Perceptron

What is a Perceptron?

A **Perceptron** is the smallest and simplest unit of a neural network, similar to a single "brain cell" in artificial intelligence.

It performs the following steps:

1. Takes inputs (data)
2. Multiplies them by weights (importance)
3. Adds a bias (adjustment)
4. Passes the result through an activation function
5. Produces an output (decision)

The mathematical formula of a perceptron is:

$$\text{Output} = f(w_1x_1 + w_2x_2 + \ldots + b)$$

where:

- $x_1, x_2, \ldots$ are the input values
- $w_1, w_2, \ldots$ are the weights (importance of each input)
- b is the bias (a constant to shift the decision boundary)
- $f()$ is the activation function (which decides the final output)

Example 1: Should I Drink Coffee?

Imagine you want to decide whether to drink coffee or not. You think about three factors:

Input	**Example Value**	**Meaning**
x_1 = Sleep hours	4 hours	Less sleep → likely yes
x_2 = Energy level	2 (low)	Low energy → likely yes
x_3 = Time of day	8 PM	Late night → likely no

Weights show how important each factor is:

Input	**Weight (w)**	**Meaning**
Sleep hours	-0.7	More sleep → less coffee
Energy level	-0.5	More energy → less coffee
Time of day	$+0.3$	Later time → less likely

Bias: $b = +0.2$ (you usually like coffee)

Step 1: Weighted Sum

$$\begin{aligned}\text{Total} &= (-0.7)(4) + (-0.5)(2) + (0.3)(8) + 0.2 \\ &= -2.8 - 1.0 + 2.4 + 0.2 = -1.2\end{aligned}$$

Step 2: Activation Function (Decision)

Use a step function:

$$f(z) = \begin{cases} 1, & \text{if } z > 0 \\ 0, & \text{if } z \leq 0 \end{cases}$$

Here, $z = -1.2$, so:

$$f(-1.2) = 0$$

Decision: Do not drink coffee.

Meaning

The perceptron learned that since you slept enough or it's late, it's better not to drink coffee. If you had less sleep or lower energy, the weighted sum would be positive, leading to $f(z) = 1$, meaning **drink coffee**.

Example 2: Should I Bring an Umbrella?

Inputs:

- x_1: Is the sky cloudy? (1 = yes, 0 = no)
- x_2: Did the weather app say rain? (1 = yes, 0 = no)

Weights:

$$w_1 = 0.6, \quad w_2 = 0.8, \quad b = -0.4$$

Weighted sum:

$$\text{Total} = 0.6(1) + 0.8(1) - 0.4 = 1.0$$

Activation:

$$f(z) = \begin{cases} 1, & z > 0 \\ 0, & z \leq 0 \end{cases}$$

Since $z = 1.0 > 0$, output $= 1 \Rightarrow$ **Take umbrella.**

Summary

Step	**Description**	**Example**
Input	Features or data	Sleep, energy, time
Weight	Importance of each input	$-0.7, -0.5, +0.3$
Bias	Small adjustment	$+0.2$
Sum	Weighted total	-1.2
Activation	Decision rule	Do not drink coffee

In Summary

A **Perceptron** is a simple decision-maker that combines inputs, assigns importance through weights, adds bias, and applies an activation function to make a final yes/no decision—just like a human makes quick judgments based on multiple factors.