

# COMP417 Lecture 1

## Introduction to Machine Learning

Dr. Hend Dawood

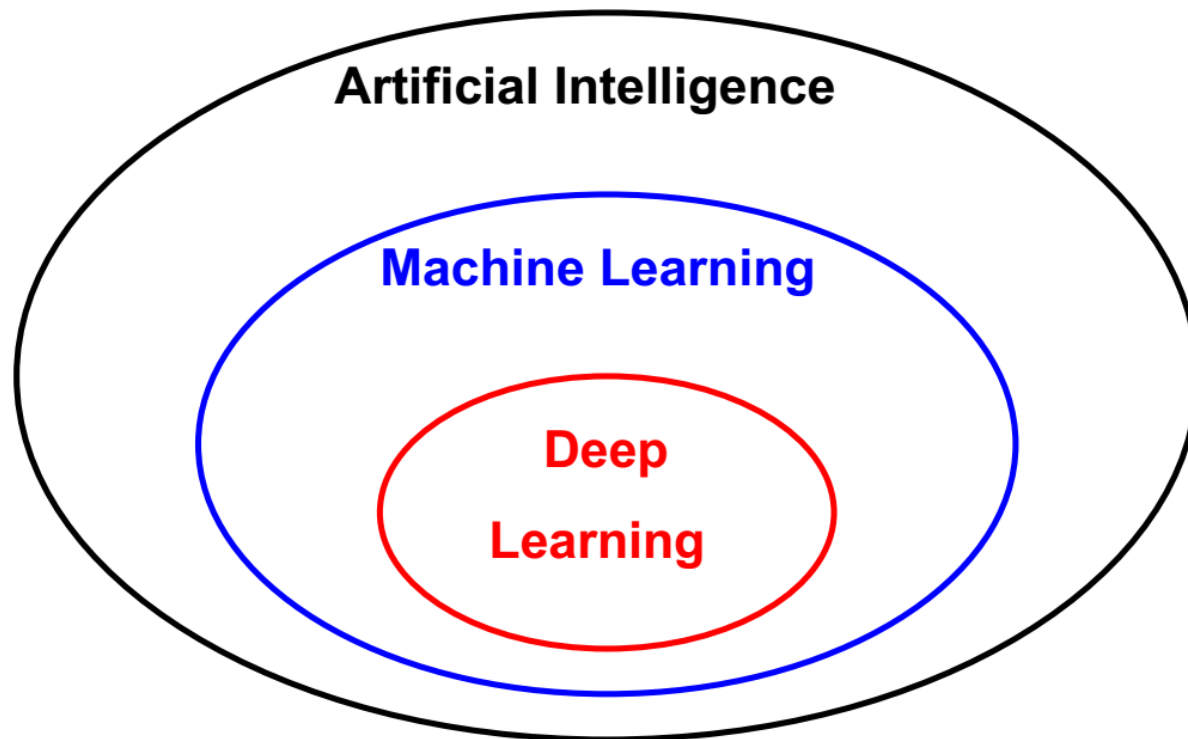
# Course Grading

Component	Grade	
Lab Work	30%	Lab Exams
Midterm	10%	
Final Exam	60%	
Bonus	2%	Class participation

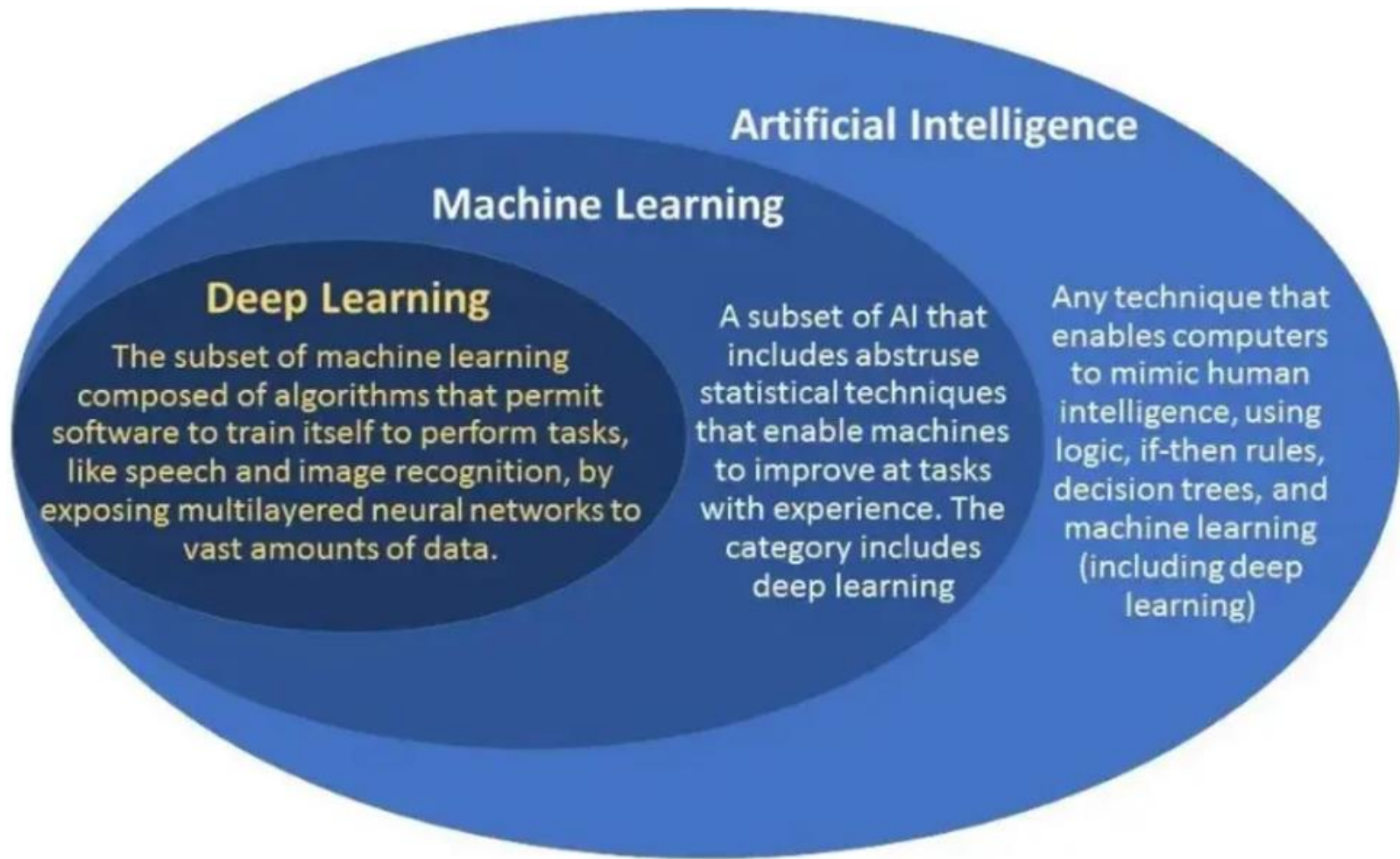
# Artificial Intelligence

## Definition (Oxford dictionary)

**Artificial Intelligence**, *noun*: the theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation.



# Artificial Intelligence, Machine Learning, and Deep Learning



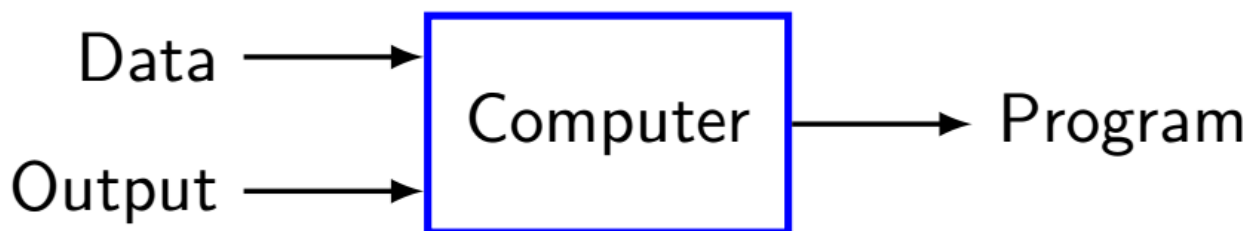
# Machine Learning

## Definition

**Machine Learning**, *noun*: type of Artificial Intelligence that provides computers with the ability to **learn without being explicitly programmed**.



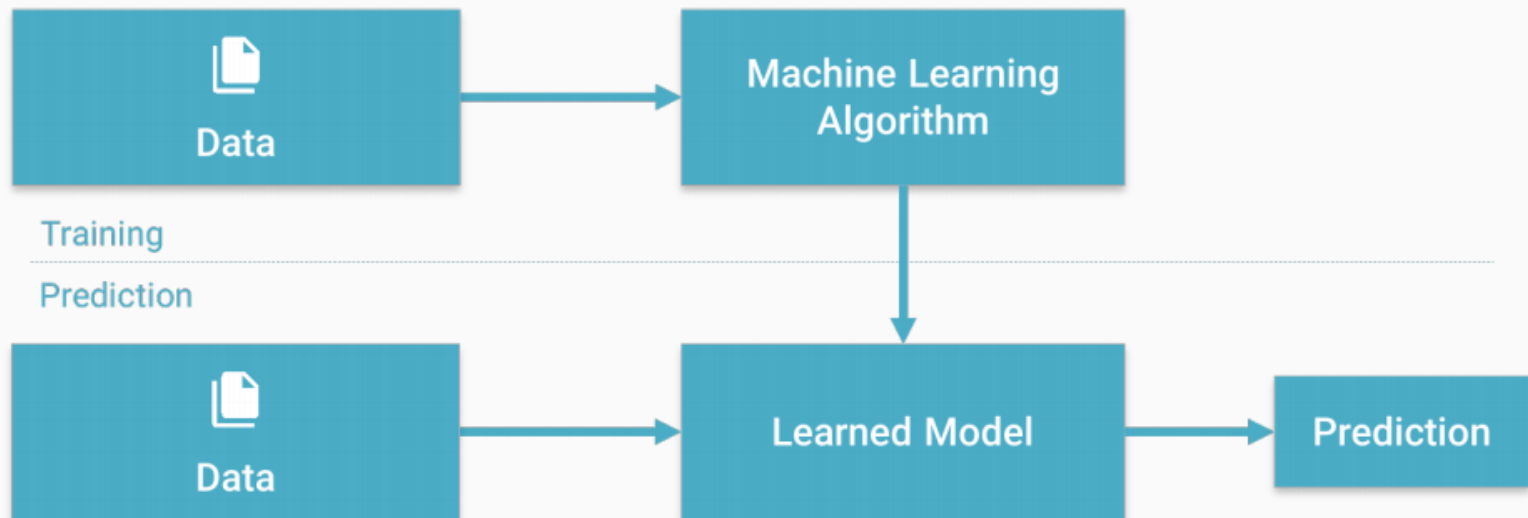
Traditional programming



Machine learning

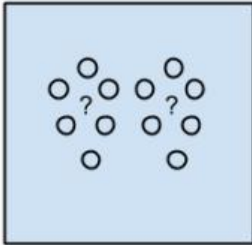
# Machine Learning

ML provides **various techniques** that can learn from and make predictions on data. Most of them follow the same general structure:

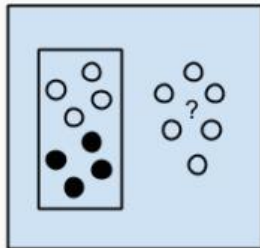


# Machine Learning- Learning approaches

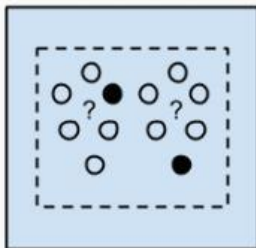
## Learning approaches



Unsupervised Learning Algorithms



Supervised Learning Algorithms



Semi-supervised Learning Algorithms

**Unsupervised learning:** Discovering patterns in unlabeled data. *Example: cluster similar documents based on the text content.*

**Supervised learning:** Learning with a labeled training set. *Example: email spam detector with training set of already labeled emails.*

**Semisupervised learning:** Learning with a small amount of labeled data and a large amount of unlabeled data. *Example: web content and protein sequence classifications.*

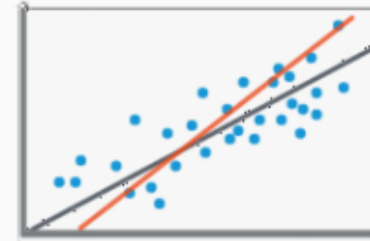
**Reinforcement learning:** Learning based on feedback or reward. *Example: learn to play chess by winning or losing.*

# Machine Learning- Problem types

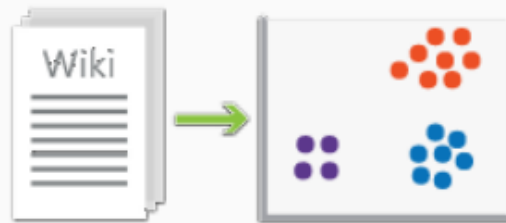
## Problem types



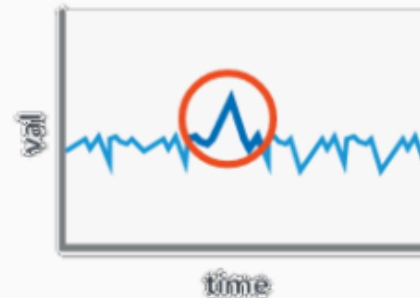
Classification  
(supervised – predictive)



Regression  
(supervised – predictive)



Clustering  
(unsupervised – descriptive)

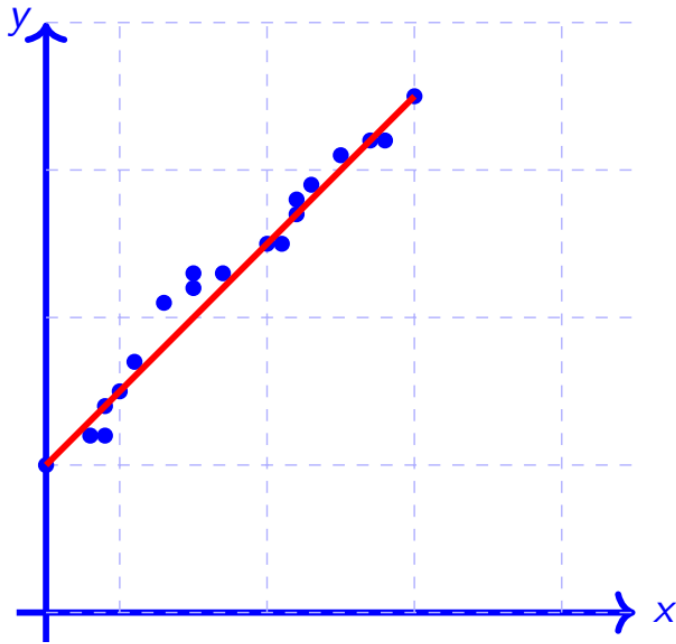


Anomaly Detection  
(unsupervised – descriptive)

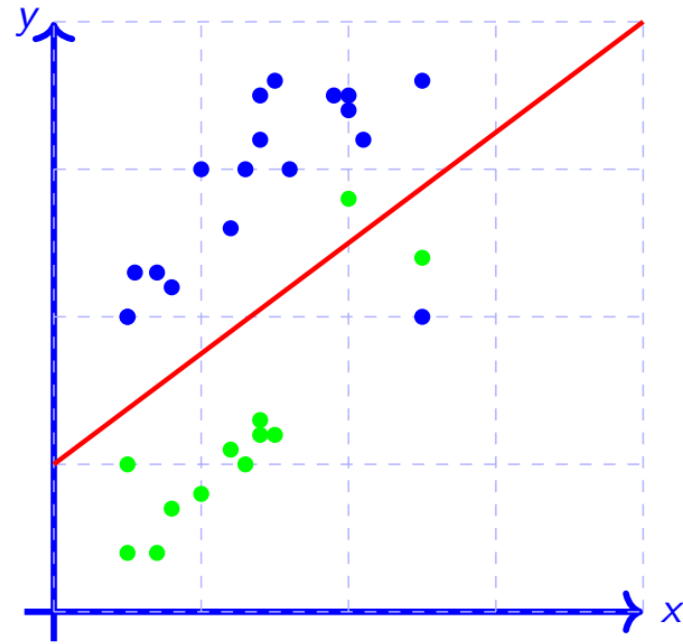


# Machine Learning- Problem types

- Regression

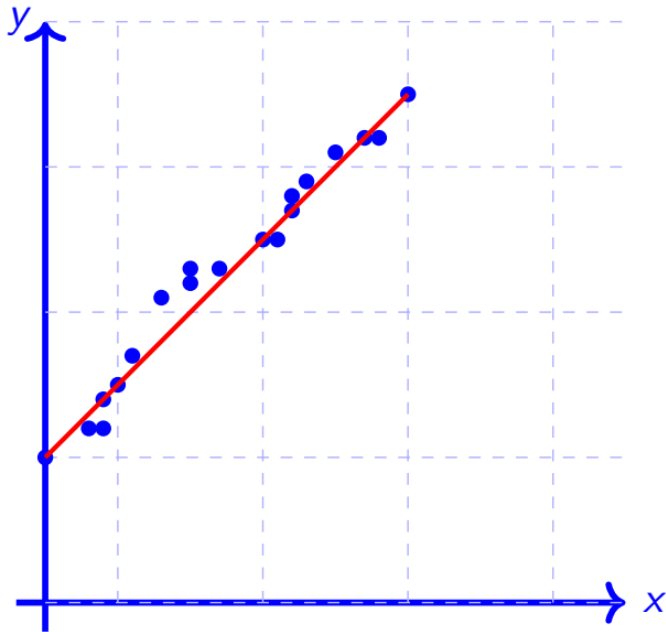


- Classification

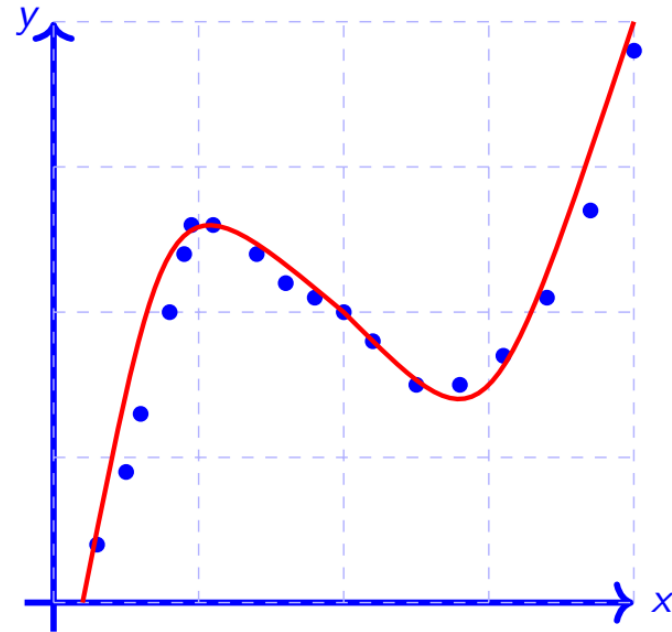


# Machine Learning- Problem types

- Regression (linear)



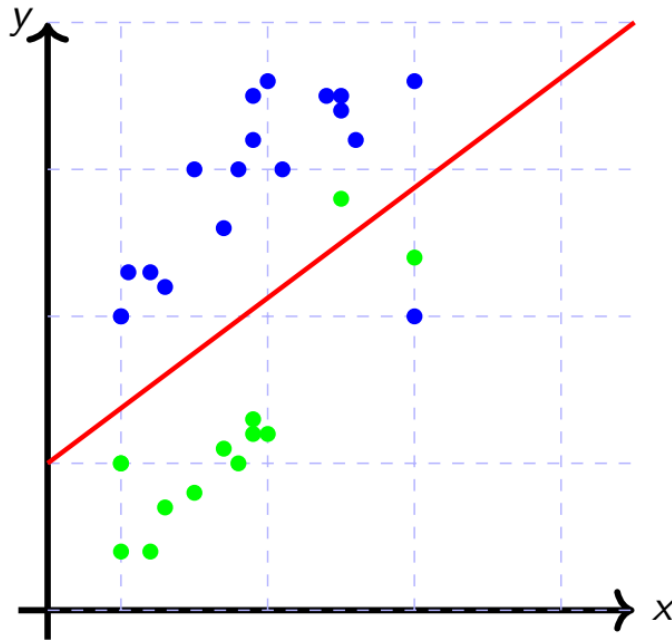
- Regression (Non-linear)



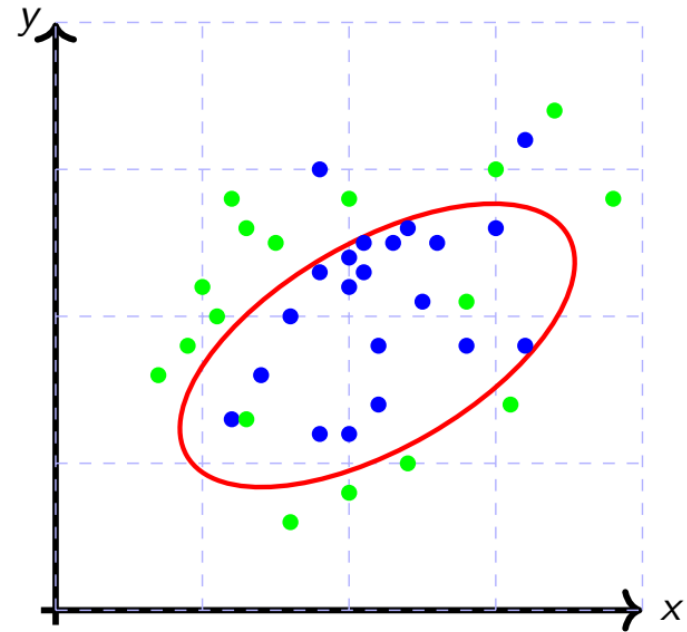
# Machine Learning- Problem types

## Classification

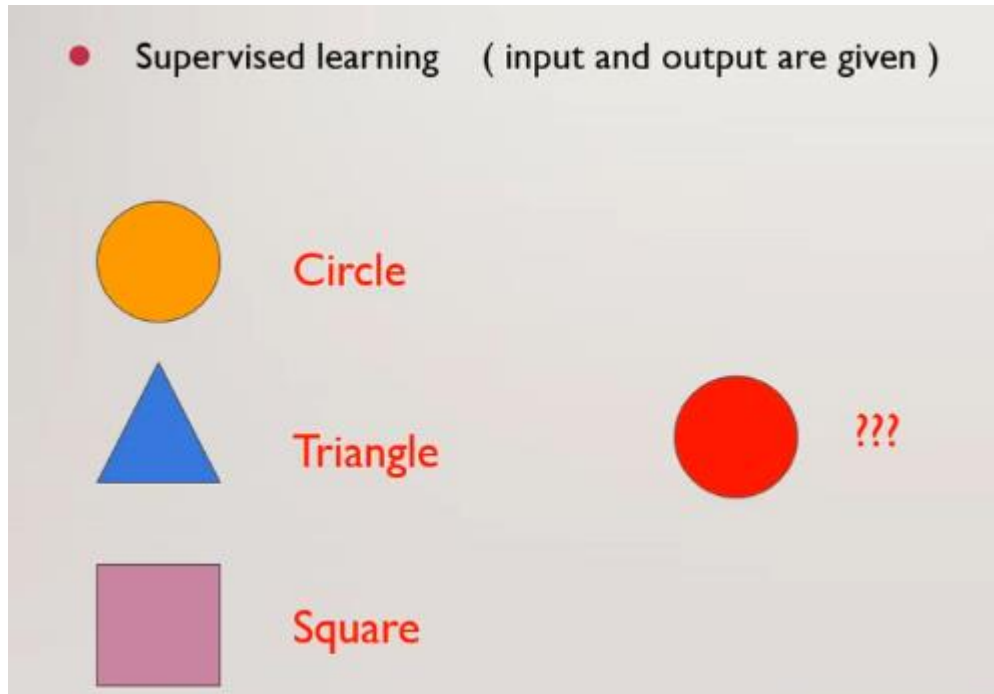
• Linear



• Non-linear

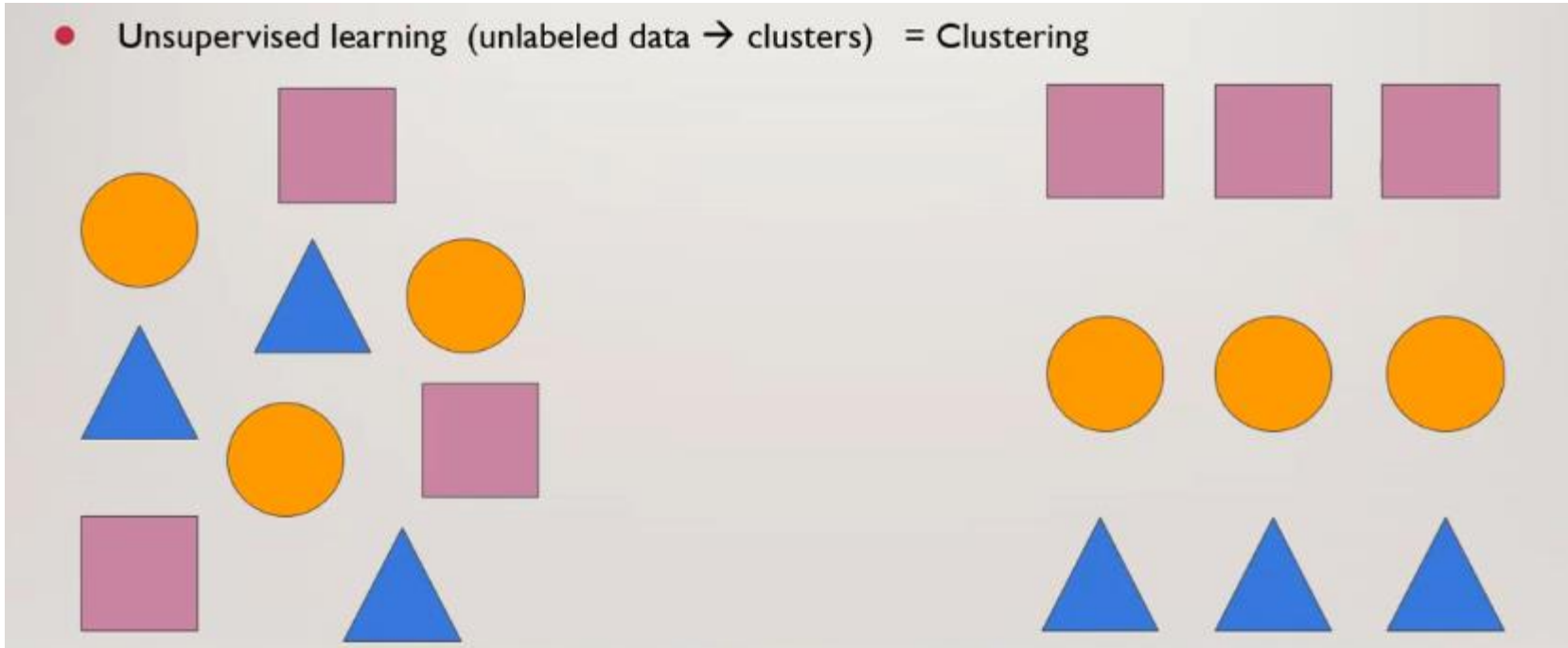


# Supervised Learning



# Unsupervised Learning

- Unsupervised learning (unlabeled data  $\rightarrow$  clusters) = Clustering



# Deep Learning

## What is deep learning?

- Part of the machine learning field of learning representations of data. Exceptionally effective at learning patterns.
- Utilizes learning algorithms that derive meaning out of data by using a hierarchy of multiple layers that mimic the neural networks of our brain.
- If you provide the system tons of information, it begins to understand it and respond in useful ways.
- Rebirth of artificial neural networks.

# Deep Learning

- Popularized by Hinton in 2006 with Restricted Boltzmann Machines



**Geoffrey Hinton:** University of Toronto & Google

- Developed by different actors:



**Yann LeCun:** New York University & Facebook



**Andrew Ng:** Stanford & Baidu



**Yoshua Bengio:** University of Montreal



**Jürgen Schmidhuber:** Swiss AI Lab & NNAISENSE

and many others...

- Yoshua Bengio, Geoffrey Hinton, and Yann LeCun recipients of the 2018 ACM A.M. Turing Award for conceptual and engineering breakthroughs that have made deep neural networks a critical component of computing.

# Deep Learning

## Actors and applications

- Very active technology adopted by big actors



- Success story for many different academic problems
  - Image processing
  - Computer vision
  - Speech recognition
  - Natural language processing
  - Translation
  - etc
- Today all industries wonder if DL can improve their process.

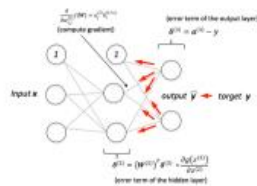


# Deep Learning

## Timeline of (deep) learning



1958 Perceptron



1974 Backpropagation



Convolution Neural Networks for Handwritten Recognition

1998



Google Brain Project on 16k Cores

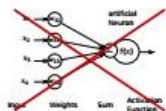
2012

awkward silence (AI winter)

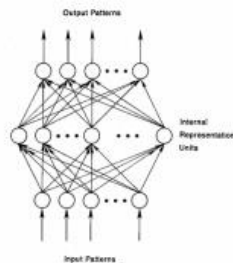


1969 Perceptrons book

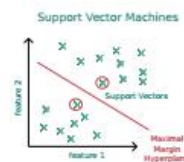
Perceptron criticized



~1980 Multilayer network



1995 SVM reigns



2006 Restricted Boltzmann Machine



2012 AlexNet wins ImageNet IMAGENET

# Neural Networks

- Neural networks have become one of *the* main approaches to AI
- They have been successfully applied to various pattern recognition, prediction, and analysis problems
- In many problems they have established the state of the art
  - Often exceeding previous benchmarks by large margins
  - Sometimes solving problems you couldn't solve using earlier ML methods

# Breakthroughs with neural networks

www.technewsworld.com/story/84013.html

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## Microsoft AI Beats Humans at Speech Recognition

By Richard Adhikari  
Oct 20, 2016 11:40 AM PT

Print  
Email



Image: Adobe Stock

Microsoft's Artificial Intelligence and Research Unit earlier this week reported that its speech recognition technology had surpassed the performance of human transcriptionists.

How do you feel about Black Friday and Cyber Monday?

- They're great -- I get a lot of bargains!
- The deals are too spread out -- I'd prefer just one day.
- They're a fun way to kick off the holiday season.
- I don't like the commercialization of Thanksgiving Day.
- They're crucial for the retail industry and the economy.
- The deals typically aren't that good.

Vote to See Results

### E-Commerce Times

Black Friday Shoppers Hungry for New Experiences, New Tech

Pay TV's Newest Innovation: Giving Users Control

Apple Celebrates Itself in \$300 Coffee Table Tome

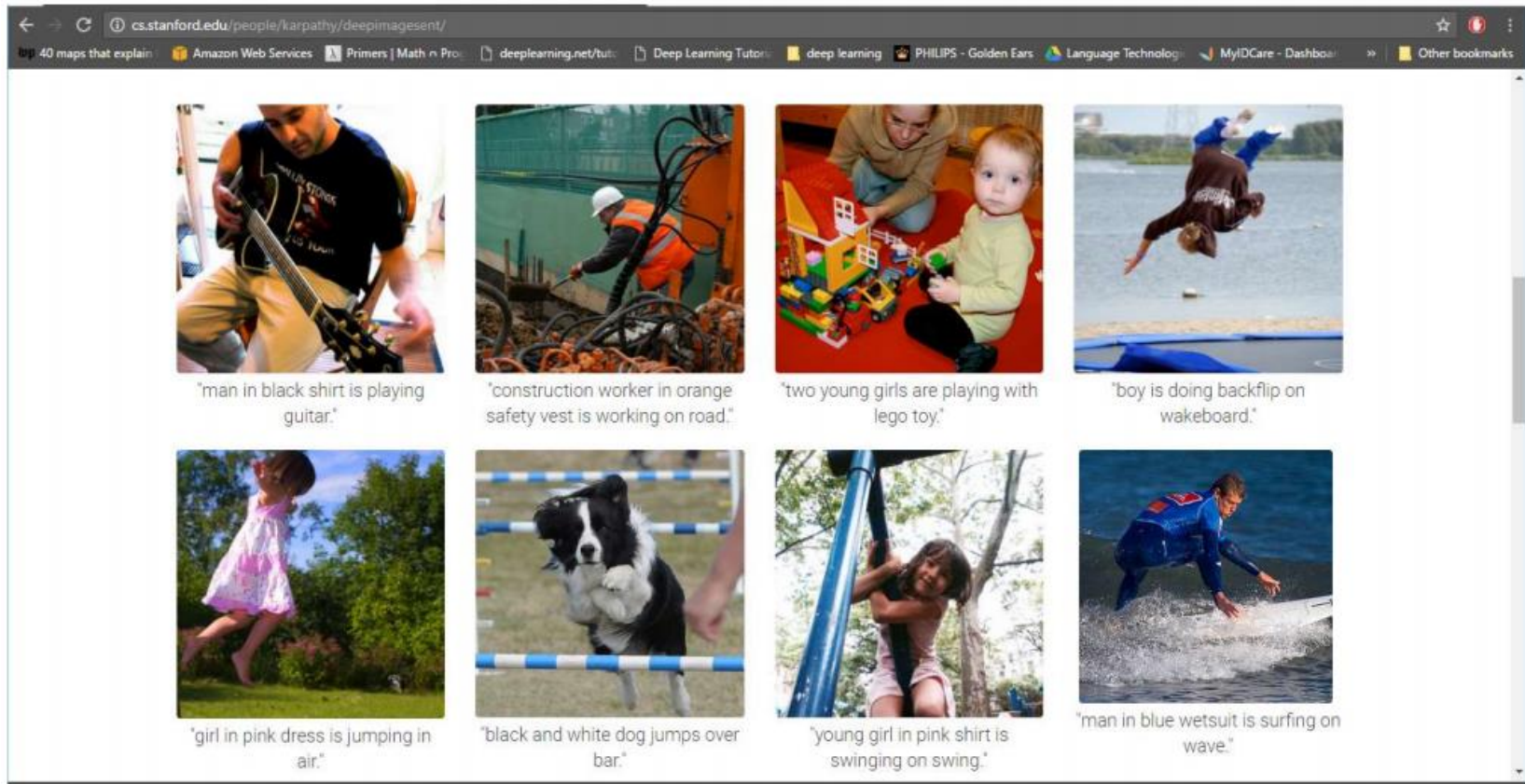
AWS Enjoys Top Perch in IaaS, PaaS Markets

US Comptroller Gears Up for Blockchain and

# Breakthroughs with neural networks



# Breakthroughs with neural networks



- Captions generated entirely by a neural network



# Breakthroughs with neural networks

## And now...

ChatGPT, tell me about this picture

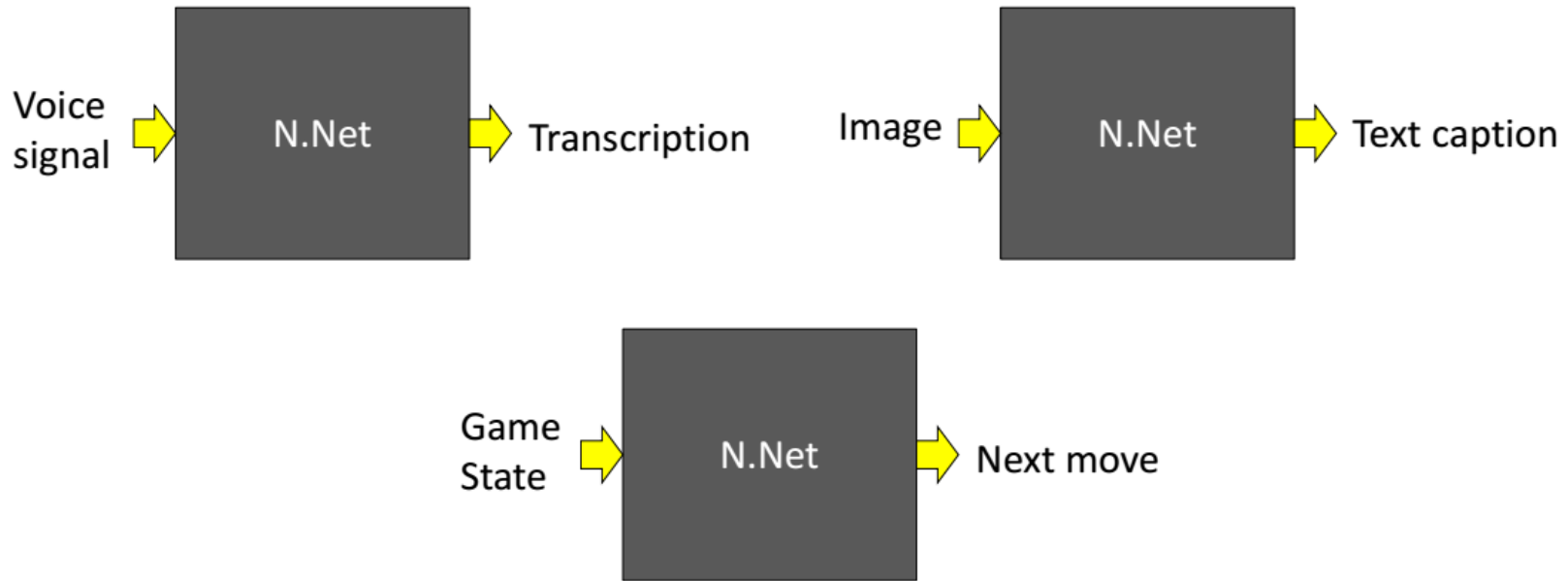


7:12 PM The ceiling in the photo appears to have several noticeable water stains, which could indicate potential water damage. The stains seem to be spread across multiple tiles, suggesting there might be a leak from the roof or pipes above. It would be advisable to address this issue promptly to prevent any further damage or potential mold growth. Notifying building maintenance or the landlord to investigate and fix the source of the leak would be the best course of action.

Besides the water stains on the ceiling, the photo shows a few other details:

1. **Posters on the Wall:** There are several posters or prints on the wall featuring various images, likely of scenes from movies, video games, or other forms of media.
2. **Furniture and Clutter:** The room contains a few pieces of furniture, including a blue chair, a black wardrobe or storage unit, and a desk with two monitors. There are clothes and other items visible on the wardrobe and desk, indicating a typical lived-in space.
3. **Lighting and Ventilation:** The ceiling has a light fixture and an air vent, suggesting this is a standard room with typical building amenities.
4. **Bed and Bedding:** The lower part of the photo shows a bed with a person lying on it, with their foot visible in the foreground. The bed has a comforter and some clothing or linens on it.
5. **Overall Condition:** The room appears somewhat cluttered, with personal belongings spread out. The presence of water stains on the ceiling is the most concerning issue visible.

# So, What are Neural Networks??



- What's in these boxes?

# Neural Networks

## Brain: Interconnected Neurons

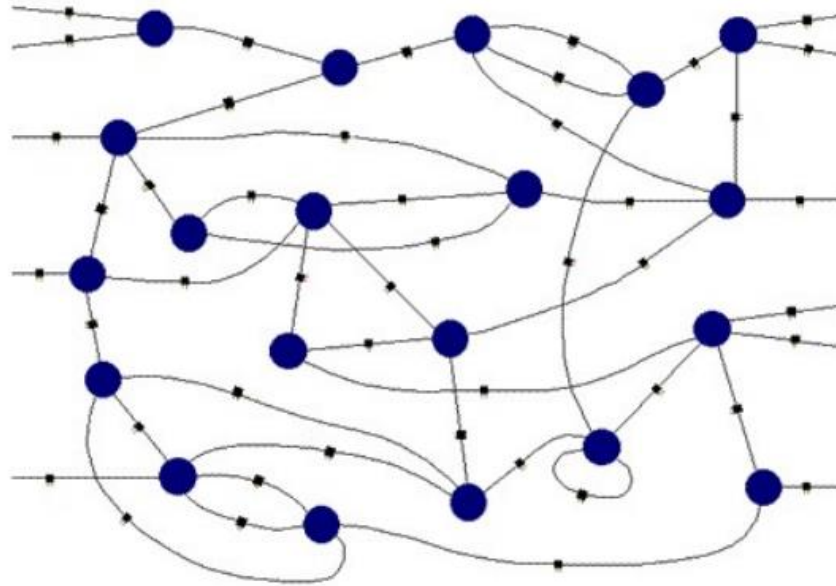


- Many neurons connect *in* to each neuron
- Each neuron connects *out* to many neurons
- The brain is a *network* of neurons



# Neural Networks

## Connectionist Machines

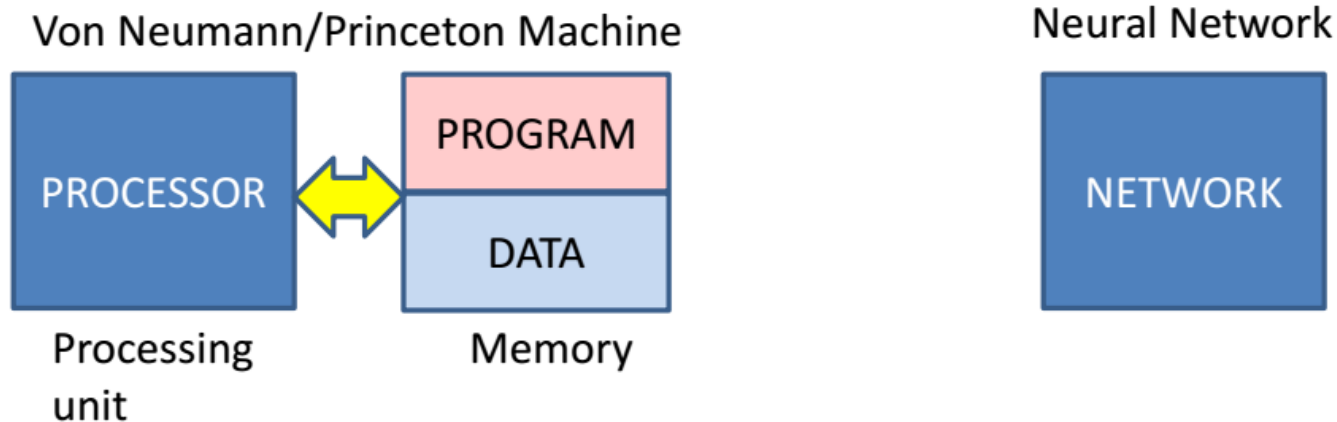


- Network of processing elements
- **All world knowledge is stored in the *connections* between the elements**

# Neural Networks

## Connectionist Machines

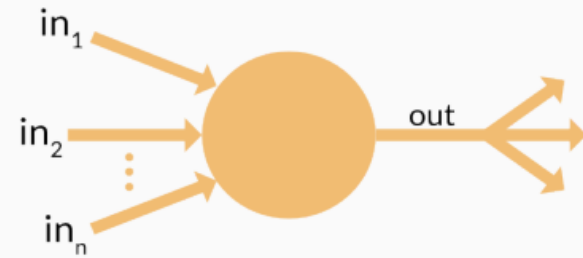
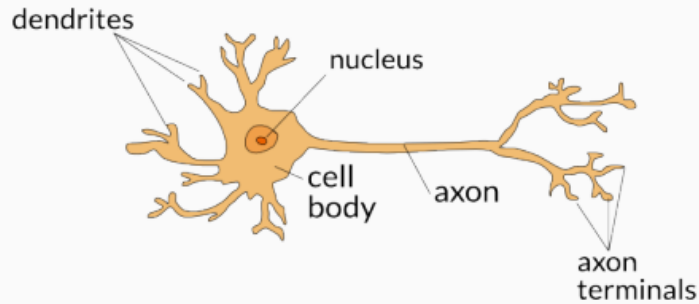
- Neural networks are *connectionist* machines
  - As opposed to Von Neumann Machines



- The machine has many non-linear processing units
  - The program is the connections between these units
    - Connections may also define memory

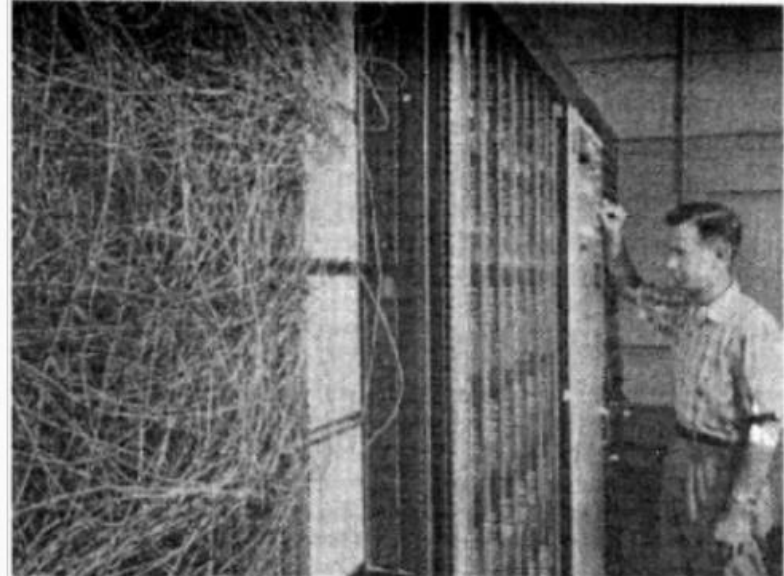
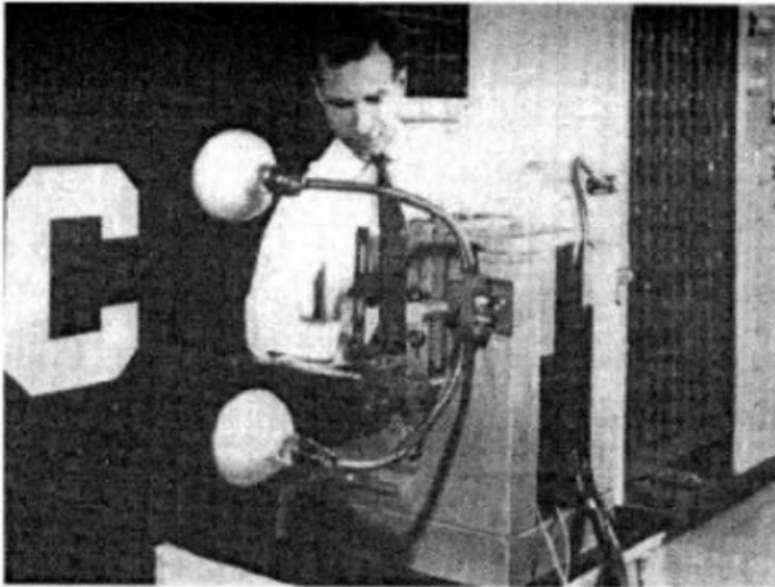
# Neural Networks: The Perceptron

## Perceptron



# Neural Networks: The Perceptron

## Perceptron (Frank Rosenblatt, 1958)



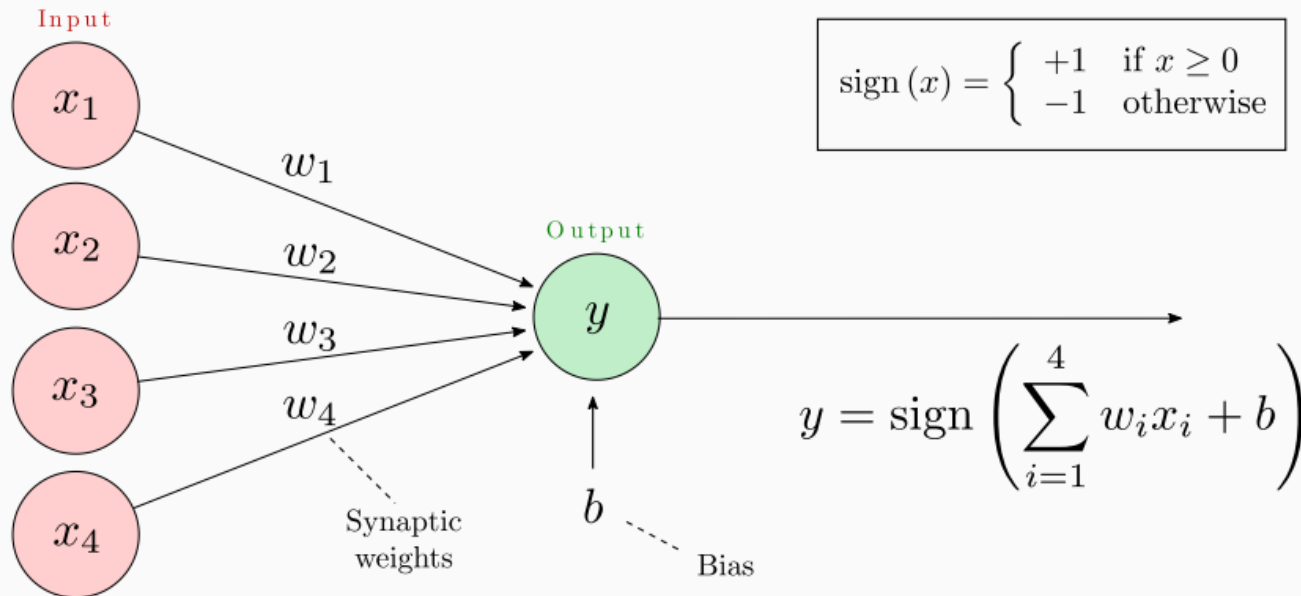
First binary classifier based on supervised learning (discrimination).

Foundation of modern artificial neural networks.

At that time: technological, scientific and philosophical challenges.

# Neural Networks: The Perceptron

## Representation of the Perceptron



## Parameters of the perceptron

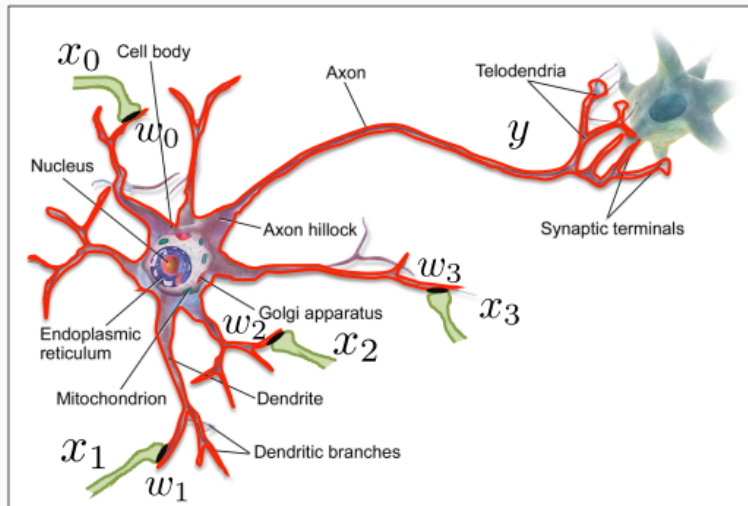
- $w_k$ : synaptic weights
  - $b$ : bias
- }  $\leftarrow$  real parameters to be estimated.

Training = adjusting the weights and biases

# Neural Networks: The Perceptron

## The origin of the Perceptron

Takes inspiration from the visual system known for its ability to learn patterns.

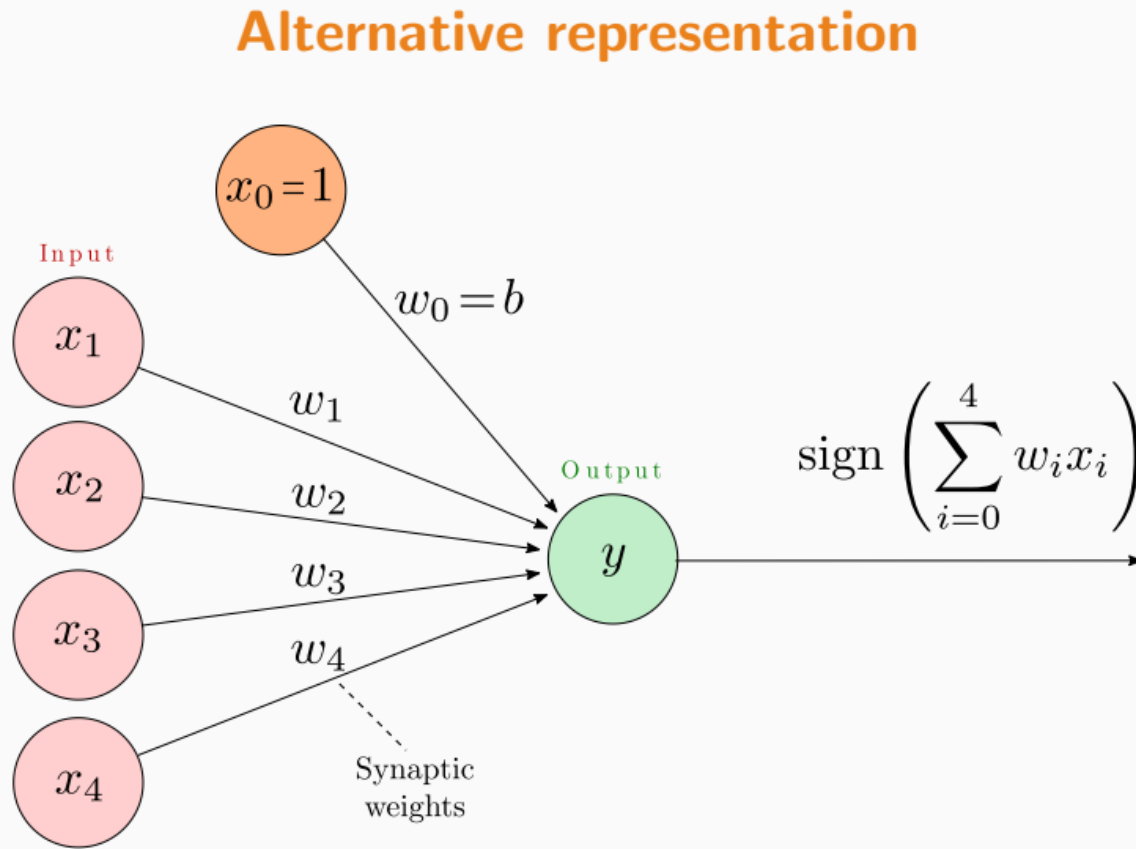


- When a neuron receives a stimulus with high enough voltage, it emits an **action potential** (aka, nerve impulse or spike). It is said to **fire**.
- The perceptron mimics this activation effect: it fires only when

$$\sum_i w_i x_i + b > 0$$

$$y = \underbrace{\text{sign}(w_0 x_0 + w_1 x_1 + w_2 x_2 + w_3 x_3 + b)}_{f(\mathbf{x}; \mathbf{w})} = \begin{cases} +1 & \text{for the first class} \\ -1 & \text{for the second class} \end{cases}$$

# Neural Networks: The Perceptron



Use the zero-index to encode the bias as a synaptic weight.

Simplifies algorithms as all parameters can now be processed in the same way.