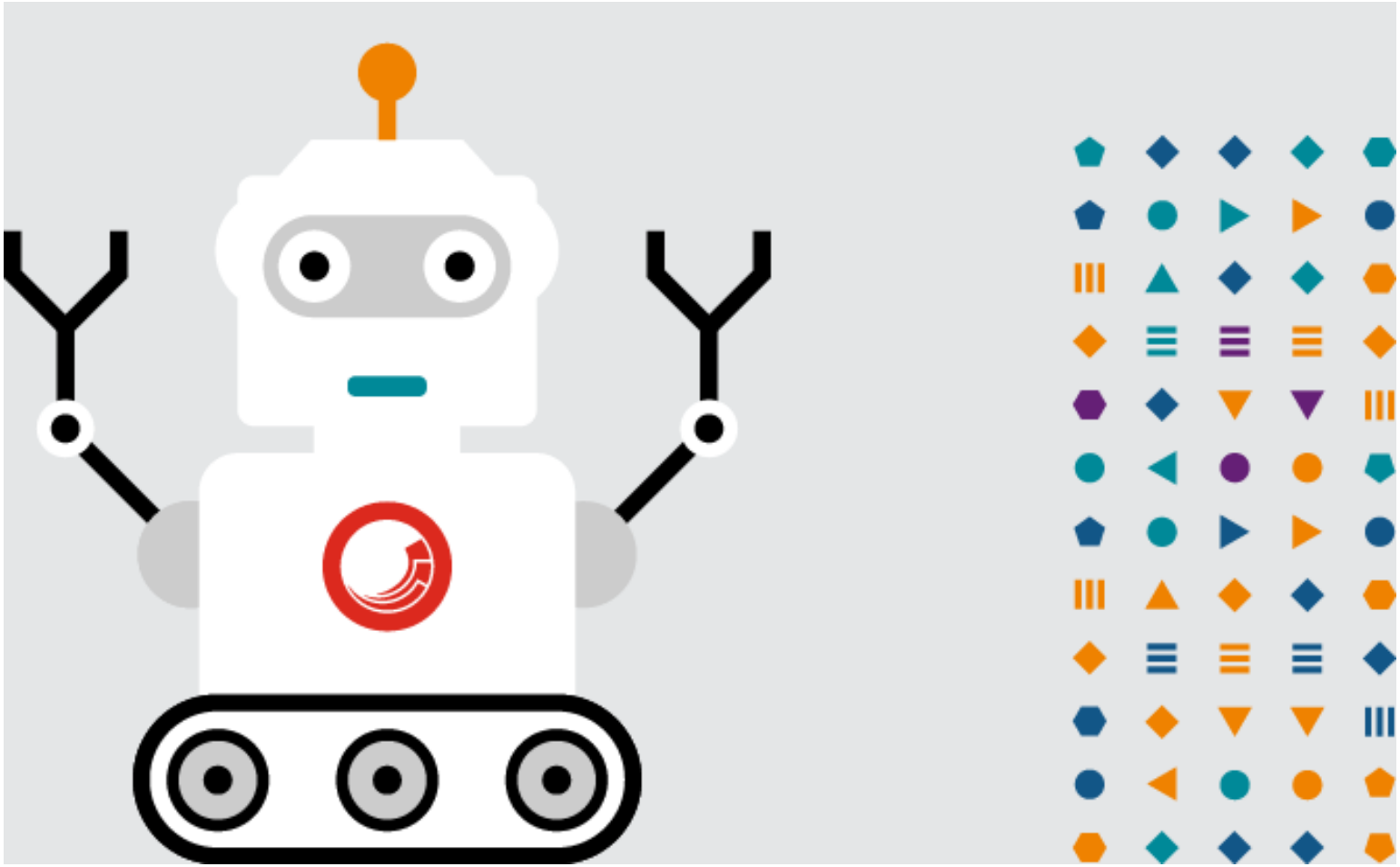
# Learning Processes

## Types of Machine Learning

- **Supervised (inductive) Learning**
  - Training data includes desired outputs
- **Unsupervised Learning**
  - Training data does not include desired outputs
- **Semi-supervised Learning**
  - Training data includes a few desired outputs
- **Reinforcement Learning**
  - Rewards from sequence of actions

# Learning Processes

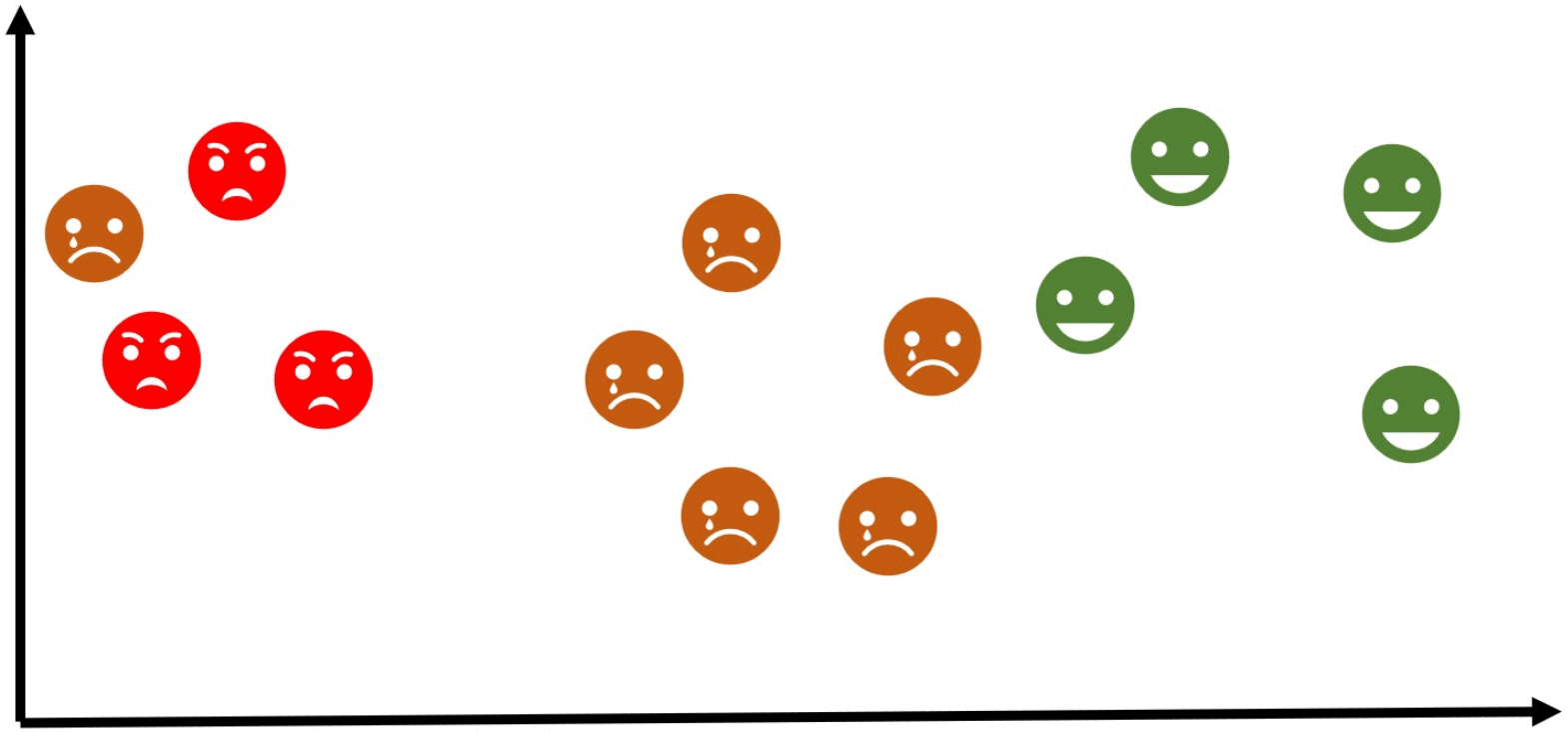
## Supervised Learning



Source: Google Images

# Learning Processes

## Unsupervised Learning



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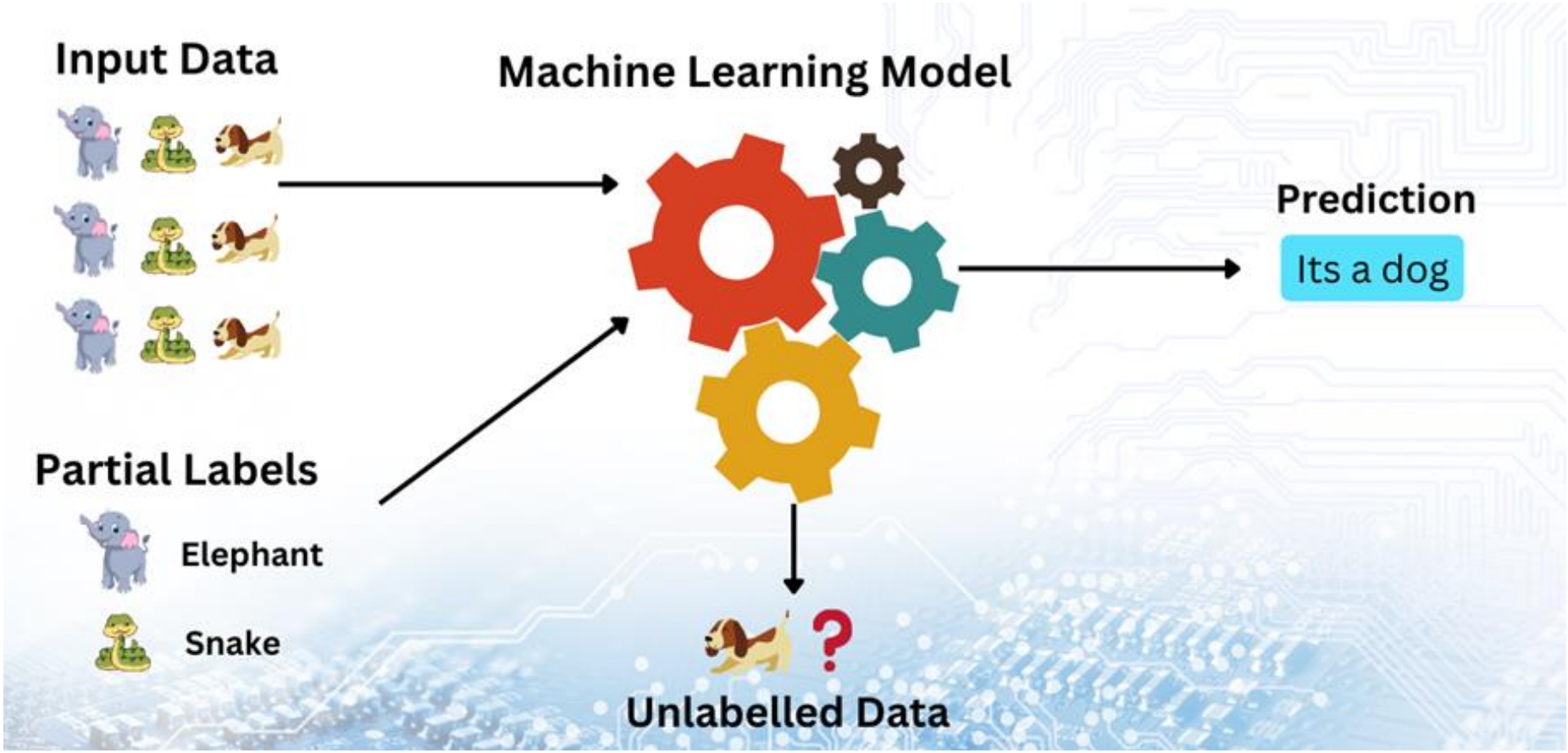
# Learning Processes

## Semi-supervised Learning

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# Learning Processes

## Reinforcement Learning

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# Learning Rules

## Hebbian Learning

- Hebbian Learning explains how neurons adapt and form stronger connections through repeated use. Each time a memory is recalled, or an action is repeated, the neural pathways involved become more robust/strong as they fire together, making that action or memory more intuitive or easy to reproduce.

**“Neurons that fire together, wire together.”**

**–Donald Hebb**

# Learning Rules

## Hebbian Learning

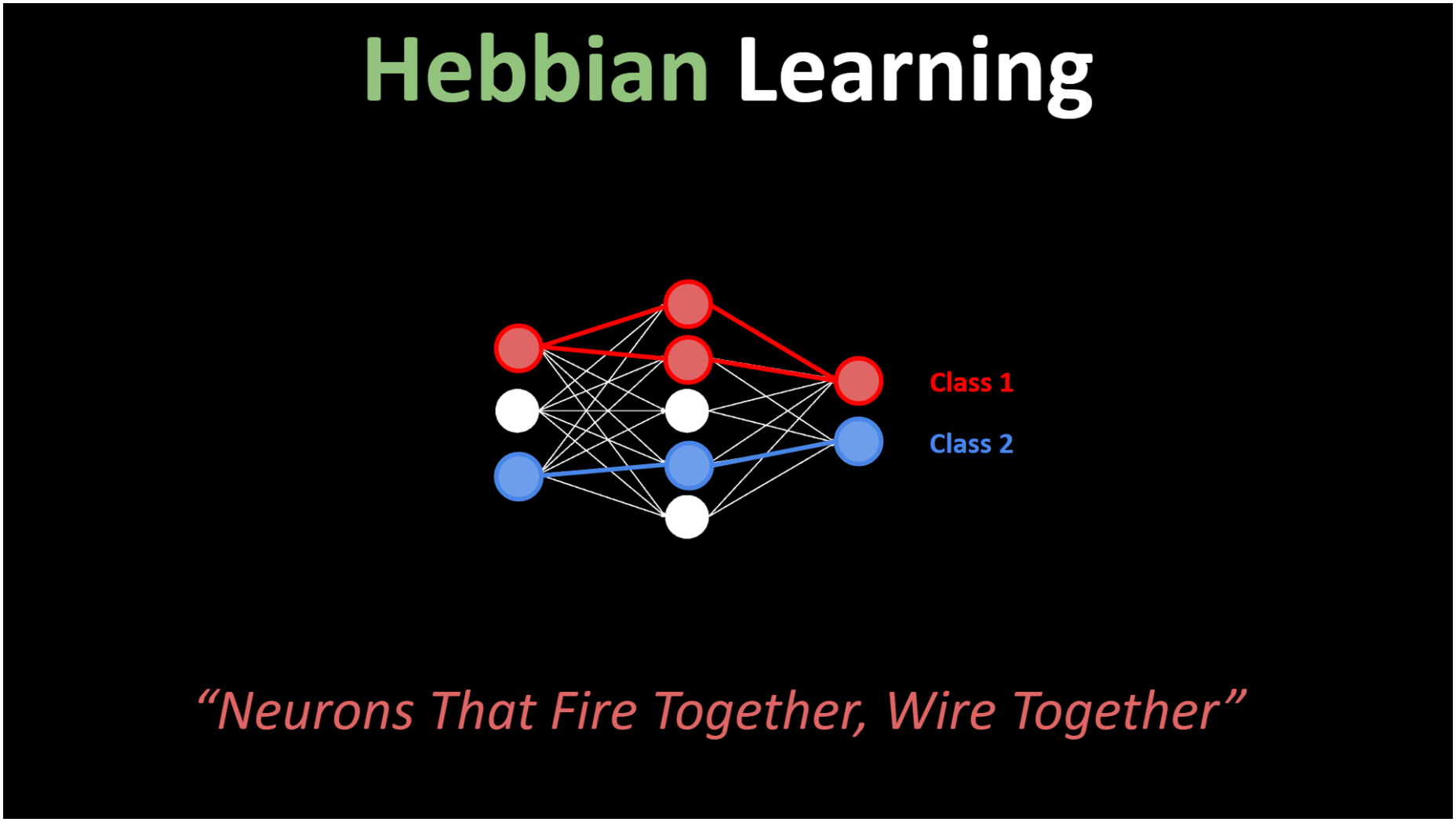
- Formula:

$$\Delta w_{ij} = \alpha x_i x_j$$

- $\Delta w_{ij}$ is the change in weight between neurons $i$ and $j$.
- $\alpha$ is the learning rate.
- $x_i$ and $x_j$ are the activation levels of the respective neurons.
- This method is useful for Unsupervised Learning.

# Learning Rules

## Hebbian Learning




Source: Google Images

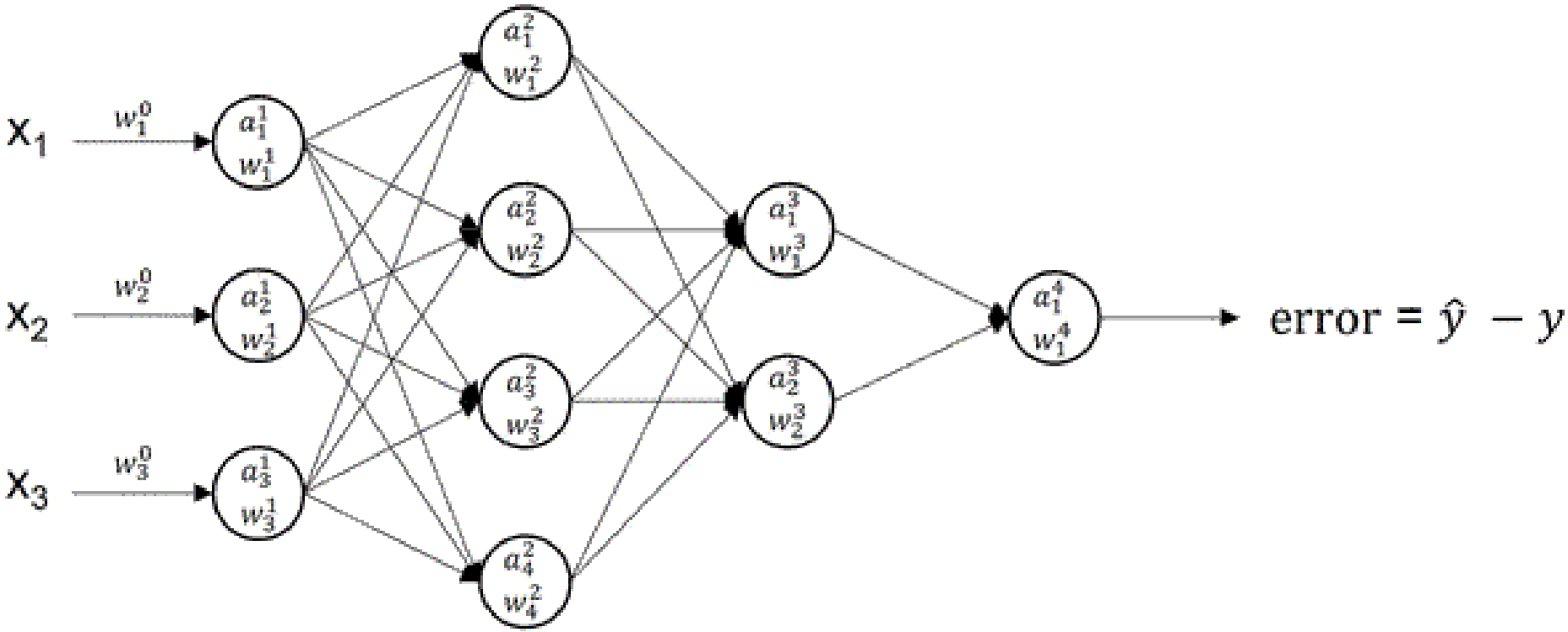
# Learning Rules

## Error Correction Learning

- Error correction learning is a learning process in which a system adjusts its parameters based on the error between its predicted output and the desired (or target) output.
- The objective is to reduce this error by iteratively modifying the system's internal parameters, such as weights in a neural network.
- This approach is used in many supervised learning algorithms.

# Learning Rules

## Error Correction Learning




Source: Google Images

# Learning Rules

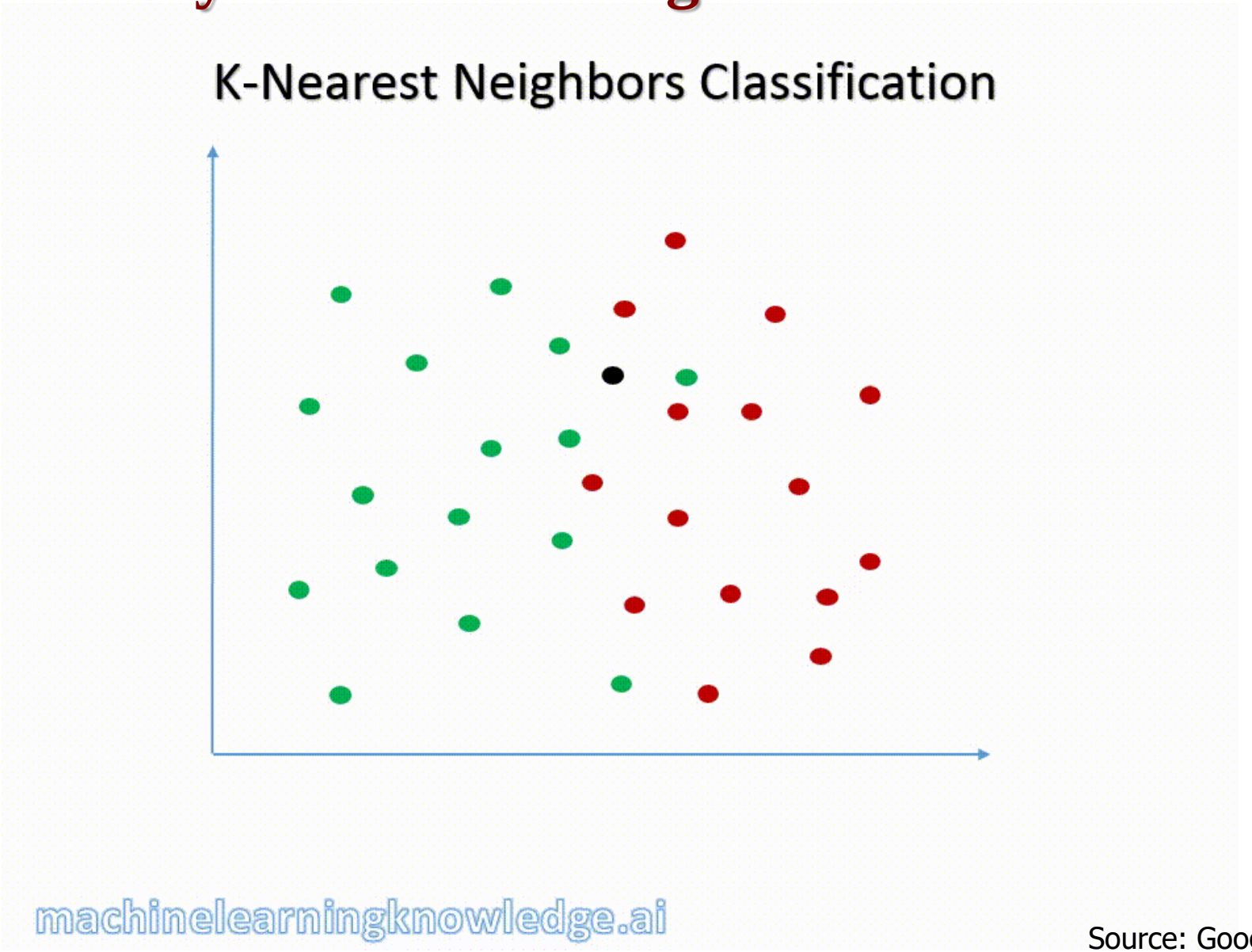
## Memory-based Learning

- Memory-based learning rely on storing and using the training data directly to make predictions, rather than learning a general model during the training phase.

- k-Nearest Neighbors (k-NN)
- Locally Weighted Regression (LWR)
- Radial Basis Function (RBF) Neural Networks

# Learning Rules

## Memory-based Learning

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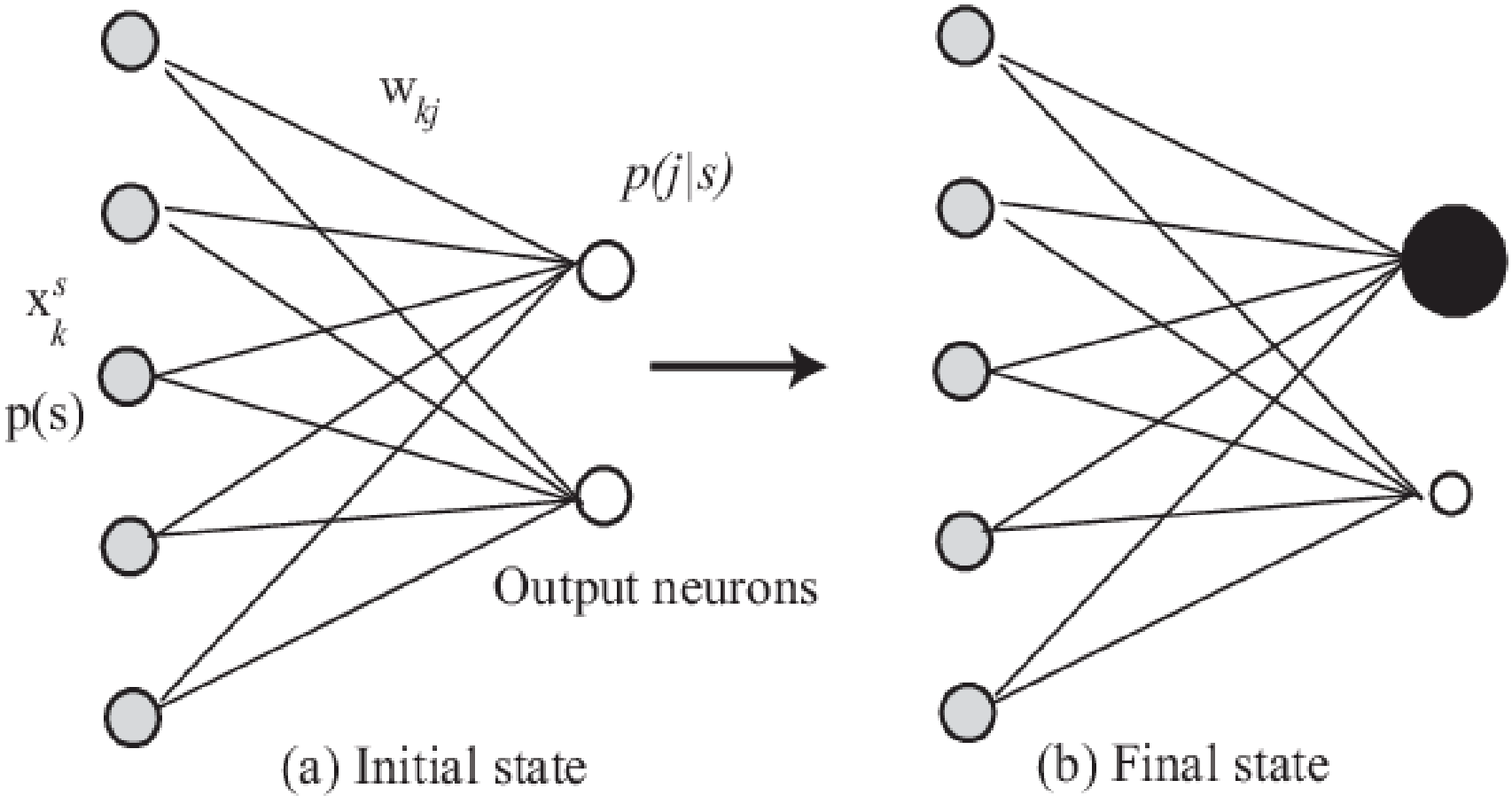
# Learning Rules

## Competitive Learning

- Competitive learning is a type of unsupervised learning in which neurons in a neural network compete with each other to become activated or "win" in response to input data.
- It is primarily used for clustering and feature extraction, where neurons learn to represent different clusters or patterns in the input data.

# Learning Rules

## Competitive Learning



# Learning Rules

## Boltzmann Learning

- In Boltzmann learning, the network is trained to minimize an energy function, so that it can model complex probability distributions and capture hidden patterns in the data.
- It is a type of stochastic **recurrent neural network** model.
- The learning in Boltzmann machines involves adjusting the weights to minimize the difference between the network's generated distribution and the actual data distribution.