

# Artificial Intelligence

CS202 Lecture 20b

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Introduction

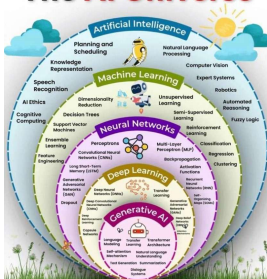
## Deep Learning

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# The AI Universe



# What is Machine Learning?

**Definition:** Computers learning from data without being explicitly programmed

**Learning from data rather than explicit programming:**

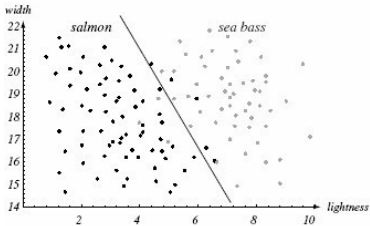
- Instead of following set instructions, ML algorithms analyze patterns in data and make predictions or decisions

**Example:**

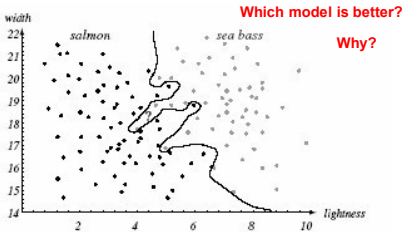
- For instance, an ML model can predict customer preferences based on past buying behavior



# A Simple Decision Model



# A Simple Decision Model



# Types of Machine Learning

## 1. Supervised Learning:

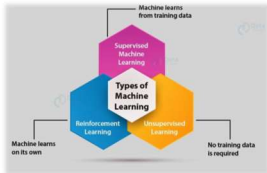
- Uses labelled data to teach models
- Much like a teacher guiding a student

## 2. Unsupervised Learning:

- Works with unlabelled data to find patterns or groupings independently

## 3. Reinforcement Learning:

- Involves an agent that learns by interacting with its environment and receiving rewards or penalties



# What is Labeled Data ?

## Definition:

Data that includes both input features (independent variables) and corresponding output labels (dependent variables)

## Example:

Predicting house prices where features are the size, location, and number of bedrooms, and the label is the price

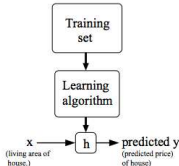


# What is Model ?

## Definition:

A mathematical function or algorithm trained to map input features to the target variable

- **Regression Models:** Predict continuous outcomes (e.g., linear regression)
- **Classification Models:** Predict discrete outcomes (e.g., logistic regression, decision trees)



# 1. Supervised Learning

## Definition

Learning method where each instance in a training dataset has input attributes and an expected output

## Example - Apple Recognition

Model is trained to identify apples using labeled images and corrected iteratively until accurate

## Applications

Speech automation, weather prediction, biometric attendance, creditworthiness prediction in banking, patient readmission prediction in healthcare, and product recommendation in retail



# 1. Supervised Learning

- **Image recognition in healthcare:**

- Helps with image recognition tasks
- For instance, identifying tumors in MRI scans



## IMAGE RECOGNITION

Identifying objects within images

- **Predictive analytics in business:**

- Forecast sales or customer behavior



## FINANCIAL ANALYSIS

Predicting stock prices

- **Language translation:**

- Foundational in language translation tools

## 2. Unsupervised Learning

### Definition

Learning from data without labeled responses to identify patterns and underlying structures

### Example – Clustering

Grouping similar data instances, like different types of fruits, based on characteristics

### Applications

Customer segmentation in banking, MRI data categorization in healthcare, and product recommendation in retail



## 2. Unsupervised Learning

- **Customer segmentation in marketing:**

- Segment customers in marketing, finding groups with similar behaviors or preferences

- **Anomaly detection in finance:**

- Identify unusual transactions that may indicate fraud

- **Clustering in genomics:**

- Clustering and uncovering hidden patterns in unlabeled data



# 3. Reinforcement Learning

## Definition

Allows agents to determine ideal behavior within specific contexts using trial and error, rewards, and penalties

## Example - Training a Dog

Using reinforcement methods (rewards and penalties) to condition behavior.

## Applications

Creating next-best-offer models in banking, allocating medical resources in healthcare, and dynamic pricing in retail.



### 3. Reinforcement Learning

- **Autonomous driving:**

- AI learns from road interactions

- **Robotics:**

- Allows machines to optimize tasks like picking and placing items

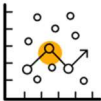
- **Game AI (e.g., AlphaGo):**

- Masters the game of Go through millions of interactions and feedback loops



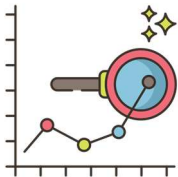
# Regression Analysis

A Set of statistical processes for **estimating the relationships between a dependent variable** ('outcome' or 'response') **and one or more independent variables** ('predictors', 'covariates', 'explanatory variables' or 'features')



# Regression Analysis

- Used to predict numerical values based on input data
- **Example:** Predicting tomorrow's temperature or determining discount amounts
- Forecasting outcomes like temperature, sales figures, or stock prices



# Linear Regression

## Definition

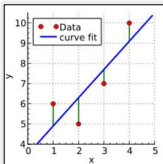
A statistical method used to model the relationship between a dependent variable (target) and one or more independent variables (predictors)

## Key Concepts

- **Dependent Variable (Target):** The variable you want to predict or explain (e.g., house prices)
- **Independent Variable(s) (Predictors):** The variable(s) you use to make predictions (e.g., square footage of a house)
- **Linear Relationship:** Linear regression assumes a straight-line relationship between the dependent and independent variables

## Applications

- Predicting trends (e.g., stock prices, sales forecasts)
- Estimating relationships between variables (e.g., impact of advertising spend on revenue)
- Risk assessment and forecasting in finance and insurance



In linear regression, the observations (red) are assumed to be the result of random deviations (green) from an underlying relationship (blue) between a dependent variable ( $y$ ) and an independent variable ( $x$ ).

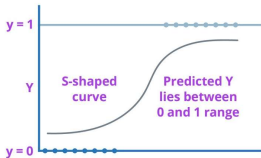
# Logistic Regression



## Introduction

Logistic regression is a statistical method used for binary classification problems in machine learning

- It predicts the probability of a binary outcome based on one or more independent variables



# Predictive Modeling with Logistic Regression

## 01 Introduction to Logistic Regression

Logistic regression is a statistical method used for predictive modeling

It is commonly applied in binary classification problems to predict the probability of a certain outcome

## 02 Understanding Logistic Regression

Logistic regression calculates probabilities using a logistic function to classify data into different categories

It is a powerful tool for predicting outcomes based on input variables

## 03 Model Building Process

The process involves training the model on labeled data to learn patterns and relationships

Logistic regression models are evaluated based on their accuracy in predicting outcomes

## 04 Application in Machine Learning

Logistic regression is widely used in machine learning for tasks like predicting customer churn, fraud detection, and medical diagnosis

It provides insights into the likelihood of an event occurring based on input features

## 05 Evaluation and Interpretation

Model evaluation involves assessing its performance metrics like accuracy, precision, recall, and F1 score

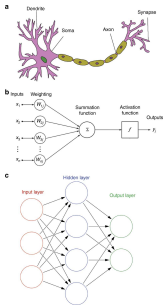
Interpretation of logistic regression coefficients helps understand the impact of input variables on the predicted outcome

# Neural Networks

**Definition:** A series of algorithms that attempt to recognize relationships in data by mimicking the human brain

## Types:

- Perceptrons
- Multi-Layer Perceptrons (MLP)
- Convolutional Neural Networks (CNNs)
- Recurrent Neural Networks (RNNs)
- Long Short-Term Memory (LSTM)
- Self-Organizing Maps (SOMs)



# Neural Networks Structure

## Structure: Input, Hidden, and Output layers

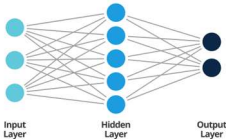
- A neural network consists of three main types of layers: the input layer, hidden layers, and the output layer

## Role of each layer in learning:

- The hidden layers process the input data, transforming it through multiple stages

## Backpropagation in training:

- The model learns through backpropagation
- Adjusts the weights between layers based on errors
- Allows the model to become increasingly accurate



# Principles of Brain Processing

How our brain manipulates with patterns?



A process of pattern recognition and pattern manipulation is based on:

## Massive parallelism

*Brain computer as an information or signal processing system, is composed of a large number of simple processing elements, called neurons. These neurons are interconnected by numerous direct links, which are called connection, and cooperate with each other to perform a parallel distributed processing (PDP) in order to solve a desired computation tasks.*

## Connectionism

*Brain computer is a highly interconnected neurons system in such a way that the state of one neuron affects the potential of the large number of other neurons which are connected according to weights or strength. The key idea of such principle is the functional capacity of biological neural nets depends mostly not so of a single neuron but of its connections*

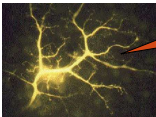
## Associative distributed memory

*Storage of information in a brain is supposed to be concentrated in synaptic connections of brain neural network, or more precisely, in the pattern of these connections and strengths (weights) of the synaptic connections.*

# The Brain Model



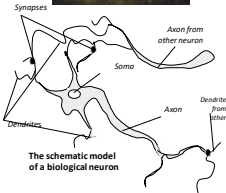
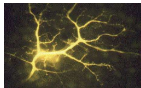
*Human brain contains a  
massively interconnected net  
of  $10^{10}$ - $10^{11}$  (10 billion)  
neurons (cortical cells)*



**Biological Neuron**  
- The simple  
"arithmetic  
computing" element

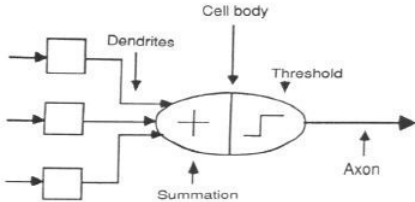
# Biological Neurons

- **Soma or body cell** - is a large, round central body in which almost all the logical functions of the neuron are realized.
- **The axon (output)**, is a nerve fibre attached to the soma which can serve as a final output channel of the neuron. An axon is usually highly branched.
- **The dendrites (inputs)** - represent a highly branching tree of fibres. These long irregularly shaped nerve fibres (processes) are attached to the soma.
- **Synapses** are specialized contacts on a neuron which are the termination points for the axons from other neurons.



# Neuron Model

Abstract Neuron Model:



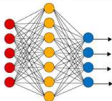
# Deep Learning

**Definition:** Using multi-layered neural networks to model complex patterns in data

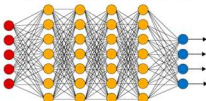
## Differences from traditional ML:

- Traditional ML requires extensive feature engineering
- Deep learning models extract features automatically
- Allows handling more complex tasks

Simple Neural Network



Deep Learning Neural Network



Input Layer



Hidden Layer



Output Layer

# Applications of Deep Learning

- **Natural Language Processing (NLP):**

- Chatbots and language translation



- **Computer Vision:**

- Identify objects, faces, and even complex patterns like handwriting



- **Autonomous vehicles:**

- Recognize and interpret surroundings in real-time



# Summary

- **AI** simulates intelligence and enables machines to think
- **Machine Learning** allows systems to learn from data
- **Neural Networks** form the basis of modern AI techniques
- **Deep Learning** offers a multi-layered approach to pattern recognition

**Thank You !**