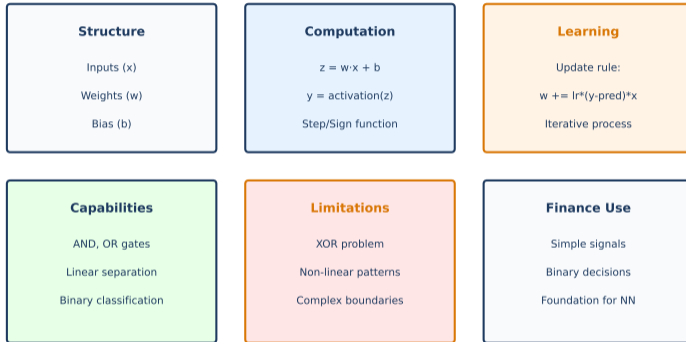


## Lesson 33 Summary: Perceptron

Data Science with Python – Key Concepts

Data Science Program

## Perceptron: Building Block of Neural Networks



The perceptron is the foundation of neural networks

# What is a Perceptron?

## Simplest neural network:

- **Inputs:** Features with associated weights
- **Weighted sum:**  $z = \sum w_i x_i + b$
- **Activation:** Step function (0 or 1)

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Single layer, single neuron binary classifier

# The Perceptron Algorithm

## Learning process:

- **Initialize:** Random weights
- **Predict:** Compute output for each sample
- **Update:**  $w_i = w_i + \eta(y - \hat{y})x_i$

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Converges if data is linearly separable

## What perceptron can solve:

- **AND gate:** Linearly separable
- **OR gate:** Linearly separable
- **XOR gate:** NOT linearly separable

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XOR limitation led to the AI winter and MLP development

## Geometric interpretation:

- **2D:** Line separating classes
- **3D:** Plane separating classes
- **nD:** Hyperplane separating classes

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**Weights define the orientation; bias shifts the boundary**

# Convergence Theorem

## Guaranteed convergence:

- **Condition:** Data must be linearly separable
- **Finite steps:** Will find solution in bounded iterations
- **Margin:** Larger margin = faster convergence

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Perceptron convergence theorem proved by Novikoff (1962)

## Why we need more layers:

- **Non-linear patterns:** Cannot capture
- **Complex boundaries:** Single line insufficient
- **Real-world data:** Rarely perfectly separable

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**Multi-layer perceptrons overcome these limitations**

## Historical and pedagogical uses:

- **Simple signals:** Buy/sell based on features
- **Binary classification:** Default/no default
- **Foundation:** Understanding for deeper networks

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Modern finance uses MLPs and deep networks

### Essential Concepts:

Component	Description
Weighted sum	$z = \sum w_i x_i + b$
Activation	Step function: $\hat{y} = 1$ if $z > 0$
Update rule	$w_i = w_i + \eta(y - \hat{y})x_i$
Learning rate	$\eta$ controls step size
Convergence	Guaranteed if linearly separable

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Perceptron: simple but foundational for deep learning